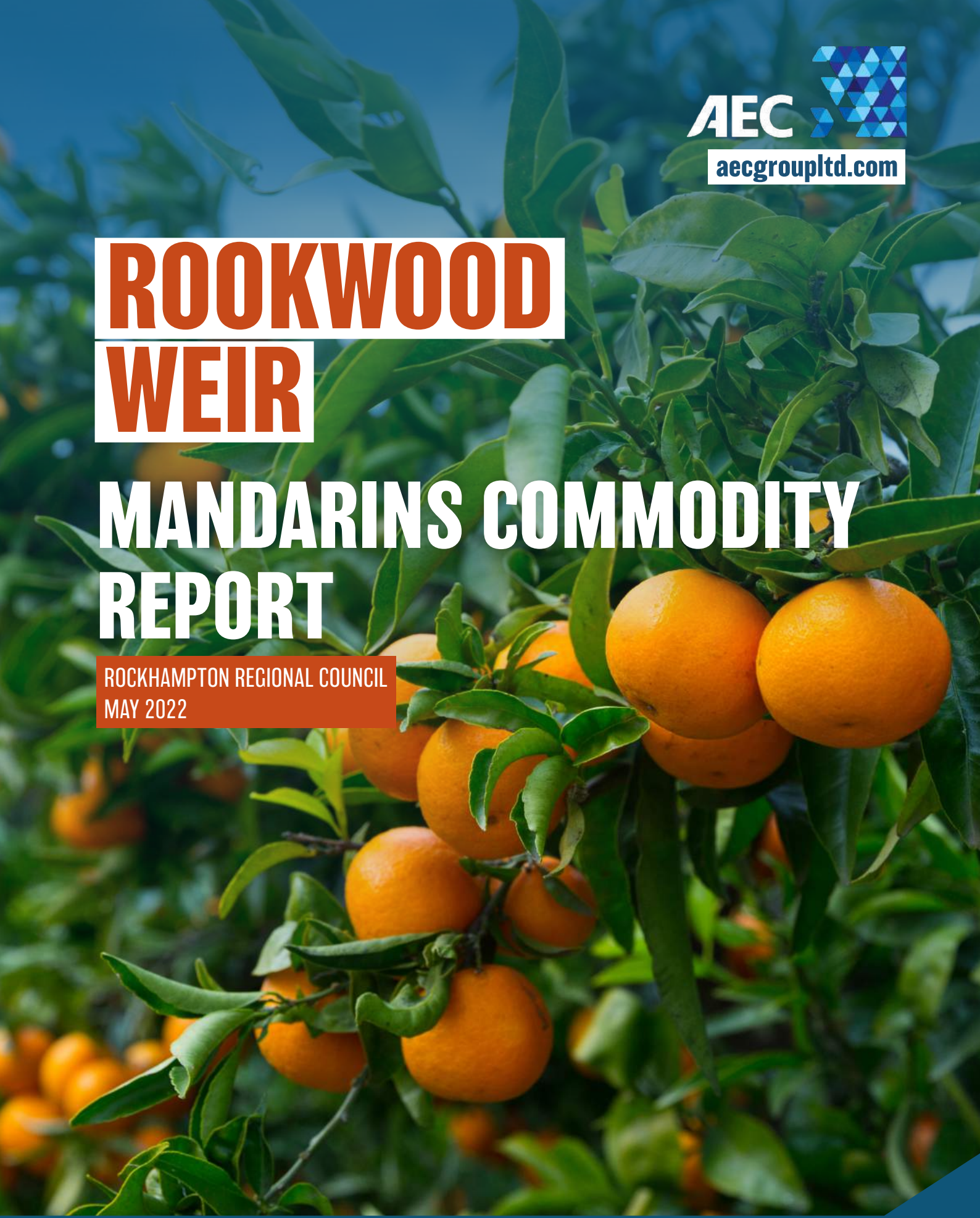

AEC

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ROOKWOOD WEIR

MANDARINS 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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EXECUTIVE SUMMARY

BACKGROUND

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 mandarins and assesses the potential agribusiness opportunities for the production of mandarins within Rookwood Weir's 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 mandarin orchards in the Australian environment, including soil suitability, water availability, orchard management, pest and weed control, infrastructure, and equipment.

COMMODITY OUTLOOK

GLOBAL PRODUCTION

From 1990 to 2021, global mandarin production increased by an average annual rate of 3.6% per annum (FOASTAT, 2022; USDA, 2022). Global mandarin production has more than tripled over the 31-year period, reaching an estimated 37.9 million tonnes in 2021. The growth in mandarin production over time has largely been driven by the increase in production within China, with a rapid expansion of citrus plantings, primarily concentrated in the Guangxi province.

As China is the world largest producer, representing 73.8% of total global production, the global harvest area and production levels are significantly impacted by China's activity. Across 2007 and 2006, there was a drought throughout China which severely impacted on global yield and production levels, which has gradually recovered over time.

The next two biggest producers are Spain, at 6% of global production, and Turkey, at 4% of global production. Spain produced 2.2 million tonnes in 2021 and over the 31 years from 1990 to 2021, production has increased at a rate of only 0.9%. Production in Turkey reached 1.8 million tonnes in 2021, and has been increasing at an average annual rate of 5.5% since 1990.

On the global scale, Australia is a relatively small producer of mandarins, representing less than one per cent of the world's mandarin production. Although Australia is small in comparison to countries like China, the industry is reportedly important to the Australian economy as it is highly labour intensive which provides a number of employment opportunities (DFAT, 2016).

The Australian mandarin industry has seen rapid growth over the past 31 years, with production growing by an average annual rate of 3.5%, largely in-line with global production. This has seen Australian production nearly triple over the period, increasing from 41,000 tonnes in 1990 to 117,729 tonnes in 2021. Although Australia is a small producer, Australia is the largest supplier of mandarins to the Chinese market. In 2020, Australian mandarin imports accounted for 38.2% of China's total imports.[1]

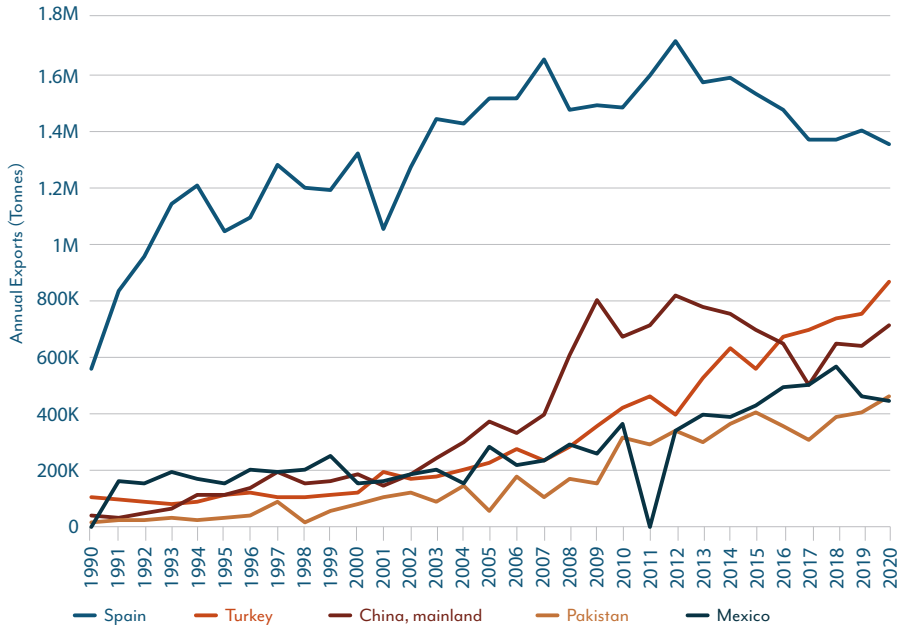
MAJOR EXPORTERS AND IMPORTERS

Exports of mandarins have been increasing by an average annual rate of 6.4% per annum from 1990 to 2020 to reach an export volume of 5.8 million tonnes in 2020.

The largest exporter of mandarins in 2020 was Spain, with exports totalling 1.4 million tonnes. Spain is currently the largest supplier of mandarins to the European Union (EU), resulting from the close proximity to market and lower transportation costs associated with exporting the fruit. Spain's key competitors in the EU market include both Italy and Greece, although supply from these two markets are small in comparison to Spain.

1 On average from 2010 to 2020.

Figure ES. 1. Top Five Export Countries in 2020, 1990 to 2020



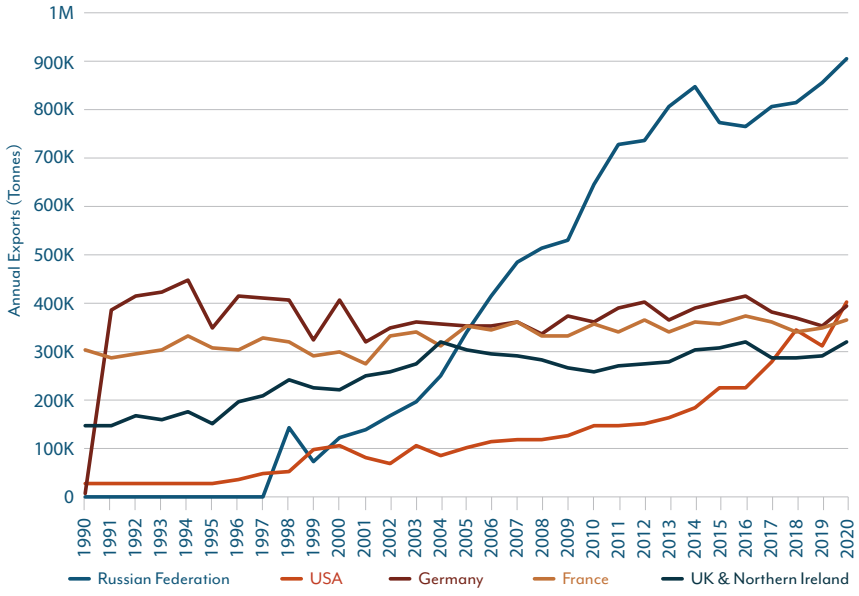
Note: Data is reflective of tangerines, mandarins, clementines and satsumas.
Source: FAOSTAT (2022).

Imports of mandarins have been increasing by an average annual rate of 5.8% per annum from 1990 to 2020 to reach an export volume of 5.2 million tonnes in 2020.

The largest importer of mandarins in 2020 was Russia, importing a total of 902,419 tonnes. Mandarin imports to Russia have increased by an average annual rate of 9.0% from 1998 to 2020. Mandarins are not grown in Russia on a commercial scale, as the cold climate is not suitable for production.

The largest supplier of mandarins to Russia in 2020 was Turkey, accounting for 51% of total imports (equating 461,567 tonnes). This was followed by Morocco (17% of total imports or 150,178 tonnes) and Pakistan (11% of total imports or 95,639 tonnes).

Figure ES. 2. Top Five Import Countries in 2020, 1990 to 2020



Notes:
- Data is reflective of tangerines, mandarins, clementines and satsumas.
- No import data is available for Russia from 1990 to 1997.

Source: FAOSTAT (2022).

GLOBAL CONSUMPTION AND DEMAND

The United States Department of Agriculture have highlighted that China was estimated to be the largest consumer of mandarins on the global scale, with total domestic consumption of fresh mandarins totalling 26.5 million tonnes. From 2010 to 2021, it was estimated that total consumption in China grew by an average annual rate of 6.7% per annum.

The top five largest consumers of fresh mandarins based on information provided by the USDA (2022) are provided in the table below.

Table ES. 1. Fresh Domestic Consumption of Mandarins, 2016 to 2021 (Million Tonnes)

Country	2016	2017	2018	2019	2020	2021
China	19.4	20.1	20.7	21.8	23.6	26.5
European Union	3.0	2.7	2.9	2.7	3.0	2.8
United States	0.9	0.9	1.0	1.0	1.0	1.0
Russia	0.8	0.8	0.9	0.8	0.9	0.9
Japan	1.0	0.9	0.9	0.9	0.9	0.9
Other	3.5	3.6	4.0	3.4	4.2	4.4
Total	**28.5**	**28.9**	**30.4**	**30.6**	**33.7**	**36.4**

Note: Top five consumers as of 2021.
Source: USDA (2022).

Mandarin popularity has grown significantly over the years, largely driven by the increase in production in China. China is the largest producer of mandarins on the global scale, producing 23.1 million tonnes in 2020 and only exporting approximately 3.1% of total production. This highlights the significant domestic demand for the fruit in China, partially attributed to the rise of incomes and Chinese consumers preferring fresh fruit over cheaper and worse quality fruit options (FAO, undated).

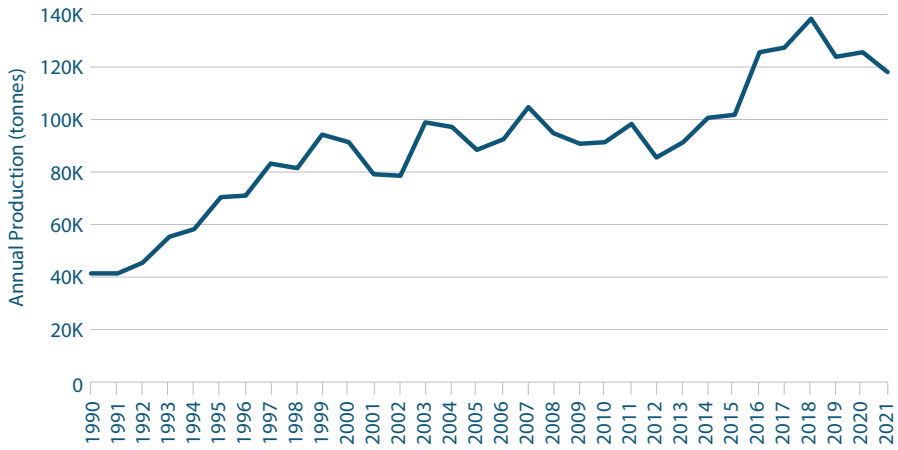
The US has experienced strong growth in Mandarin imports over the years, growing by an average annual rate of 10.2% per annum from 1990 to 2020. In 2020, the US was also the 7th largest producer on mandarins on the global scale, highlighting the significant domestic demand for mandarins. This market present key growth opportunities for mandarins, with relatively strong domestic demand.

AUSTRALIAN INDUSTRY

The mandarin market in Australia is largely dominated by three varieties, including Murcott, Imperial and Afourer. Murcott mandarins accounted for approximately 29% of fresh production, Imperial mandarins accounted for 24% of production and Afourer mandarins accounted for 23% of fresh production (Hort Innovation, 2021).

Mandarin production in Australia has experienced downwards trends from 2018, with the number of bearing mandarin trees experiencing rather significant decline in 2018-19 (see Figure ES.4 below). The decline in production from 2020 to 2021 can partially be attributed to the strict COVID-19 protocols implemented in Australia throughout the height of the pandemic. The citrus industry workers in Australia mostly consist of those on the Pacific Seasonal Worker Program and overseas labour (USDA, 2020). With the international boarder closures, these overseas workers were not permitted into Australia and the industry faced labour shortages. Mandarin harvesting is labour intensive, and without the usual foreign workers, a portion of the yield has been left unharvested in Australia (Fresh Plaza, 2021).

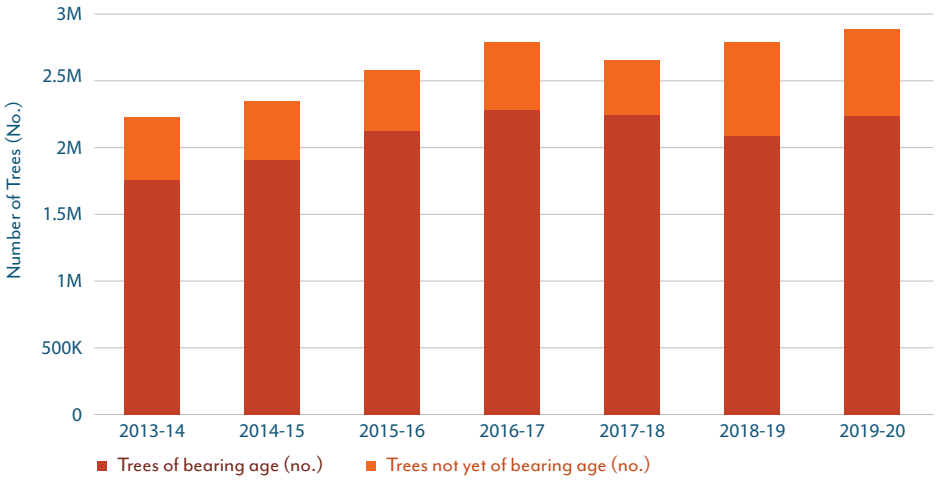
Figure ES. 3. Australian Mandarin Production (Tonnes), 1990 to 2021



Source: ABARES (2021).

In 2017, it was reported that imperials mandarins were being oversupplied by around 10,000 tonnes per annum (ABC, 2017). The opportunities for imperial mandarins are on the decline with the market being labelled as mature (ABC, 2017). The decline in trees in Australia could be a result of the oversupply of imperial mandarins, where trees have been removed if they were not cost effective or have been replaced with new varieties.

Figure ES. 4. Number of Mandarin Trees, Australia (2013-14 to 2019-20)



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. 4.
Source: ABS (2021, 2020, 2019, 2018a & b, 2016, 2015).

Imperial mandarins are not suitable for export, however low-seeded varieties such as Murcott are in demand within the export market (Citrus Australia, 2021). Australia largely produces the Afourer and Murcott mandarin varieties, which are proving to be more popular within the market.

QUEENSLAND PRODUCTION

Queensland is the largest area of mandarin production in Australia, with the Central Burnett area around Gayndah and Munduberra being the major production area, supported by smaller production areas in Queensland including Emerald (Central Queensland) and Mareeba (North Queensland).

Mandarin production is prominent throughout the broader Central Queensland region with approximately 965,124 trees of bearing age and an additional 157,189 trees, which are not yet of bearing age in 2019-20. The new plantings are a result of growth in the industry and a shift from Imperial mandarins due to lower domestic demand. The mandarin production in Central Queensland will increase as these trees begin to mature.

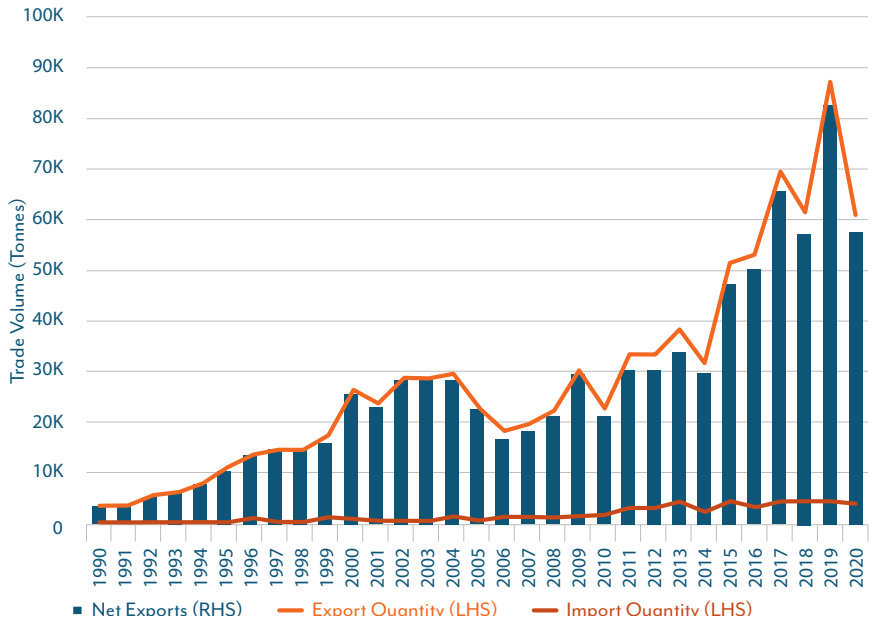
From 2016-17 to 2018-19 the Central Queensland region experienced a year-on-year decline in the number of bearing trees. Over the two-year period, the number of bearing trees declined by 272,353 trees (largely attributed to the Wide Bay Statistical Area 4 (SA4)). The decline in mandarin trees could be similar to the effects stated above, with the oversupply of imperial mandarins in Australia by around 10,000 tonnes a year.

AUSTRALIAN EXPORT MARKET

AUSTRALIA'S TRADE BALANCE

In 2020, it was estimated that Australia exported approximately 61,181 tonnes of mandarins and imported 3,730 tonnes, leaving net exports at 57,451 tonnes.

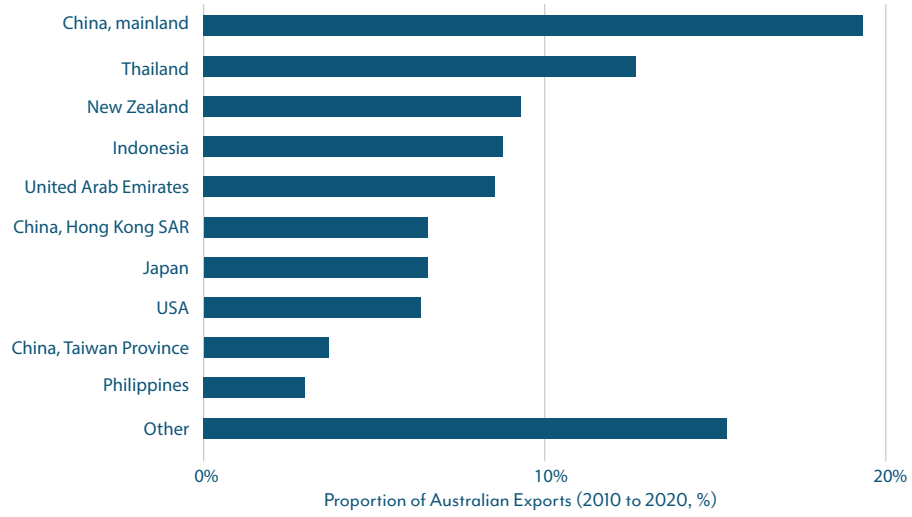
Figure ES. 5. Australia's Trade Balance



Source: FAOSTAT (2022).

China has been Australia's largest export market for mandarins on average from 2010 to 2020, accounting for 19.2% of Australia's exports on average over the period of 10 years. This was followed by Thailand (12.6%) and New Zealand (9.3%).

Figure ES. 6. Australia's Top 10 Key Export Markets, 2010 to 2020



Note: Data is reflective of tangerines, mandarins, clementines and satsumas.
Source: FAOSTAT (2022).

CHINA

Both China and Australia are reliant on each other for mandarin trade (China is Australia's largest export market and Australia is China's largest import market). From 2010 to 2020, China sourced approximately 38.2% of total mandarin imports from Australia (on average). Australia was granted official market access to China in 2006, however, the industry was relatively slow to capitalise on the market due to challenging government registration processes and phytosanitary requirements (Citrus Australia, 2021). As a result, mandarin exports to China prior to 2012 were small volumes limited to Queensland mandarins (Citrus Australia, 2021).

Queensland mandarin exports to China require cold disinfestation[2] treatment at three degrees Celsius to treat the Queensland fruit fly, while Western Australia mandarin exports require treatment at 2.1 degrees Celsius (for treatment of Mediterranean fruit fly). Citrus Australia (2021) reports that cold treatment at 2.1 degrees Celsius is damaging to the fruit, leading to poor quality.

Chile gained access to China in 2020 for citrus exports, however, the process was not finalized until mid-way through the season due to the requirement for registering orchards and pack houses with authorities (Citrus Australia, 2021). It is unclear on the impact that Chile will have on the mandarin market in China, however, Australia will continue to have proximity to market advantages.

THAILAND

The largest source of mandarins in Thailand was from China, accounting for 93.6% of total imports on average from 2010 to 2020. China dominates the market for mandarins, which are supplied during the northern hemisphere season. China supplies Thailand with small and low-cost mandarins (typically Nanfeng mandarins), which are a different market to Thailand's second largest supplier, Australia.

In 2020, Australia exported approximately 6.6% of total mandarin production to Thailand, equating to 8,246 tonnes. Thailand is an important market for Queensland mandarins with strong demand for Murcotts and Murcott varieties (Citrus Australia, 2021).

Exports to Thailand, which are not accompanied by a certificate of analysis (from an accredited laboratory) must be subject to on-arrival screening by authorities (Citrus Australia, 2021). This was implemented in 2020 as Thailand had reforms to its agrichemical residue monitoring process (Citrus Australia, 2021). Due to Australia's well-established testing program, Citrus Australia highlight that this will unlikely be a barrier to trade in coming years (Citrus Australia, 2021).

NEW ZEALAND

New Zealand was Australia's third largest export market for mandarins (on average) between 2010 and 2020. New Zealand is largely reliant on mandarin imports from Australia, with Australian mandarins comprising approximately 80.0% of total mandarin imports to New Zealand from 2010 to 2020.

The second largest supplier of mandarins to the New Zealand market was the US, accounting for 19.5% of total imports on average from 2010 to 2020.

Australia and the US have historically been the only two countries, which supply the New Zealand market. Citrus Australia (2021) have reported that the US supplies New Zealand small volumes between January to March, while Australia supplies the market from July to October.

The Australian Citrus Industry Export Strategy 2021-2025 highlights mandarin plantings are beginning to expand in New Zealand (particularly Satsumas), which will capture some of the current market share currently supplied by imports from the US and Australia (Citrus Australia, 2021). The strategy highlights that export growth potential for New Zealand is limited, with future domestic production likely be sufficient to meet domestic demand (Citrus Australia, 2021).

2 Cold disinfestation is a treatment for fruit fly, where the mandarin is subject to low temperatures for an extended period of time. This cold temperature will kill fruit fly eggs and/or larvae if they are on the fruit. The treatment can be undertaken prior to export or during transit.

COMPETITIVE OUTLOOK

Over recent years, the Australian mandarin industry has been experiencing an increase in exports, growing by an average annual rate of 10.4% from 2010 to 2020. This is largely through the demand from China, where exports to China have grown by 50% on average per annum from 2010 to reach a total of 13,401 tonnes in 2020.

Australia has the opportunity to further increase mandarin exports in the international market, recently being granted expanding access for exports. Citrus that is grown in inland Queensland, Western Australia, and Bourke and Narromine in New South Wales can now be exported to the US (Australian Government, 2021). Previously, only citrus exported to the US was from Riverina, the Riverland, and Sunraysia (Australian Government, 2021).

Over the years Chile has grown to become the largest supplier of mandarins to the US market. Chile has a number of competitive advantages in supplying the US market including proximity to market, lower production costs and is focused almost exclusively on the US for export (Citrus Australia, 2021). Although Australia is a smaller player compared to Chile, Australia has a 'quality niche' that cannot be provided by Chile (Citrus Australia, 2021).

FINANCIAL AND COMMERCIAL ANALYSIS

Rookwood Weir's Tender 2 water sales allows for a maximum 500ML water allocation for agricultural landholders. Under the assumption this water is provided with a conservative 80% reliability and mandarins require an estimated 10ML per ha per year (DAF, 2004), the maximum growing area in the Rookwood Weir Catchment Area is 40ha.

The key guiding outcomes of the financial analysis for an 40ha farm are:

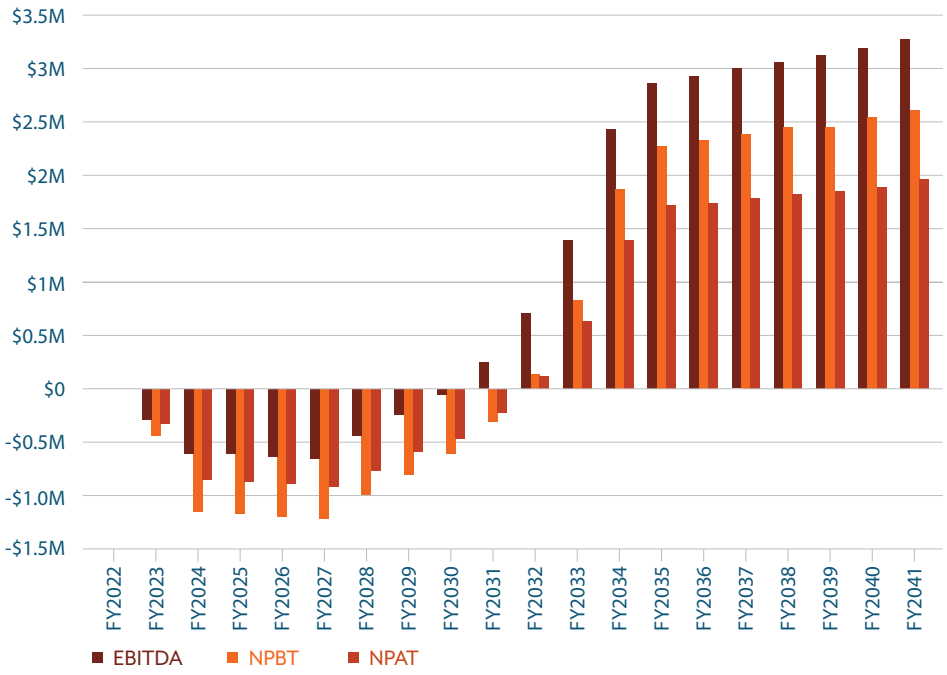
- The anticipated initial capital investment for a mandarin orchard is $8.7 million – including, land, land clearing, infrastructure and equipment, water entitlements, and planting
- The first harvest is not expected to occur until the fourth year of growing, when the trees will yield, on average, 18.3kg per tree. The farm will be operating at a loss until the commercial return is achieved when the trees reach their seventh year (FY2031), with a yield of 56.4kg per tree.
- The break-even point (for Murcott), at the current weighted average cost of $1.54 per kg is September 2029. However, the first year of operating at a profit is predicted to be FY2031, 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 FY2030.
- 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 17.1%. The terminal value of the mandarin farm at the conclusion of the analysis (FY2041) is $97.8 million (undiscounted).

The orchard revenue consists of the operating income associated with the sale of produce (both fresh fruit and fruit for juice or processing). The price point is determined by the quality of the fruit, determined through a number of grade points. The estimated weighted average price per kilogram used in modelling the example Murcott mandarin farm is $1.54.

The assumed mandarin 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 FY2032. The breakeven point is in FY2030, which operating revenue exceeds the cost of goods sold. Given general farm operating costs, overhead operating costs and asset depreciation, the NPAT is expected to be positive two years after the break even point.

By FY2041 the NPAT of the orchard is estimated to be $1.95 million. The NPAT profile over the FY2030 to FY2041 shows a steep increased in profitability from FY20231 to FY2035, when the trees reach maturity and continue to produce at a relatively consistent level. The consistent yield does not reflect potential year of year conditions, such as water availability, and weather events, which will impact the annual return.

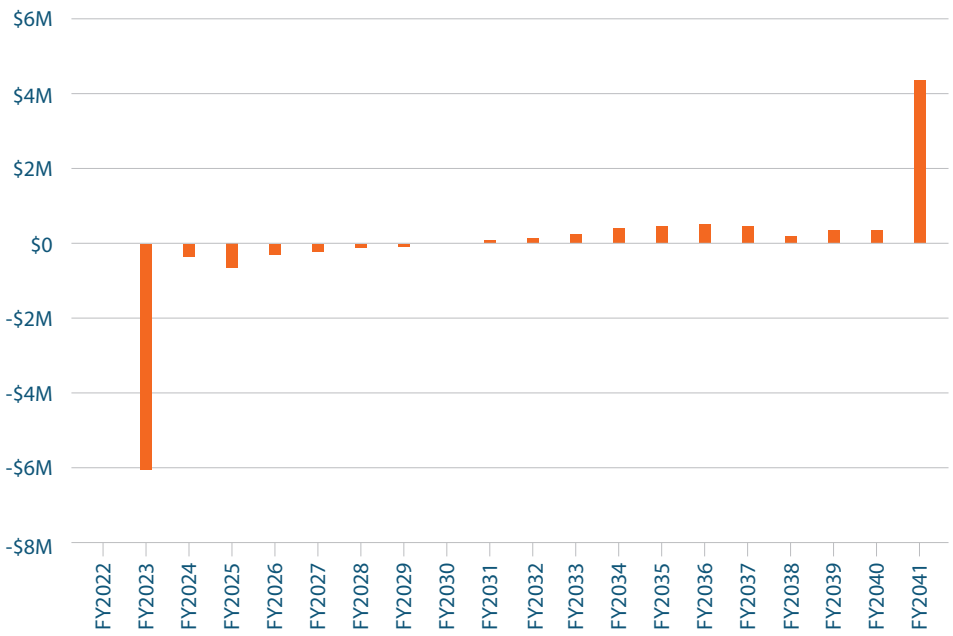
Figure ES. 7. Orchard Operating Profit (FY2022 – FY2041)



Source: AEC (2022).

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 FY2035 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 in the 20-year analysis, refer to the figure below.

Figure ES. 8. Discounted Cashflows, Including Terminal Value (FY2022 – FY2041)



Note: Discounted cashflows have been estimated on a 17.1% post-tax discount rate, which is the implied internal rate of return.

Source: AEC.

ECONOMIC IMPACT

Initial capital investment of the orchard is anticipated to cost approximately $7.1 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 $6.8 million in industry output (i.e. revenues) to local businesses within the Rockhampton LGA.

A further $4.5 million in industry output is estimated to be supported in the catchment's economy through flow-on activity, including $2.6 million in production induced (i.e. supply chain) activity and $1.8 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 $4.9 million contribution to GRP including $2.7 million directly
- 41 FTE jobs (including 25 FTE jobs directly), paying a total of $3.4 million in wages and salaries ($2.1 million directly).

Table ES. 2. Economic Activity Supported by a Mandarin Orchard Enterprise, Rockhampton LGA

Impact	Output ($M)	Gross Regional Product ($M)	Incomes ($M)	Employment (FTEs)
Direct	$6.8	$2.7	$2.1	25
Production Induced	$2.6	$1.1	$0.8	9
Consumption Induced	$1.8	$1.0	$0.5	7
Total	**$11.3**	**$4.9**	**$3.4**	**41**

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
EBIT	Earnings before interest and tax
FTA	Free Trade Agreement
Ha (ha)	Hectares
HTW	Herron Todd White
Km	Kilometres
ML	Megalitres
NIS	Nut in-shell
NPAT	Net Profit After Tax
NPBT	Net Profit Before Tax
NSW	New South Wales
QLD	Queensland
ROCE	Return on Capital Employed
CPTPP	Comprehensive and Progressive Agreement for Trans-Pacific Partnership
AANZFAT	ASEAN-Australia-New Zealand-Free Trade Area
IACEPA	Indonesia-Australia Comprehensive Economic Partnership Agreement
FTA	Free Trade Agreement
KAFTA	Korea-Australia Free Trade Agreement
ChAFTA	China-Australia Free Trade Agreement
RCEP	Regional Comprehensive Economic Partnership
AUSFTA	Australia-United States Free Trade Agreement

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 $367.2 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 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 Grants Program (RWGP), 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 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 macadamias, mandarins and mangoes.

AEC Group Pty Ltd (AEC) and Herron Todd White (HTW) have been commissioned to undertake Business Case Studies 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 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 mandarin crops 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 mandarin 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:

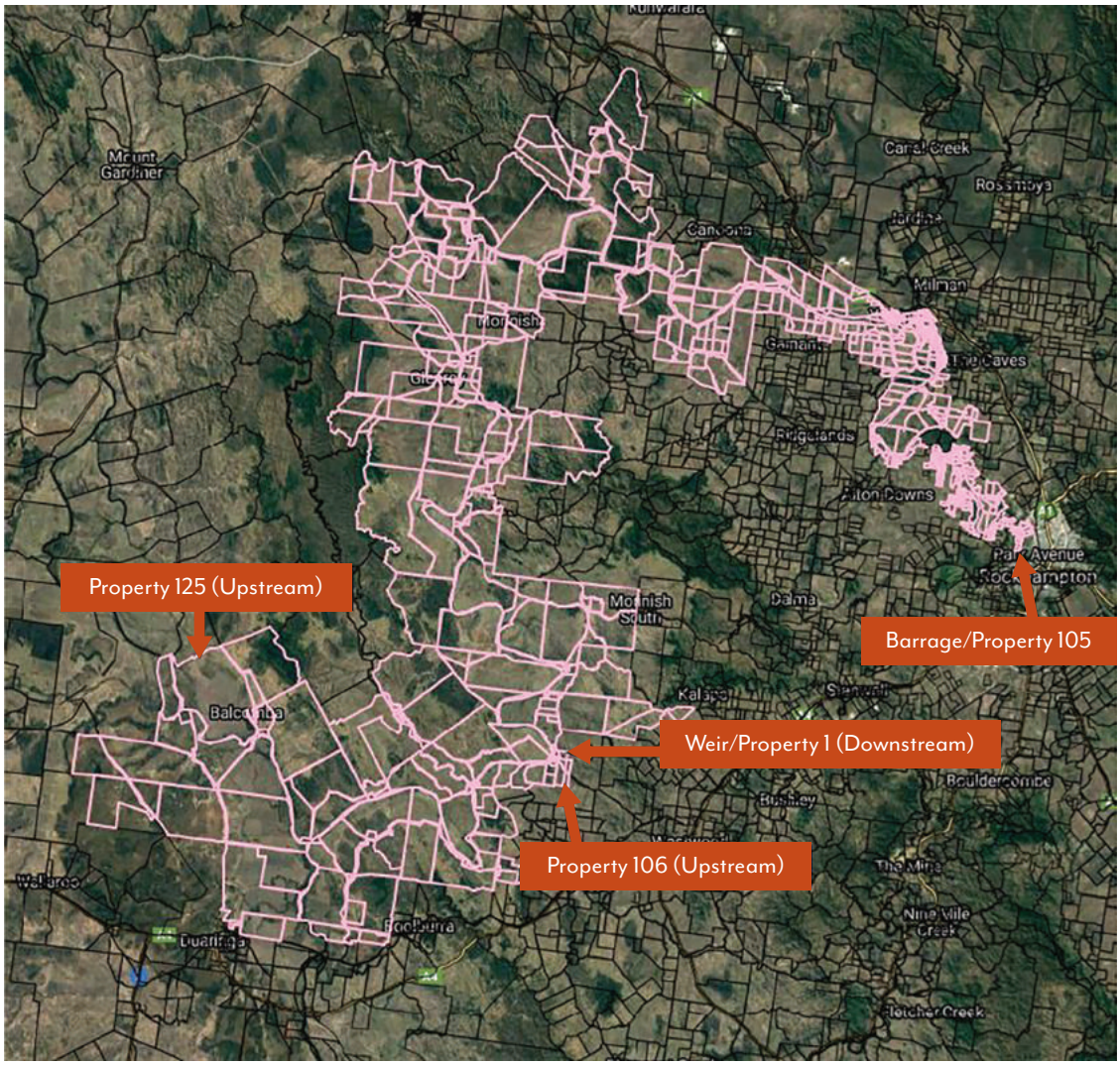
Source: AEC.

1.4 ROOKWOOD WEIR CATCHMENT AREA

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 approximately within five kilometres of either side of the Fitzroy River, and can be potentially suitable for irrigated crops.

Figure 1.1. Rookwood Weir Catchment Area



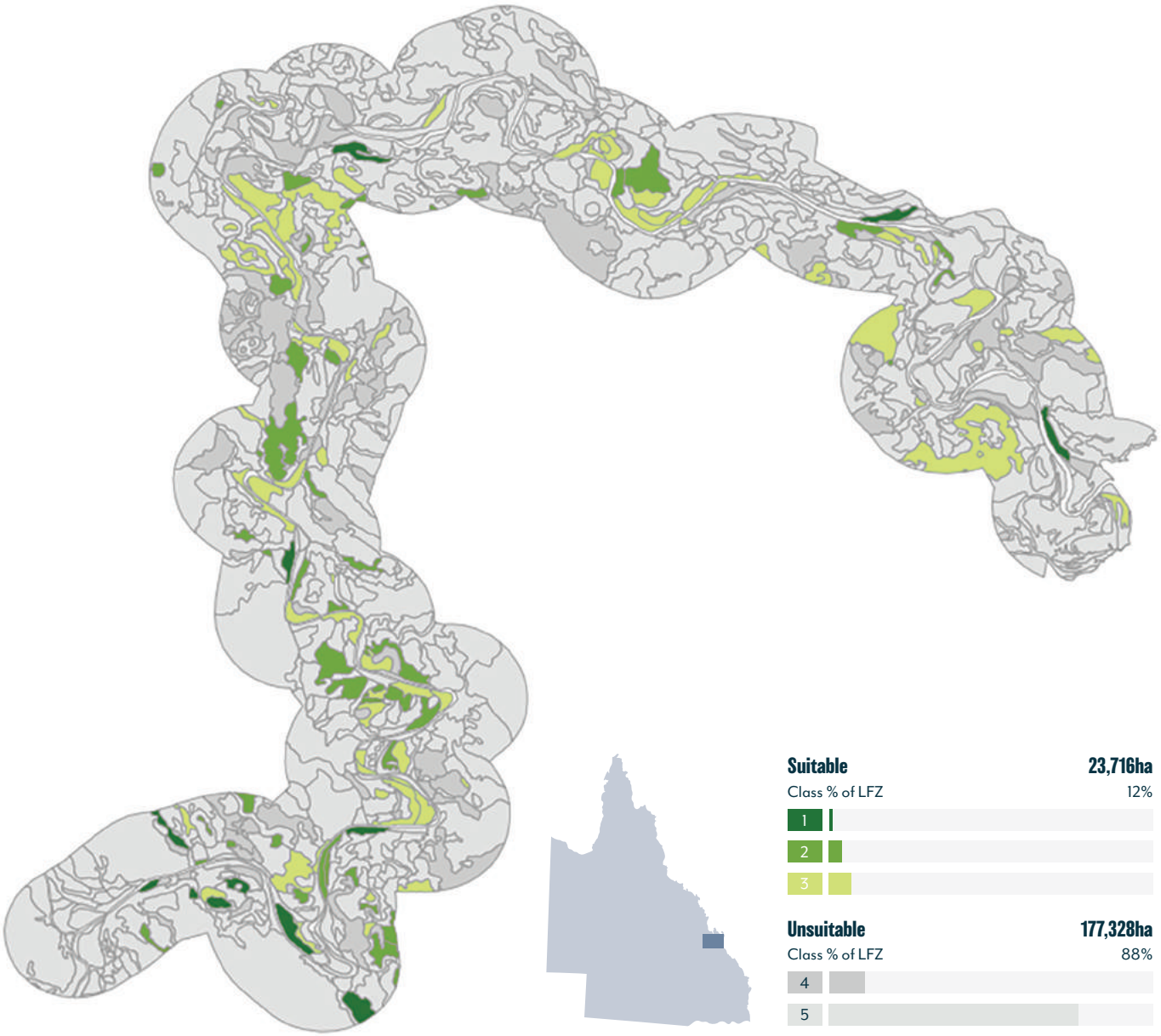
Source: HTW.

1.4.1 LAND SUITABILITY FOR CITRUS PRODUCTION

Rookwood Weir's project team 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 mandarins in the Fitzroy River region based on the DAF soil suitability tool.

Figure 1.2. Land Suitability Fitzroy River



Source: Queensland Government (2021).

Based on the identified area, the maximum suitable land area that could be used to produce mandarins 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 citrus crops suitability, the total land available for mandarins reduces to approximately 18,780 Ha (HTW, unpublished b).

2. OVERVIEW OF THE GLOBAL MARKET

2.1 INTRODUCTION

The mandarin was thought to originate initially from India, travelling to China and from China to Europe, Africa, and Australia. Over the years many new mandarin varieties have been introduced into Australia, with the main driver being the demand for low-seed and easy to peel varieties.

Australia has a number of mandarin varieties growing today, with the market being largely dominated by Murcott, Imperial and Afourer. Of important note, the Imperial mandarin is not suited for export as the variety is soft skinned and does not withstand the conditions of transport (DFAT, 2016).

On the global scale, Australia is a relatively small producer of mandarins, representing less than one per cent of the world's mandarin production. Although Australia is small in comparison to countries like China, the industry is reportedly important to the Australian economy as it is highly labour intensive which provides a number of employment opportunities (DFAT, 2016).

The Australian mandarin industry has seen rapid growth over the past 31 years, with production growing by an average annual rate of 3.5%. This has seen Australian production nearly triple over the period, increasing from 41,000 tonnes in 1990 to 117,729 tonnes in 2021. Although Australia is a small producer, Australia is the largest supplier of mandarins to the Chinese market. In 2020, Australian mandarin imports accounted for 38.2% of China's total imports. [1]

Australia is currently facing transport and labour constraints in the industry, largely resulting from the impact of the COVID-19 pandemic. The labour shortages are stemming from international boarder closures, which were implemented by the Australian Government during the height of the COVID-19 pandemic at the beginning of 2020. Although international borders are now open, labour shortages from international markets continue. This challenge is negatively impacting on Australian production, with a portion of production being left unharvested, resulting in a higher than average production cost per kilogram sold.

Additionally, transportation costs have increased significantly with freight pressures impacting the industry. In some instances, shipping times have nearly doubled, providing an unviable option for delivering fruit in a timely manner so quality is maintained.

Australia is currently recorded as the 15th largest exporter of mandarins, accounting for approximately 1.1% of the export market in 2020. By 2025, Citrus Australia project that Australian mandarin exports will more than quadruple in volume reaching a total of 230,000 tonnes (Citrus Australia, 2020a). This indicates strong future demand for Australian mandarins over the short-term.

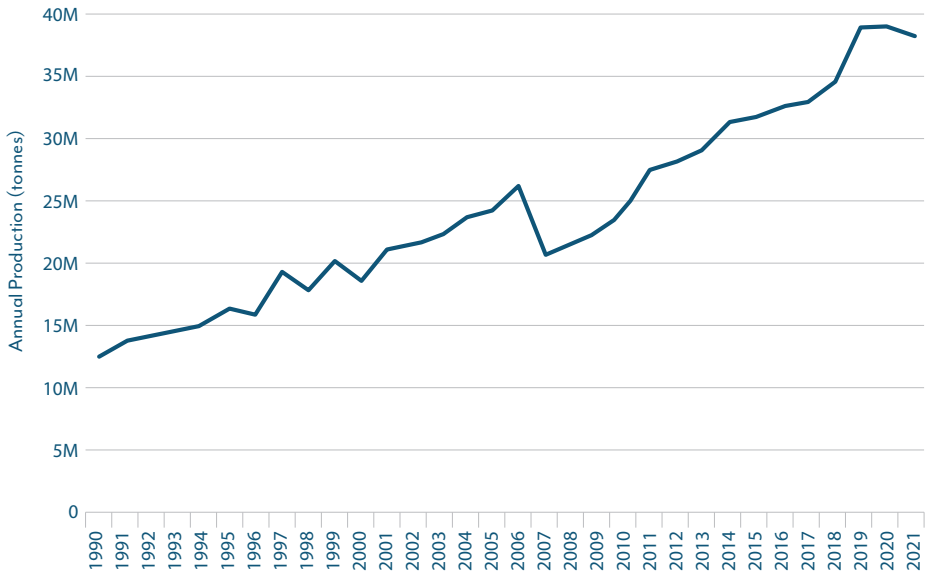
International commodity classifications do not require information on tangerines, mandarins, clementines and satsumas to be reported separately. Therefore, data for mandarins as a standalone segment remains limited across international and Australian datasets. The main dataset for production, import 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 (tangerines, mandarins, clementines and satsumas). Additional information was sought from Citrus Australia but was unavailable at the time of publishing this report.

1 On average from 2010 to 2020

2.2 GLOBAL PRODUCTION

From 1990 to 2021, global mandarin production increased by an average annual rate of 3.6% per annum (FOASTAT, 2022; USDA, 2022). Global mandarin production has more than tripled over the 31-year period, reaching an estimated 37.9 million tonnes in 2021. The growth in mandarin production over time has largely been driven by the increase in production within China, with a rapid expansion of citrus plantings, primarily concentrated in the Guangxi province.

Figure 2.1. Global Production, Tonnes (Mandarins)

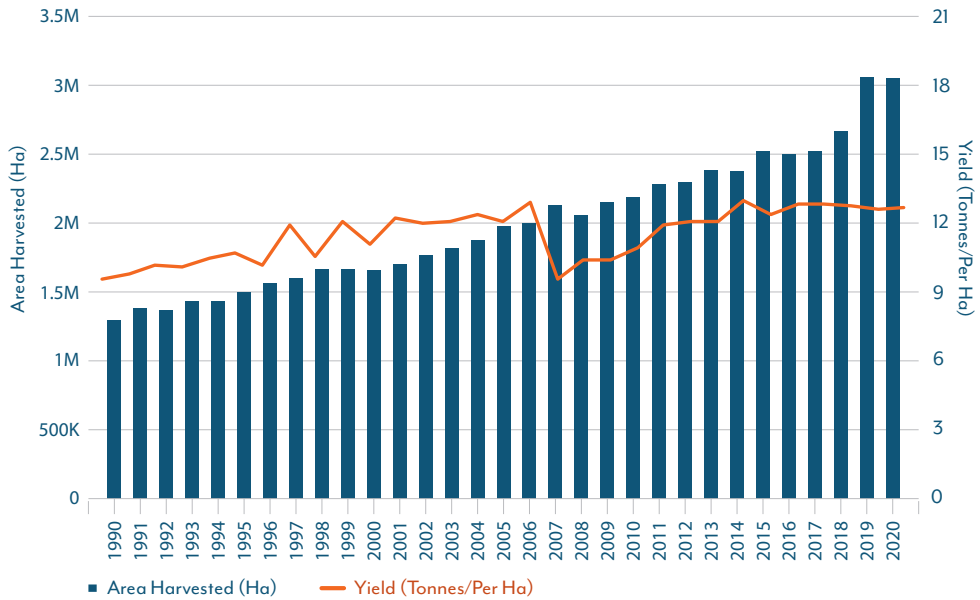


Notes:
- Data is reflective of tangerines, mandarins, clementines and satsumas.
- 2021 production is an estimate based on USDA information. Historical USDA production information differs from the estimates provided by FAO.

Source: FAOSTAT (2022), USDA (2022).

Historically, the mandarin harvested area has grown substantially, increasing by 2.9% on average per annum from 1990 to 2020. The change in mandarin harvest area and annual production has been largely driven by China, who is the largest producer in the world. The 2006-07 drought in China's production area severely impacted on global yield and production levels, which has gradually recovered over time.

Figure 2.2. Global Area Harvested & Yield, 1990 to 2020



Source: FAOSTAT (2022).

2.3 MAJOR PRODUCERS

In 2021, China represented 73.8% of total global mandarin production with production totalling an estimated 28.0 million tonnes. The second largest producer of mandarins in 2021 was Spain (2.0 million tonnes), followed by Turkey (1.8 million tonnes).

The section below provides more detail about the mandarin production for China, Spain and Turkey.

Table 2.1. Top 10 Mandarin Producers, Tonnes

	2020		2021	
Country	Tonnes	Proportion	Tonnes	Proportion
China	23,120,000	60%	28,000,000	74%
Spain	2,317,019	6%	2,083,000	5%
Turkey	1,585,629	4%	1,819,000	5%
Brazil	1,026,638	3%	NA	NA
Egypt	968,047	2%	NA	NA
Morocco	926,566	2%	1,360,000	4%
US	856,380	2%	797,000	2%
Japan	690,703	2%	924,000	2%
Italy	660,280	2%	660,000	2%
Republic of Korea	658,859	2%	610,000	2%
Other	5,935,625	15%	1,680,000	4%
Total	**38,745,746**	**100%**	**37,933,000**	**100%**

Notes:
- Data is reflective of tangerines, mandarins, clementines and satsumas.
- Production estimates for Brazil and Egypt are not available on the USDA database.
- 2021 data is reflective of 2021-22 estimates from USDA.
- 2021 production is an estimate based on USDA information. Historical USDA production information differs from the estimates provided by FAO.

Source: FAOSTAT (2022), USDA (2021a, b, c & d), USDA (2022)

CHINA

From 1990 to 2021, mandarin production in China has experienced an average annual increase of 7.2% per annum. Over the 31-year analysis period, China has always been the largest producer of mandarins on the global scale, with production reaching an estimated 28.0 million tonnes in 2021.

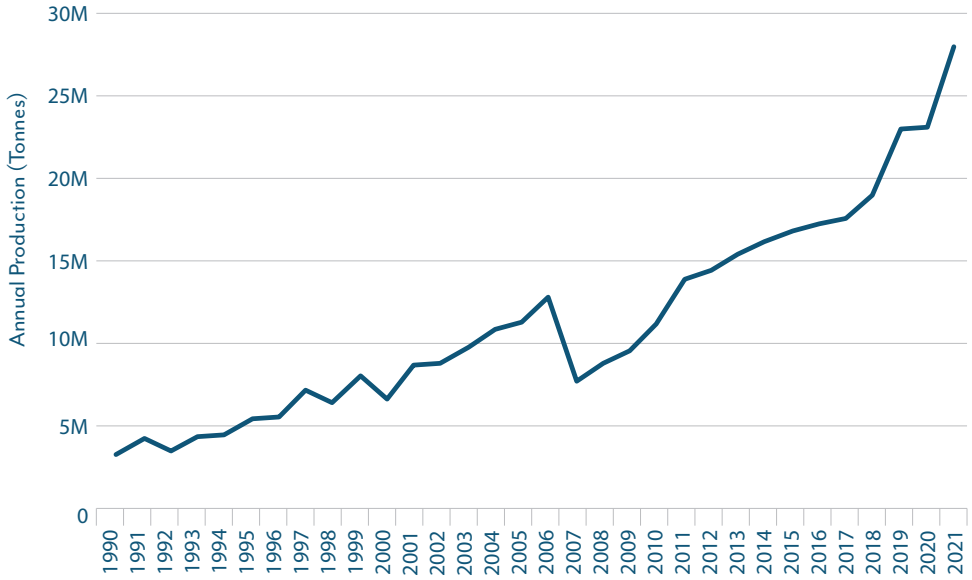
China experienced a significant decline in production from 2006 to 2007, with production declining by 5.2 million tonnes over the year. In 2006 and 2007, Southwest China and Sichuan experienced the worst drought for more than a century (Facts and Details, 2011). Water levels in the Yangtze River were one of the lowest experienced in the past century and rainfall was limited (Facts and Details, 2011). There was also a significant drought experienced in 2009 and 2010 in the provinces of Yunnan, Guangxi, Sichuan and Guizhou which had another significant impact on crops (Facts and Details, 2011). The sustained drought saw drinking water limited, with many farms and livestock also being short of water (Facts and Details, 2011).

Mandarins in China are targeted towards easy peel options including Wogan, Papagan, Ganpin, Red Beauty, Shatangju and Buzhihuo (USDA, 2021a). Emerging trends for mandarin consumption in China reflect similar trends around the world towards varieties that include easy to peel convenience, sweet and juicy textures and the health benefits associated with mandarin consumption (USDA, 2021).

The largest citrus producing region in China is Guangxi, which has the largest production areas for the Wogan and Shatangju mandarin varieties (USDA, 2021a). These varieties are also prominent in other provinces Sichuan, with Yunnan and Fujian both emerging production areas (USDA, 2021a). The Red Beauty is currently considered the most high-end variety of tangerine, with the key features being seedless and very thin peel (USDA, 2021a). Production of this variety is relatively small, with a largely portion of the production stemming from the Zhejiang province (USDA, 2021a).

The red beauty tangerine variety originated in Japan and is popular for its taste and aroma (China Daily, 2020). This variety takes around three times longer to grow than other mandarin orange varieties (China Daily, 2020).

Figure 2.3. China's Mandarin Production, 1990 to 2021 (Tonnes)

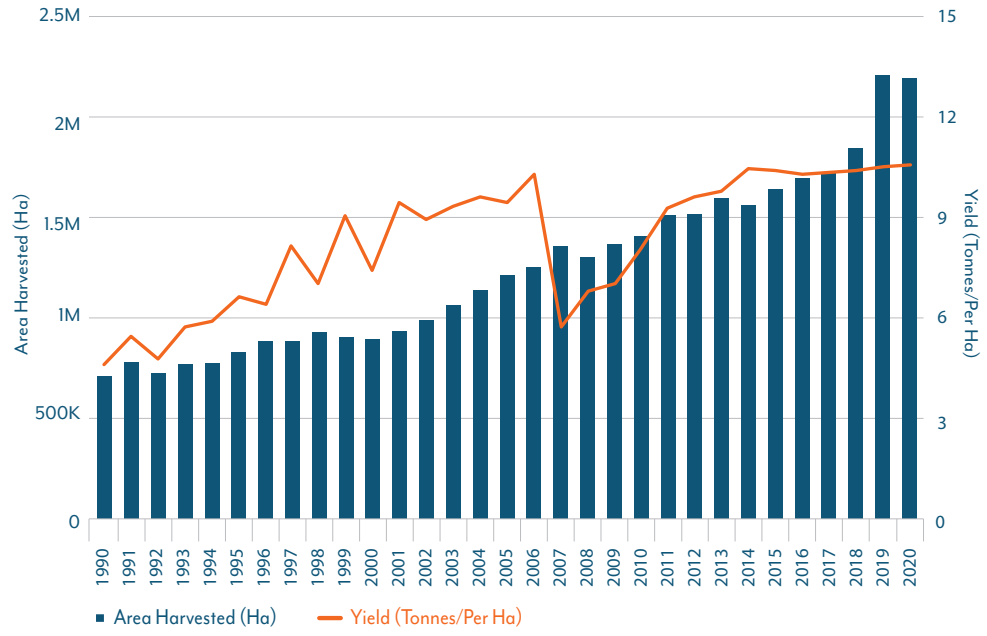


Notes:
- Data is reflective of tangerines, mandarins, clementines and satsumas.
- 2021 production is an estimate based on USDA information. Historical USDA production information differs from the estimates provided by FAO.

Source: FAOSTAT (2022), USDA (2022).

From 1990 to 2006, mandarin yield per hectare has largely been experiencing an increase. This increase is largely resulting from maturing mandarin trees and an increase in mandarin plantings. However, the drought over 2006 and 2007 impacted the production of a number of farms within China as productivity declined.

Figure 2.4. Area Harvested & Yield (China), 1990 to 2020

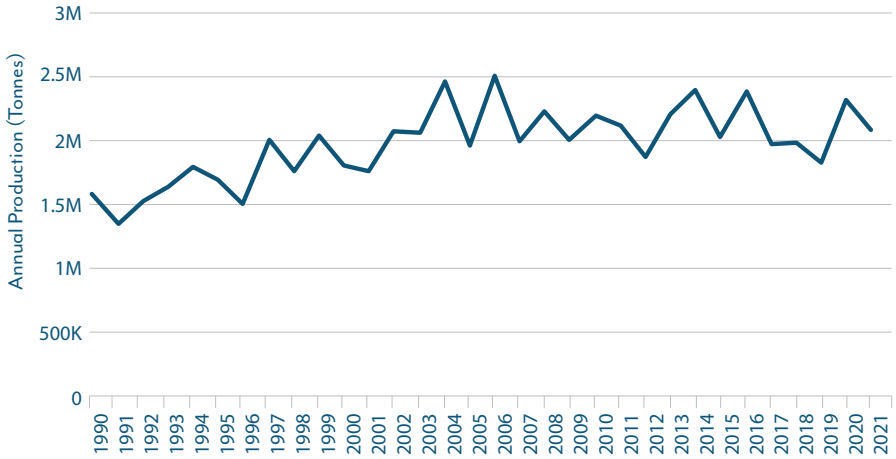


Note: Data is reflective of tangerines, mandarins, clementines and satsumas.
Source: FAOSTAT (2022).

The second largest producer of mandarins on the global scale in 2021 was Spain, producing an estimated 2.2 million tonnes. Over 31 years from 1990 to 2021, mandarin production has increased by an average annual rate of 0.9%.

Mandarin production in 2021 was lower due to unfavourable weather conditions (USDA, 2021c).

Figure 2.5. Spain's Mandarin Production, 1990 to 2021 (Tonnes)



Notes:
- Data is reflective of tangerines, mandarins, clementines and satsumas.
- 2015 and 2020 data has been retired from the Ministry of Agriculture, Fisheries and Food
- 2021 production data is an estimate identified by the USDA (2021c).

Source: FAOSTAT (2022), Ministry of Agriculture, Fisheries and Food (2021)

The main citrus growing regions in Spain are Valencia, Andalusia, Catalonia and Murcia (Singerman & Futch, 2018). The main producing regions are continuing to develop late and early seedless varieties, which will extend the availability of mandarins throughout the year (USDA, 2021c). Valencia is the largest mandarin growing province in Spain, accounting for approximately 68.8% of total mandarin production in 2020. Clementines are the largest mandarin variety grown in Valencia and throughout the broader country.

The table below provides a breakdown of mandarin production by variety and province in 2020.

Table 2.2. Mandarin Production (Tonnes) in Spain by Province and Variety, 2020

Provinces	Satsumas		Clementines		Other Mandarins		Total Spain	
	Hectares	Production	Hectares	Production	Hectares	Production	Hectares	Production
Galicia								
A Coruña	NA	NA	NA	NA	NA	151	NA	151
Lugo	NA	NA	NA	NA	NA	3	NA	3
Ourense	NA	NA	NA	NA	NA	12	NA	12
Catalonia								
Barcelona	NA	NA	NA	NA	1	20	1	20
Tarragona	66	1,356	6,321	130,158	197	4,067	6,584	135,581
Baleares								
Total Production	**NA**	**NA**	**206**	**668**	**55**	**261**	**261**	**929**
Valencia								
Alicante	305	5,719	2,719	45,433	4,740	84,462	7,512	135,614
Castellón	64	1,068	22,853	576,956	4,162	81,017	27,079	659,041
Valencia	5,823	137,364	18,911	425,407	12,070	233,089	36,804	795,860
Murcia								
Total Production	**127**	**1,718**	**3,153**	**64,888**	**2,509**	**54,342**	**5,789**	**120,948**
Extremadura								
Badajoz	NA	NA	7	70	NA	NA	7	70

Provinces	Satsumas		Clementines		Other Mandarins		Total Spain	
	Hectares	Production	Hectares	Production	Hectares	Production	Hectares	Production
Andalucia								
Almería	51	1,283	1,642	33,934	902	27,408	2,595	62,625
Cádiz	130	1,757	213	3,005	223	6,620	566	11,382
Córdoba	NA	NA	18	420	169	3,887	187	4,307
Granada	NA	NA	19	350	3	70	22	420
Huelva	145	5,718	2,345	71,718	9,270	203,763	11,760	281,199
Málaga	56	585	1,671	12,545	253	1,337	1,980	14,467
Sevilla	16	78	241	4,230	2,990	88,801	3,247	93,109
Canarias								
Las Palmas	20	245	18	216	24	284	62	745
S.C. de Tenerife	20	260	7	102	13	174	40	536
Total Production in Spain	**6,823**	**157,151**	**60,092**	**1,370,100**	**37,581**	**789,768**	**104,496**	**2,317,019**

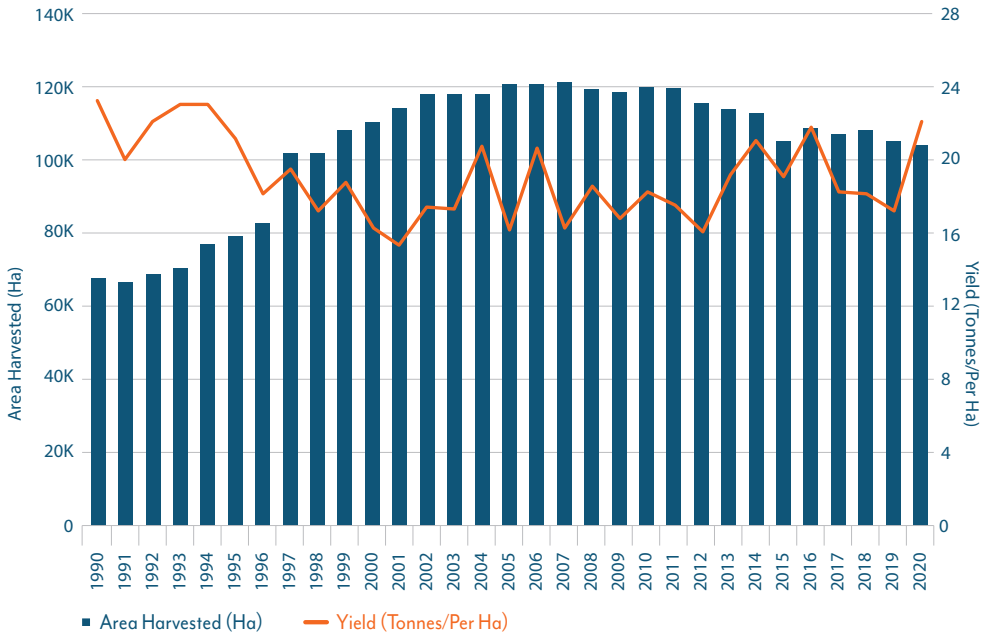
Source: Ministry of Agriculture, Fisheries and Food (2021).

Disadvantages for citrus production in Spain include (Singerman & Futch, 2018):

- Limited rainfall
- Lack of different varieties (with varieties including satsumas and clementines)
- Smaller orchard sizes, with a significant portion of plantings being less than 2.8 hectares. In Valencia, citrus orchards are planted alongside hillsides and require terraces, which limit the use of farm machinery, increase the costs of labour and potentially negatively impacts on productivity and economies of scale compared to other countries.

From 1990 to 2020, mandarin production has yielded an average of 19.1 tonnes per hectare. This is largely above the average annual yield volumes achieved in China, which was estimated to average 8.3 tonnes per hectare between 1990 to 2020. In 2020, it was estimated that mandarin yield in Spain totalled 22.2 tonnes per Ha.

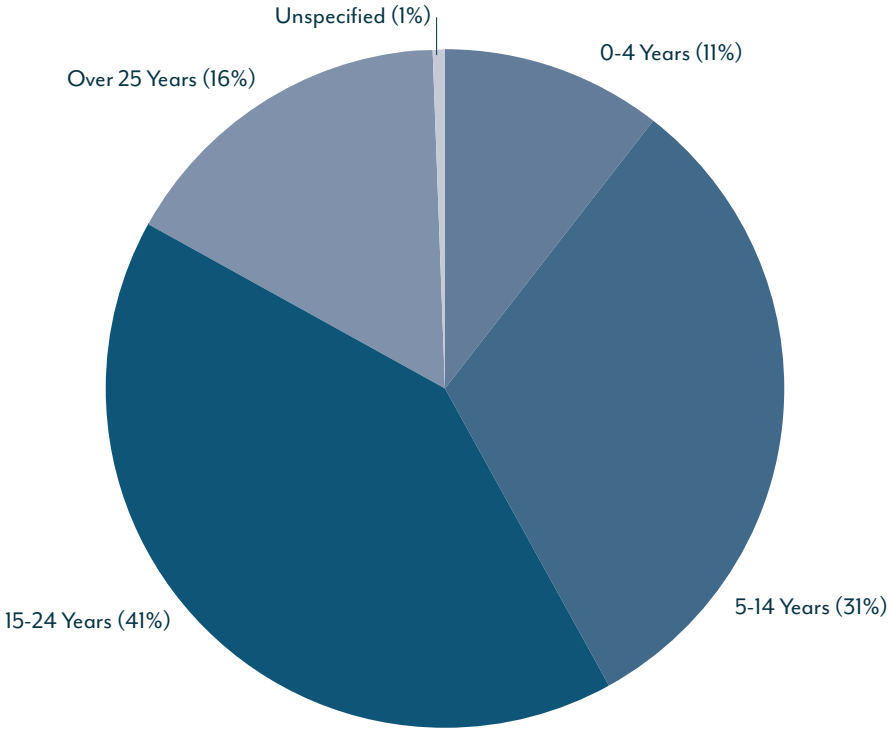
Figure 2.6. Area Harvested & Yield (Spain), 1990 to 2020



Source: FAO (2022).

In 2017, majority of the mandarin area in Spain were between the years of 15 and 24 (approximately 41.1%), followed by those aged between 5 and 14 years (approximately 31.5%). The figure below provides a breakdown of mandarin tree age in 2017.

Figure 2.7. Distribution of Mandarin Area by Age (Proportion of Area 2017)



Source: Ministry of Agriculture, Fisheries and Food (2017).

TURKEY

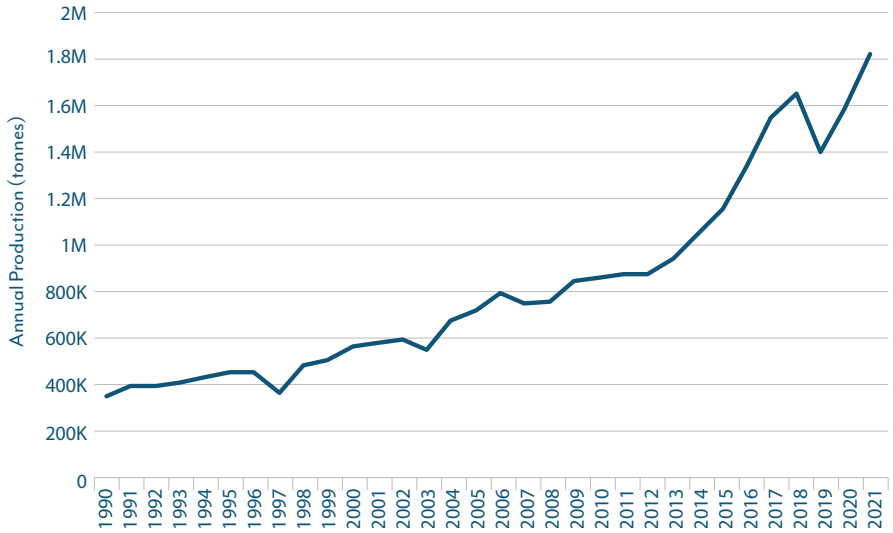
The second largest producer of mandarins on the global scale in 2021 was Turkey, with production totalling an estimated 1.8 million tonnes. From 1990 to 2021, mandarin production has increased by an average annual rate of 5.5%.

Mandarin production experienced a decline in 2019, with production totalling an estimated 1.4 million tonnes. This decrease is lower than the previous season due to the impact of weather conditions. In 2019 mandarin production in Turkey was impacted by freezing climate conditions and heavy storms during the blooming period of the mandarin trees (USDA, 2021b).

The United States Department of Agriculture have highlighted producers are struggling to cover production costs with low farm gate prices (USDA, 2021b). It is reported that farm gate prices have decreased by 50% from the previous season, resulting from low demand in foreign markets (USDA, 2021b). This low demand is being met in period of excessively high summer temperatures (USDA, 2021b).

Satsumas are the dominant variety of mandarin in Turkey, which is largely preferred in the domestic market. Turkey also produce Easy-N, Okitsu and Miho Wase varieties which begin harvesting early in October. Turkey is turning towards planting new varieties including Nova, Murcott and Fremont as they believe these varieties are profitable in the export market (USDA, 2021b).

Figure 2.8. Turkey's Mandarin Production, 1990 to 2021 (Tonnes)

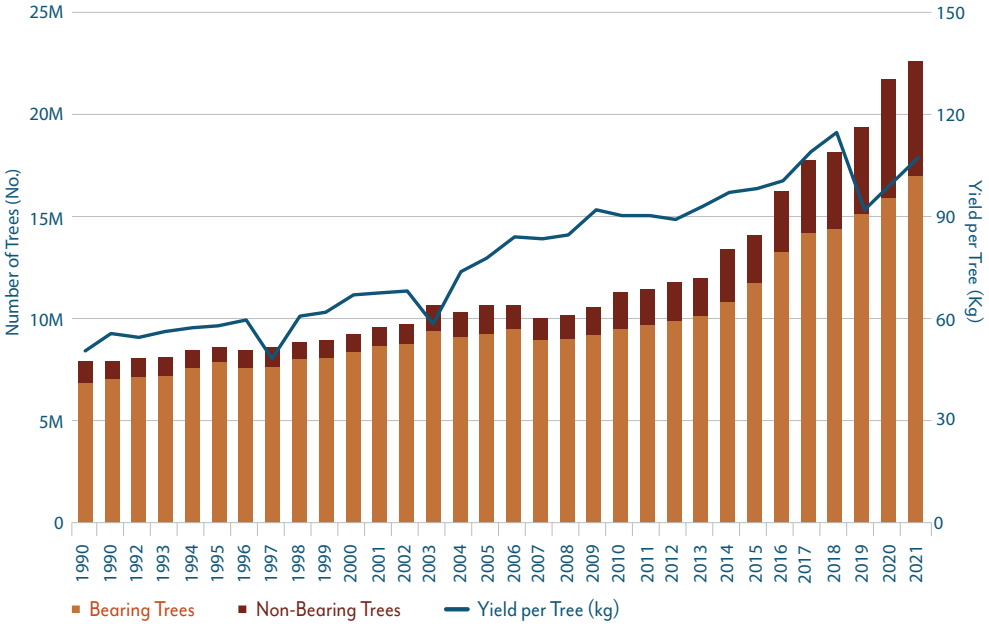


Note: Data is reflective of tangerines, mandarins, clementines and satsumas.
Source: FAOSTAT (2022).

The number of mandarins trees in Turkey have been growing by 3.5% on average per annum from 1990 to 2020. In 2021 Turkey had a total of 22.6 million mandarin trees, of which 75.3% were bearing with the remaining 24.7% of trees being non-bearing.

Mandarin yields per tree have largely been increasing year on year from 2003 to 2021, with the exception of decline in 2019 due to weather impacts. In 2021, it was estimated that the average yield per bearing tree was 107.1 kilograms.

Figure 2.9. Bearing and Non-Bearing Mandarin Trees in Turkey, 1990 to 2021



Note: Yield has been calculated based on production volumes and the number of bearing mandarin trees.
Source: TURKSTAT (2021).

2.4 MAJOR EXPORTERS

Exports of mandarins have been increasing by an average annual rate of 6.4% per annum from 1990 to 2020 to reach an export volume of 5.8 million tonnes in 2020.

The largest exporter of mandarins in 2020 was Spain, with exports totalling 1.4 million tonnes. Spain is currently the largest supplier of mandarins to the European Union (EU), resulting from the close proximity to market and lower transportation costs associated with exporting the fruit.

Spain's key competitors in the EU market include both Italy and Greece, although supply from these two markets are small in comparison to Spain. These markets are also key competitors due to proximity to the EU markets. From 2011 to 2020, mandarin planted area experienced a decline across both Spain and Italy and an increase in Greece, including an approximate (USDA, 2021a):

- 13% decline in planted area in Spain, totalling 104,496 hectares in 2020 (see Figure 2.5 above)
- 8% decline in planted area in Italy, totalling 34,240 hectares in 2020
- 43% increase in planted area in Greece, totalling 9,900 hectares in 2020.

There were fears that Brexit would negatively impact Spanish mandarin imports to the United Kingdom, with a proposed import tariff of 16%. However, the implementation of the EU-UK Trade and Cooperation Agreement at the beginning of 2021 saw tariffs for Spanish mandarin imports into the United Kingdom remain at 0%.

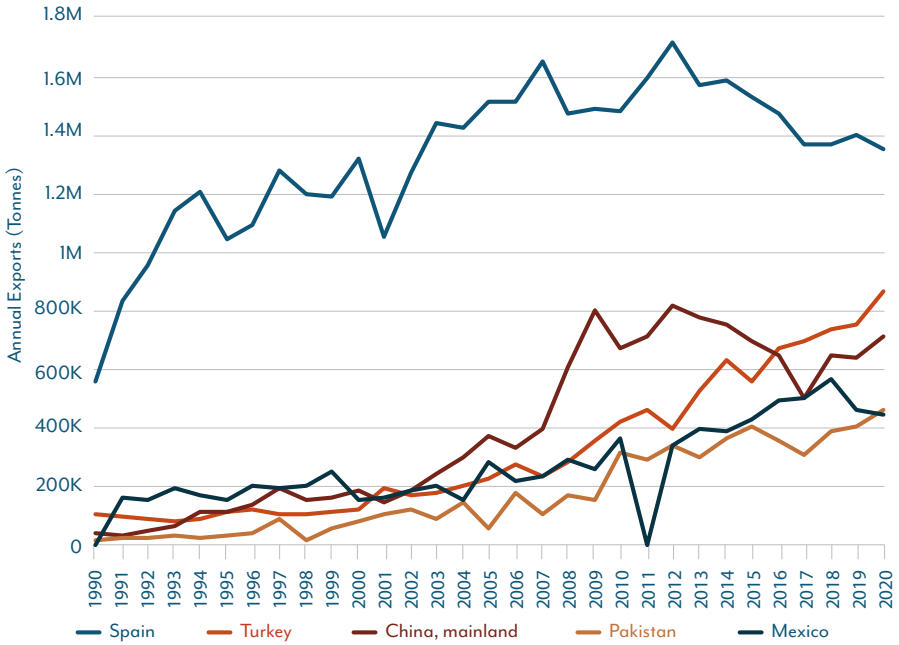
The second largest export market in 2020 was Turkey, exporting over 868,000 tonnes of mandarins. The export season for mandarins in Turkey starts in September each year and usually comes to an end towards the end of March (USDA, 2021 b). It was estimated that Turkey exported 868,562 tonnes of mandarins in 2020 with the largest export markets including Russia, Ukraine, and Iraq (FAOSTAT, 2022).

Over 2019 and 2020, mandarin exports from Turkey to Iraq experienced a decline due to disputes on industry marketing preferences and logistics with COVID-19 related supply chain disruptions (USDA, 2021 b). It was identified that Iraq largely prefers green mandarins with leaves while exports from Turkey consists of orange mandarins (USDA, 2021b). Additional strain was placed on export volumes from supply chain disruptions from border precautions during the initial impact of the COVID-19 pandemic causing transportation struggles (USDA, 2021 b). The Unites States Department of Agricultural have highlighted that the 2021 season saw improvements in logistical issues and a better understanding of consumption preferences (USDA, 2021 b).

Unlike Spain, Turkey is not a large supplier of mandarin to the EU market. However, in 2020 the EU rejected approximately 250 tonnes of mandarins from Turkey due to the presence of the Mediterranean Fruit Fly and Maximum Residue Limits (MRLs) exceeding regulations (USDA, 2021 b). This resulted in the EU increasing the inspection control frequency on Turkish mandarin exports to the EU.

Australia is currently recorded as the 15th largest exporter of mandarins, accounting for approximately 1.1% of the export market in 2020. By 2025, Citrus Australia project that Australian mandarin exports will more than quadruple in volume reaching a total of 230,000 tonnes (Citrus Australia, 2020a). This indicates strong future demand for Australian mandarins over the short-term.

Figure 2.10. Top Five Export Countries in 2020, 1990 to 2020



Note: Data is reflective of tangerines, mandarins, clementines and satsumas.
Source: FAOSTAT (2022).

2.5 MAJOR IMPORTERS

Imports of mandarins have been increasing by an average annual rate of 5.8% per annum from 1990 to 2020 to reach an export volume of 5.2 million tonnes in 2020.

The largest importer of mandarins in 2020 was Russia, importing a total of 902,419 tonnes. Mandarin imports to Russia have increased by an average annual rate of 9.0% from 1998 to 2020. Mandarins are not grown in Russia on a commercial scale, as the cold climate is not suitable for production.

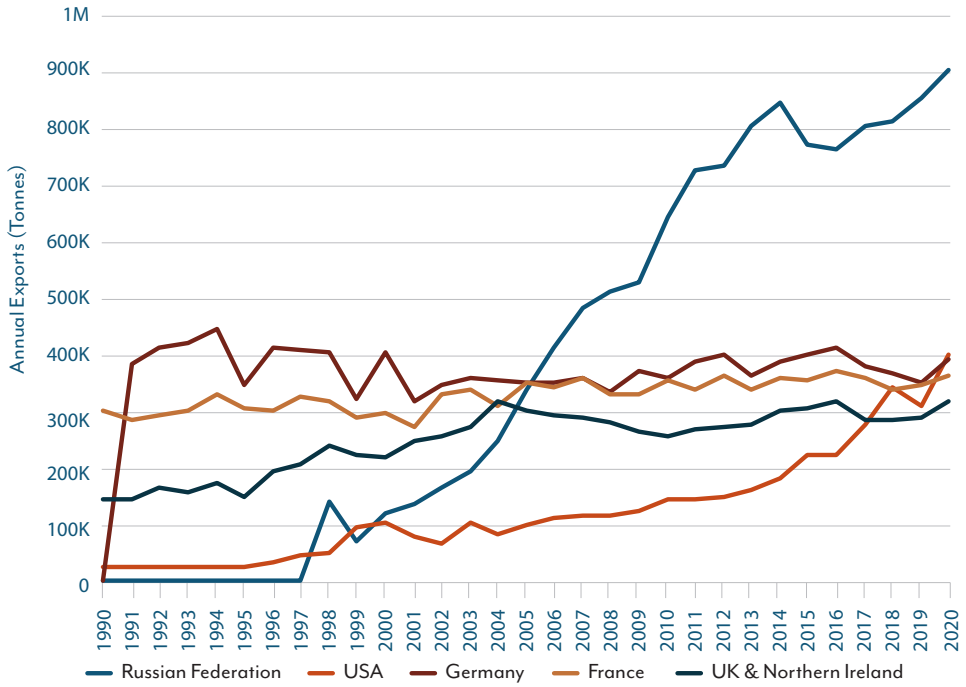
The largest supplier of mandarins to Russia in 2020 was Turkey, accounting for 51% of total imports (equating 461,567 tonnes). This was followed by Morocco (17% of total imports or 150,178 tonnes) and Pakistan (11% of total imports or 95,639 tonnes).

The second largest importer of mandarins in 2020 was the US, importing a total of 395,641 tonnes. The US has experienced a steeper increase in mandarin imports from 2010 onwards, stemming from high demand for the fruit. The largest supplier to the US in 2020 was Chile, accounting for 44% of total imports (or 174, 068 tonnes). This was followed by Peru (26% of total imports or 104,181 tonnes) and Morocco (11% of total imports or 43,479 tonnes).

The Australian Citrus Industry Export Strategy 2021-2025 highlights that Chile gained market access into the US in 2006. Chilean citrus exports to the US have a number of competitive advantages, including (Citrus Australia, 2021):

- Proximity to market advantages
- Lower production cost advantages
- Focused almost exclusively on the US for export.

Figure 2.11. Top Five Import Countries in 2020, 1990 to 2020



Notes:

- Data is reflective of tangerines, mandarins, clementines and satsumas.
- No import data is available for Russia from 1990 to 1997.

Source: FAOSTAT (2022)

2.6 GLOBAL CONSUMPTION

The United States Department of Agriculture have highlighted that China was estimated to be the largest consumer of mandarins on the global scale, with total domestic consumption of fresh mandarins totalling 26.5 million tonnes. From 2010 to 2021, it was estimated that total consumption in China grew by an average annual rate of 6.7% per annum.

The top five largest consumers of fresh mandarins based on information provided by the USDA (2022) are provided in the table below.

Table 2.3. Fresh Domestic Consumption of Mandarins, 2016 to 2021 (Million Tonnes)

COUNTRY	2016	2017	2018	2019	2020	2021
China	19.4	20.1	20.7	21.8	23.6	26.5
European Union	3.0	2.7	2.9	2.7	3.0	2.8
United States	0.9	0.9	1.0	1.0	1.0	1.0
Russia	0.8	0.8	0.9	0.9	0.9	0.9
Japan	1.0	0.9	0.9	0.9	0.9	0.9
Other	3.5	3.6	4.0	3.4	4.2	4.4
Total	28.5	28.9	30.4	30.6	33.7	36.4

Note: Top five consumers as of 2021.
Source: USDA (2022).

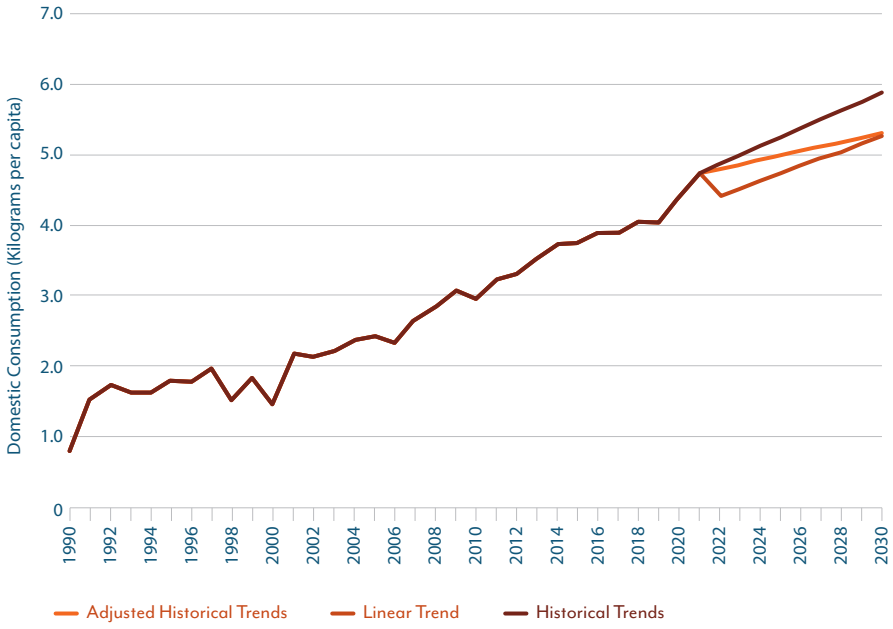
Consumption estimates have been developed based primarily developed consumption rates per capita (utilising USDA consumption information and historical population estimates), and population projections. Initial estimates of consumption per capita has been developed based on:

- 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 mandarins, there is more potential for future domestic consumption to reach historical trend volumes.

Based on the historical trend volumes, consumption could total approximately 5.9 kilograms per capita in 2030.

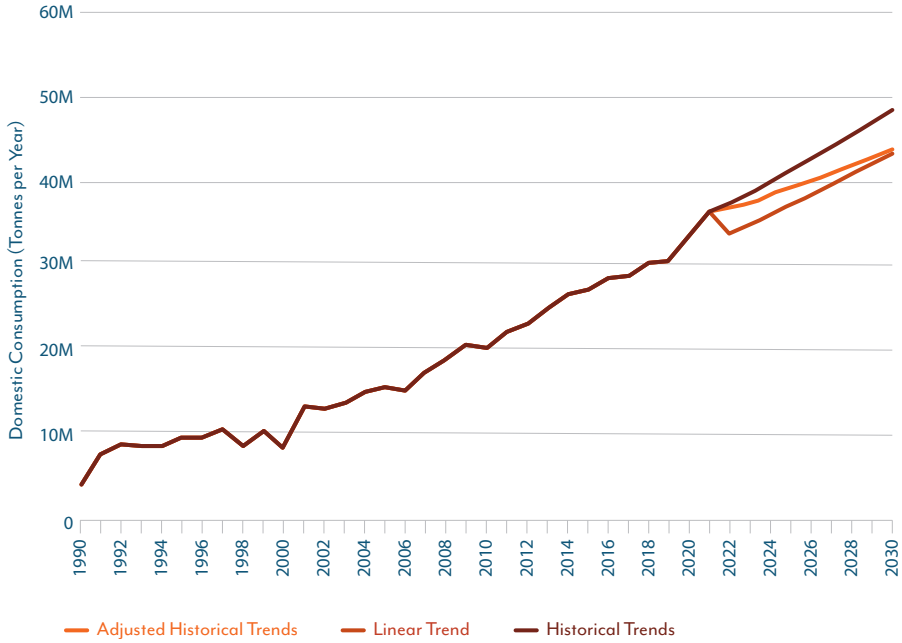
Figure 2.12. Consumption, 1990 to 2030 (Kilograms Per Capita)



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

Based on historical trends, it is estimated that domestic consumption of fresh mandarins could grow from 36.4 million tonnes in 2021 to 48.4 million tonnes in 2030. Global consumption could also reach adjusted historical trend volumes of 43.6 million tonnes.

Figure 2.13. Consumption Per Capita, 1990 to 2030 (Tonnes per Year)



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

2.7 GROWTH MARKET FOR MANDARINS

Mandarin popularity has grown significantly over the years, largely driven by the increase in production in China. China is the largest producer of mandarins on the global scale, producing 23.1 million tonnes in 2020 and only exporting approximately 3.1% of total production. This highlights the significant domestic demand for the fruit in China, partially attributed to the rise of incomes and Chinese consumers preferring fresh fruit over cheaper and worse quality fruit options (FAO, undated). In 2020, China only imported 47,719 tonnes of mandarins, highlighting domestic demand is largely met by domestic production. Based on historic trends, it is likely that majority of domestic demand will be met by domestic production.

Global increase in production has allowed the fruit to be more accessible to the public along with consumer demand for healthy snack, safe produce and its zipper skin has continued to skyrocket the fruits popularity as a common lunchbox snack (Produce Business (2021). The COVID-19 pandemic saw a strong increase in the demand for oranges, which in some countries such as South Africa and the US, overshadowed mandarins (Fresh Plaza, 2020). However, the demand for mandarins remained relatively strong, particularly in the US and Europe (Fresh Plaza, 2020).

The US has experienced strong growth in Mandarin imports over the years, growing by an average annual rate of 10.2% per annum from 1990 to 2020. In 2020, the US was also the 7th largest producer on mandarins on the global scale, highlighting the significant domestic demand for mandarins. This market present key growth opportunities for mandarins, with relatively strong domestic demand.

3. THE AUSTRALIAN MANDARIN INDUSTRY

3.1 CULTIVARS

The Department of Primary Industries have identified the major mandarin varieties which are grown by region in Australia. Refer to the table below for the dominant varieties grown domestically.

Table 3.1. Key Growing Regions & Major Varieties

REGION	MAJOR VARIETY	OTHER VARIETIES (GROWN IN ORDER OF NUMBER OF TREES)
Riverina (NSW)	Imperial, Afourer, Dekopin	Satsuma Okitsu Wase, Summerina, Honey Murcott, Amigo, Ellendale, Daisy
Murray Valley (SW NSW & NW Victoria)	Afourer, Imperial	Daisy, Amigo, Dekopon, Ellendale, Murcott, Gold Nugget, Orri, Caffin Clementine, Satsumas Miho Wase and Okitsu Wase, Mystique, Avana, Fallglo, Fewtrell, Emperor
Riverland (SA)	Afourer, Imperial	Nules Clementine, Honey Murcott, Daisy, Satsume Okitsue Wase, Gold Nuggest, Dekopon, Avana, Amigo, Murcott, Summerina, Satsuma Miho Wase, Ellendale, Topaz Ortanique, Murcott (Low seeded), Orri, Nectare, Hickson
QLD	Imperial, Murcott, IrM1, IrM2	Afourer, Avana, Goldup, Hickson, Tyalor Lee, Nectar Daisy, Fremont, Nova, Empress, Sunburst, TDE, Success, Gold Nuggest, Alkantara, Monarch, Orri, Ellendale, Emperor
WA	Afourer, Imperial	Hickson, Nules Clementine, Mystique, Daisy, Gold Nugget, Nectare, Satsumas Silverhill and Okitsu Wase, Murcott, Caffin Clementine, Kara, Emperor, Honey Murcott, Ellendale, Ortanique

Source: DPI (2017).

For more information, particularly regarding varieties grown in international markets, refer to Appendix A.

3.2 AUSTRALIAN MANDARIN PRODUCTION

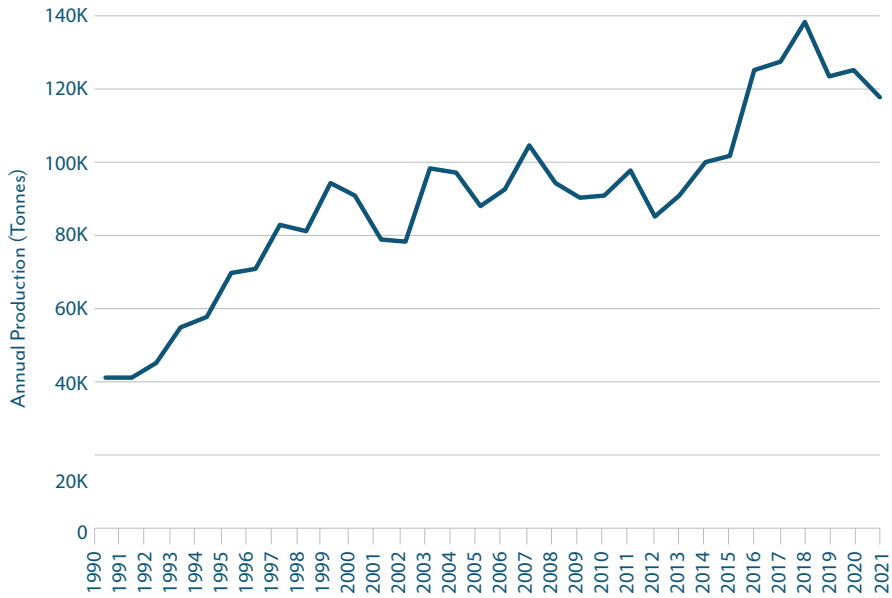
The mandarin market in Australia is largely dominated by three varieties, including Murcott, Imperial and Afourer. Murcott mandarins accounted for approximately 29% of fresh production, Imperial mandarins accounted for 24% of production and Afourer mandarins accounted for 23% of fresh production (Hort Innovation, 2021).

Mandarin production in Australia has experienced an average annual growth of 3.5% from 1990 to 2021 to reach a total of 117,729 tonnes.

Mandarin production in Australia has experienced downwards trends from 2018, with the number of bearing mandarin trees experiencing rather significant decline in 2018-19 (see Figure 3.2below). The decline in production from 2020 to 2021 can partially be attributed to the strict COVID-19 protocols implemented in Australia throughout the height of the pandemic. The citrus industry workers in Australia mostly consist of those on the Pacific Seasonal Worker Program and overseas labour (USDA, 2020). With the international boarder closures, these overseas workers were not permitted into Australia and the industry faced labour shortages. Mandarin harvesting is labour intensive, and without the usual foreign workers, a portion of the yield has been left unharvested in Australia (Fresh Plaza, 2021).

Mandarin production continues to face increasing price pressures in relation to transport and labour shortages.

Figure 3.1. Australian Mandarin Production (Tonnes), 1990 to 2021

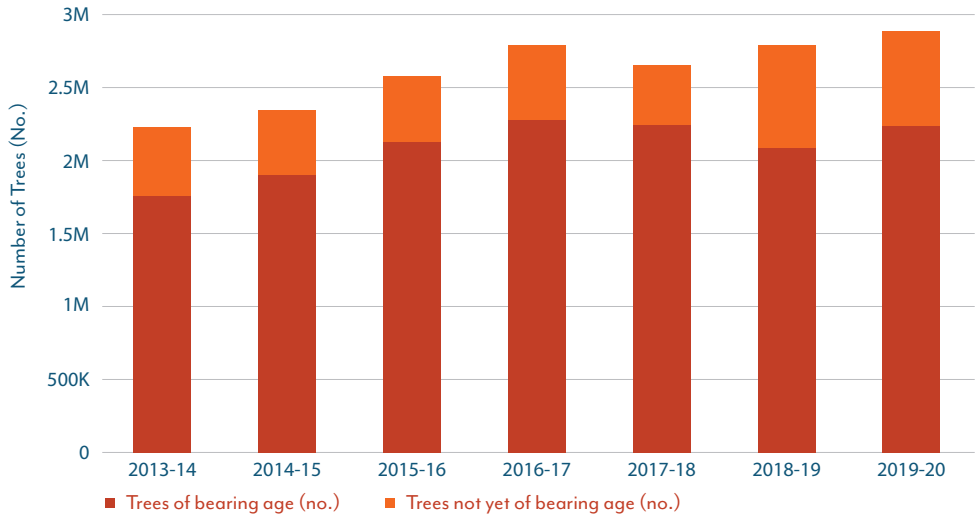


Source: ABARES (2021).

The number of bearing trees in Australia experienced an increase from 2013-14 to 2016-17, reaching a total of 2.3 million bearing trees. Over the following two years (2017-18 and 2018-19), the number of bearing trees decreased by a total of 195,898 trees. This decrease was largely driven by Queensland

In 2017, it was reported that imperials mandarins were being oversupplied by around 10,000 tonnes per annum (ABC, 2017). The opportunities for imperial mandarins are on the decline with the market being labelled as mature (ABC, 2017). The decline in trees in Australia could be a result of the oversupply of imperial mandarins, where trees have been removed if they were not cost effective or have been replaced with new varieties.

Figure 3.2. Number of Mandarin Trees, Australia (2013-14 to 2019-20)



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. 4.

Source: ABS (2021, 2020, 2019, 2018a & b, 2016, 2015).

Australia largely produces the Afourer and Murcott mandarin varieties, which are proving to be more popular within the market. Imperial mandarins are not suitable for export, however low-seeded varieties such as Murcott are in demand within the export market (Citrus Australia, 2021). Other mandarin varieties in Australia which are available for export include Clementine, Satsuma, Freemonts, Tangelo, Nova and Daisy (Citrus Australia, 2021).

Table 3.2. Mandarin Planting in Australia, 2020

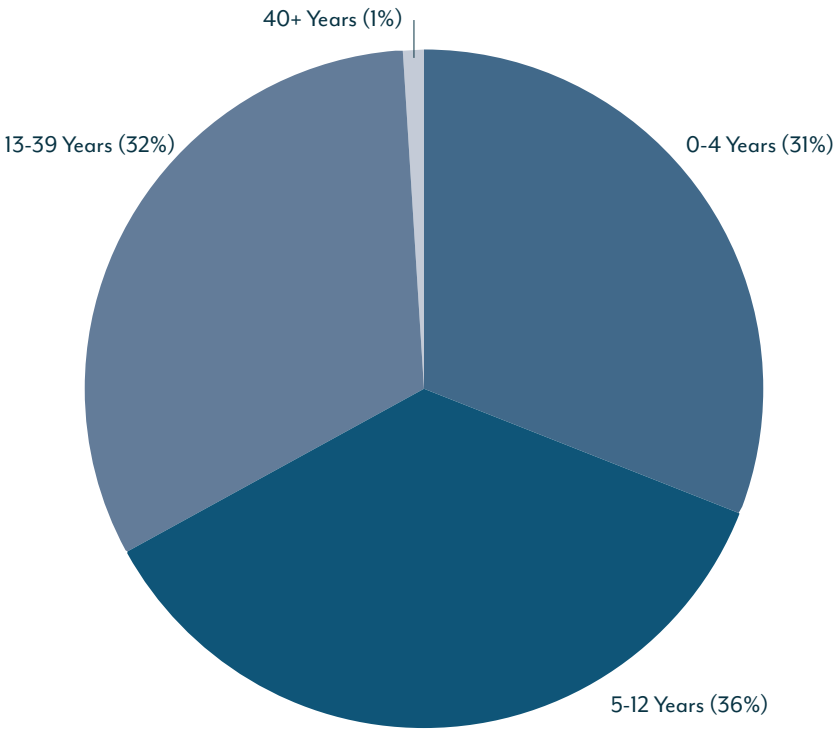
Region	Afourer	Imperial	Murcott	Other	Total
Murray Valley	822	318	4	220	**1,364**
Queensland	556	580	1,928	768	**4,102**
Riverina	269	74	5	109	**457**
Riverland	624	339	104	392	**1,459**
WA	133	66	1	98	**298**
Other	44	11	2	33	**90**
Total	**2,448**	**1,658**	**2,044**	**1,620**	**7,767**

Notes:
- Afourer includes Amoretto & Tango
- Imperial includes Goldup & Avana
- Murcott includes low-seeded
- Other includes Tangelo & 29 varieties

Source: Citrus Australia (2020b).

The 2020 Citrus Australia tree census have highlighted that a significant portion of the mandarin trees in Australia are either non-bearing, entering production or in mature phases (see figure below). There is currently 1% of trees in Australia which are over the ages of 40 years.

Figure 3.3. Tree Age Distribution, 2020



Source: Citrus Australia (2020b).

3.3 KEY GROWING AREAS

MANDARIN TREES & SEASONALITY

There are approximately 2.9 million mandarin trees, with majority of the trees concentrated in Queensland (accounting for 41% of total trees). Of the total mandarin trees in Australia, it is estimated that approximately 653,310 trees are not yet of bearing age (approximately 22.6% of Australia's total mandarin trees).

Table 3.3. Australian Mandarin Production, 2019-20

	NSW	Vic	Qld	Sa	Wa	Tas	Total
Total trees (no.)	486,412	229,329	1,184,087	825,016	161,371	18	**2,886,232**
Trees not yet of bearing age (no.)	143,228	63,333	217,303	206,731	22,698	18	**653,310**
Trees of bearing age (no.)	343,184	165,996	966,784	618,285	138,673	-	**2,232,922**
Production (t)	10,640	8,847	65,652	35,258	4,930	-	**125,327**
Yield (kg/tree)	31.0	53.3	67.9	57.0	35.6	-	**56.1**

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. 4.
Source: ABS (2021).

Figure 3.4 illustrates the key production regions in Australia. Queensland is the largest area of mandarin production in Australia, with the Central Burnett area around Gayndah and Munduberra being the major production area, supported by smaller production areas in Queensland including Emerald (Central Queensland) and Mareeba (North Queensland).

Figure 3.4. Mandarin Production Regions in Australia

Source: USDA FAS (2020).

Across Australia, mandarins are largely available from July to August, with low seasonality between March and May.

Table 3.4. Fresh Mandarins by Seasonality

STATE	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
NSW												
VIC												
QLD												
WA												
SA												

LEGEND: High Medium Low
Source: Hort Innovation (2021).

The table below identifies the seasonality of mandarins by variety.

Table 3.5. Mandarin Variety by Seasonality

VARIETY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Murcott												
Imperial												
Afourer												
Others												

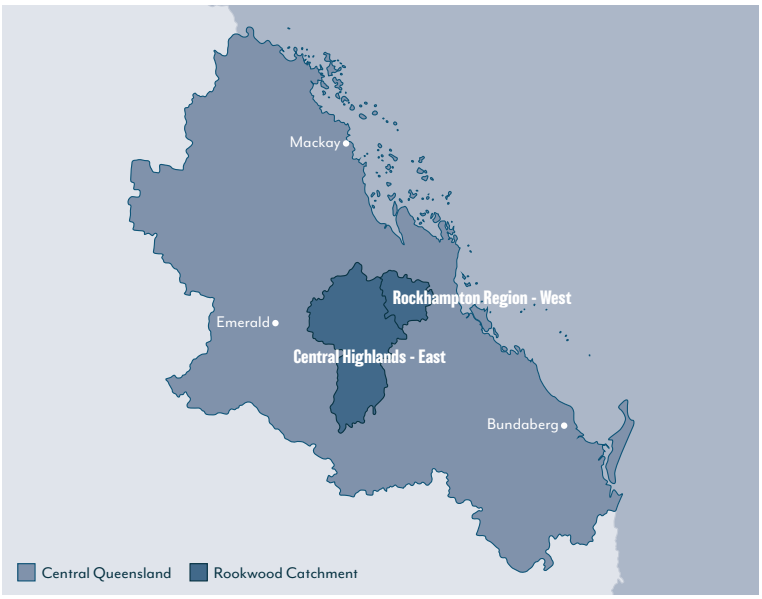
LEGEND: High Medium Low
Source: Hort Innovation (2021).

CENTRAL QUEENSLAND

Mandarin production is prominent throughout the broader Central Queensland region with approximately 965,124 trees of bearing age and an additional 157,189 trees, which are not yet of bearing age in 2019-20. The new plantings are a result of growth in the industry and a shift from Imperial mandarins due to lower domestic demand. The mandarin production in Central Queensland will increase as these trees begin to mature.

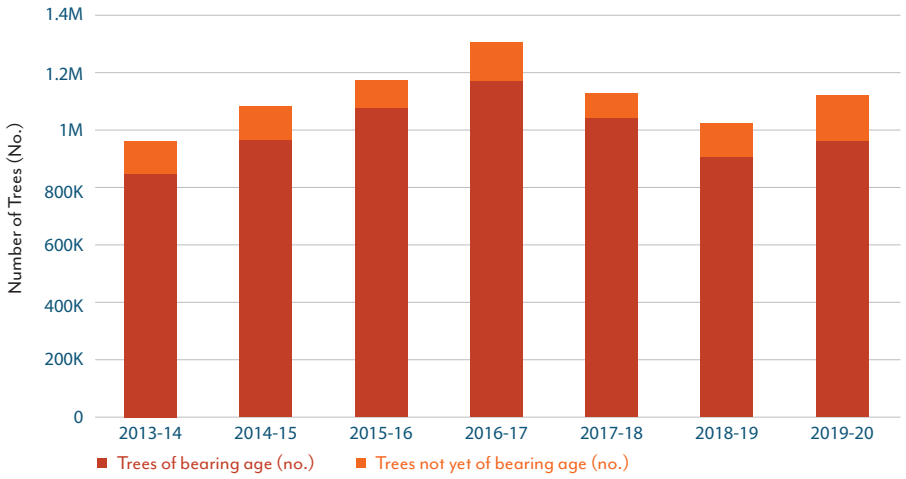
From 2016-17 to 2018-19 the Central Queensland region experienced a year-on-year decline in the number of bearing trees. Over the two-year period, the number of bearing trees declined by 272,353 trees (largely attributed to the Wide Bay Statistical Area 4 (SA4)). The decline in mandarin trees could be similar to the effects stated above, with the oversupply of imperial mandarins in Australia by around 10,000 tonnes a year.

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 Mandarin Trees, Central Queensland (2013-14 to 2019-20)



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. 4.
Source: ABS (2021, 2020, 2019, 2018a & b, 2016, 2015).

3.4 FUTURE PRODUCTION

Based on the number of mandarin trees in Australia in 2019-20 and the tree age distribution, an estimated breakdown of trees by age is provided below.

Table 3.6. Estimated Trees by Age (2020)

Tree Age Distribution	Number Of Trees
0-4 Years	894,732
5-12 Years	1,039,044
13-39 Years	923,594
40+ Years	28,862
Total	**2,886,232**

Source: ABS (2021), Citrus Australia (2020).

The number of estimated trees by age and estimated yield by age (highlighted in Table A. 4) have been utilised in forecasting Australia's future production of mandarins to the year 2030. To break trees down by single age, it has been assumed an even split between age grouping.

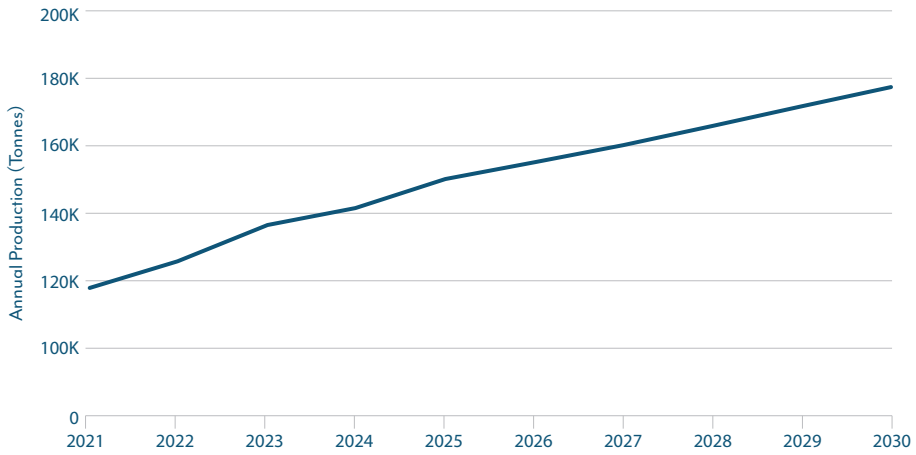
For the purposes of modelling, it has been assumed that from year 35 onwards, mandarin trees are unproductive and are assumed to not provide yield. The productive trees which are 34 years old, are assumed to be replanted in the following year to replace the older non-bearing trees. However, depending on orchard management practices, new replacement plantings may occur at an earlier age (approximately three to four years before the end of useful life) to ensure there are an appropriate number of bearing trees to replace the older, non-yielding trees.

Over the analysis period until 2030, it has been assumed that 342,702 trees will be listed as unproductive and subsequently will be replanted, resulting in an unchanged volume of total trees from 2021 to 2030. Although the number of trees are assumed to remain unchanged, there will be variances in yield productivity as trees begin to mature. Yield productivity by tree age is presented in Table A. 4, highlighting an increase in yield as trees mature. This yield productivity by tree age has been applied to the number of trees by age listed in Figure 3.7 below. This provides an estimate of mandarin production by tree age in Australia.

The proportion of production by tree age in 2021 was applied to the total production volumes in Australia (117,729 tonnes) to rebase production data to actual estimates. The average production growth rate by tree age was then applied to the estimated 2021 figures resulting in an estimated future production volume from 2022 to 2030 (as highlighted in the figure below).

Mandarin production is estimated to increase year on year to reach a total of 176,844 tonnes in 2030.

Figure 3.7. Estimated Future Australian Production, 2021 to 2030



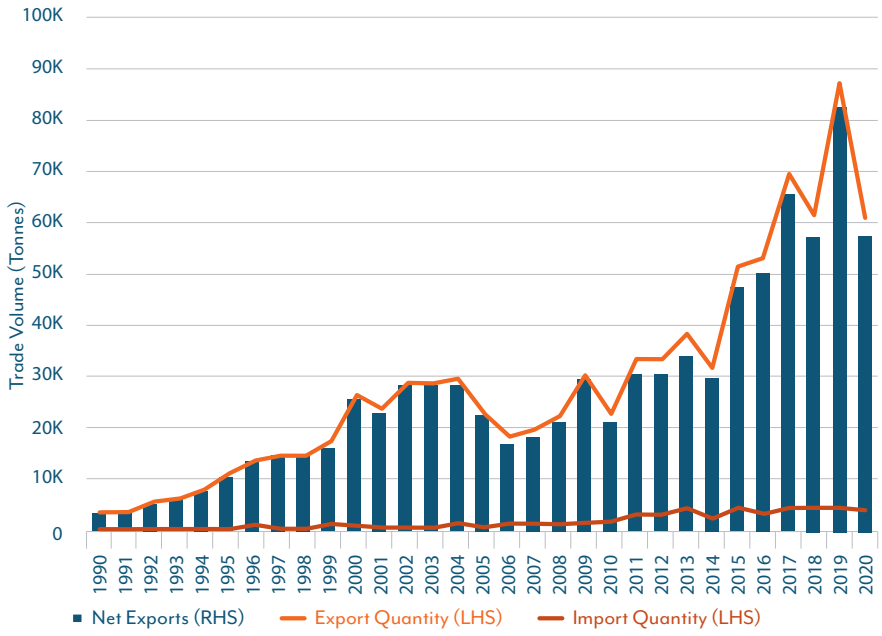
Source: DAF (1997), ABARES (2021), Citrus Australia (2020b).

3.5 AUSTRALIA'S TRADE BALANCE

Australia emerged as a large exporter from 2014 onwards, which was driven by the sharp increase in exports from 2012.

In 2020, it was estimated that Australia exported approximately 10,065 tonnes of mandarins and imported 3,730 tonnes, leaving net exports at 6,335 tonnes.

Figure 3.8. Australia's Trade Balance



Source: FAOSTAT (2022).

3.6 MANDARIN PRICES IN AUSTRALIA

In January 2020, there was a peak in average Queensland mandarin prices for those listed in the 'other' category. This price increase was due to the Page No 1 (airfreight) variety, which reached an average of $8.6 per kilogram in December 2019 and $8.3 per kilogram in January 2020. This variety had no values attributed throughout any other month over the entire analysis period.

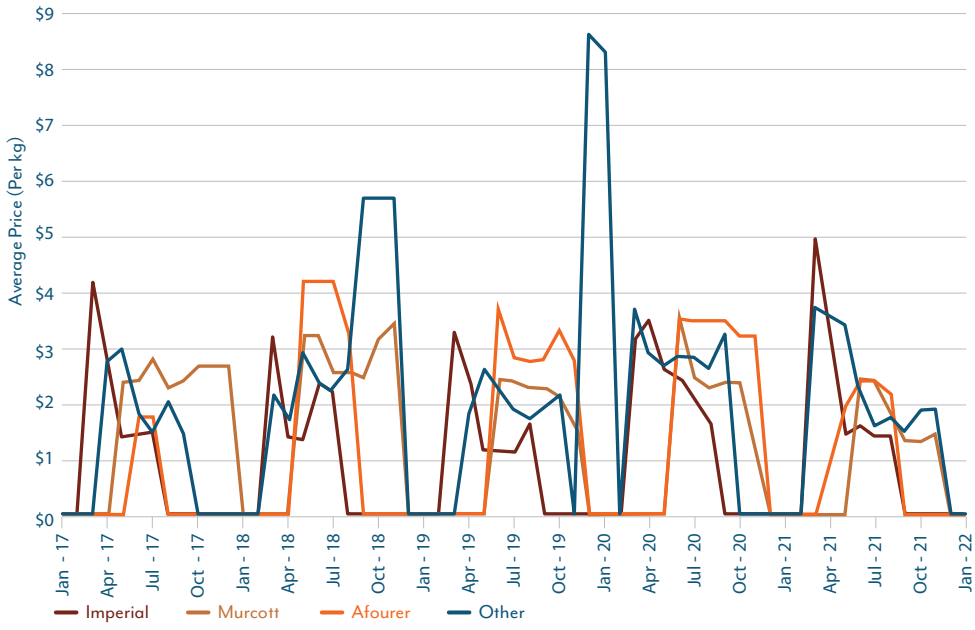
Key trends in pricing include:

- Imperial mandarin prices have experienced a peak in March each year, with prices in March 2021 totalling an estimated $5.0 per kilogram.
- On average Murcott mandarins have experienced peak prices in June every year. In June 2021, prices were estimated to total $2.4 per kilogram.
- On average Afourer mandarins have experienced peak prices in June every year, with prices in June 2021 totalling an estimated $2.4 per kilogram.

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 3.9. Queensland Mandarin Prices (Average $/kg)

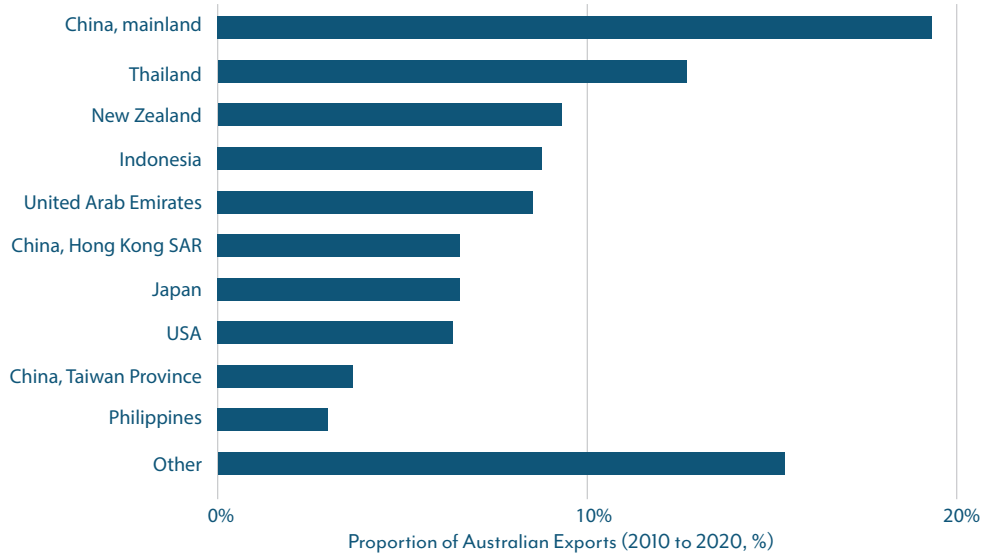


Notes:
• Average annual and average by variety.
• Other includes Daisy No1, Daisy, Goldup No1 & No2, Nova No1 & No2, Avana No1 & No2, Hickson No1 & No2, Monarch No1, Tayler Lee No1 & No2, Unique No1 & No2, Sumo No1, Amigo, Amigo No1, Freemont No1 & No2, Nectar No1 & No2, Dekopon No 1, Page No1 (air-freight), Tangold No1.
Source: Ausmarket Consultants (unpublished).

3.7 AUSTRALIA'S KEY MARKETS

China has been Australia's largest export market for mandarins on average from 2010 to 2020, accounting for 19.2% of Australia's exports on average over the period of 10 years. This was followed by Thailand (12.6%) and New Zealand (9.3%).

Figure 3.10. Australia's Top 10 Key Export Markets, 2010 to 2020



Note: Data is reflective of tangerines, mandarins, clementines and satsumas.
Source: FAOSTAT (2022).

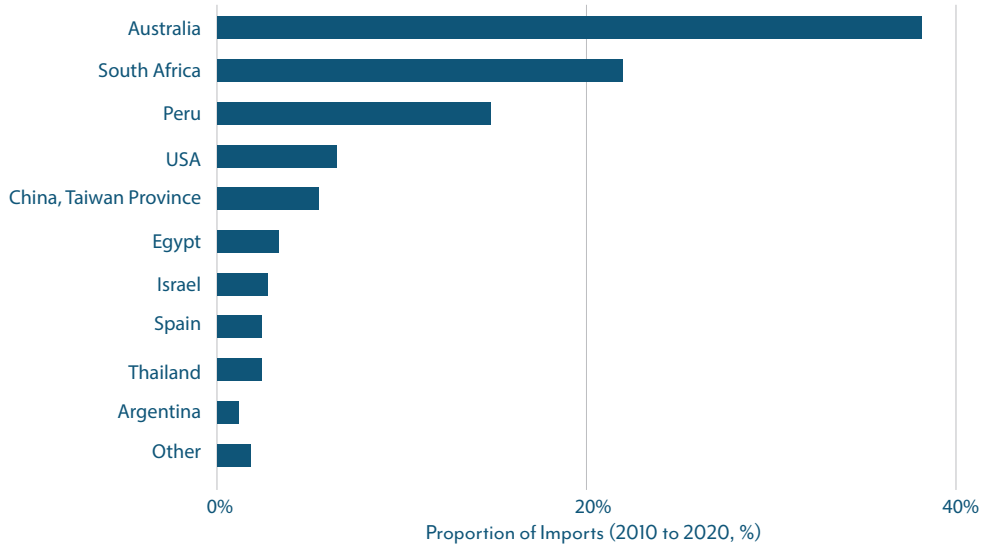
CHINA

Both China and Australia are reliantly reliant on each other for mandarin trade (China is Australia's largest export market and Australia is China's largest import market). From 2010 to 2020, China sourced approximately 38.2% of total mandarin imports from Australia (on average). Australia was granted official market access to China in 2006, however, the industry was relatively slow to capitalise on the market due to challenging government registration processes and phytosanitary requirements (Citrus Australia, 2021). As a result, mandarin exports to China prior to 2012 were small volumes limited to Queensland mandarins (Citrus Australia, 2021).

The second largest source of mandarins in China was from South Africa, accounting for 21.8% of total imports on average from 2010 to 2020. South Africa was once considered as not being competitive in the mandarin market due to the requirements of cold disinfestation at sub-zero temperatures which negatively impacts on quality of the fruit (Citrus Australia, 2021). However, South Africa exporters are finding ways to overcome these challenges with export volumes growing at relatively fast rates, particularly to China.

Peru was estimated as the third largest supplier of mandarins on average from 2010 to 2020. However, mandarin imports from Peru do not present a significant threat to Australia due to poor flavour, colour and cosmetics (Citrus Australia, 2021).

Figure 3.11. Mandarin Imports to China, 2010 to 2020



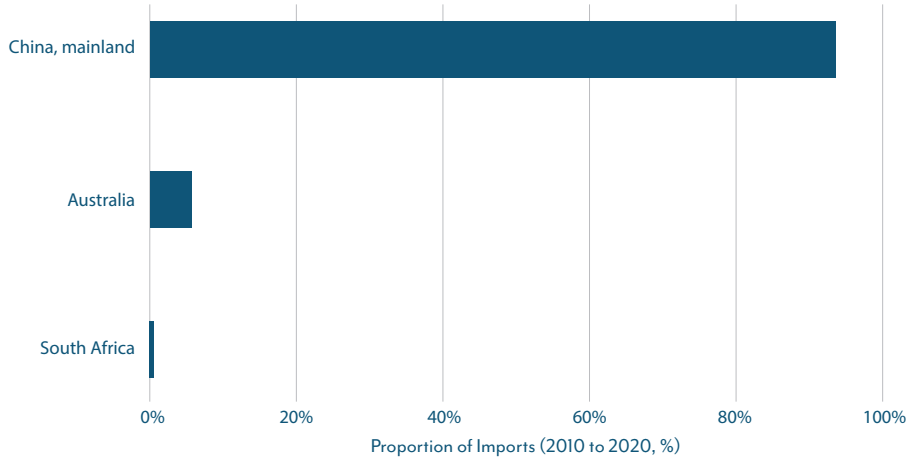
Note: Data is reflective of tangerines, mandarins, clementines and satsumas.
Source: FAOSTAT (2022).

THAILAND

The largest source of mandarins in Thailand was from China, accounting for 93.6% of total imports on average from 2010 to 2020. China dominates the market for mandarins, which are supplied during the northern hemisphere season. China supplies Thailand with small and low-cost mandarins (typically Nanfeng mandarins), which are a different market to Thailand's second largest supplier, Australia.

The second largest source of mandarins in Thailand was from Australia, accounting for 5.7% of total imports on average from 2010 to 2020. Australia is the dominant supplier of mandarins during the southern hemisphere season. Thailand is a key market for Queensland Murcott mandarins, with only moderate interest in other varieties including Afourer, Nova, Fremont and daisy mandarins (Citrus Australia, 2021).

Figure 3.12. Mandarin Imports to Thailand, 2010 to 2020



Notes: Data is reflective of tangerines, mandarins, clementines and satsumas. Only the top three major countries have been included.
Source: FAOSTAT (2022).

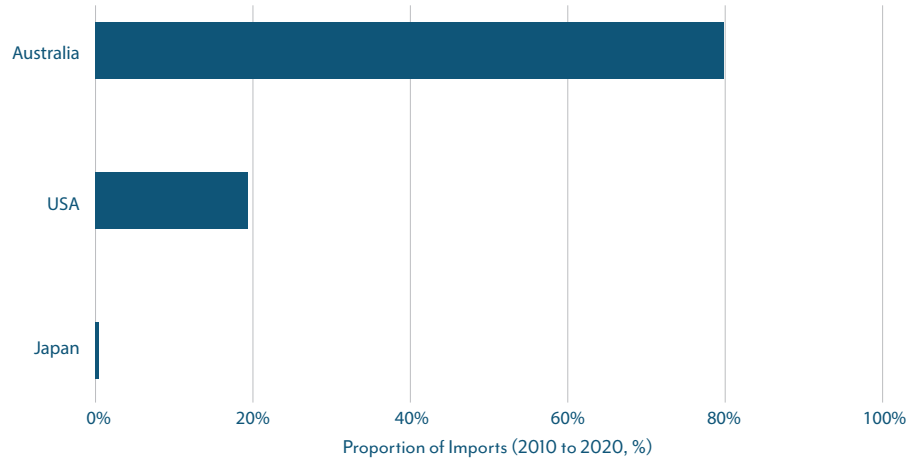
NEW ZEALAND

New Zealand was Australia's third largest export market for mandarins (on average) between 2010 and 2020. New Zealand is largely reliant on mandarin imports from Australia, with Australian mandarins comprising approximately 80.0% of total mandarin imports to New Zealand from 2010 to 2020.

The second largest supplier of mandarins to the New Zealand market was the US, accounting for 19.5% of total imports on average from 2010 to 2020.

Australia and the US have historically been the only two countries, which supply the New Zealand market. Citrus Australia (2021) have reported that the US supplies New Zealand small volumes between January to March, while Australia supplies the market from July to October. From April to June, the gap in imports is largely supplied from domestic production in New Zealand, which consists mostly of the Satsuma variety.

Figure 3.13. Mandarin Imports to New Zealand, 2010 to 2020



Note: Data is reflective of tangerines, mandarins, clementines and satsumas. Only the top three major countries have been included.
Source: FAOSTAT (2022).

3.8 MARKET VIABILITY ANALYSIS

The three key markets for Australia that were identified in section 3.7 above include:

- China
- Thailand
- New Zealand

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

CHINA

China has historically been Australia's largest market for mandarin exports, with Australia exporting 13,401 tonnes of mandarins in 2020. In 2020, Australia exported approximately 10.7% of total production to China, highlighting the significance of the market to Australian mandarins.

POPULATION & 2050 FORECAST

2021: 1.44 billion

2050: 1.40 billion

China is the world's largest producer of mandarins

GDP

2020: $10,451 per capita (USD)

2026: $17,493 per capita (USD)

From 2010 to 2020, China sourced approximately 38.2% of total mandarin imports from Australia

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

MARKET ACCESS CONSIDERATION

- Under the ChAFTA free trade agreement the tariff for Australian mandarin exports to China stand at 1.3%, decreasing to 0% from 2023 onwards.
- China's second largest supplier for mandarins, South Africa, does not have any FTAs in place. Mandarin exports from South Africa to China are subject to a 12% tariff.
- Queensland mandarin exports to China require cold disinfestation[2] treatment at three degrees Celsius to treat the Queensland fruit fly, while Western Australia mandarin exports require treatment at 2.1 degrees Celsius (for treatment of Mediterranean fruit fly). Citrus Australia (2021) reports that cold treatment at 2.1 degrees Celsius is damaging to the fruit, leading to poor quality.
- In 2020, a number of Australian agricultural products (including beef and wine) were negatively impacted by the Government of China (including increased costs or removal of market access). The rising tensions between Australia and China provide uncertainty around import bans, or future disruptions on Australia's exports to China.

PRODUCTION SEASONALITY AND IMPORT COMPETITION

The shipping season for mandarins from South Africa to China is from the months of July to September, with peaks experienced between July and August (Citrus Australia, 2021). Australian mandarin exports to China largely take place between July and August (Citrus Australia, 2021). South Africa has historically had lower export volumes to China compared to Australia due to cold disinfestation treatment being required at sub-zero temperatures and cost of transport due to their greater distance to the Chinese market.

China became an important market for Australian mandarins once Australia lost its market share in the US to Chile (Citrus Australia, 2021). Australia was required to search for another key market, with China representing the greatest opportunity. Today, China is the leading export destination for Australian mandarins.

Chile gained access to China in 2020 for citrus exports, however, the process was not finalized until mid-way through the season due to the requirement for registering orchards and pack houses with authorities (Citrus Australia, 2021). It is unclear on the impact that Chile will have on the mandarin market in China, however, Australia will continue to have proximity to market advantages.

2 Cold disinfestation is a treatment for fruit fly, where the mandarin is subject to low temperatures for an extended period of time. This cold temperature will kill fruit fly eggs and/or larvae if they are on the fruit. The treatment can be undertaken prior to export or during transit.

THAILAND

In 2020, Australia exported approximately 6.6% of total mandarin production to Thailand, equating to 8,246 tonnes. Thailand is an important market for Queensland mandarins with strong demand for Murcotts and Murcott varieties (Citrus Australia, 2021). There is only moderate demand for other mandarin varieties including Daisy, Fremont, Afourer and Nova (Citrus Australia, 2021).

POPULATION & 2050 FORECAST

2021: 70 million

2050: 65.5 million

From 2010 to 2020, Thailand sourced approximately 5.7% of total mandarin imports from Australia

GDP

2020: $7,188 per capita (USD)

2026: $10,441 per capita (USD)

Australia has virtually no competition from other Southern Hemisphere suppliers

Note: Population forecasts have been estimated based on population projections by IMF and OECD.
Source: OECD (2022), IMF (2022), World Bank (2022), Statista (2022).

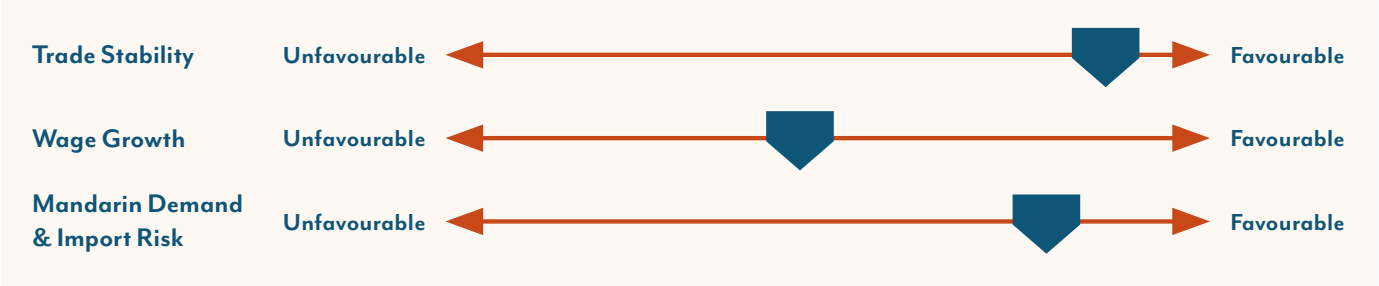
MARKET ACCESS CONSIDERATION

- Exports to Thailand, which are not accompanied by a certificate of analysis (from an accredited laboratory) must be subject to on-arrival screening by authorities (Citrus Australia, 2021). This was implemented in 2020 as Thailand had reforms to its agrichemical residue monitoring process (Citrus Australia, 2021). Due to Australia's well-established testing program, Citrus Australia highlight that this will unlikely be a barrier to trade in coming years (Citrus Australia, 2021).
- Of important note, Thailand recognises Fuller's Rose Weevil as a quarantine pest. This pest is not easily removed by usual packing house procedures and are a difficult pest to control in orchards with traditional chemistry (Citrus Australia, 2021).
- Tariff on Australian mandarins to Thailand were limited under the TAFTA[3] in 2015.
- China also does not have any tariff implications imposed for exporting mandarins to Thailand under the ASEAN-China FTA [4].

PRODUCTION SEASONALITY AND IMPORT COMPETITION

In 2019, China supplied most mandarins from the months of November to January while Australia was the largest supplier from July to September (Citrus Australia, 2021). Chinas and Australia's mandarin offering in Thailand target two very different markets – China targets small and low-cost mandarins, while Australia targets a niche market.

Large fruit is the preference in Thailand, and quality wise, the country will accept class one, composite and class two fruit (depending on the retailer) (Citrus Australia, 2021).



3 Thailand-Australia Free Trade Agreement.
4 Association of Southeast Asian Nations – China Free Trade Agreement.

NEW ZEALAND

New Zealand has historically been Australia's third largest market for mandarin exports, with Australia exporting 5,306 tonnes of mandarins in 2020, accounting for 4.2% of Australia total production for the year.

POPULATION & 2050 FORECAST

2021: 5.1 million

2050: 6.3 million

From 2010 to 2020, New Zealand sourced approximately 80.0% of total mandarin imports from Australia

GDP

2020: $41,441 per capita (USD)

2026: $58,293 per capita (USD)

Only two markets supplying New Zealand (Australia and the US)

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

MARKET ACCESS CONSIDERATION

- Australia and New Zealand have a number of FTAs in place, eliminating tariffs for Australian mandarin exports to the country. The AANZFTA[5] eliminated all tariff regimes on Australian mandarins in 2012.
- The US is currently New Zealand's second largest supplier of mandarins annually, and like Australia, has no tariffs in place on mandarin exports (under the Most Favoured Nation Duties).

PRODUCTION SEASONALITY AND IMPORT COMPETITION

The US supplies small volumes of mandarins to New Zealand between January to March (section 3.7), while Australia supplies the market from July to October. From April to June, the gap in imports is largely supplied from domestic production in New Zealand, which consists mostly of the Satsuma variety.

The Australian Citrus Industry Export Strategy 2021-2025 highlights mandarin plantings are beginning to expand in New Zealand (particularly Satsumas), which will capture some of the current market share currently supplied by imports from the US and Australia (Citrus Australia, 2021). The strategy highlights that export growth potential for New Zealand is limited, with future domestic production likely be sufficient to meet domestic demand (Citrus Australia, 2021).

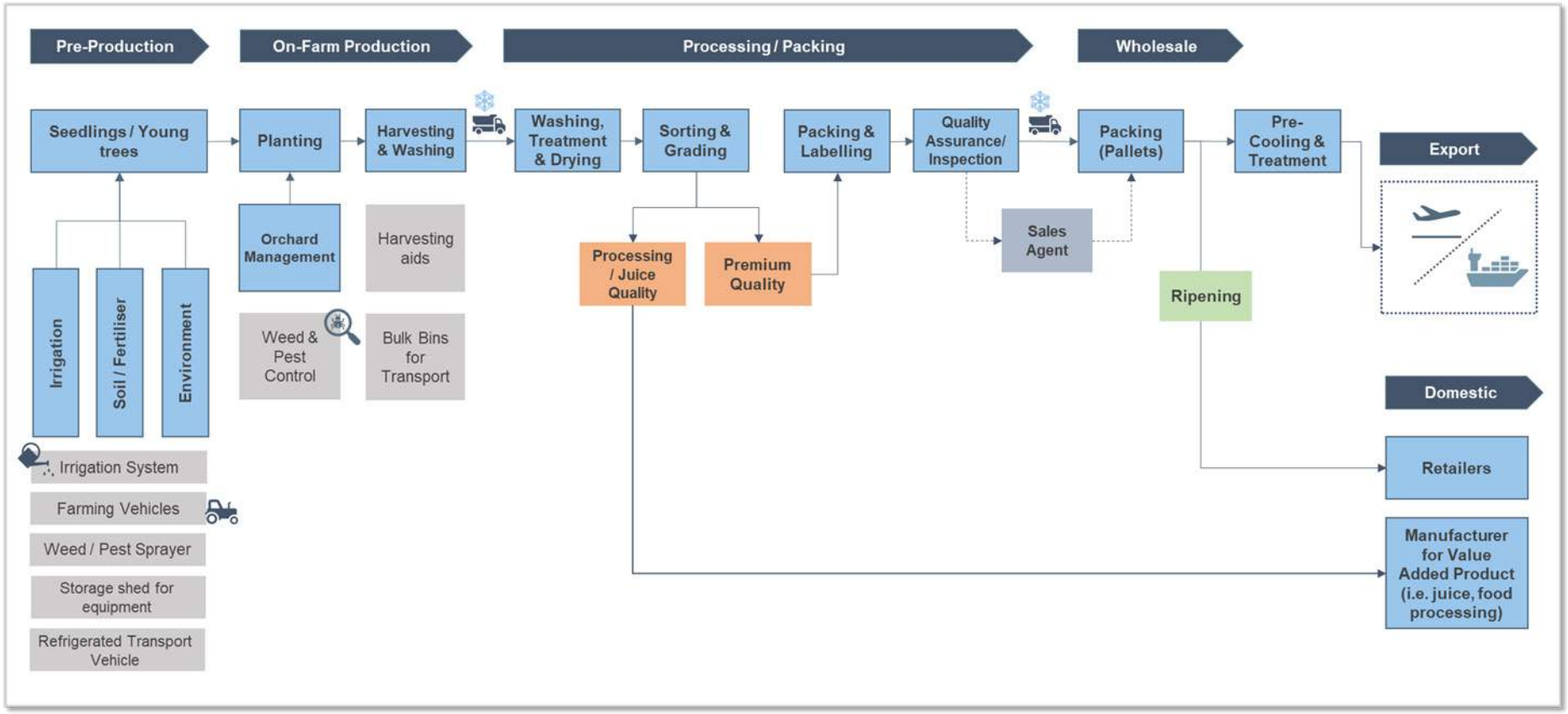
5 ASEAN-Australia-New Zealand Free Trade Area.

4. MANDARIN 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 mandarins 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. Mandarins 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 mandarin trees. According to the Queensland Government's Citrus Information Kit (1997), essential infrastructure and equipment to set up and operate a citrus orchard include:

- An irrigation system including a dam, piping and under-tree sprinklers
- Soil and fertiliser (and fertiliser spreader)
- Cultivation equipment
- Weed and pest sprayers, and safety equipment
- Pruning equipment
- Trailer and truck with water tank and pump
- Storage shed for farm chemicals.

By the fourth year, additional equipment for spraying, pruning, harvesting and packing will be required, including:

- Packing shed, including fork-lift, packing and grading equipment and a degreening/cool room (some growers use central packing sheds)
- Cherry pickers or ladders
- Bulk bins and bin trailers
- Oscillating boom sprayer
- Generator for emergency power.

While the majority of 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

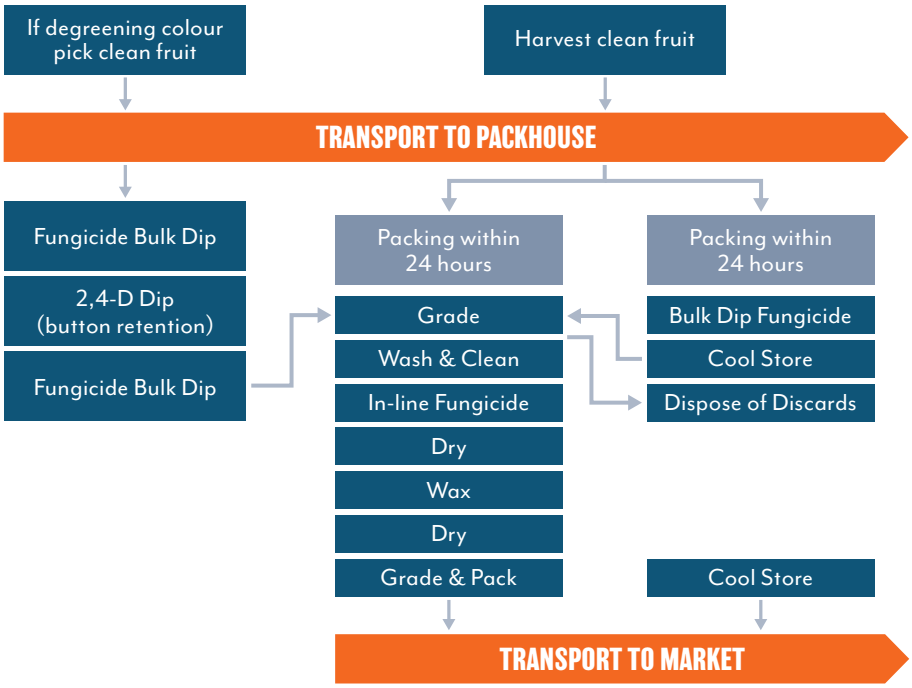
Healthy mandarin trees will begin to bear fruit after three years. Growing conditions and orchard management practices are outlined in Appendix A.

Mandarins must be harvested with care as they are susceptible to rind damage and plugging of the stalk from the fruit.

PROCESSING / PACKING

After harvest, fruit are delivered to the packing shed where they go through a range of post-harvest activities. Figure 4.2 the typic al sequence of post-harvest operations.

Figure 4.2. Post-Harvest Handling Processing and Packing



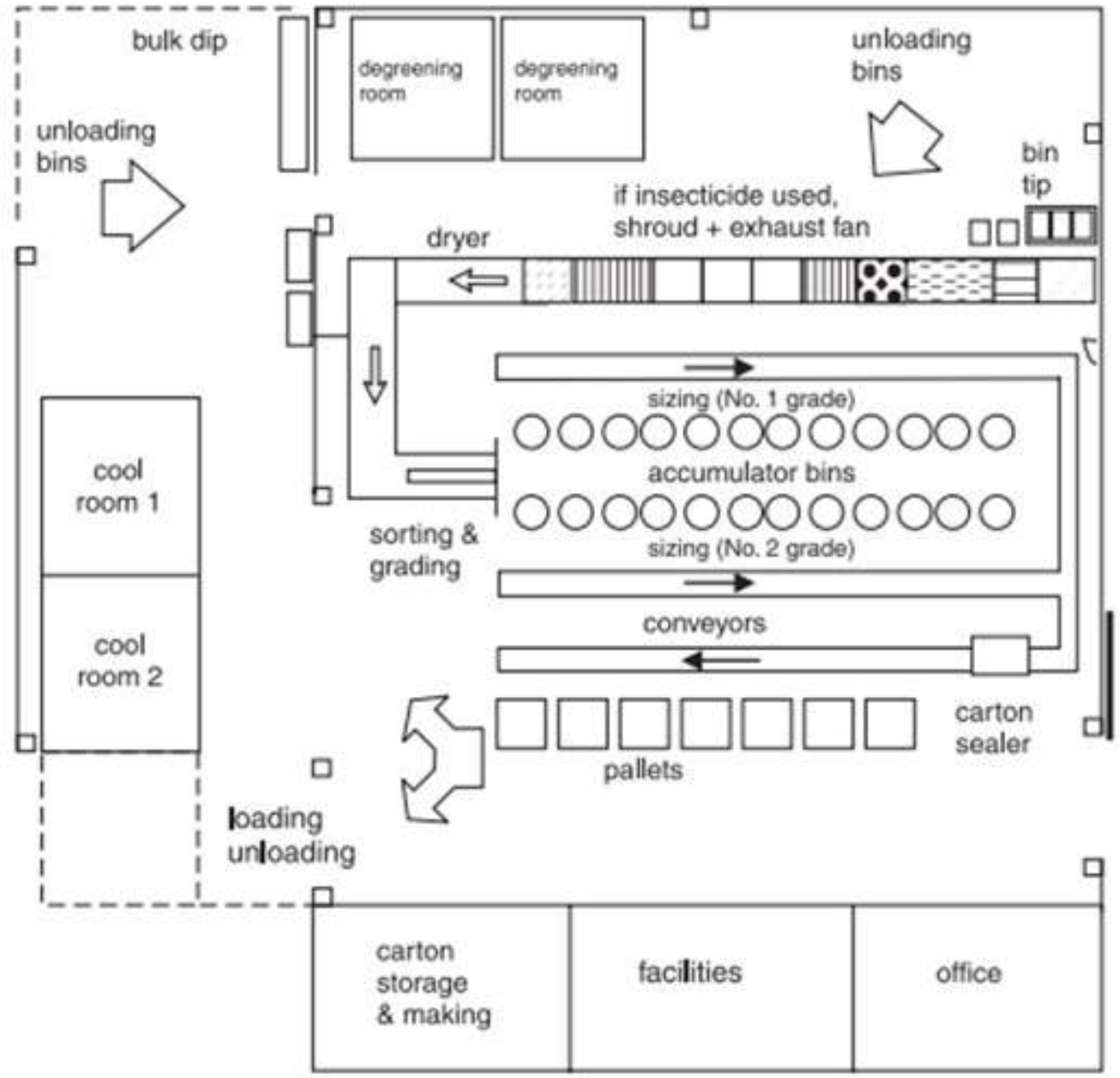
Source: Adapted from DPI (2017).

Infrastructure for washing, treatment, drying, sorting, packing and cool storage is required.

Mandarins have a much shorter shelf life compared to other citrus varieties, and are prone to a loss of quality during storage. Optimum storage time varies with variety, but generally fruit should only be stored for a maximum of 4–6 weeks. Fruit are best stored at temperatures between 5–8 °C prior to consumption.

Figure 4.3 illustrates the layout of a typical fruit treatment line in post-harvest operations.

Figure 4.3. Typical Fruit Treatment Line



LEGEND: Crop Feed Pre-sort Dip tank Wash off Spinoff Rollers Spare Fungicide (+insecticide where necessary) Wax
Source: DAF (1997).

WHOLESALE

Wholesalers (or distributors) refer to the entities that buy fresh citrus in bulk from packers and resell to the other supply chain partners such as retailers or processors. Wholesalers have facilities to store the produce at their premises for a short period of time.

Growers can sell their mandarins directly to retailers and processors, or through wholesale agents based at the major metropolitan produce markets and distribution centres. Most Queensland citrus are consigned to wholesalers in Brisbane, Sydney, and Melbourne. There may also be quarantine requirements as defined by each state.

Transport to the distribution centres is required to be in refrigerated vehicles, otherwise the quality of the fruit may be impacted.

EXPORT MARKETS

Australian mandarins are sold into export markets for fresh consumption. Mandarins are packed in 15-kilogram cartons fibreboard cartons for export and each shipping container has the capacity to hold 1260 cartons, or 22 tonnes, of fruit (Austrade, 2014).

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 mandarins, these are China, Japan, South Korea, Thailand and New Zealand. 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. Protocol Market Requirements

Country	Orchard Approved By Dawe (Annually)	Packhouse Approved By Dawe (Annually)	In-Transit Cold Treatment	Onshore Cold Treatment Facility Approval	Fumigation (Fullers Rose Weevil)
China	✓	✓	✓		✓
Japan		SA ONLY	✓	✓	
South Korea	✓	✓	✓		
Thailand	✓	✓	✓	✓	✓
New Zealand	QLD ONLY	QLD ONLY			
United States		✓	✓		
Taiwan		SA ONLY	✓	✓	

Source: Micor (2022).

DOMESTIC MARKET

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 IDA, 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 Tropico Pty Ltd at Palmwoods and CB Juice (Central Burnett Fruit Processors) in Munduberra.

4.2 INFRASTRUCTURE REQUIREMENTS AND GAPS IN CENTRAL QUEENSLAND

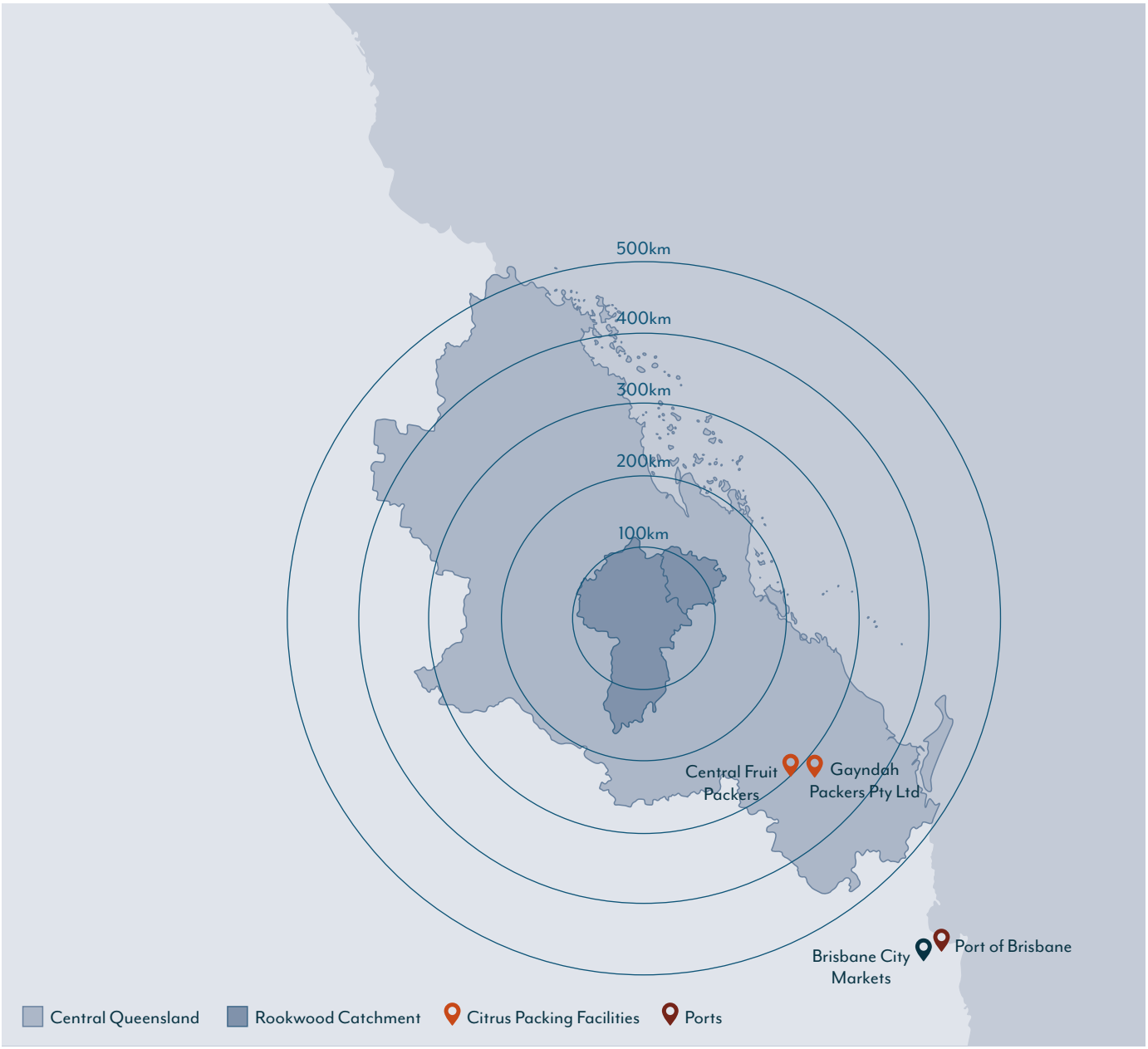
Most independent Queensland growers have their own packing facilities, and therefore grow, pack and market their own product. There are a number of corporate citrus packers in the Mundubbera area, including Central Fruit Packers and Gayndah Packers Pty Ltd in Gayndah.

Once the product has been processed and packed, it is transported to either the wholesalers at the major metropolitan markets of each state, for distribution to either other domestic retailers or for export.

Mandarin exports are currently transported via sea freight from all major Australian ports, including the Port of Brisbane. It is assumed that mandarins produced in the Rookwood Weir Catchment Area will also be exported from the Port of Brisbane.

Figure 4.4 illustrates the distance from the Rookwood Weir Catchment Area to the corporate packing facilities, as well as the main sales location, the Brisbane City Markets and Port of Brisbane.

Figure 4.4. Packing Facilities & Domestic and Export Markets, Rookwood Weir Catchment Area



Source: AEC.

Shutdowns of major global ports due to COVID-19 (including China, South Korea and United States) resulted in ripple effects across global supply chains, creating logistic challenges for Australian citrus exports. This has caused goods to back up in storage and ships to be diverted or slowed down (Agrifutures, 2021). In some instances, shipping times have nearly doubled, providing an unviable option for delivering fruit in a timely manner where quality is still maintained.

In addition to freight disruptions, there are major challenges linked to labour due to international border closures. Citrus harvesting heavily relies on seasonal workers such as backpackers and temporary visa holders. A shortage of labour has supposedly pushed harvest later into the season, resulting in an oversupply of citrus as Queensland growers are forced to compete with fruit from other regions. This challenge is negatively impacting on Australian production, with a portion of the yield being left unharvested.

5. COMPETITIVE ANALYSIS AND MARKET OUTLOOK

Over recent years, the Australian mandarin industry has been experiencing an increase in exports, growing by an average annual rate of 10.4% from 2010 to 2020. This is largely through the demand from China, where exports to China have grown by 50% on average per annum from 2010 to reach a total of 13,401 tonnes in 2020. Demand has also been strong in Thailand, with exports from Australia growing by an average annual rate of 18% per annum from 2010 to reach 8,246 tonnes in 2020.

Australia has the opportunity to further increase mandarin exports in the international market, recently being granted expanding access for exports. Citrus that is grown in inland Queensland, Western Australia, and Bourke and Narromine in New South Wales can now be exported to the US (Australian Government, 2021). Previously, only citrus exported to the US was from Riverina, the Riverland, and Sunraysia (Australian Government, 2021).

Over the years Chile has grown to become the largest supplier of mandarins to the US market. Chile has a number of competitive advantages in supplying the US market including proximity to market, lower production costs and is focused almost exclusively on the US for export (Citrus Australia, 2021). Although Australia is a smaller player compared to Chile, Australia has a 'quality niche' that cannot be provided by Chile (Citrus Australia, 2021). This expanded market access provides Australia with an opportunity to increase exports to the US and target a niche market.

The table below provides a snapshot of the top five exporters and importers of mandarins in the global market. The top five exporters accounted for 66.7% of total mandarin exports in 2020, while the top five importers accounted for 45.8% of total mandarin imports in 2020.

Figure 5.1. Major Exporters and Importers of Mandarins

Note: Largest importers and exports in 2020.
Source: AEC.

Appendix B provides a summary of citrus industry market access and market development issues.

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

Table 5.1. SWOT Analysis – Australian Mandarin Production

Strengths	Weaknesses
› Mandarin exports to China from Peru are not a threat to Australia due to poor cosmetics, colour, flavour and increased transport costs. › Little current competition from Southern Hemisphere competitors in the Japanese market.	› The Imperial mandarin is not suited for export as it does not travel well due to it' soft skin. › Domestic demand for Imperial mandarins is falling with a strong preference shift towards newer varieties which has resulted in significant excess supply issues for the imperial variety and consequential price declines. › Afourer mandarin does not grow easily in Queensland. › Fruit fly treatment from Western Australia to China is at 2.1 degrees Celsius which is damaging to the fruit. › Cold disinfestation requirements for fruit flies adds between $1.50 to $.2.50 per carton to the cost of supply. › Ongoing detections of fruit flies to the Riverland has threatened the areas fruit fly free status. Some markets do not recognise Riverland as being fruit fly free, including Indonesia, the Philippines and Vietnam.
Opportunities	**Threats**

› Expanded export access to the US
› Tariffs on mandarin exports to China will be eliminated by the beginning of 2030 under the ChAFTA.
› Protocol improvements to allow additional mandarin varieties under in-transit cold disinfestation to Japan.
› Under the ICEPA which entered into force in 2020 the tariff for mandarins was cut to 10% (from 25%) for 7,500 tonnes per year. The tariff will be reduced to 0% over 20 years, providing duty free access to unlimited volumes of mandarins to Indonesia.
	› Logistic challenges due to the impact of COVID-19.
	› Trade disputes between China and Australia may impact future supply to the market.
	› Since 2020 China has not approved new businesses, meaning no new businesses can export.
	› Mandarin exports from South Africa are overcoming challenges, with exports growing. South African mandarin exports to China are growing at fast rates.
	› In 2016, South Africa was granted rights to a seedless Afourer variety (TangoTM) which is expected to compete with Australia's standard Afourer variety.
	› New plantings and improved practices are increasing yield and quality of mandarins in South Africa.
	› The need for existing imperial mandarin trees to be replaced to maintain market relevance will place pressure on local producer balance sheets and income streams. This may drive consolidation in the industry and reduce the number of smaller producers in Australia.
	› Increased competition in key markets:
	  › In 2019 Peru gained market access to Japan for mandarins. There are also negotiations to allow exports to Thailand.
	  › In 2020, Chile was granted market access to China. Chile is a nation that is free of fruit flies, unlike production in Australia.
	  › In 2020, South Africa was granted market access to the Philippines.

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 Mandarin 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 40ha.
- The anticipated initial capital investment for a Mandarin orchard is $8.7 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, 18.3kg per tree. The farm will be operating at a loss until the commercial return is achieved when the trees reach their seventh year (FY2031), with a yield of 56.4kg per tree.
- The break-even point (for Murcott), at the current weighted average cost of $1.54 per kg is September 2029. However, the first year of operating at a profit is predicted to be FY2031, 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 FY2030.
- 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 17.1%. The terminal value of the mandarin farm at the conclusion of the analysis (FY2041) is $97.8 million (undiscounted).

6.1 APPROACH

The commercial and financial feasibility of an average Murcott mandarin 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
- Sources of funding
- Orchard operations
- Financial Feasibility (including sensitivity analysis).

6.2 ROOKWOOD WEIR WATER AVAILABILITY

The Rookwood Weir Scheme allows for a maximum 500ML water allocation for agricultural landholders. Under the assumption this water is provided with a conservative 80% reliability and 10ML per ha per year is required for mandarin production (DPI, 2017), the maximum growing area in the Rookwood Weir Catchment Area is 40ha for Murcott mandarins.

DPI recognise the typical water usage for mandarin production fall in the 7-12ML range. Analysis has been conducted on 10ML of water applied per hectare, as it is slightly above the mid-point to reflect the relatively high potential of negative net rainfall in the Rookwood Weir Catchment Area (BOM, 2022a & 20202b).

However, water requirements are not consistent across all varieties considered in the sensitivity analysis and will have an impact on the land farmed for each variety, refer to Section 6.3 for details.

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	30 ha	40 ha	50 ha	160 ha

Source: HTW, AEC.

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: Murcott, Imperial, and Afourer. Each variety is anticipated to have the same capital and asset requirements. Varietal difference will be evidenced through the orchard operations and structure. There are other varieties which could be grown in the Rookwood Weir Catchment Area, however, are not modelled in this analysis given the limited access to information.

The three key differences modelled between the selected varieties are:

- Water use
- Tree population
- Price
- Yield
- Harvest period.

Table 6.2. Variety Summary

Variety	Water Use (Ml/Ha)	Hectares Planted	Tree Density (Tree/Ha)	Weighted Average Price	Average Yield Mature Tree	Harvesting Months
Imperia	10ML	40ha	350	$1.53/kg	170kg/tree	6
Murcott	10ML	40ha	350	$1.54/kg	174kg/tree	3
Afourer	12ML	33ha	350	$1.86/kg	165kg/tree	3

Source: Ausmarket Consultants (unpublished), DPI (2017), Hort Innovation (2021), Consultation with Growers.

Financial evaluation has been undertaken for a typical Murcott farm, with sensitivity analysis undertaken for and Afourer varieties. Although its common practice to often grow more than one variety in a single orchard, analysis has been undertaken for single variety orchards.

WATER USE

Imperial and Murcott are commonly grown throughout Queensland and are suited to the warmer climate (compared to southern states). Afourer mandarins are typically grown in southern Australia, where winters are much cooler. In order to grow this variety in Queensland, a higher-than-average water use is required to ensure yield quantity and quality is sufficient.

In variety sensitivity analysis, water availability is assumed to be 500ML at an 80% reliability rate. The total land available for planting is shown in the table below.

Table 6.3. Water Use and Farmed Land by Variety

Grade	Water Used (Ml/Ha)	Total Ha Planted
Imperial	10ML	40ha
Murcott	10ML	40ha
Afourer	12ML	33ha

Source: DPI (2017), Consultation with Growers.

TREE POPULATION

There is a range of tree densities within mandarins can be farmed, all of which present unique array of benefits and costs. Citrus farm tree density is a decision to be made by the grower, typically, mandarin farms can plant between 250 to 440 trees per hectare (Citrus Australia, no date; University of California, no date). However, there has been a trend toward higher density plantings because the operators will be able to achieve higher yields from the young trees, allowing them to break even earlier (DAF, 2013). It's noted that modern mandarin farms which opt for higher density tree planting experience a trade-off between higher operating costs such as pruning and harvesting with the potential yield.

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 pruning costs which can mitigate potential benefits associated with increase yield or high harvesting efficiencies.

Table 6.4. Tree population by Variety

Variety	Tree Planting Density	Total Trees (Mature Farm)
Imperial	350	10,310
Murcott	350	10,310
Afourer	350	8,498

Source: Citrus Australia (2020a), Consultation with Growers.

Citrus farms typically see tree losses throughout the orchard for the first three years after planting. On average, the orchard will decrease 10% each year over this period. In modelling the tree losses its assumed tree replacement will occur at the end of the orchard's 20th year after planting. This is in line with common practice across the industry, although some farmers and orchard operations will opt to undertake tree replacement in the year of tree loss.

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, 14,000 trees will be able to be sourced and planted during orchard establishment

PRICE

Prices for each variety and grade are presented in Table 6.5. 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 6.5. Price Per Kilogram, by Variety and Grade

Variety	Grade One	Grade Two	Grade Four
Imperial	$2.16	$1.44	$0.47
Murcott	$2.13	$1.38	$0.65
Afourer	$2.55	$2.32	$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 18 kilograms per tree. The variance in variety is in the growth of the yield and, ultimately the maximum yield each variety typically achieves.

According to Citrus Australia (2020a) mature Murcott orchards produce approximately 45 tonnes per hectare and mature Afourer orchards produce approximately 35 tonnes per hectare. Based on a tree population of 258 and 212 trees per hectare, respectively, the yield per tree has been estimated, as shown in Table 6.6.

It can be inferred from data published by Citrus Australia (2015 & 2020a) that Imperial mandarins will produce, on average, 44 tonnes per hectare. Based on a tree population of 258 trees per hectare, the average yield at maturity is 170kg per tree.

Table 6.6. Yield in Kilogram per Tree, by Variety

Variety	Yield
Imperial	170kg/tree
Murcott	174kg/tree
Afourer	165kg/tree

Source: Citrus Australia (2020a)

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 6.7. Share of Yield by Grade

Grade	Share Of Total Yield
Grade One	50%
Grade Two	25%
Grade Four/Juice	20%
Spoilage	5%

Source: 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 Section 3.3 for more detail). Imperial is modelled as having six productive harvest months and is the first to start harvest in April. Murcott and Afourer are harvest for three months starting from July and May, respectfully.

Table 6.8. Varietal Harvest Period

VARIETY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Imperial	■	■	■							■	■	■
Murcott	■	■	■									
Afourer	■										■	■

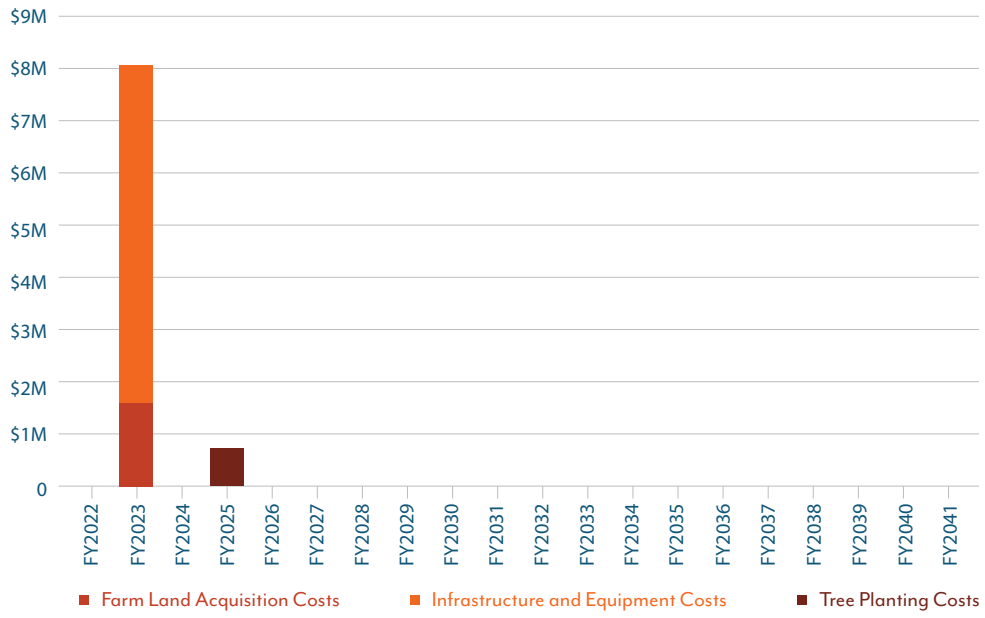
Source: Hort Innovation (2021). 6.4

6.4 ORCHARD CAPITAL INVESTMENT

6.4.1 ORCHARD ESTABLISHMENT

Mandarin 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 $8.7 million ($217,328/ha).

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



Source: HTW; AEC.

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 hectares suitable for growing Mandarins. 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 mandarin 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. Based on anecdotal evidence from HTW and other key regional producers, and the typical terrain of the Rookwood Weir Catchment Area, the per hectare 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 mandarins on the example farm, the necessary infrastructure and equipment will cost an estimated $6.5 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 $122,700/ha (DPIF, 2002, with clarification provided by Growers).

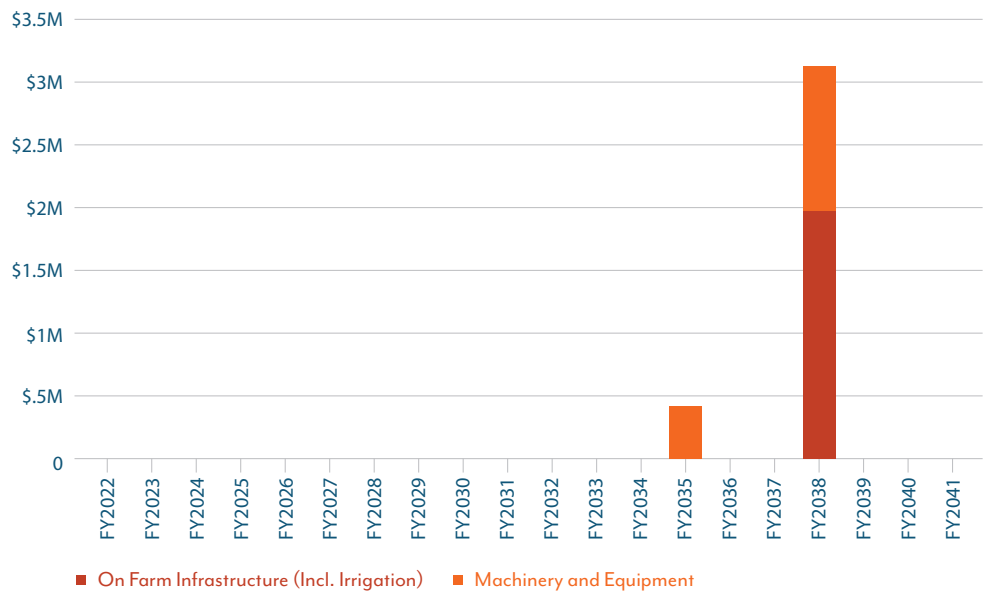
TREE PLANTING COSTS

Planting costs are incurred across spring – September to November. It is assumed mandarin 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.

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 $3.6 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)

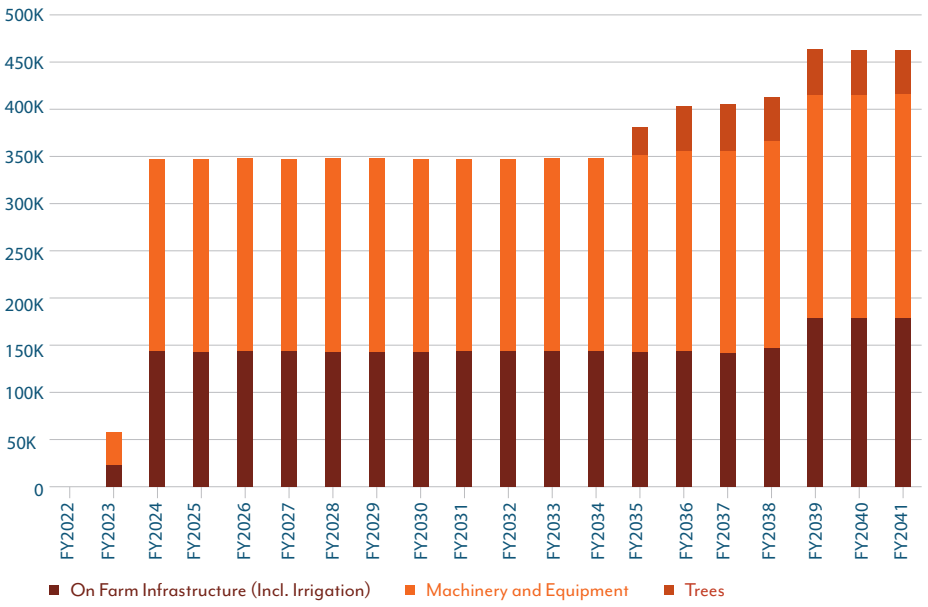


Source: AEC.

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.
Treatment of each asset type is outlined in Appendix C.

6.5 SOURCES OF INVESTMENT

Establishment of the Mandarin 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.

- The capital investment is assumed to be funded at a notional gearing ratio of 40%. The total capital investment of $8.7 million, $3.5 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%.
- Debt repayment can be structured as either interest only or principal and interest, in all outputs present, interest only repayment structure has been assumed.
- 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.
- 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 typically spends an additional 30-50% on labour.

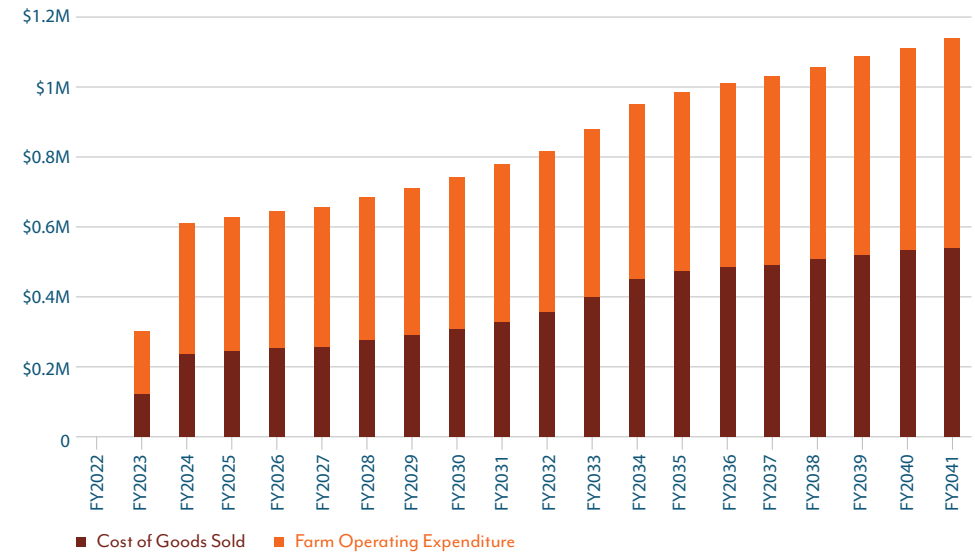
It is assumed that the farm manager (the owner) will pay themselves a notional salary on an ongoing basis. Additionally, all positive net profit after tax (NPAT) positions are assumed to be paid out as a dividend to the farm owner (as the farm is an owner-operated enterprise). These dividends are paid 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 47.6% 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 (either when at maximum production or within that period), a share of revenue, or an annual fixed cost. Each operating cost and their cost driver are listed in the following table.

Table 6.9. Operating Costs

Operating Costs	Cost Driver	Cost Per Driver (Real $Fy2021)
Non-Labour Operating Costs		
Consultancy Fees	Maximum production	$0.06
Electricity	Maximum production	$0.50
Fertiliser	Maximum production	$1.04
Pest Control	Maximum production	$0.05
Fuel and Gas	Maximum production	$0.31
Repairs and Maintenance	Maximum production	$0.83
Sprays	Maximum production	$0.93
Contract Thinning/Hedging	Maximum production	$1.37
Operating Costs	**Cost Driver**	**Cost Per Driver (Real $Fy2021)**
Non-Labour Operating Costs		
Water (incl. Irrigation)	ML	$250
Other Growing Costs	Maximum production	$0.07
Harvesting Cost	Tray	$4.17
Packaging Equipment	Tray	$2.50
Labour Operating Costs		
Harvesting Labour	Maximum production	$2.13
Other Labour	Maximum production	$0.48
Farm Manager	Fixed	$120,000
Overhead Operating Costs		
Levies	Revenue	0.5%
Water and Rates	Maximum production	$0.26
Insurance	Maximum production	$0.30
Other Administration Expenses	Maximum production	$0.37

Source: Consultation with Growers.

Of note, the packing equipment varies by variety. Murcott packing equipment is estimated to be $2.50 per tray, Imperials packing equipment is $4.17 per tray and Afourer packing equipment is $3.34 per tray.

Key limitations noted in modelling the operating costs include:

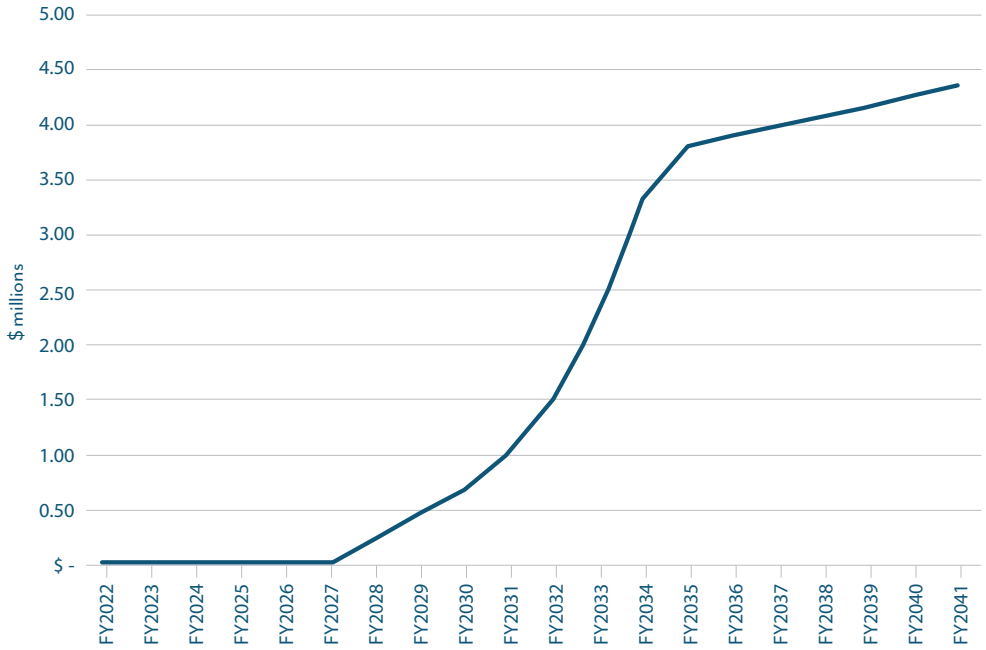
- The transport costs included in the analysis represent average historical costs. They do not take into account the increased transports costs experienced across the sector due to COVID-19. The longevity of these cost increases will impact the short-term profitability of the example mandarin farm.
- Citrus farms will experience changes in operating costs over time. For example, pruning costs will increase with tree maturity. For the purpose of analysis, the long-term average is applied to the whole orchard.

6.6.3 ORCHARD REVENUE

The orchard revenue consists of the operating income associated with the sale of mandarins, pursuant to the fruit's grade. The grade prices are listed in Table 6.5.

The mandarin 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. The increase between FY2028 and FY2035 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.

For the purpose of analysis, all revenue has been accounted for in the month after which the mandarins 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.

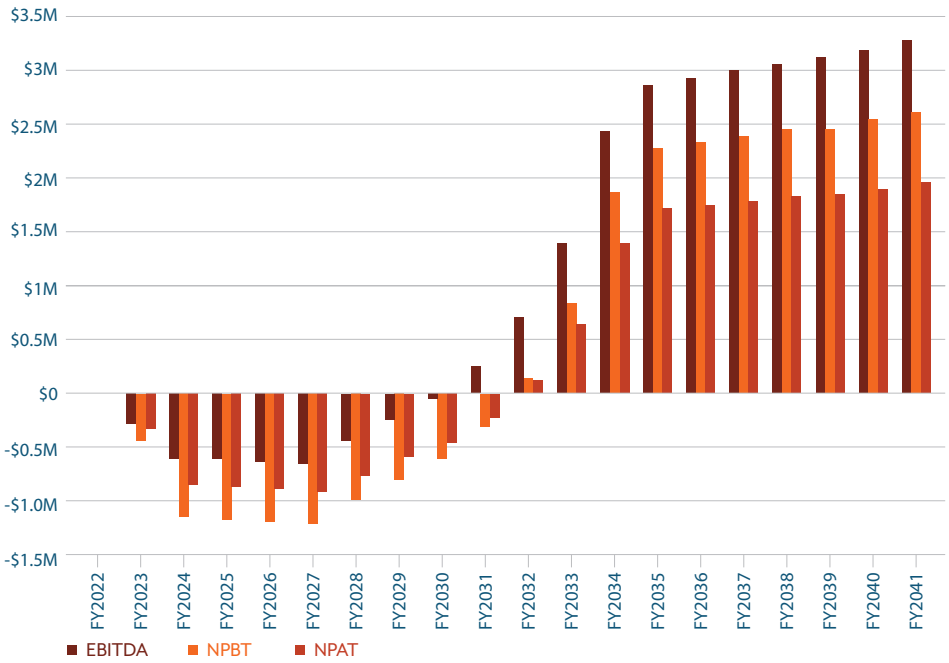
6.7 FINANCIAL FEASIBILITY

The assumed mandarin 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) seven years after orchard establishment, that is FY2032.

The operating breakeven month for the example farm orchard modelled is September 2029 when the average age of the trees is six years old. This shows the price point for Murcott is sufficient to recover the cost of goods sold from the onset of harvesting. The farm will require another two years, and the trees to reach at least eight years of age to recover all operating costs, show in Figure 6.6.

By FY2041 the NPAT of the orchard is estimated to be $1.95 million. 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)



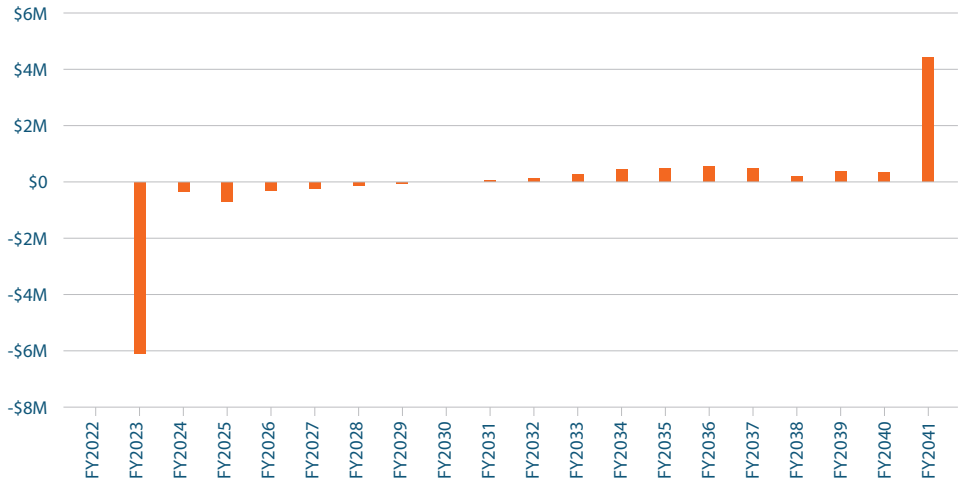
Source: AEC.

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, 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 17.1%.

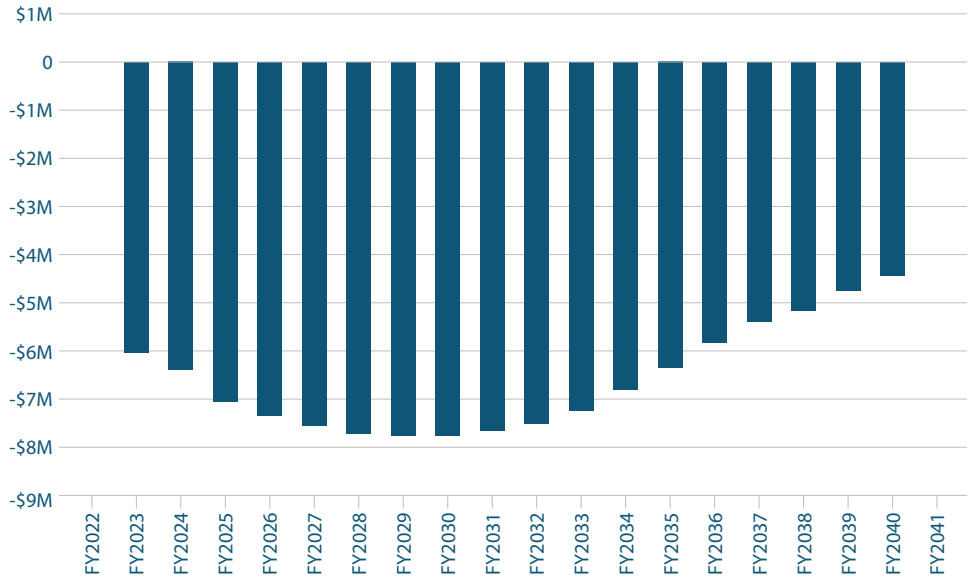
Figure 6.7. Discounted Cashflows, Including Terminal Value (FY2022 – FY2041)



Note: Discounted cashflows have been estimated on a 17.1% 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 17.1% post-tax discount rate, which is the implied internal rate of return.
Source: AEC.

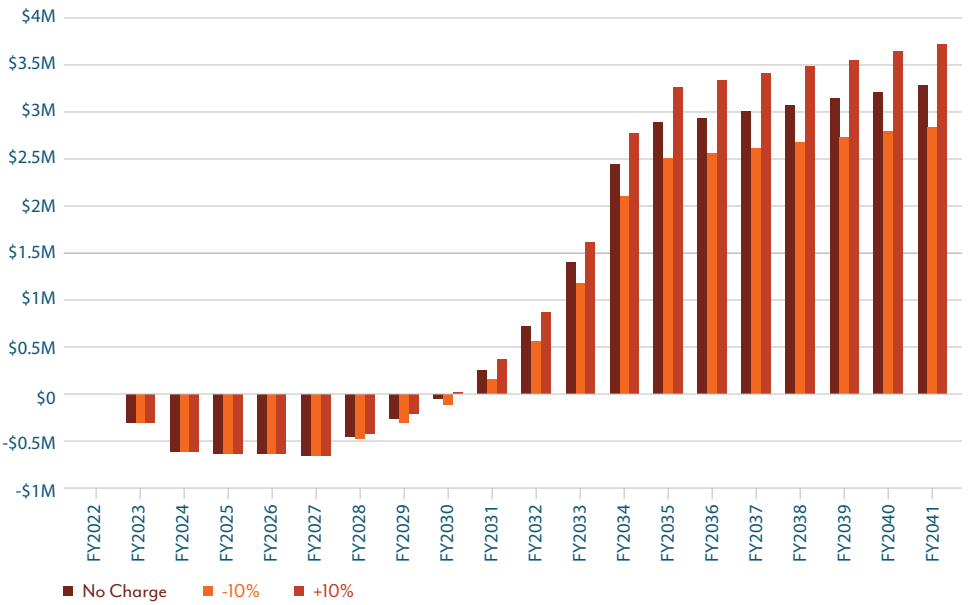
6.7.1 SENSITIVITY ANALYSIS

PRICE SENSITIVITY

To account for external price pressure on future Mandarin 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. Murcott Price Impact on Profitability (FY2022 – FY2041)



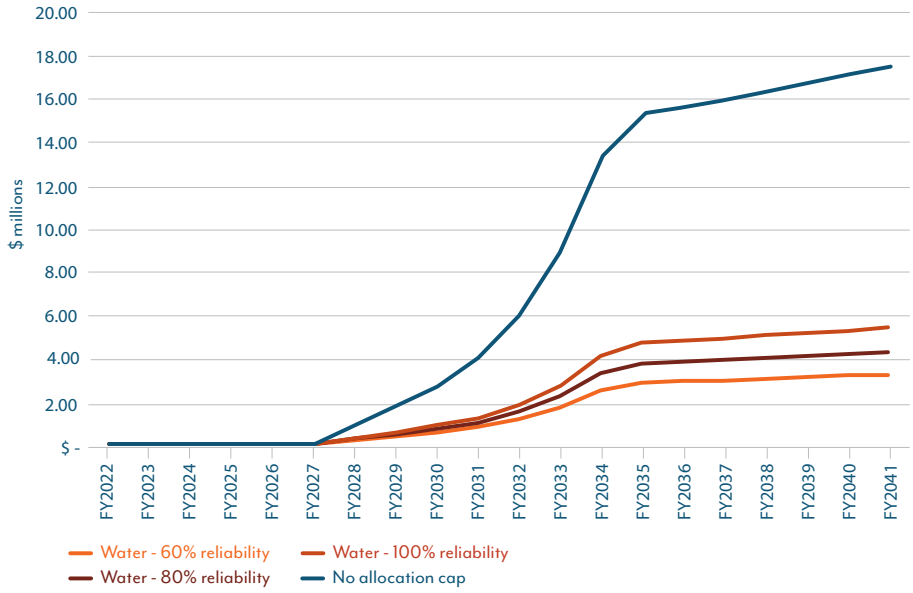
Source: AEC.

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 mandarin 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 Afourer, Murcott and Imperial can grow an additional 21.2% of trees per Ha. Imperials will experience approximately 5.5% less yield than the Murcott, with the same number of trees planted. The Afourer, with a smaller sized farm and lower yield per tree. is expected to harvest 27.8% less produce.

Table 6.10. Variety Production

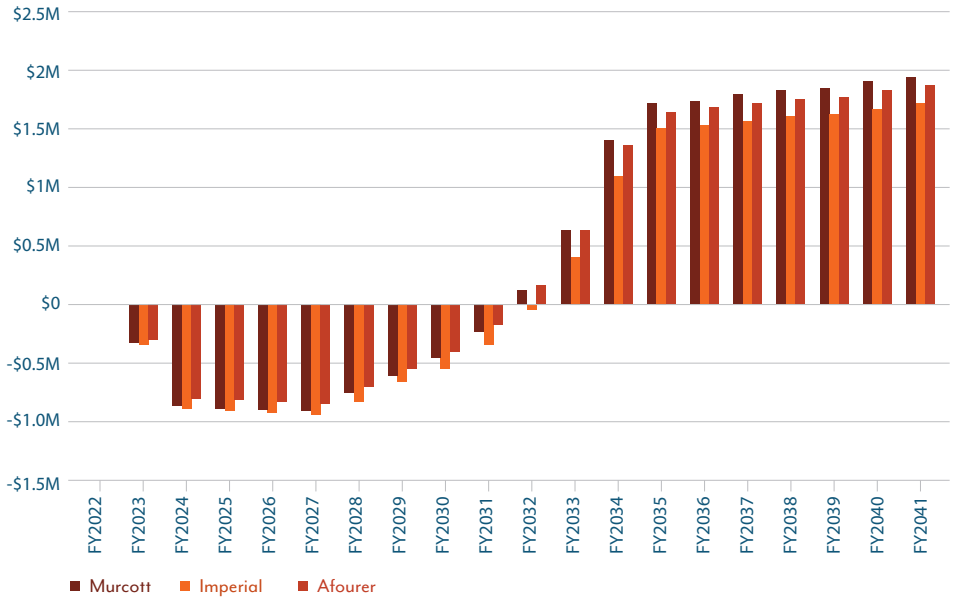
Variety	Total Trees	Total Tonnes Produced	Weighted Average Price
Imperial	10,310	1,773	$1.53
Murcott	10,310	1,870	$1.54
Afourer	8,498	1,463	$1.86

Source: AEC.

Operating costs such as levies and marketing and ripening costs are held consistent across all three varieties, with only packing equipment costs differing between the three varieties and the water expense (due to each variety's water requirement). Similarly, the orchard operation and management costs are assumed to remain constant, as too are the capital deployed.

The follow figure shows the NPAT for each variety. All varieties show to be profitable options, with similar break-even points. Afourer, although having a significantly lower tree population and yield is balanced by the strong price position.

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



Source: AEC.

6.8 ECONOMIC IMPACT

Investment in a mandarin 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 D.

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) positions6.

6 Where one FTE is equivalent to one person working full time for a period of one year.

The economic contribution of a Mandarin orchard enterprise in the Rookwood Weir Catchment Area is presented in Table 6.11. Initial capital investment of the orchard is anticipated to cost approximately $7.1 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 $6.8 million in industry output (i.e. revenues) to local businesses within the Rockhampton LGA.

A further $4.5 million in industry output is estimated to be supported in the catchment's economy through flow-on[7] activity, including $2.6 million in production induced (i.e. supply chain) activity and $1.8 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 $4.9 million contribution to GRP including $2.7 million directly
- 41 FTE jobs (including 25 FTE jobs directly), paying a total of $3.4 million in wages and salaries ($2.1 million directly).

Table 6.11. Economic Activity Supported by a Mandarin Orchard Enterprise, Rockhampton LGA

Impact	Output ($M)	Gross Regional Product ($M)	Incomes ($M)	Employment (Ftes)
Direct	$8.8	$2.7	$2.1	25
Production Induced	$2.6	$1.1	$0.8	9
Consumption Induced	$1.8	$1.0	$0.5	7
Total	**$11.3**	**$4.9**	**$3.4**	**41**

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

7. CONCLUSION

The Rookwood Weir Catchment Area provides the region with a unique opportunity to increase farm incomes and employment through higher value production activities

Based on an analysis of 2021 sales data (HTW, unpublished), the estimated average land value is approximately $3,800 per hectare (ha). In contrast, moving from non-irrigated land to irrigated agriculture could see value uplift range between $6,200/ha and $16,200/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.

Mandarin orchards are a long-term investment, taking up to seven years to break-even operationally depending on maturity and productivity of the trees. This lag between commitment and sustainable profitability makes the long-term industry outlook a critical issue in evaluating any investment decision.

Mandarin crops are an attractive investment opportunity, with an IRR of around 17.1% (depending on orchard management and varietal selection). However, whilst the outlook for the overall industry remains positive, there are number of challenges emerging across the domestic and international markets.

On the global scale, Australia is a relatively small producer of mandarins, representing less than one per cent of the world's mandarin production. Although Australia is small in comparison to countries like China, the industry is reportedly important to the Australian economy as is it highly labour intensive which provides a number of employment opportunities (DFAT, 2016).

7 Both Type I and Type II flow-on impacts have been presented in this report. Refer to Appendix D for a description of each type of flow-on impact.

The Australian mandarin industry has seen rapid growth over the past 31 years, with production growing by an average annual rate of 3.5%. This has seen Australian production nearly triple over the period, increasing from 41,000 tonnes in 1990 to 117,729 tonnes in 2021. Although Australia is a small producer, Australia is the largest supplier of mandarins to the Chinese market. In 2020, Australian mandarin imports accounted for 38.2% of China's total imports[8].

A key challenge for the industry has been the domestic focussed imperial mandarin variety losing its appeal to domestic consumers. With the inability to export the variety, those orchards focussed on the production of imperials has seen a marked decline in profitability due to decreasing prices created by surplus supply. Industry participants with large exposure to the imperial variety will need to invest significant capital to establish the newer more attractive varieties such as Murcott which has both domestic and international demand.

In addition, the impact of the COVID-19 pandemic on labour availability and transport costs is negatively impacting on Australian production resulting in a higher than average production cost per kilogram sold. This short-term impact may extend the timeframe to achieve profitability if the costs cannot be passed on to the retailers and consumers.

From an infrastructure standpoint, there is no large-scale local packing and grading capability at present. As a result, a significant transport cost for the growers to transport their output to the nearest facility in the Mundubbera area can be expected. This gap can be addressed in the future as the production volumes from the region increase to levels which can justify the capital costs associated with the establishment of a new shared packing facility.

The Rookwood Weir Catchment Area has the potential to grow up over 18,000ha of mandarins based on constraints imposed by various production factors including slope and soil suitability. The expected allocation of 7,500ML under this phase of scheme allocations will restrict the total land able to be converted to mandarin production. As a result of water availability, the typical farm size suitable for citrus production (with consideration given to slope, soil suitability and distance from the weir) would be about 160ha. With the water constraints, only 40ha, would, on average, be able to be farmed for mandarins. This represents only 25% of the average farm size in the catchment suitable for citrus production.

This area would produce in excess of 841,500 tonnes of Murcott mandarins, which would significantly increase Australia's total production when mature at around 10 years of age, resulting in a potential farm-gate value of over $1.3 billion. Whilst it is improbable that the whole area will be planted with mandarin crops, Australia's production levels are currently projected to only reach approximately 180,000 tonnes by 2030. There would need to be a significant shift in either the Australian domestic market and/ or Australia's export position to support such widespread investment.

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 macadamia sector, the annual access price is expected to be $25 per ML. Actual water demand will be phased and really ramp up after the saplings are planted in the orchard. At approximately 10ML per hectare, efficient water infrastructure and minimising the lift distance will be critical in managing this input cost.

Citrus production, with high labour requirements and high capital investment, is expected to have a relatively large impact on the Rockhampton LGA, with an anticipated increase of 25 FTE directly attributable to the example mandarin farm. A further 16 indirect FTE would be required across the region, paying a total $3.4million in wages.

In conclusion, Mandarins have the capacity to improve the economic contribution of the agricultural production in the catchment provided new orchards are planted with newer more market acceptable varieties. Care should be taken to obtain detailed agronomic advice on fruit quality and yields for individual investors as revenue and profit for the operations are highly correlated to those key variables. Likewise, the need to collaborate to establish a local packing and sorting facility will also have an impact on long term profitability.

8 On average from 2010 to 2020.

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APPENDIX A: MANDARIN GROWING CONDITIONS CULTIVARS

A more detailed description of the major mandarin varieties are as follows (DPI, 2017):

- Afourer: First introduced to Australia in the 1990s, the fruit has a deep orange coloured skin and is late maturing. Significant areas of low-seeded Afourer are being planted in China and most other citrus production countries, with the variety now being the most popular in the world. If managed well, the trees can yield 60 to 80 tonnes per hectare.
- Avana: This mandarin variety was first introduced to Australia in 1999, however there is little commercial interest as it matures around the same time as the Imperial mandarin variety.
- Clementines: Around 13 different Clementine selections have been introduced from Spain and New Zealand since the 1980's. These varieties are one of the most popular in the world, however not as popular for production in Australia. This is resulting from a number of factors including, high management requirements and inconsistent production and fruit quality (partly stemming from weather conditions).
- Daisy: This variety was developed by the United States Department of Agriculture, however this mandarina variety has a number of seeds which are not demanded in the Australian market. There are low-seeded selections being commercially tested in Australia, with the aim of exporting to Asian markets.
- Dekopon: Also known as Sumo Citrus in Australia and the US, the mandarin is a hybrid that was developed in Japan. Most of the Dekopon plantings in Australia are located in the Sunraysia/Riverland and Riverina areas in Southern Australia.
- Hickson: This is an Australian mandarin which are easy to peel, are medium to large in size and are less prone to wind-rub than any other variety.
- Imperial: This mandarin variety is popular in Australia; however, it is not grown commercially anywhere else. The imperial was largely the most prominent variety, but is not second to the Murcott tangor.
- Murcott: The Murcott variety is very seedy, however new low-seeded selections have been developed by irradiation including IrM1 and IrM2. If the crop is not managed sufficiently, the Murcott trees can develop an alternative bearing pattern.
- Satsumas: This variety originated from Japan and are grow in Spain, China, Korea, South Africa, Argentina, the US, and New Zealand.

There are a number of other mandarin varieties which have not been highlighted in the table above. There are some varieties that are not grown in Australia, but are prominent in the international market, as highlighted in the table below.

Table A. 1. Major Varieties in International Markets

Country	Major Varieties
South Africa	Clementines: Nules, Marisol. SRA, Oroval, Esbal, Clemenpons, Oronules, Nadorcott (Afourer), Nova, Or (Orri), Minneola, Mor, B17, Tambor, Naatjie, Thoro Temple, Sonet, B24 (African Sunset). Satsumas: Miho Wase, Owari, Kuno, Miyagawa Wase, Okitsu Wase, Aoshima
Japan	Satsumas: Miyagawa Wase, Nakate Unshui, Okitsu, Miyamoto, Yamakawa, Tokimori, Aoshima, Iyokan, Dekopon (sold under the name Cumo Citrus in the US and Australia), Ehime, Mikan, Harehime, Ponkan, Setoka, Haruka, Kiyomi, Kara, Beni Madonna Kanpei
China	Ponkan, Satsumas
India	Kinnow, Sangtra, Coorg, Nagpu, Khasi
Pakistan	Kinnow
Italy	2 Clementines: Comune or Oroval and Montreal, SRA 63, Fefele IAM-UBA, Fedele IAM-UBA, Spinoso VCR, Hernandina VCR, Ruby VCR, Avana Tardivo di Ciaculli, Fortune, Tacle, Clara, Satsuma Miyagawa
Country	**Major Varieties**
California	Clementines: Algerian, Caffin, Clemenules (Nules), Fina Sodea, Oro Grande, Gold Nuggest, Fairchild, Pixie, Shasta Gold, Tango (Seedless W. Murcott); W. Murcott (Afourer); Minneola tangelo; Tangor/Temples: Royal Mandarin
Chile	Clementines, Afourer, Clemengold
Agentina	Clementina, Clemenvilla, Ellendale, Malvasio, Montenegrina, Clemenules, Murcott, Ortanique, Tango
Uraguay	Satsuma mandarins: Okitsu and Owari Clementines: Marisol, Fina and Nules Clemenvilla, Murcott, Afourer, Ortanique, Saltenitas
Peru	Minneola Tangelo, Satsumas, Afourer, Clementines

Source: DPI (2017).

For a more detailed description on varieties of mandarins, refer to the Australian mandarin production manual from the Department of Department of Primary Industries Australia Mandarin Production Manual (DPI, 2017).

GROWING CONDITIONS

ORCHARD ESTABLISHMENT

Establishing a mandarin 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 – For a commercial yield, mandarin trees begin bearing when they are three years old, with trees maturing around 10 to 15 years (see Table A. 2 below for yield information). As a result, initial capital outlay will not see sustainable returns until FY2029

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

- Soil depth: Mandarins require at least one meter of soil which is well-drained to support the root system.
- Soil drainage: Mandarin orchards grow best in well-drained soil that is not prone to water logging.
- Soil texture: Citrus crops largely grow best on soil which has good drainage and nutrient storage capacity such as sandy loams, loams and clay loams. Sandy soils are also suitable for growing mandarins; however they have poor nutrient and water holding capacity which requires more careful management.
- Optimum slope: Slopes of up to 20% are best suited for growing mandarin orchards. To optimise exposure to sunlight, trees should be orientated to run north to south.

ENVIRONMENT

Mandarins are grown in a broad range of climates around the globe, ranging from humid and hot climates to tropical and cooler climates. Each variety of mandarin have different adaptability to climates, with some having a broad tolerance to conditions while others do not (DPI, 2017). For example, Clementine mandarins are a variety which can be grown in a number of climates around the world, however Satsuma mandarins require cooler climates and thrives in regions such as Japan (DPI, 2017).

Although there are a number of climatic factors which will impact on the productivity of mandarin trees, temperature is the most important. When considering a site for mandarin production, it is important to note that temperatures below 13 degrees Celsius will negatively impact fruit production and growth. Similarly, temperatures with frost can damage the fruit, with the possibility of killing the trees and causing burn on the leaves.

Not only do the climatic conditions impact on productivity, but it also has an impact on the size and shape of the fruit. The Australian mandarin production manual highlights climates with (DPI, 2017):

- Low humidity causes the fruit to become rounder and less flat
- Humid subtropical climates resulting in larger mandarins which are more elongated and likely to mature earlier
- Cooler humid climate usually see smaller and flatter mandarins.

Mandarins are most suited to warmer climates, and are the most heat resistant citrus type (DPI, 2017). A hotter period during the end of the growing season has the potential to enhance the flavour of the mandarin (DPI,2017). For citrus, the optimum temperature is considered to be between 13 degrees Celsius and 35 degrees Celsius.

WATER REQUIREMENTS

Mandarin trees require a reliable supply of water all year round to enable high quality yield, with water use usually highest in the warmer months between October and March. The Department of Primary Industries growing guide suggests that mandarin trees use up to 38% more water than orange trees, particularly between the months of March and May (DPI, 2017).

Mandarin trees usually require between seven and 12 mega litres (ML) of water per hectare per year (DPI, 2017). Water stress on an orchard development can impact on canopy development and negatively affect fruit quality, size and number of fruits. It is particularly important to avoid water stress at flowering, fruit set and from September to February during the early cell division stage of fruit growth (DPI, 2017). The table below provides additional information on the key growth stages of mandarin fruit and the impact that water availability has on development.

Table A. 2. Water Availability & Mandarin Growth Stages

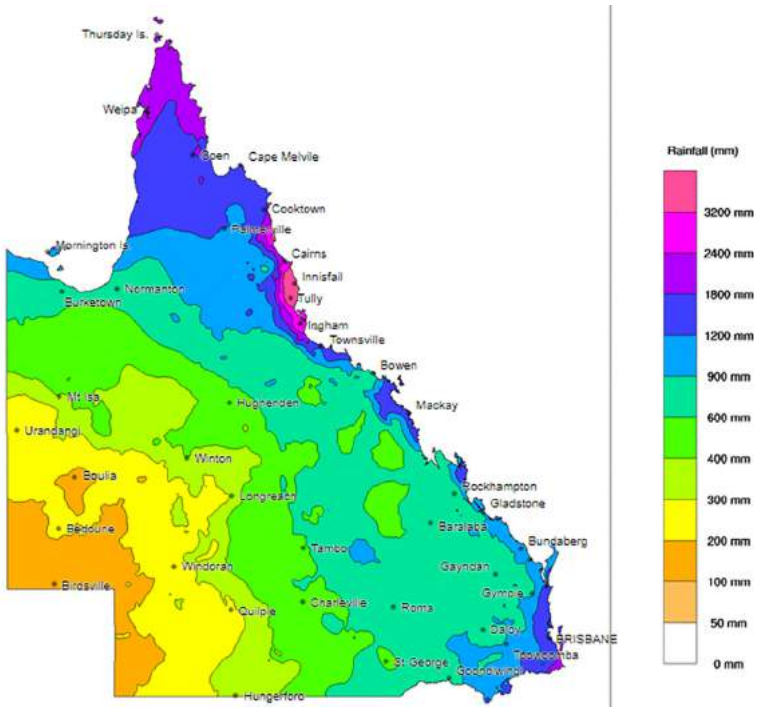
Growth Stage	Season	Water Availability Impact
Bud formation & flower initiation	Mid to late winter	Potential to increase flower production.
Flowering & fruit set	Early spring	Reduce fruit set and cause excessive fruit drop. Water stress can also reduce yield and suppress spring flush, which impacts on the next season's potential flowering sites.
Fruit growth (cell division)	Late spring to early summer	Results in smaller fruit and potential to increase fruit drop.
Fruit growth (cell expansion)	Mid-summer to autumn	This is a crucial stage for water use, accounting for approximately 40% of the tree's annual water requirement. It is particularly important to avoid water stress to December to February as it largely determines the final fruit size.
Fruit maturation	Late autumn to winter	Water stress can impact on fruit maturity and quality (such as total acidity, total soluble solids, and percent juice). Irrigation is usually restrict in the weeks prior to harvest (two to four weeks) to improve sugar levels of the mandarin.

Source: DPI (2017).

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.

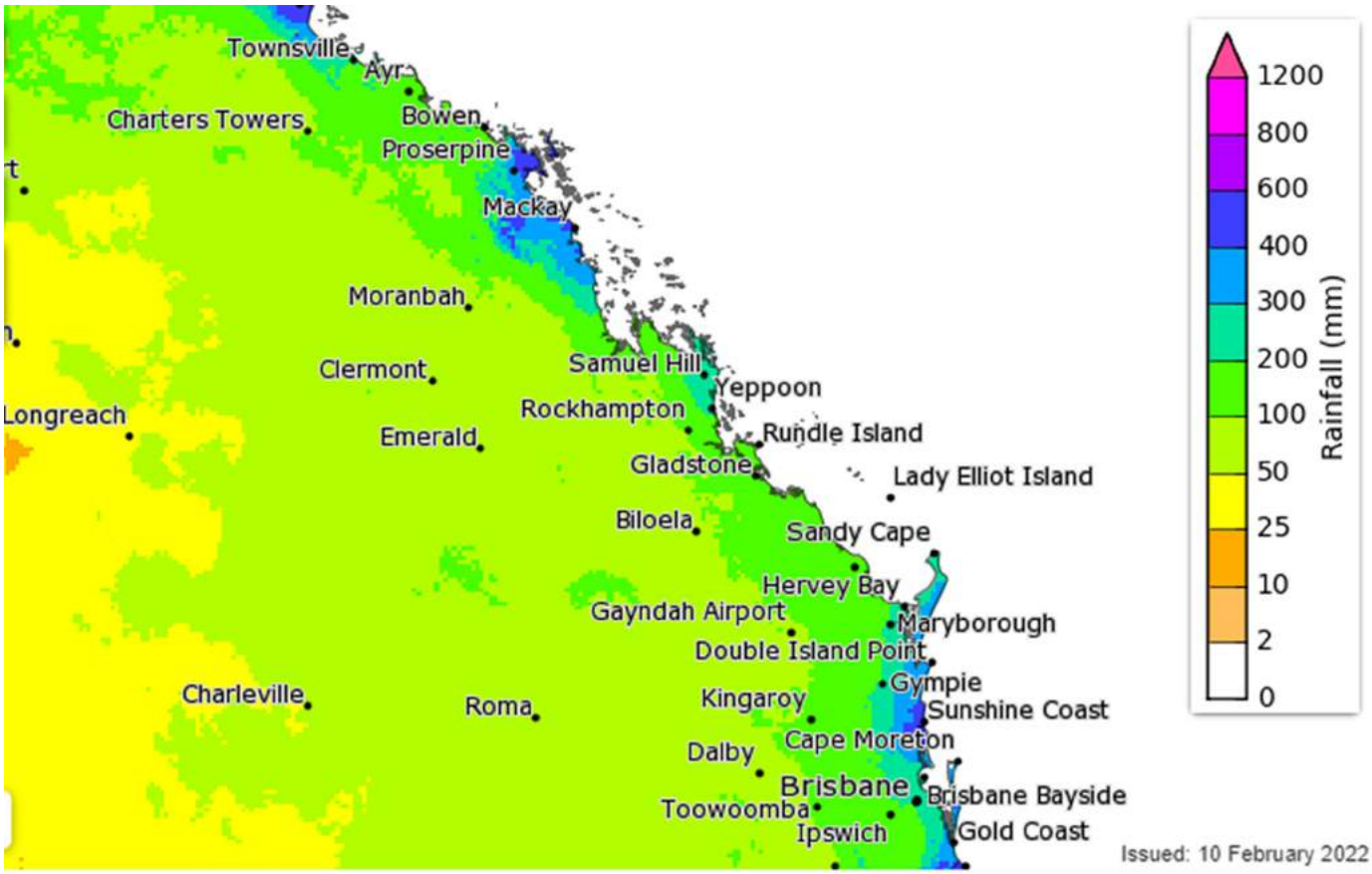
Figure A. 1. Rainfall Map Queensland, 2021



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

The table below provides a breakdown on potential plantings. Commonly, mandarin trees are planted at row spacing between five-to-seven-meter trees and spacing between three and three and a half meters.

If trees are planted closer (i.e., two to two and a half meters), production may be achieved earlier, however every second tree may be required to be removed after four to five years.

Table A. 3. Various Planting Distances & Number of Trees

Distance Between Trees In Row (M)	Distance Between Rows (M)		
	5.0m	6.0m	7.0m
2.0m	1,000	833	714
2.5m	800	666	571
3.0m	666	555	476
3.5m	571	476	408
4.0m	500	416	357
4.5m	444	370	317
5.0m	400	333	285
5.5m	363	303	259

Source: DPI (2017).

The table below highlights potential mandarin yields by tree age based on information provided by DAF in the Citrus Information Kit (1997).

Table A. 4. Mandarin Yield by

Age	Yield Per Tree (Kg)
1	0.2
2	0.9
3	18.3
4	30.0
5	31.5
6	57.6
7	69.2
8	90.2
9	81.7
10	82.1
11	117.7
12	82.8
13	110.2
14	109.0
15	158.7
16	72.8
17	154.9
18	97.0
19	115.7
20	171.8
25	126.6
30	109.0
35	109.0

Note: Average yield has been calculated based the total yield for a 10 Ha orchard, based on 380 trees per Ha.
Source: DAF (1997)

ORCHARD MANAGEMENT

Good crop management is key to producing a higher quality and quantity of fruit for the domestic and export market. The table below highlights some crop management and canopy management practices.

Table A. 5. Crop Management

COUNTRY	MAJOR VARIETIES
CROP MANAGEMENT	
Flower Biology	Pollination is an important process in the flowering of the crop. Citrus pollen is dispersed primarily by bees, and the most favourable temperatures for pollination, fertilisation and seed set is between 15 to 25 degrees Celsius.
Understanding Seediness	Different cultivars vary in their level of seediness from nearly completely seedless to heavily seeded. The focus throughout the last decade has been to develop new seedless or low seeded mandarin varieties.

COUNTRY	MAJOR VARIETIES
Reducing Seediness	"Self-incompatible parthenocarpic varieties can set seedless fruit if they are grown in isolation or are protected from cross-pollination by other fertile varieties" (DPI, p.165, 2017). Of important note, some varieties (including Nules/Clemenules Clementine mandarins and Minneola, Nova and Orlando tangelos) will not set commercial yields if they are prevented from cross pollination. Techniques include: Physical isolation Netting Copper application at flowering GA application, however, this is not registered for this purpose in Australia.
Crop Management	
Factors affecting development stages	During the flowering and fruit set stages, there is strong demand for water and nutrients. To reduce complications between fruitlets and spring leaf flush than it is critical to ensure appropriate water supply and nutrients. Key factors include: Temperature Presence of fruit Inflorescence type Plant growth regulators Carbohydrates Nutrients GA application before budbreak to reduce flower numbers GA application at flowering to enhance fruit set in varieties with low natural parthenocarpy.
Manipulating fruit set	There are methods to either reduce the number of flowering or increase fruit set in varieties which have problems with setting fruit. This is through the application of GA at flowering, however, there is currently no registration in Australia for the application of GA at flowering. Cross pollination can improve fruit set in parthenocarpic varieties, but they fruit will be seeded.
Crop load	Mandarins have a strong tendency to develop alternative bearing patterns, initially triggered by unfavourable weather. To reduce or eliminate alternate bearing it is key to even out crop load. If fruit counts are more than 8-10 fruit/frame for Imperial mandarins, then research suggests that thinning could be undertaken in South Australia. In Queensland, thinning should be undertaken with more than 10-15 fruit/frame. Fruit can be thinned by hand or though chemicals. Before using chemicals on fruit for export it is important to check importing country permits.
Fruit growth and size	Temperature is a big influence over fruit growth, but other impacts include water availability and management practices. An increase in fruit size can be achieved by reducing crop load or the application of a plant growth regulator (or both).
Improving rind quality and slowing ageing	Gibberellins is a naturally occurring plant growth regulator and is available to manipulate flowering and fruit development, improve fruit appearances and post-harvest performance.
Preventing pre-harvest fruit drop	Fruit drop can occur pre-harvest at colour change or soon after, which may result in heavy crop losses. This can be reduced by applying selected synthetic auxins at low rates.
Canopy Management	
Tree growth	Light is crucial to tree development and fruit growth and improving light penetration to the tree canopy will improve productivity and fruit quality.
Hand pruning	In young trees, pruning begins when they are 12 months old. The hand pruning is key to developing the trees structural framework. Pruning is also normally undertaken after harvest to maintain good cropping potential.

COUNTRY	MAJOR VARIETIES
Rejuvenating older trees	To rejuvenate older trees, improve air, and light penetration, there are several styles including:
	Window or chunk pruning
	Canopy thinning
	Open centre pruning
	Skeletonising
Mechanical pruning	There are three styles for mechanical pruning, including:
	Hedging: To remove the outer canopy
	Topping: To reduce tree height
	Skirting: Removal of the lower branches.

Source: DPI (2017).

HARVESTING

Care must be taken when handling mandarins, as they are more susceptible to rind damage and plunging of the stalk from the fruit (particularly Imperial and Satsuma) (DPI, 2017). Mandarins are usually picked using soft cotton gloves to minimise rind damage.

Mandarins also have a shorter maturity period than other citrus fruit, and can quickly pass the maturity stage if they are left on the tree. If fruit pass maturity, they will continue to grow where the rind separates from the pulp and the fruit becomes puffy and dries out (DPI, 2017). The maturity window differs by location and variety, for example satsumas should be harvested within seven to 10 days while Afourers should be harvested between four to six weeks.

POST-HARVEST PROCESSING ACTIVITIES

After the harvesting process is complete, the fruit is delivered to the packing shed where the fruit will undergo a range of post-harvest activities. The process of degreening is to change the colour of the fruit, in which the green colour from the peel changes to yellow and orange through an ethylene gas treatment.

The fruit is washed and cleaned, then treated with post-harvest fungicide, sorted, graded, waxed and packed for market as highlighted in the figure below.

APPENDIX B: SUMMARY OF MARKET ACCESS AND MARKET DEVELOPMENT ISSUES

The table below provides a summary of the market access and market development issues for Australian mandarin exports. This is a summary provided by Citrus Australia in the Australian Citrus Industry Export Strategy 2021-2025.

Table B. 1. Summary of Market Access and Market Development Issues (Citrus)

Importing Country	Summary Of Issues	Summary Of Actions	Tariffs On Australian Mandarin Exports
Canada	❯ There are no major phytosanitary barriers for citrus exports to Canada ❯ Implementing sweeping reforms to its food safety systems ❯ Continually reviewing agrichemical MRLs (and are relatively stringent)	❯ Monitor and respond to regulatory changes to phytosanitary, food safety and agrichemical residue regulations	0% under the CPTPP from 2018
New Zealand	❯ Ongoing phytosanitary violations ❯ Standardising a single policy for citrus from all countries ❯ Not accept cold disinfestation at 3 degrees Celsius	❯ Provide technical and commercial advice to government to resolve trade issues when they arise ❯ Contribute to New Zealand's review of import health standards for citrus ❯ Progress data packages on cold disinfestation and prosecute technical case with New Zealand	0% under the AANZFTA from 2012
Japan	❯ Strict MRLs and strictly enforces food safety laws ❯ Only allows access for certain citrus varieties under cold disinfestation ❯ Authorities must visit Australia annually to verify cold disinfestation procedures and fruit fly trapping ❯ Fruit fly outbreaks in the pest free area in Riverland are threatening export ❯ No accurate picture of the volume of fruit that is "on the water" at any point in time.	❯ Monitor and communicate changes to Japanese MRLs. Maintain agrichemical residue monitoring service for citrus industry ❯ Progress technical case or expended access to allow additional varieties under cold disinfestation. Provide technical and commercial advice to government to support negotiations ❯ Coordinate annual visit by Japanese importing authorities ❯ Explore possible ways of collecting, aggregating and disseminating live shipping data for citrus exports to Japan	Currently 5.6%, decreasing to 0% in April 2023 under the CPTPP

Importing Country	Summary Of Issues	Summary Of Actions	Tariffs On Australian Mandarin Exports
Indonesia	› The FTA with Indonesia has provision for Tariff Reduced Quotas and 'fixed' import volumes for citrus. These are managed by the Australian Government. › Indonesia has import regulations set by two separate ministries and they are in constant state of change › Indonesia and Australia have a Country Recognition Agreement on Food Safety and this allows citrus to be exported to Indonesia. The agreement must be renewed every three years › Indonesia has suspended the recognition of the Riverland Fruit Fly Pest Free Area › Import regulations require that all consignments be verified by a third party prior to export. Exporters have reported difficulty in accessing third-party inspectors in some regions	› Engage with exporters and the Australian Government to ensure Tariff Reduced Quotas and import volumes are being equitably distributed and that Indonesia is honouring the agreement › Monitor and communicate changes to Indonesia's import regulations. › Monitor changes and assist citrus businesses in understanding and fulfilling conditions of trade › Provide technical advice to government to minimise trade disruption › Provide technical and commercial advice to government to support renewal of Recognition Agreement › While the industry is not currently in a strong negotiation position in relation to the Riverland, this am change at some stage in the future › Streamlining third-party inspection arrangements could form part of the higher-level dialogue that takes place regularly under IA-CEPA	Currently 10.0%, decreasing to 5.0% in January 2030 and 0% from January 2035 onwards under the IACEPA
India and the subcontinent	› Currently reviewing a number of agrichemicals related to citrus › Bangladesh required cold disinfestation to be carried out prior to shipment at maximum temperatures of 1.1 degrees Celsius › Sri Lanka is imposing tariffs on Australian mandarins of 90% › FTA negotiations with India underway › India has been identified as a market for potential growth in the premium fruit sector	› Monitor and communicate MRL changes in India. Provide technical and commercial advice to government to minimise trade disruptions › Progress citrus industry case for in-transit cold disinfestation at 3 degrees Celsius › Engage with the Australian government on Sri Lanka's mandated tariff › Provide commercial advice to the Australian Government to achieve tariff reductions › Opportunity to work with state government trade agencies and the Australian Trade Commission but this would be contingent upon the support of the export trade	› Australia to India: 30% › Australia to Bangladesh: 25% › Australia to Sri Lanka: 15% or Rs 0.45 per kilogram
The Philippines	› Low-returning market and the cost of applying in-transit cold disinfestation erodes profitability › Does not currently recognise the Riverland Fruit Fly Pest Free Area	› Engage with government to progress case for alternative temperature logging technology to reduce costs associated with cold disinfestation › While the industry is not currently in a strong negotiation position in relation to the Riverland, this may change at some stage in the future	0% under the AANZFTA from 2012

Importing Country	Summary Of Issues	Summary Of Actions	Tariffs On Australian Mandarin Exports
South Korea	› South Korea requires that all fruit exported via cold infestation must be inspected by a South Korea quarantine inspector prior to export. This requirement is costly to industry, creates a bottleneck and represents a barrier to trade › South Korea considers red scale and Fuller's rose weevil to be a quarantine pest and these represent trade barriers › South Korea is developing a 'positive list' system for agrichemical residues. Any agrichemical that South Korea has not previously assessed will be assigned a default limit (effectively zero) › South Korean import conditions include the requirement that orchards must be surveyed by trained pest scouts › South Korean import conditions include the requirement that orchards and packinghouses by audited annually and accredited with DAWE › DAWE requires that industry associations manage annual applications for export accreditation	› Coordinate annual pre-clearance program with exporters and Australia Government › Continue to progress the case for removal of pre-clearance inspection requirement › Continue to explore improved options to control red Scale and Fuller's rose weevil › Engage with other citrus exporting nations (e.g. USA, South Africa) to ensure workable MRLs are established for the key agrichemicals used by citrus producers. Communicate changes to citrus businesses › Maintain online learning system for citrus pest scouts. Maintain list of trained personnel › Maintain instructional material for grower and packers to understand and fulfill requirements › Maintain industry-based application system for export accreditation	144% under the KAFTA from 2014
Taiwan	› Taiwan has reduced (and deleted) MRLs for a number of important agrichemicals used to control fungal diseases in Queensland › Taiwan strictly enforces its agrichemical residue laws	› Work with AgVet companies to identify suitable replacement chemistry that meets Taiwan's requirements › Maintain agrichemical residue monitoring service for citrus industry	15% tariff

Importing Country	Summary Of Issues	Summary Of Actions	Tariffs On Australian Mandarin Exports
China	❯ China's import conditions include the requirement that growers and packers must be approved by the Chinese government prior to export. China has not approved any new businesses since 2020 due to political tensions between government. This effectively means that no new businesses will be able to export to China until China approves those businesses ❯ China's import conditions include the requirement that orchards must be surveyed by trained pest scouts ❯ China's import conditions include the requirement that orchards and packinghouses be audited annually and accredited with DAWE ❯ DAWE requires that industry associations manage annual applications for export accreditation ❯ China does not recognise cold disinfestation treatment at 3 degrees Celsius against Mediterranean fruit fly. This impacts producers in Western Australia that must treat at 2.1 degrees Celsius	❯ It is not expected that China will change its position in the short to medium term. Nevertheless, it is important that the infrastructure around the China export program be maintained with a view to the trade relationship being restored some time in the future. This includes: ❯ Grower and packer instructional material to be maintained and updated ❯ Export registration system to be maintained and improved ❯ Crop monitor training package to be maintained and update ❯ Assisting growers and packers with annual registration process ❯ Assisting grower and packers to understand and fulfil export requirements ❯ Maintain online learning system for citrus pest scouts. Maintain list of trained personnel ❯ Maintain instructional material for grower and packers to understand and fulfil requirements ❯ Maintain industry-based application system for export accreditation ❯ Technical negotiations with China are currently in a state of uncertainty and it is unlikely that China will amend its policy on cold disinfestation. However, this may change in the long term	Currently 1.3%, decreasing to 0% in January 2023 under the ChAFTA
Gulf Countries	❯ Gulf countries are considered open markets with no phytosanitary barriers, these countries are becoming focussed on agrichemical residues in food	❯ Monitor and communicate changes to MRLs in Gulf countries	❯ Australia to the UAE: 0% ❯ Australia to the Saudi Arabia: 0% ❯ Australia to Qatar: 0% ❯ Australia to Oman: 0% ❯ Australia to Kuwait: 0% ❯ Australia to Bahrain: 0%

Importing Country	Summary Of Issues	Summary Of Actions	Tariffs On Australian Mandarin Exports
Thailand	› Thailand's 2018 food safety amendments require export packing houses to have food safety certification. While this is not an issue for Australian businesses, there have been some "teething" problems associated with the verification process. Austrade Bangkok has assisted with verifying food safety certificates › In 2020, Thailand announced reforms to its agrichemical residue monitoring procedure. Exports not accompanied by certificate of analysis (from an accredited laboratory) must be tested on arrival. There have been a number of "teething" problems and Thailand's requirements are continually changing › Thailand has zero-tolerance for omethoate residues, meaning that Australian citrus industry is unable to use Dimethoate › Thailand's import conditions include the requirement that orchards must be surveyed by trained pest scouts. › Thailand's import conditions include the requirement that orchards and packinghouses be audited annually and accredited with DAWE › DAWE requires that industry associations manage annual applications for export accreditation	› Engage with Australian Trade Commission to assist industry to comply with Thailand's food safety requirements › Monitor changes to Thailand's MRLs and testing requirements. Engage with laboratory to ensure compliance with Thailand's residue testing and reporting requirements › Engage with industry and research community to examine solutions to dimethoate › Maintain online learning system for citrus pest scouts. Maintain list of trained personnel › Maintain instructional material for growers and packers to understand and fulfill requirements › Maintain industry-based application system for export accreditation.	Currently 40%, reducing to 0% from January 2022 onwards under the RCEP

Importing Country	Summary Of Issues	Summary Of Actions	Tariffs On Australian Mandarin Exports
US	❯ Australian citrus exports to the United States are currently limited to the Riverland, Sunraysia, and Riverina production regions. Access for other regions (chiefly Queensland) has been the subject of negotiations for many years and are thought to be in the final stages ❯ The USDA is currently developing an operational work plan for Australian citrus imports. The work plan is in its final stages of review ❯ USA import conditions include the requirement that packinghouses be audited annually and accredited with DAWE ❯ DAWE requires that industry associations manage annual applications for export accreditation	❯ Continue to press the United States importing authorities for prompt resolution ❯ Contribute to development of operational work plan ❯ Maintain instructional material for growers and packers to understand and fulfill requirements ❯ Maintain industry-based application system for export accreditation	0% under the AUSFTA from 2016
All trading partners	❯ Agrichemicals used in citrus production in Australia will continue to be scrutinised by overseas authorities. Lower MRLs and deletion of certain chemicals are inevitable	❯ Monitor changes to importing country MRLs and ensure that effective testing services are available to exporters to mitigate risks. Ensure industry has access to adequate MRL testing facilities	NA
All fruit fly sensitive countries	❯ Trading partners continue to raise questions about 'other lesser-known' species of fruit flies ❯ The Riverland Fruit Fly Pest Free Area is under threat due to ongoing detections and formal outbreaks	❯ Research to demonstrate the efficacy of existing fruit fly treatments to be finalised and presented in a format that is acceptable to trading partners ❯ Work with businesses and government agencies to ensure business continuity during outbreaks (e.g. firming up cold disinfestation schedules) ❯ Prepare for the possibility that certain trading partners will no longer recognise the Pest Free Area.	NA

Source: Citrus Australia (2021), Australian Government (2022).

APPENDIX C: 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 mandarin 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

Description	Assumptions	
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 mandarin trees, this effective life for tax purposes often over 30 years (Citrus Australia, 2020b). The ATO provides a schedule of annual write-off value, as a percentage of capitalised value. With an effective life of 30 years, the annual write off for a mandarin 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 D: 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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