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ROOKWOOD WEIR

IRRIGATED CROPPING COMMODITY REPORT

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

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EXECUTIVE SUMMARY

BACKGROUND AND PURPOSE

Rookwood Weir is a landmark project that will capture water in the lower Fitzroy River for use across the Region. Rockhampton Regional Council, Advance Rockhampton, and Sunwater 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 increasing the water accessible for agricultural production in the area.

This report provides an in-depth analysis of the global market for irrigated cropping of soybean, chickpea, mungbean and lucerne and assesses the potential agribusiness opportunities for production of wheat within the Rookwood Weir Catchment Area.

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 cropping in the Australian environment, including soil suitability, water availability, farm management, pest and weed control, infrastructure, and equipment.

COMMODITY OUTLOOKS

Soybean

Soybean meal is primarily used for animal feed and with the growing demand for meat products, the consumption of soybean meal is likely to increase. The growth in soybean meal will likely be more modest compared to historical years due to the slowdown in demand from China from improved feeding efficiencies and lower protein meal feed rations (OECD-FAO, 2021b).

Globally, there is an increase in consumer preferences for healthier foods, driving the demand for soybean derivatives such as soy milk and soy oil (Research and Markets, 2022). Additionally, the demand for dairy alternatives have been driving the soybean market (EMR, 2021).

Historically, global soybean production has been growing at substantial rates, increasing by more than six-fold to reach a total of 353.5 million tonnes in 2020. Growth is expected to soften through to 2030 with production estimated to total 411.1 million tonnes.

Chickpea

Global consumer preference shifts in recent years has seen a rise in chickpea demand as chickpeas are regarded as a meat alternative option. In 2020, global chickpea production totalled 15.0 million tonnes, having increased by an average annual rate of 2.7% per annum from 1990. Global production experienced relatively strong growth over 2016 and 2017, largely driven by production in Australia and India.

The primary producer of chickpeas on the global scale is India, accounting for 73.7% of total production in 2020. Production of chickpeas in India dwarf volumes achieved by every other country, however, Australia is relatively competitive in the export market. It is estimated that only 1% of chickpeas in Australia are consumed domestically, with the remainder being exported to international markets, including India, Bangladesh and Pakistan (GRDC, 2017).

Chickpea production could reach 18.2 million tonnes in 2030 and could reportedly experience significant short-term growth of 4-6% annually over the next five years.

Production in Australia has experienced an increase of 2.6% on average from 1990 to 2020, roughly in line with the growth in the global market. Projections to possibly reach almost 800,000 tonnes by 2023. Central Queensland accounted for over half of Australia's total production in 2020.

Mungbean

Mungbeans have a number of different uses including feed for both livestock or for human consumption. Mungbeans are sold in three main grades, including sprouting, cooking and processing. Most of Australia's mungbean production (approximately 80%) is utilised in the processing market, with only a very small proportion achieving price premiums in the sprouting grade (less than 10% of all mungbeans produced).

The global area dedicated to mungbean production was estimated at 7.3 million Ha and production was estimated to total 5.3 million tonnes per annum. Mungbean production in Australia was estimated to reach approximately 100,000 tonnes in 2020-21 (FY2021). Production in Australia is estimated to have remained fairly stable since FY2015, with 2022 set to be Australia's largest production year on record.

Australia is a key competitor of mungbeans on the global scale, being recorded as the third largest exporter in 2020. Australia's key export markets are India, Vietnam and China and the key competitors for these markets is largely Myanmar (formerly Burma).

Australia is an emerging player in the international mungbean market. Australian mungbeans are regarded as the most hygienic and safest mungbeans available in the world, thus positioning itself well for export growth opportunities given the market is strict around quality and expectations including appearance, consistency, taste and texture.

Lucerne

The global lucerne market (including hay, silage, grazing, processed and seed) is driven primarily by the dairy industry. In Australia, the two key lucerne markets of interest are seed and hay. In many instances throughout Australia lucerne is grown, not for resale, but for grazing. Approximately 55% of lucerne production in 2016 was for grazing, including beef, dairy, and lamb grazing.

Lucerne pasture is grown in all states and territories of Australia, with the majority used for grazing purposes. Fodder production primarily occurs in New South Wales, Victoria and Queensland. Over 90% of lucerne seed production occurs in the south-east of South Australia, with the remainder scattered in southern New South Wales and southern Western Australia.

Lucerne is reportedly grown across 30 million Ha worldwide, with Australia producing an estimated 150,000 Ha in FY2018. The USA was the largest producer of lucerne in 2013, however, contemporary lucerne production or consumption data is not comprehensively captured. Production of seed and hay is concentrated in North America, with the USA also the largest exporter of both lucerne commodities. Demand for lucerne is likely to remain consistent in the short-term, given its wide use in agricultural applications.

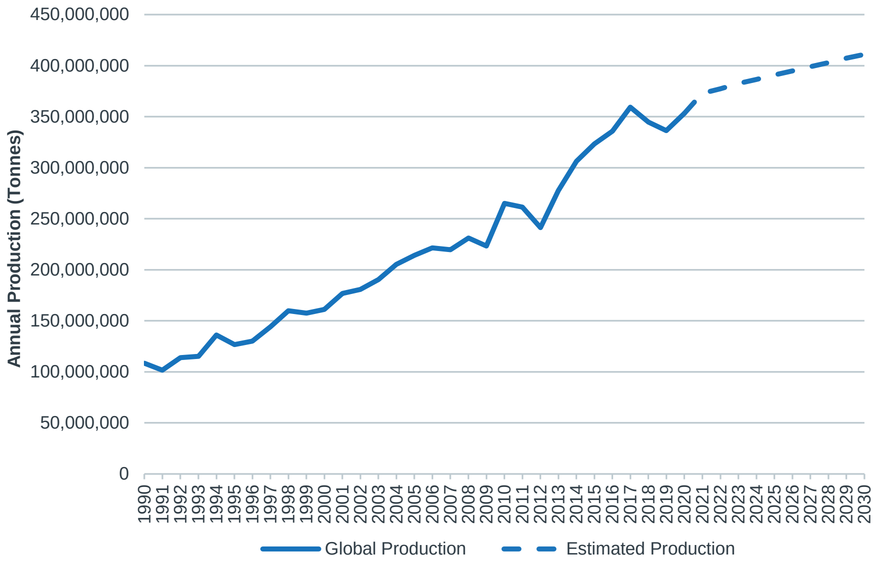
Australia's key export markets are located in the Middle East (Saudi Arabia), North America (US) and South America (Argentina), with these countries fairly reliant on Australia's product.

GLOBAL PRODUCTION

Soybean

Global soybean production has been growing by an average annual rate of 4.0% per annum from 1990 to 2020, to reach a total of 353.5 million tonnes in 2020. Projections from the *OECD-FAO Agriculture Outlook 2021-2030* indicate that soybean production could increase by an average annual rate of 1.5% from 2020 to 2030. Soybean production is estimated to reach a total of 411.1 million tonnes in 2030, driven largely by an increase in yields.

Figure ES. 1. Global Soybean Production, 1990 to 2030



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

The harvested area is projected to increase by 0.5% on average per annum to reach an estimated 132.8 million hectares (Ha) in 2030. The *OECD-FAO Agriculture Outlook 2021-2030* identifies that a large portion of the increase in additional harvested area will be a result of double cropping soybean with wheat in Argentina and maize in Brazil (OECD-FAO, 2021b).

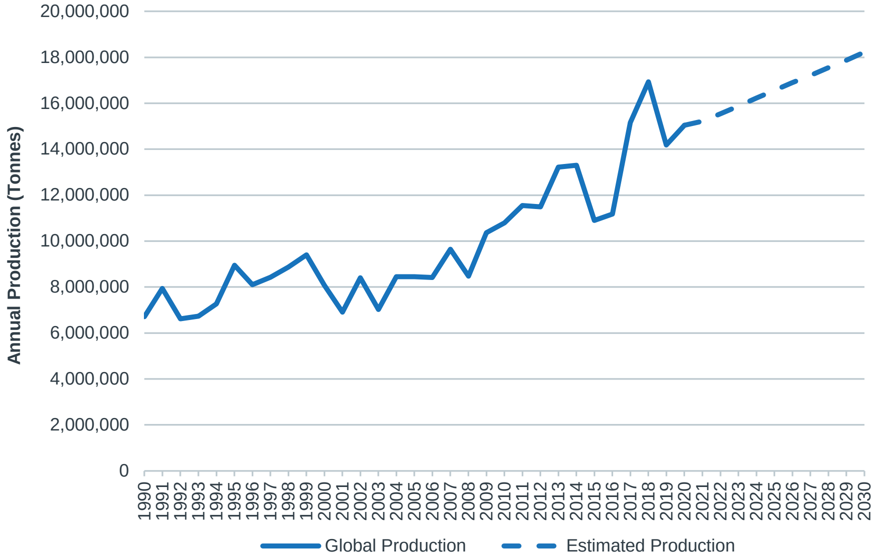
In 2020, Brazil represented 34.5% of total global soybean production, totalling an estimated 121.8 million tonnes. The second largest producer of soybean in 2020 was the United States of America (USA) (112.5 million tonnes), followed by Argentina (48.8 million tonnes).

- **Brazil** – From 1990 to 2020, soybean production in Brazil has experienced rapid growth, increasing by an average annual rate of 6.2%. Brazil is expected to maintain its position as the largest global producer of soybeans, with production expected to increase by 2.1% on average per annum from 2020 to 2030. In 2030, it is estimated that production will reach a total of 149.3 million tonnes.
- **USA** – Historically, the USA has been the largest producer of soybeans on the global scale until 2019 where Brazil took precedence as the number one producer. From 1990 to 2020, soybean production in the USA experienced an average annual growth rate of 2.6%. Growth is projected to soften to 2030, increasing by an average annual rate of 0.9% per annum to reach 123.1 million tonnes.
- **Argentina** – From 1990 to 2020, soybean production in Argentina has experienced rapid growth, increasing by an average annual rate of 5.2% and peaking in 2015 at 61.4 million tonnes. Production has more than quadrupled since 1990 and is projected to experience strong growth to 2030, increasing by an average annual rate of 1.2% to reach 55.2 million tonnes in 2030.

Chickpea

In 2020, global chickpea production totalled 15.0 million tonnes, having increased by an average annual rate of 2.7% per annum from 1990. Global production experienced relatively strong growth over 2016 and 2017, largely driven by production in Australia and India. Projections from the *OECD-FAO Agriculture Outlook 2021-2030* indicate that global pulse production could increase by an average annual rate of 1.9% from 2020 to 2030.

Figure ES. 2. Global Production of Chickpeas, 1990 to 2030



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

Historically, the chickpea harvested area has grown by an average of 1.4% per annum from 1990 to 2020 to reach 14.9 million Ha in 2020.

In 2020, India represented 73.7% of total global chickpea production, totalling an estimated 11.1 million tonnes. The second largest producer of chickpeas in 2020 was Turkey (630,000 tonnes), followed by Pakistan (497,000 tonnes).

- **India** – From 1990 to 2020, chickpea production in India has experienced strong growth, increasing by an average annual rate of 3.3%. Historically, the chickpea harvested area has increased by an average of 1.8% per annum from 1990 to 2020 to reach 10.9 million Ha.
- **Turkey** – From 1990 to 2020, chickpea production in Turkey have been on the decline, decreasing by an average annual rate of 1.0% per annum. The decline in production is being met with an increase in chickpea imports. Over the years, Turkey has been experiencing a decline in total pulse production, which could be attributed to inconsistent rainfall and severe harmattan[1] weather related conditions (Ertuk, A., & Gul, M, 2018).
- **Pakistan** – From 1990 to 2020, chickpea production in Pakistan has been on the decline, decreasing by an average annual rate of 0.4% per annum. Production of chickpeas in Pakistan has been relatively volatile over the years, stemming from the country's reliance on rainfall to cultivate chickpeas. Yield productivity was significantly lower than what was achieved in both India and Turkey throughout 2020.

Mungbean

Overall, publicly available information on mungbean production and trade is limited.

Based on consultation with the Mungbean Industry Association, it has been identified that this estimate of global production is high and is likely to be the global maximum achieved in recent years. Global mungbean production reached a volume of 2.6 million tonnes in 2018 (Insider, 2019).

[1] Brings desert-like conditions.

It was estimated that India and Myanmar each accounted for approximately 30% of production while China accounted for approximately 16%, followed by Indonesia which was estimated to account for 5% (ACIAR, 2022).

- **Myanmar** – From 2012 to 2019, mungbean production in Myanmar has experienced an average annual growth rate of 0.7%. Information identified by the Myanmar Statistical Information Service (MMSIS) estimates production to total 996,279 tonnes in 2019.
- **China** – It is estimated that mungbean production represents approximately 19% of the total legume production in China. Mungbean production has been relatively volatile over the years, with production declining by approximately 50% in 2014. Challenges in production include limited research and poor access to quality seeds (USDA, 2019e).

Lucerne

Information regarding lucerne on both the global and domestic scale is very limited and not necessarily complete.

According to AgriFutures (2017b), lucerne is currently estimated to be grown across about 30 million Ha worldwide, down from about 33 million Ha during the 1970s and 32 million Ha in the 1900s. In the northern hemisphere, production is largely concentrated in the USA, Canada, Italy, France, China and southern Russia. In the Southern Hemisphere, production of lucerne is concentrated in Argentina, Chile, South Africa, Australia and New Zealand.

The AgriFutures (2017b) report highlights that in 2013, North America was the largest producer of hay and silage on the global scale. The area under production was estimated to total 11.9 million Ha, accounting for approximately 41% of total global production area. On average, the USA produces approximately 36,300 tonnes of lucerne seed each year, while it was estimated that the USA produced 42.0 million tonnes of lucerne hay and haylage in 2021.

MAJOR EXPORTERS AND IMPORTERS

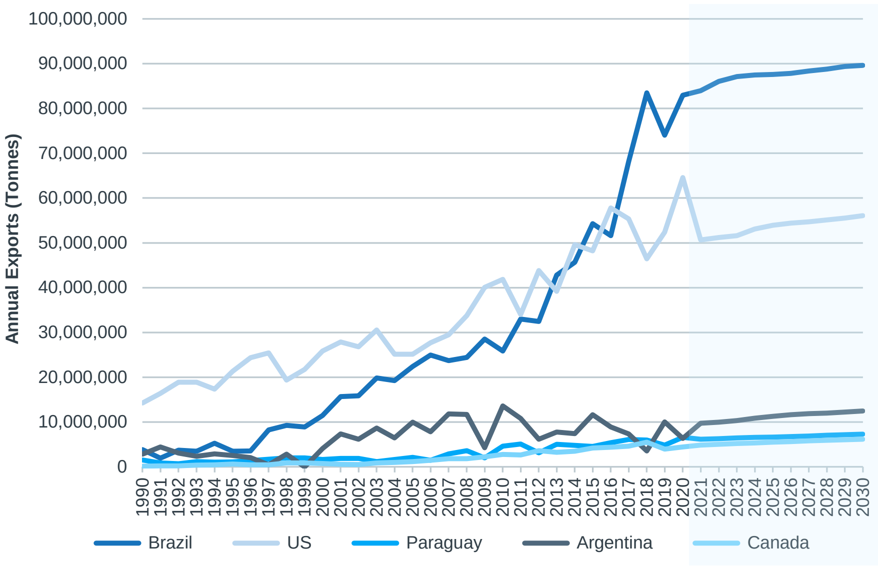
Soybean

Exporters

Global exports of soybean have experienced an average annual growth rate of 6.8% since 1990, totalling 172.1 million tonnes in 2020. It is projected that soybean exports will increase by 0.4% per annum from 2020 to 2030, reaching a total of 178.6 million tonnes in 2030.

- **Brazil** – Historically, the largest exporter of soybeans on the global scale was the USA, until 2017 when Brazil emerged as the largest exporter. Similar to global production, Brazil has experienced rapid growth in soybean exports (growing by an average annual rate of 10.8% from 1990 to 2020). Brazil’s emergence as the largest global exporter is a result of both an increase in production as well as lower production costs.
- **USA** – The second largest exporter in 2020 was the USA, exporting an estimated 64.6 million tonnes. In 2018, soybean exports from the USA experienced a decline to reach a four year low of 46.4 million tonnes resulting from rising trade tensions between the USA and China.
- **Paraguay –** The third largest exporter of soybeans on the global scale was Paraguay, exporting an estimated 6.6 million tonnes of soybean in 2020. Paraguay exported approximately 60.0% of total production in 2020, with 76.0% of this destined for Argentina.

Figure ES. 3. Top Five Global Exporters of Soybeans, 1990 to 2030



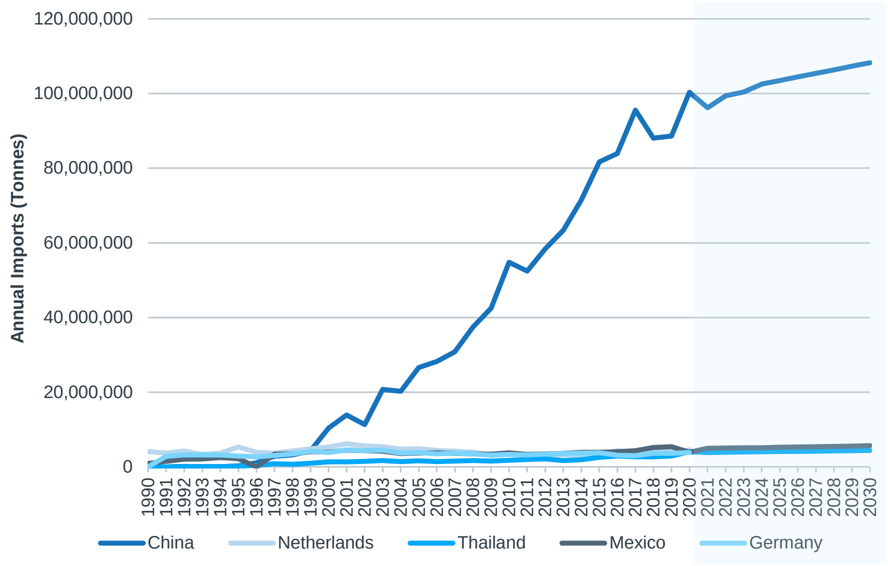
Note: Top five exporters in 2020.
Source: FAOSTAT (2022), OECD-FAO (2021a).

Importers

Global imports of soybeans have experienced an average annual increase of 6.9% since 1990, totalling 165.0 million tonnes in 2020. It is projected that soybeans imports will increase by 0.8% per annum from 2020 to 2030, reaching a total of 178.6 million tonnes in 2030.

- **China** – China emerged as the largest importer of soybeans in the early 2000s, with demand for imports experiencing a significant increase. From 1990 to 2020, soybean imports in China have experienced an average annual increase of 47.6%. In 2020, China accounted for 60.8% of total global soybean imports, importing a total of 100.3 million tonnes. China is also the fourth largest producer of soybeans globally, however, their domestic production is not sufficient to meet demand.
- **Netherlands** – The second largest importer of soybeans in 2020 was the Netherlands, importing a total of 4.5 million tonnes. Reports suggest that around one third of soybeans imported into the Netherlands are re-exported to other countries, with the remainder being processed into soybean meal for animal feed and soy oil for human consumption (CBS, 2020).

Figure ES. 4. Top Five Global Importers of Soybeans, 1990 to 2030



Notes:

- Top five importers in 2020.
- No projected data available for Germany or the Netherlands.

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

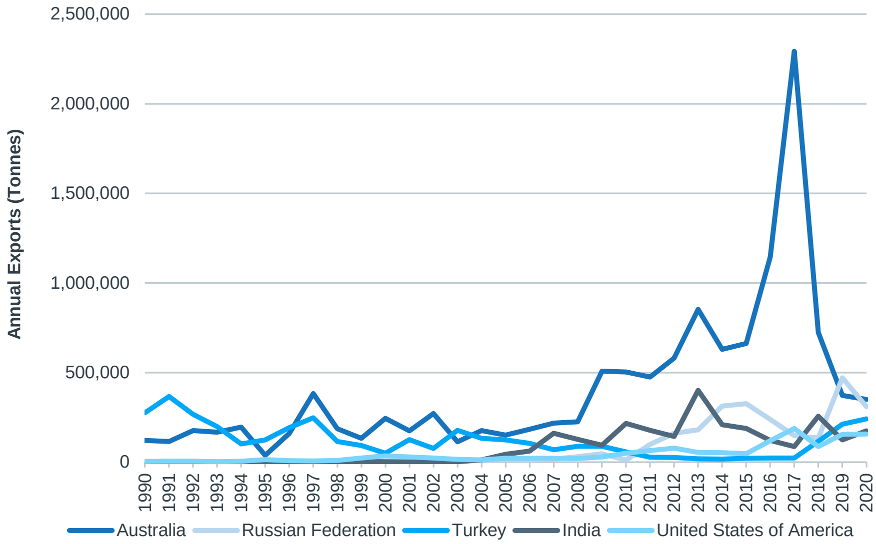
Chickpea

Exporters

From 1990 to 2020, exports of chickpeas have experienced an average annual growth of 4.8% per annum to reach 1.9 million tonnes in 2020.

- **Australia** – The largest exporter of chickpeas in the global market in 2020 was Australia, with exports estimated to total 349,325 tonnes. Majority of the chickpeas grown in Australia are for exports to international markets including India, Bangladesh and Pakistan (FAOSTAT, 2022).
- **Russia** – Based on data provided by FAOSTAT, Russia emerged as an exporter of chickpeas in 1999 and was identified as the second largest exporter in 2020. In 2020, the largest export market for Russian chickpeas was Pakistan, accounting for 45.5% of total exports. With the Russian invasion of Ukraine, many western countries have placed sanctions on many agricultural commodities from Russia.
- **Turkey** – Turkey was the third largest exporter of chickpeas in 2020. Additionally, in 2020, Turkey was the third largest importer as well as the second largest producer of chickpeas. In October 2021, the Turkish Government introduced a ban on chickpea exports which originated from Turkey to support domestic prices and help ease inflation (Pulse Pod, 2022). Turkey is focused on re-exporting chickpeas from different origins including Russia, Ukraine and some Asian and American origins (Pulse Pod, 2021;2022).

Figure ES. 5. Top Five Major Exporters of Chickpeas, 1990 to 2020



Notes:

- Top five largest exporters in 2020.
- ABARES export data for Australia differs from what is reported in FAOSTAT. The above graph is reflective of the information provided by ABARES.
- FAOSTAT's detailed trade matrix does not record exports for Russia from 1990 to 1998.

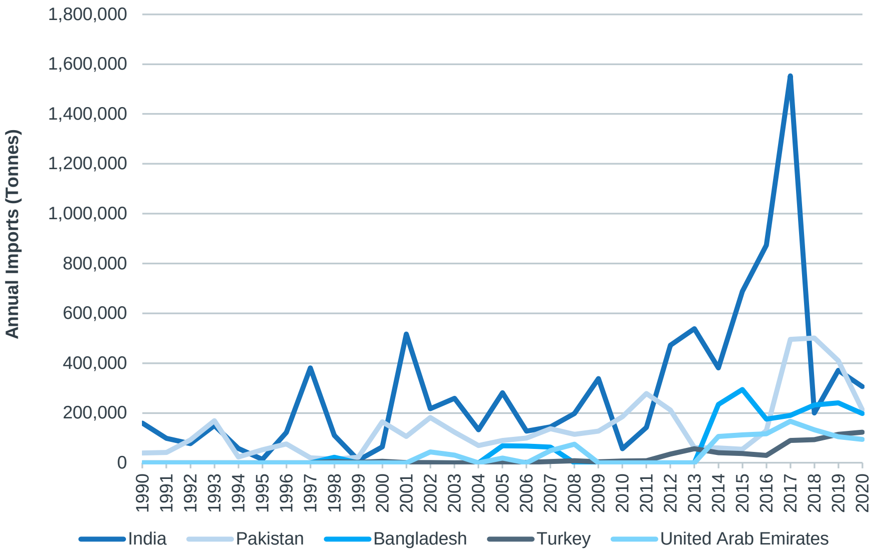
Source: FAOSTAT (2022), ABARES (2022a).

<u>**Importers**</u>

From 1990 to 2020, imports of chickpeas have experienced an average annual growth of 5.3% per annum to reach 1.8 million tonnes in 2020.

- **India** – In 2020, the largest importer of chickpeas was India, importing a total of 305,838 tonnes. Chickpea imports to India have been experiencing an average annual increase of 2.2% per annum from 1990 to 2020. To support local farmers and protect domestic prices, India imposed significant tariffs on chickpeas throughout 2017 and 2018.
- **Pakistan** – Pakistan was the second largest importer of chickpeas in 2020, importing 212,992 tonnes. This import volume dropped to 68,040 tonnes in 2021 (Com Trade, 2022). The variance in imports from Pakistan is reflective of the volatile production due to the country's reliance on rainfed production.
- **Bangladesh** – The third largest importer of chickpeas in 2020 was Bangladesh, importing around 197,645 tonnes. The domestic demand for chickpeas in Bangladesh exceeds domestic supply and the deficit is met through imports.

Figure ES. 6. Top Five Major Importers of Chickpeas, 1990 to 2020



Notes:

- Top five largest importers in 2020.
- FAOSTAT detailed trade matrix does not have import data for Pakistan from 2013 onwards. Therefore, the import from 2014 to 2020 reflects Com Trade data.
- FAOSTAT's detailed trade matrix does not record imports for Bangladesh from 1990 to 1997, 1999 to 2004 and 2008 to 2013. Similarly, data is not recorded for the UAE from 1990 to 2001, 2004, 2006 and 2009 to 2013.

Source: FAOSTAT (2022), Com Trade (2022).

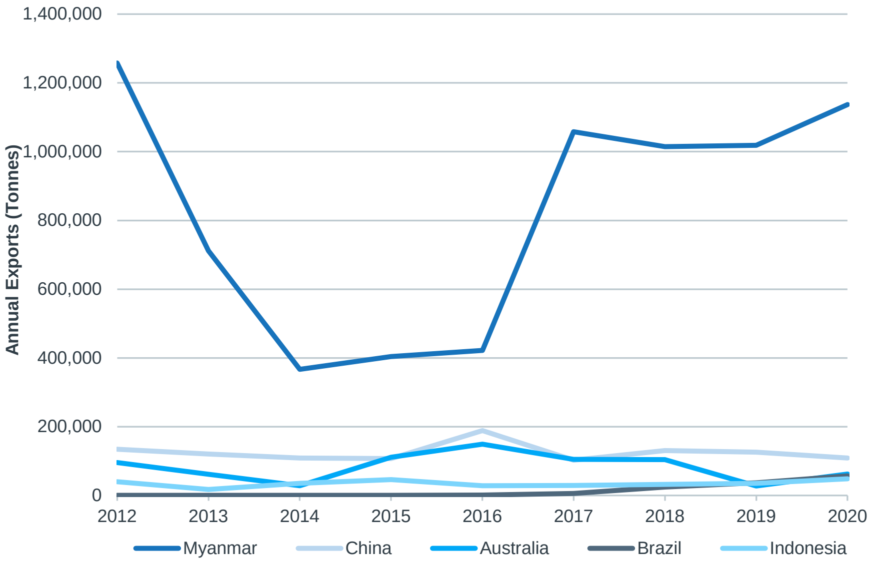
Mungbean

Exporters

From 2012 to 2020, global exports of mungbeans have experienced an average annual growth rate of 1.3% per annum to reach a total of 1.7 million tonnes in 2020.

- **Myanmar** – From 2012 to 2020, Myanmar has been the largest exporter of mungbeans on the global scale, representing 65.8% of total global exports in 2020. India is the largest export market for Myanmar.
- **China** – The second largest exporter of mungbeans in 2020 was China, exporting a total of 109,103 tonnes. In 2020, China's largest export market was Japan, accounting for 36.3% of total exports for the year.
- **Australia** – Australia was the third largest exporter of mungbeans on the global scale, with exports totalling 62,190 tonnes in 2020. Australian mungbeans are regarded as the most hygienic and safest mungbeans available due to the strict measures the industry has taken to ensure the highest quality of supply (Australian Mungbean Association, undated c).

Figure ES. 7. Top Five Major Exporters of Mungbeans, 2012 to 2020



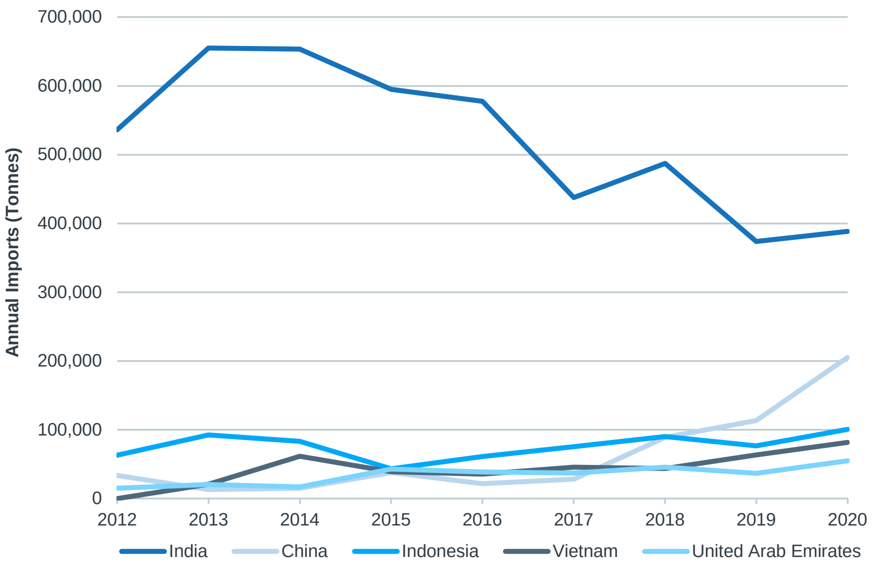
Note: Excluding re-exports.
Source: Com Trade (2022).

<u>Importers</u>

From 2012 to 2020, global imports of mungbeans have risen by an average annual rate of 2.5% per annum to reach a total of 1.2 million tonnes in 2020.

- **India** – From 2012 to 2020, India has been the largest importer of mungbeans on the global scale, accounting for 32.6% of total global mungbean imports in 2020. India is both the world's largest producer and the world's largest importer of mungbeans, highlighting the significant domestic demand for the pulse crop in India.
- **China** – The second largest importer of mungbeans in 2020 was China, with imports increasing by an average annual rate of 25.5% from 2012 to 2020. From 2012 to 2020, mungbean imports to China have increased by over six-fold reaching 205,343 tonnes in 2020.
- **Indonesia** – Indonesia was the third largest importer of mungbeans in 2020, importing a total of 100,479 tonnes. Similar to India and China, Indonesia's largest mungbean supplier was Myanmar, accounting for 69.3% of total imports in 2020.

Figure ES. 8. Top Five Major Importers of Mungbeans, 2012 to 2020



Note: Excludes re-imports.
Source: Com Trade (2022).

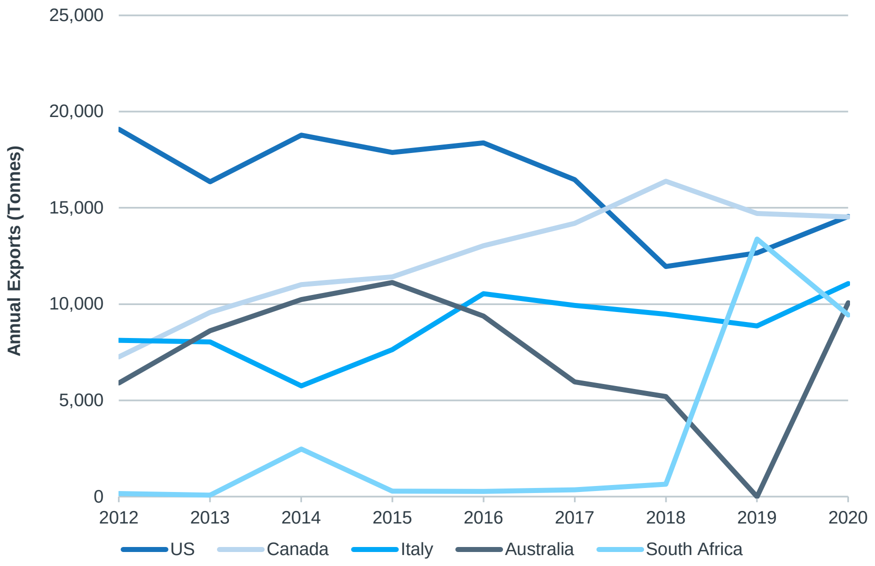
Lucerne

Exporters

From 2012 to 2020, global exports of lucerne seed have experienced an average annual growth rate of 3.9% per annum to reach an estimated 87,738 tonnes in 2020.

- **USA** – The largest global exporter in 2020 was the USA, exporting an estimated 14,550 tonnes which represented 16.6% of total global exports for the year. Exports from the USA have experienced an average annual decline of 3.3% from 2012 to 2020, largely due to lower domestic production as the focus has shifted towards lower-risk crops such as corn (AgriFutures, undated).
- **Canada** – The second largest global exporter in 2020 was Canada, exporting an estimated 14,532 tonnes, representing 16.6% of total global exports for the year. Unlike exports from the USA, exports from Canada have been experiencing an increase since 2012, growing by an average annual rate of 9.1% per annum.

Figure ES. 9. Top Five Major Exporters of Lucerne Seed, 2012 to 2020



Notes:
- Excluding re-exports.
- No export data for Australia in 2019.

Source: Com Trade (2022).

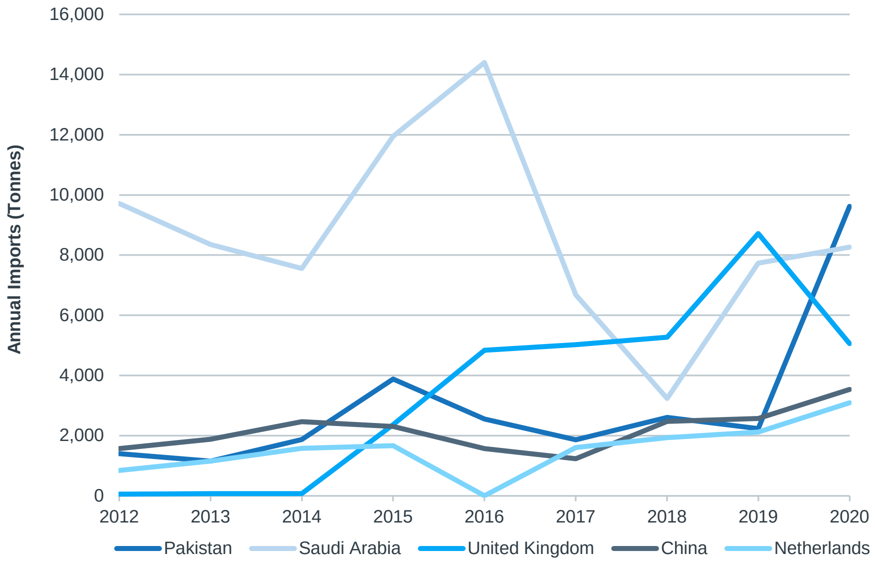
The USA is the largest exporter of hay on the global scale, dominated by lucerne hay (AFIA, 2021), with exports totalling 2.9 million tonnes in 2021. Lucerne hay exports from the USA have been increasing by 5.6% per annum from 2012 to 2021. AgriFutures (2020) have highlighted that a key threat to the USA export market for lucerne hay and seed has been the introduction of GM lucerne.

Importers

From 2012 to 2020, global imports of lucerne seed have experienced an average annual growth rate of 3.3% per annum to reach an estimated 63,373 tonnes in 2020.

- **Pakistan** – The largest global importer of lucerne seed in 2020 was Pakistan, importing 9,617 tonnes. From 2019 to 2020, imports to Pakistan increased significantly which was largely driven by an increase in imports from Afghanistan.
- **Saudi Arabia** – Saudi Arabia was the second largest global importer of lucerne seed in 2020, importing an estimated 8,265 tonnes. Australia and the USA together accounted for 98.1% of total imports to Saudi Arabia in 2020.
- **United Kingdom (UK)** – The UK was the third largest importer of lucerne seeds in 2020, importing a total of 5,058 tonnes. The UK's largest lucerne seed supplier was France, accounting for 94.7% of total imports in 2020.

Figure ES. 10. Top Five Major Importers of Lucerne Seed, 2012 to 2020



Note: Excluding re-imports.
Source: Com Trade (2022).

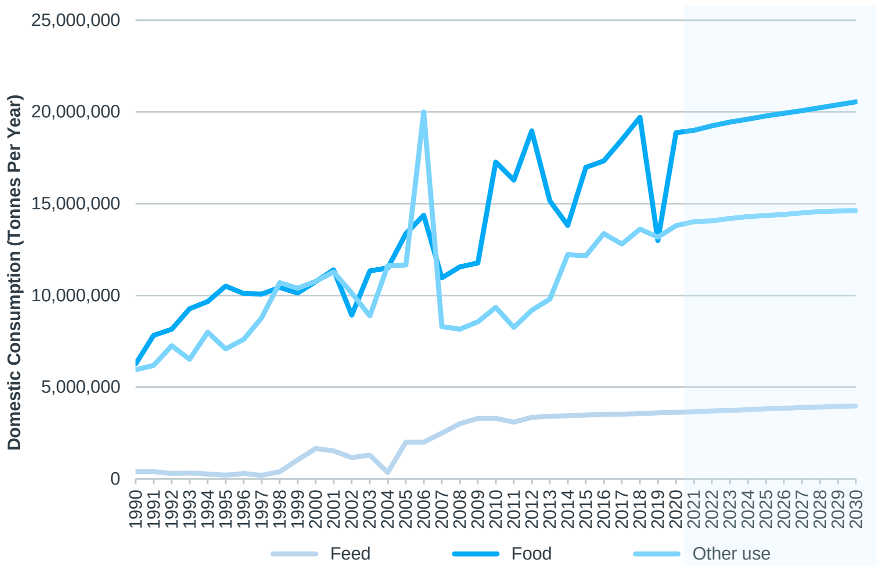
GLOBAL CONSUMPTION

Soybean

The *OECD-FAO Agriculture Outlook 2021-2030* highlights the consumption of soybean from 1990 to 2030, split by consumption type (crush, feed, food, biofuel use and other use). In 2020, it was estimated that 90.0% of total global consumption of soybean was for crush purposes. The second largest consumption of soybean in 2020 was for food purposes, accounting for 5.2% of total global consumption.

Soybean meal is a major source of protein and is largely used for animal feed across the globe. Consumption of crushed soybean (including soybean meal and soybean oil) has increased by 4.9% on average per annum from 1990 to 2020.

Figure ES. 11. Global Soybean Consumption, 1990 to 2030



Source: OECD-FAO (2021a), IMF (2022), OECD (2022).

China is the largest consumer of soybeans, with total consumption estimated at 116.6 million tonnes in 2020 (OECD-FAO, 2021a; USDA FAS, 2022), far outweighing consumption of other countries. The strong growth in

Chinese consumption is attributable to growth in its use as an input of animal feed for chicken and pigs and in the culinary market.

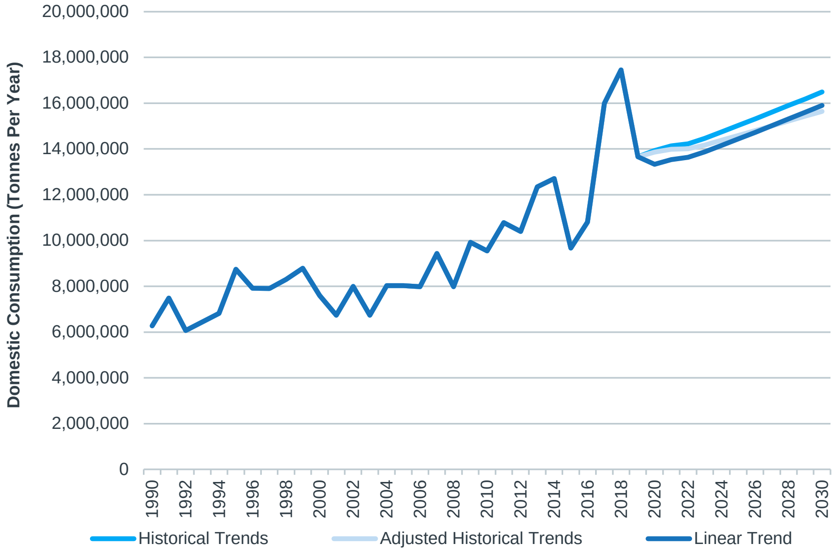
In 2020, it was estimated that consumption of soybean totalled 2.5 kilograms per capita. As population increases, this is projected to remain at 2.5 kilograms per capita in 2030. The volatility in consumption in FY2020 coincides with the tightening of supply and demand and COVID-19 related lockdowns.

Chickpea

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

Based on historical trends, it is estimated that domestic consumption of chickpeas could grow from an estimated 13.1 million tonnes in 2021 to 16.5 million tonnes in 2030.

Figure ES. 12. Global Chickpea Consumption, 1990 to 2030 (Tonnes)



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

Mungbean

Information on global consumption is limited and data is not available.

Lucerne

No publicly available information was found for the global consumption of both lucerne seed or lucerne hay.

GROWTH MARKETS

Soybean

Soybean consumption is primarily driven by the crushing industry, which produces soybean meal and soybean oil. Europe is a key market for non-GMO and high-protein soybean meal. Additionally, soybean derivatives (such as soy milk and soy oil) are in demand due to consumer preferences for healthier foods (Research and Markets, 2022).

China continues to be a key growth market for soybeans. Its primary use will be for animal feed and other agricultural functions as it begins to ramp up its recovery of livestock production and rebuilding of the national pig herd in the short to medium term. Another growing market for soybeans on the global scale is Mexico. Imports to the country grew by 5.0% per annum from 1990 to 2020, with projections to increase further in the next few years.

Chickpea

The demand for chickpeas is growing, particularly with the rising awareness of health benefits combined with the trend of substituting meat options for vegetarian alternatives (EMR, 2022a). It is unlikely that the demand from the Indian subcontinent will diminish in the near future, however, the tariff applications are likely to remain a feature of this market (GRDC, 2018).

Turkey is becoming more and more reliant on chickpea imports over the years due to declining production. In 2020, Turkey was the third largest importer of chickpeas on the global scale, with imports increasing by over 16-fold from 2010 to 2020.

Pakistan is another key market for chickpeas, with highly volatile domestic production. Where there are production deficits (primarily due to dry conditions), Pakistan seeks to fill the deficit via imports.

Mungbean

Mungbean production in Myanmar, Bangladesh and Pakistan could experience an increase over the coming years with ACIAR-funded research to modernise production practices (ACIAR, 2020b). It is reported that the research may also support Myanmar in finding more suitable varieties for the sprout mungbean market in Europe (ACIAR, 2020b).

Generally, the demand for mungbean is rising due to a number of factors including rising demand for organic food products, awareness regarding health and substitutions for meat products (EMR, 2022 b). Future key growth markets for Australia include southeast Asia, Philippines, Indonesia, Vietnam and China.

Lucerne

There is not enough publicly available information to draw sufficient conclusions on the key future growth markets for lucerne.

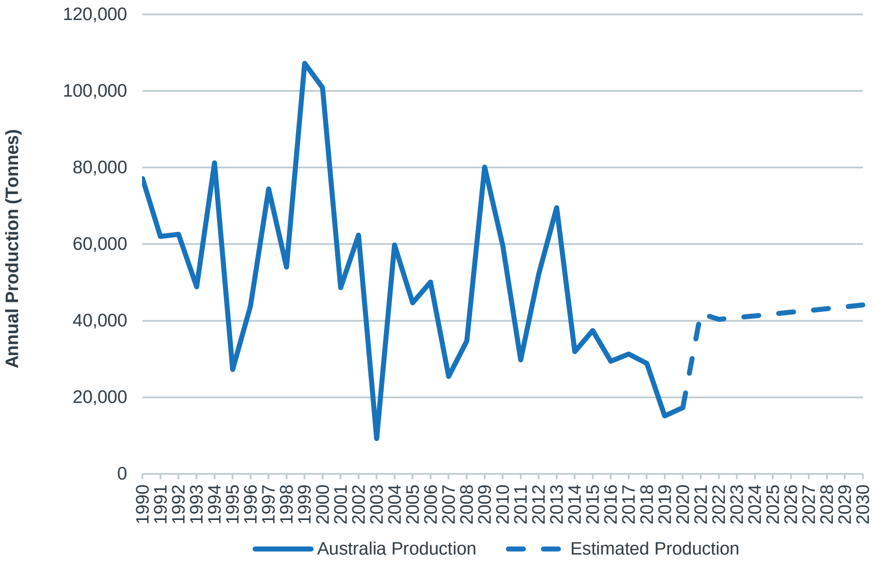
AUSTRALIAN PRODUCTION

Soybean

From 1990 to 2020, soybean production in Australia has been experiencing a declining trend, decreasing by an average annual rate of 4.9% per annum. Over the 30-year analysis period, soybean production has been rather volatile, reflective of the change in harvested area from 1990 to 2020. By 2030, it is projected that the harvested area in Australia will total 34,700 Ha with a yield return of 1.27 tonnes per Ha.

Australian soybeans are unique in the market, holding a position of non-GMO and specifically suited for food and drink processing (Soy Australia, 2019), providing them with a competitive advantage.

Figure ES. 13. Australian Soybean Production, 1990 to 2030



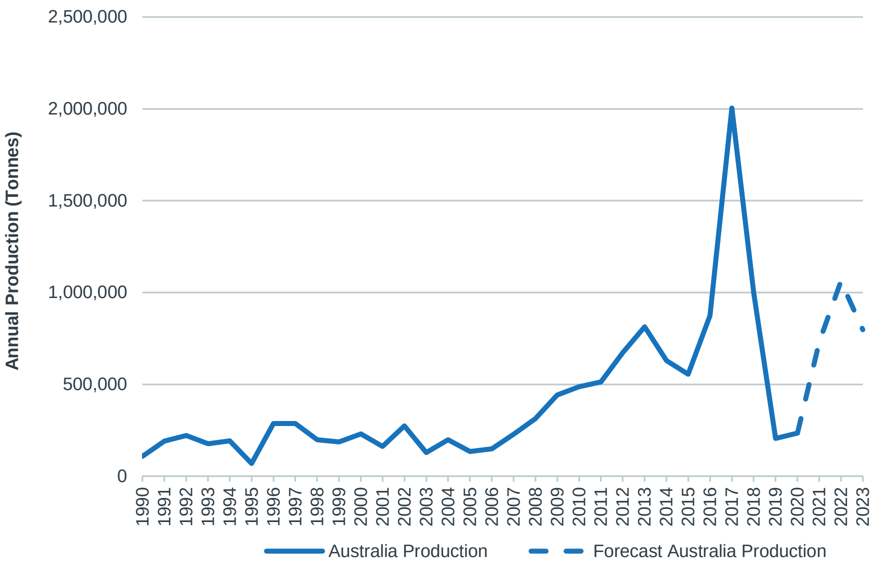
Source: ABARES (2022a), OECD-FAO (2021a).

Chickpea

From 1990 to 2020, the production of chickpeas in Australia has experienced a 2.6% average annual increase to reach 235,165 tonnes. The significant increase in production was driven by a combination of increased prices providing attractive profits, heightened demand from India and almost perfect seasonal growing conditions. The subsequent large fall in production was attributable to India's implementation of tariffs on chickpeas in 2017 and 2018.

Projections developed by ABARES highlights that chickpea production could reach 798,000 tonnes in 2023.

Figure ES. 14. Australian Total Production of Chickpeas, 1990 to 2023



Source: ABARES (2022a).

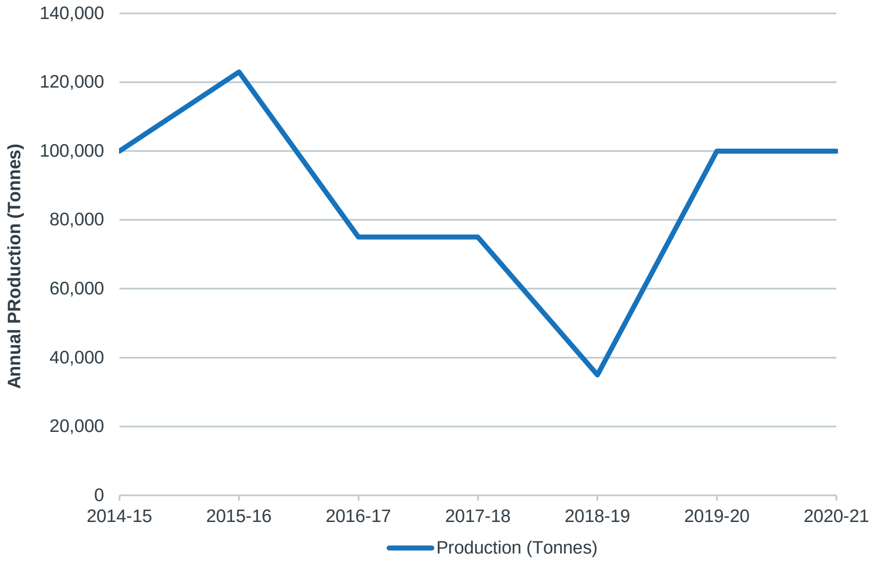
Mungbean

Definitive mungbean production values for Australia are not currently available.

Data provided by the ABS indicates that mungbean production in FY2016 was estimated to total 122,953 tonnes. However, consultation with industry and information highlighted by ACIAR (2020d) and Grain Central (2016) suggests that production totalled approximately 150,000 tonnes.

Both 2020 and 2021 were favourable years for mungbean production in Australia, reaching approximately 100,000 tonnes per annum (information based on consultation). Based on the planted area, 2022 is set to be Australia's largest production year ever, achieving well over 150,000 tonnes of mungbeans (information based on consultation).

Figure ES. 15. Estimated Australian Mungbean Production



Notes:

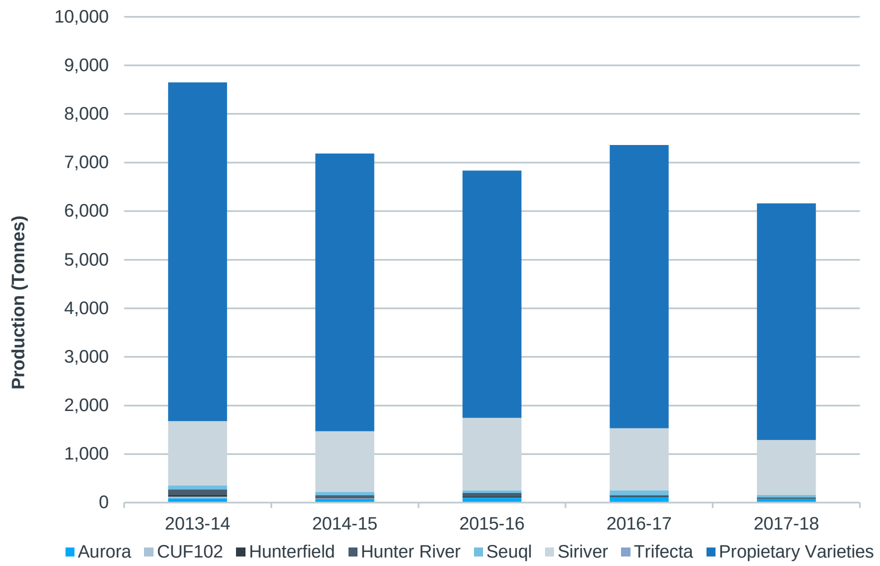
- The above figures are based on information highlighted in a 2016 Grain Central article and on consultation with the Australian Mungbean Association. The above figures only provide an estimation of Australian mungbean production and may not reflect the exact production volumes for the year.
- The graph above reflects mid-point estimates provided in consultation with the Australian Mungbean Association, providing an indicative quantity.

Source: Grain Central (2016), ABS (2017a), consultation with the Australian Mungbean Association.

Lucerne

From FY2014 to FY2018, production of lucerne seeds in Australia experienced an average annual decline of 8.1% per annum to reach 6,162 tonnes in FY2018. Of all lucerne seeds produced in the FY2018, approximately 79.0% of the seeds were proprietary varieties. Annual production in Australia has been variable due to a range of seasonal factors including dryland production being more opportunistic (AgriFutures, 2020).

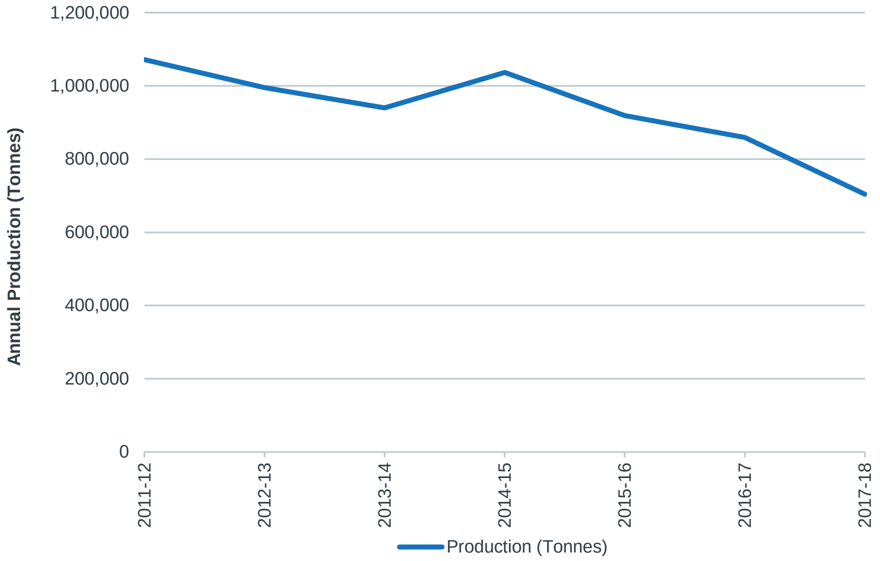
Figure ES. 16. Australian Total Production of Lucerne Seed by Variety, FY2014 to FY2018



Source: AgriFutures (2020).

From FY2012 to FY2018, the production of lucerne cut for hay experienced an average annual decline of 6.8% per annum. Over the analysis period, production peaked at 1.1 million tonnes in FY2012, declining to an estimated 704,257 tonnes in FY2018.

Figure ES. 17. Australia Production of Lucerne Cut for Hay, FY2012 to FY2018



Note: ABS data in FY2019 and FY2020 is grouped and defined as "hay and silage – pasture (including lucerne), cereal and other crops cut for hay". The above figures only reflect the ABS data provided for lucerne cut for hay.
Source: ABS (2014, 2015, 2016, 2017a, 2018, 2019).

AUSTRALIAN GROWING AREAS

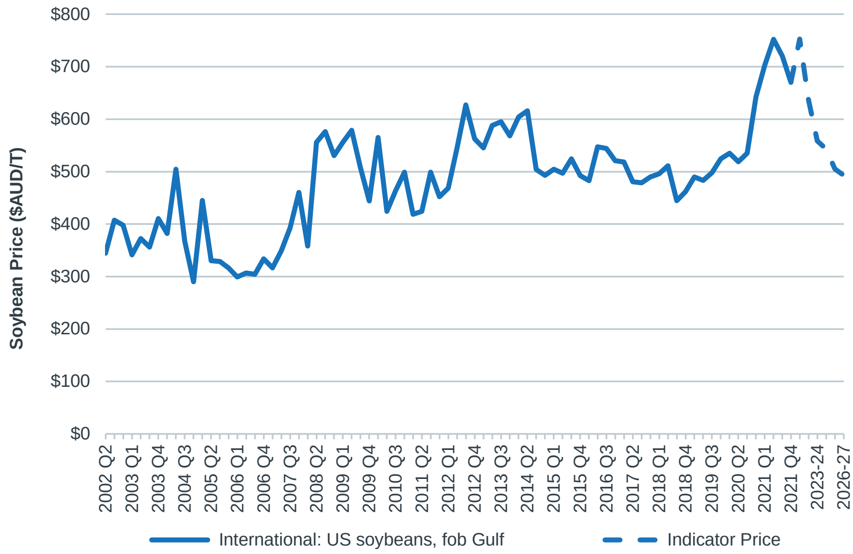
- **Soybean** – Historically, New South Wales has been the largest producer of soybeans on average. In 2020, Queensland was the largest producer of soybeans (accounting for 51.1% of total production), followed by New South Wales (47.8% of total production) and Victoria (1.1% of total production).
- **Chickpea** – On average, New South Wales has also historically been the largest producer of chickpeas in Australia, with production totalling an estimated 374,000 tonnes in 2021. In 2022, it is estimated that New South Wales will account for 47.7% of the Australian chickpea crop, with Queensland accounting for 47.1%.
- **Mungbean** – Current production is generally concentrated in Central Queensland, Southern Queensland and northern New South Wales (AgriFutures, 2017). Mungbean in Australia is predominately grown in the summer-dominant rainfall areas in Queensland and northern New South Wales (AEGIC, 2021). The Australian Mungbean Association have also identified potential production in the Northern Territory.
- **Lucerne** – Given its ability to grow in a range of climactic conditions from tropical to temperate, lucerne pasture is grown in all states and territories of Australia, with the majority used for grazing purposes. Lucerne production for the purposes of fodder is primarily grown in New South Wales (40%), followed by Victoria (25%) and Queensland (16%) (AgriFutures, 2017). Lucerne seed production is heavily concentrated in the south-east of South Australia (between 90% to 95%).

PRICES IN AUSTRALIA

Soybean

In the second quarter of 2021, soybean prices reached AUD $752 per tonne – one of the highest prices that has been achieved over the past 20 years. A major contributing factor to this has been China's recovery from the African Swine Flu and its resulting increased demand for soybean imports. The price movement throughout 2020 also correlates with the COVID-19 supply chain issues for exports and imports on the global scale. Soybean prices are forecast to experience gradual decline due to growth in global soybean production, which is expected to be greater than demand (ABARES, 2022b).

Figure ES. 18. Soybean Prices ($/tonne)



Notes:

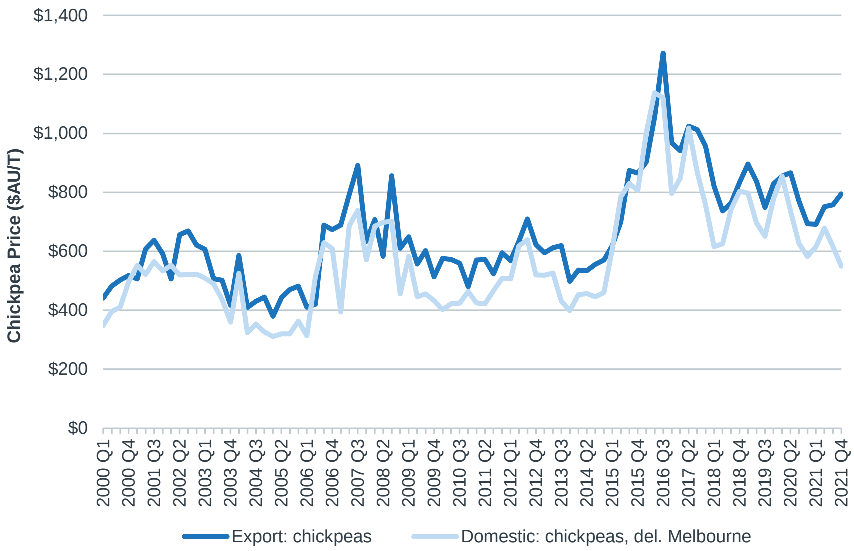
- Future prices have been converted from USD to AUD based on spot exchange rate forecasts provided by NAB until December 2024. Prices from FY2025 to FY2027 are assumed to have the same currency conversion as FY2024.
- FOB prices.

Source: ABARES (2022a), NAB (2022).

Chickpea

In the fourth quarter of 2021, Australian prices for chickpeas totalled approximately AUD $550 per tonne in the domestic market and AUD $795 per tonne in the export market. With relatively low demand for chickpeas in Australia, the export market prices provide greater returns for growers. Chickpea prices experienced a peak in the second quarter of 2016, reaching $1,272 per tonne for exported chickpeas. High prices were also experienced in the domestic market and led to an increase in plantings.

Figure ES. 19. Average Australian Chickpea Prices ($AUD/t)

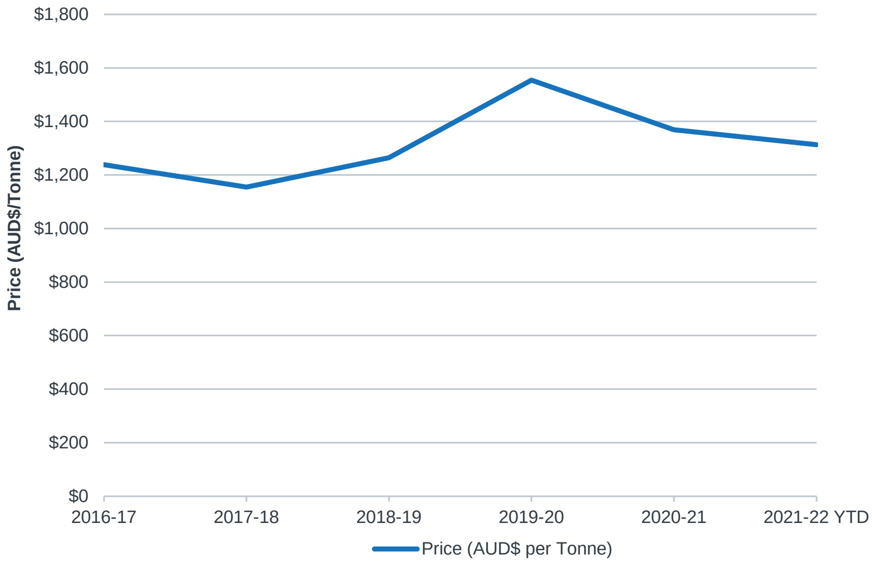


Source: ABARES (2022a).

Mungbean

China and Myanmar are the two largest exporters of mungbeans on the global scale, with production and export volumes in these two countries having a large influence on the price (GRDC, 2014). In the second half of 2021, Queensland export mungbean prices were estimated to total AUD$1,314 per tonne. Queensland mungbean export prices peaked in FY2020 over the analysis period, with prices estimated at AUD$1,554 per tonne.

Queensland Mungbean Prices ($/Tonne)



Notes:

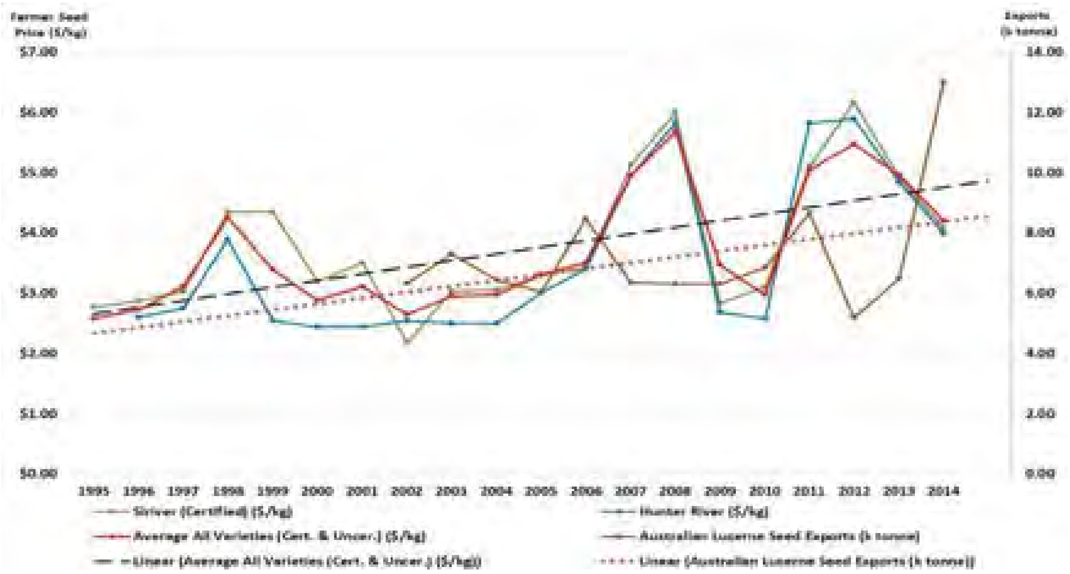
- Based on export data from Queensland
- Prices FOB (Free on Board).
- Latest data included is until the first of December 2021.

Source: ABS 2021, as cited in Pulse Australia (unpublished).

Lucerne

The value of contract lucerne seed (certified and uncertified) was estimated to grow from $2.58 per kg in 1995 to approximately $5.00 per kg in 2015. More recent pricing information for lucerne seed was not publicly available.

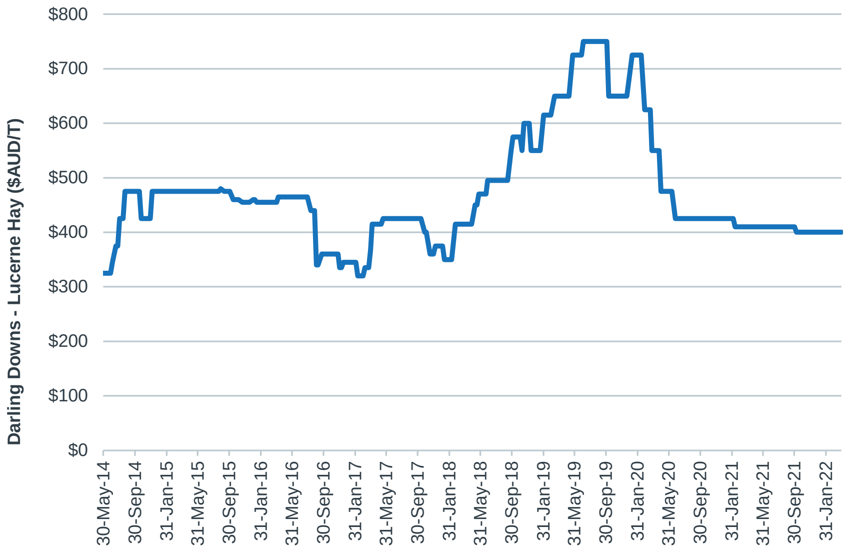
Figure ES. 20. Average Lucerne Contract Seed Prices and Exports of Australian Lucerne Seed



Source: AgriFutures (2017b).

From the beginning of October 2021 to the beginning of April 2022, lucerne hay prices in the Darling Downs (most comparable region available to Central Queensland) was estimated to total $400 per tonne. Hay prices experienced a spike from 2018 due to the extended drought along the east coast of Australia (GRDC, 2019).

Figure 6.1. Darling Downs Lucerne Hay Prices ($AUD/T)



Notes:

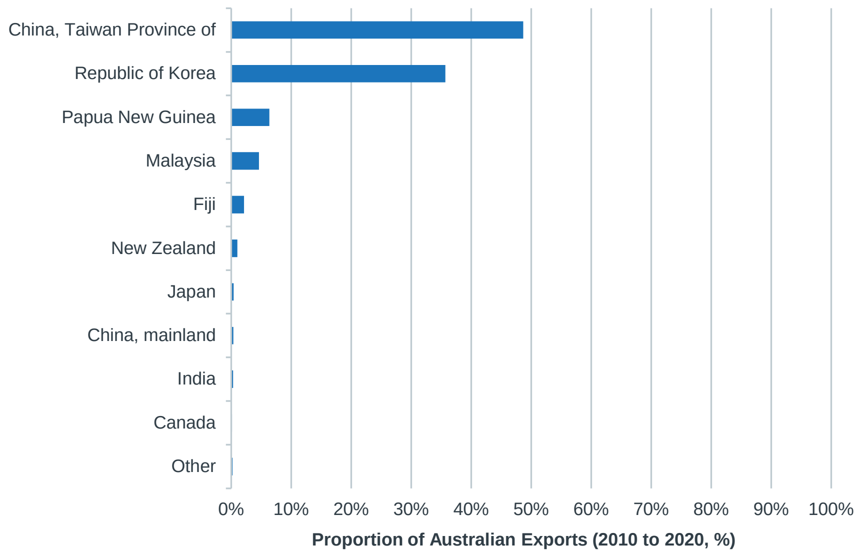
- Only 40 reports are released each year, therefore information is not reported consistently every week.
- Prices are inclusive of delivery.

Source: Dairy Australia (2022).

AUSTRALIA'S KEY MARKETS

Soybean

Figure ES. 21. Key Exports Markets for Australian Soybeans (Top 10), 2010 to 2020



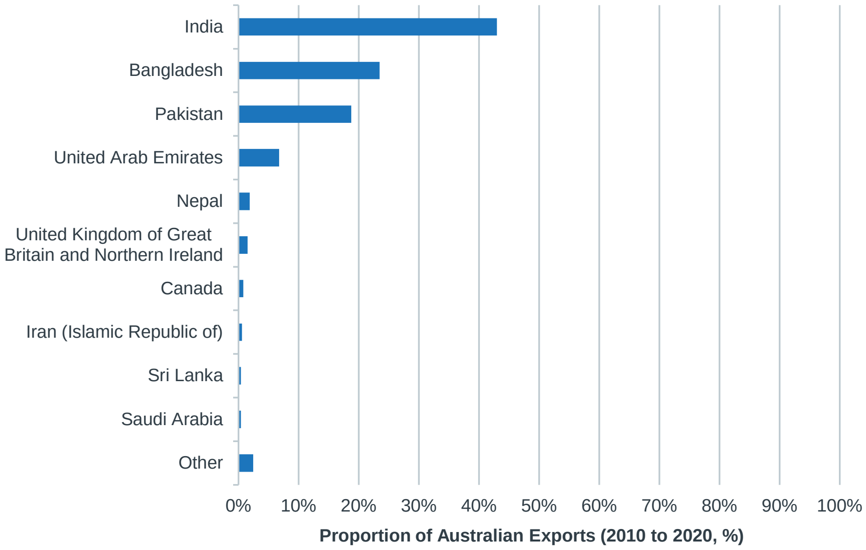
Source: FAOSTAT (2022).

- **Taiwan** – From 2010 to 2020, Taiwan was Australia's largest export market for soybeans, accounting for an average of 49% of Australia's total exports. However, Taiwan source the majority of their soybeans from the USA and Brazil. Australian soybeans only accounted for 0.1% of total soybean imports into Taiwan (on average from 2010 to 2020).
- **South Korea** – Similar to Taiwan, Australia was largely reliant on South Korea for the export of soybeans, but the country sources majority of their soybeans from the USA and Brazil. Australian soybeans only accounted for 0.1% of total soybean imports into South Korea (on average from 2010 to 2020).

- **Papua New Guinea** – From 2010 to 2020, Papua New Guinea sourced the majority of their soybeans from the USA, accounting for 74.5% of total imports. Australia was their second largest supplier, accounting for 24.6% of total imports.

Chickpea

Figure ES. 22. Key Exports Markets for Australian Chickpeas (Top 10)

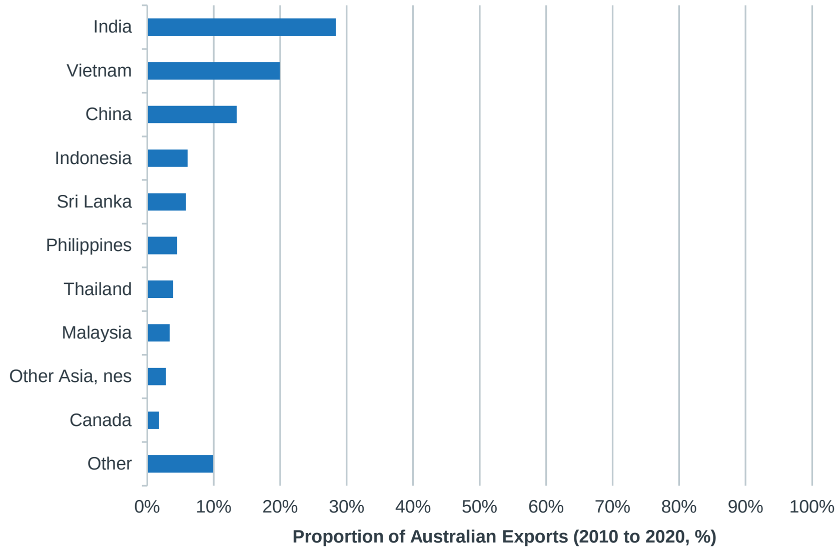


Note: ABARES export data for Australia differs from what is reported in FAOSTAT. The above graph is reflective of the information provided by FAOSTAT.
Source: FAOSTAT (2022).

- **India** – India accounted for 43.0% of Australia's total chickpea exports – its largest export destination. The largest source of chickpeas in India was also from Australia, accounting for 64.5% of total imports. Russia accounted for the second largest source of chickpeas in India, comprising 13.0% of total imports.
- **Bangladesh** – Bangladesh is highly reliant on Australian chickpeas, accounting for 89.4% of total imports. The second largest source of chickpeas in Bangladesh was from Canada, accounting for 5.0% of total imports.
- **Pakistan** – Similar to India and Bangladesh, Australia is Pakistan's largest source of chickpeas, accounting for 36.6% of total imports in 2021. The second largest source of chickpeas in Pakistan was from Russia, accounting for 24.2% of total imports in 2021.

Mungbean

Figure ES. 23. Key Export Markets for Australian Mungbeans (Top 10)

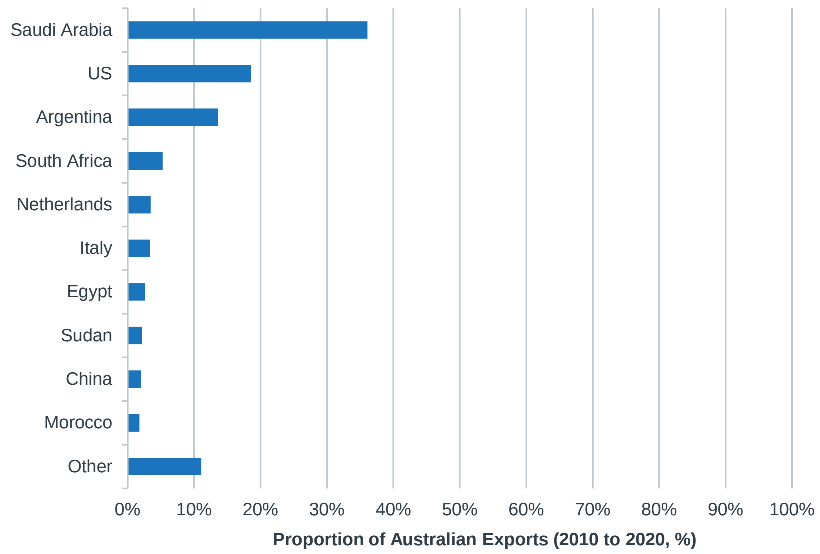


Source: Com Trade (2022).

- **India** – India accounted for 28.4% of Australia's total mungbean exports. The largest source of mungbean in India was from Myanmar, accounting for 77.8% of total imports. The second largest source of mungbeans in India was from Tanzania, accounting for just 4.5% of total imports.
- **Vietnam** – Vietnam was Australia's second largest export market for mungbeans, accounting for 20.0% of exports. The largest source of mungbeans in Vietnam was from Myanmar, accounting for 65.8% of total imports, with China accounting for 14.4% of total imports.
- **China** – Australian exports of mungbeans to China comprised 13% of its total exports of mungbeans. The largest source of mungbeans in China was again from Myanmar, accounting for 46.4% of total imports. The second largest source of mungbeans in China was from Australia, accounting for 18.4% of total imports.

Lucerne

Figure ES. 24. Key Export Markets for Australian Lucerne Seed (Top 10)



Source: Com Trade (2022).

- **Saudi Arabia** – Saudi Arabia accounted for 36.1% of Australia's total lucerne seed exports. The largest source of lucerne seeds in Saudi Arabia was from the USA, accounting for 56.2% of total imports to Saudi Arabia. Australia was Saudi Arabia's second-largest supplier of lucerne seed, comprising 33.8% of their total imports.
- **USA** – The USA was Australia's second largest export market for lucerne seeds, accounting for an average of 18.6% of exports. The USA only imports lucerne seed from three countries – Canada, Australia and Italy. The vast majority (79.8%) are sourced from Canada, with 17.8% coming from Australia.
- **Argentina** – While Australia exports less than 20% of its lucerne seed to Argentina, Australia is the country's largest source of lucerne seeds making up 43.2% of total imports. The USA also supplies a notable portion, with 31.4% of Argentina's imports coming from the USA.

AUSTRALIA'S KEY COMPETITORS

- **Soybean** – In Australia's key export markets (Taiwan, South Korea and Papua New Guinea), Australia's key competitors are primarily the USA and Brazil, which have a very large total market share. Canada is Australia's only major competitor in the market for non-GMO soybeans.
- **Chickpea** – A key competitor for Australia's Desi chickpeas is the Canadian yellow field pea (Pulse Australia, 2015 b), with Canada the world's largest producer and exporter of yellow field pea (Pulse Australia, 2015 b). In Australia's key export markets (India, Bangladesh and Pakistan), key competitors include Canada, Russia and Myanmar.
- **Mungbean** – Australia is currently identified as only an emerging force in the global mungbean market. In Australia's key export markets (India, Vietnam and China), Australia's key competitors include Myanmar, China and Uzbekistan.
- **Lucerne** – In Australia's key export markets (Saudi Arabia, USA and Argentina), Australia's key competitors include Canada and the USA.

SUPPLY CHAIN GAPS

Soybean

The majority of Australian soybean buyers are located approximately 400-500km from the Rookwood Weir Catchment Area, closer to the Port of Brisbane. While soybeans can use existing grain infrastructure facilities, if soybeans were to be selected as a commodity for the Rookwood Weir Catchment Area, it is anticipated that a processing facility may be required to be established within the region if the scale of production increases. Otherwise, soybeans would need to be transported to the processing establishments near the Port of Brisbane.

Chickpea

In Queensland, GrainCorp is the largest bulk handler of grains, with 15 country silos which accept chickpeas at its port terminals in Brisbane, Mackay and Gladstone. Within the Rookwood Weir Catchment Area, there are six GrainCorp bulk receival sites which accept chickpeas, including three which are in the Gladstone port zone and three facilities in the Mackay port zone.

If chickpeas were to be produced within the Rookwood Weir Catchment Area, farmers are well-placed to utilise the services at GrainCorp's receival sites, or alternatively, can implement on-farm storage facilities. GrainCorp's Gladstone port terminal is also the closest to the Rookwood Catchment, within a 200-kilometre radius.

Mungbean

All mungbean exports are required to be handled through Registered Processing Establishments, which are mainly located in southern Queensland. There is one processing facility within 100km of the Rookwood Weir Catchment (Allenden Seeds in Jambin, QLD), while all other facilities are located approximately 400-500km from the Catchment, closer to the Port of Brisbane.

If mungbeans were to be selected as a commodity for the Rookwood Weir Catchment Area, it is anticipated that the Allenden Seeds facility will service the catchment, with a further processing facility required if the scale of mungbean production surpasses the processing capabilities at this plant. Mungbeans can also be transported to the processing establishments near the Port of Brisbane.

Lucerne

Lucerne hay and silage can be largely produced on-farm and do not require off-site processing facilities. Additional infrastructure and equipment will be required depending on the end product. Hay is usually transported by road within Australia when selling in the domestic market, often at high cost.

If lucerne seed were to be produced in the Rookwood Weir Catchment, it is likely that seeds will need to be transported to processing facilities in key growing regions of South Australia (such as Keith, Naracoorte, Tintinara and Bordertown) in order to be cleaned, sampled and certified. There are existing seed processing facilities within Queensland, however, these facilities do not appear to process lucerne seed (based on desktop research).

FINANCIAL AND COMMERCIAL ANALYSIS

The Rookwood Weir Scheme (second tranche of water sales) allows for a maximum 500ML water allocation for agricultural landholders. Under the assumption this water is provided with a conservative 84% reliability, the maximum growing area in the Rookwood Weir Catchment Area for each commodity differs due to the inherent water requirement of each commodity. This is shown in the table below.

Table ES. 1. Land Availability

Key Farmed Commodity	84% Reliability
Soybean	39.3 ha
Chickpea	62.7 ha
Mungbean	54.5 ha
Lucerne	48.0 ha

Water allocations have been assumed to cost landholders $1,500 per ML. This cost may not be reflective of the cost to landholders through the tender process and may impact the financial feasibility of the development for the landholders.

It should be noted that the final reliability levels and maximum water allocations will be determined by Sunwater after the publication of this report. This report is based on levels estimated by Sunwater at the time of publication. Any increase in water availability (either through reliability improvements or through volume increases) should increase the financial viability of the crops analysed in this report.

Sunwater and Advance Rockhampton have commissioned a financial modelling tool to aid landholders in the region assess the potential financial benefit of accessing water through the Rookwood Weir Supply Scheme. The tool can be downloaded here.

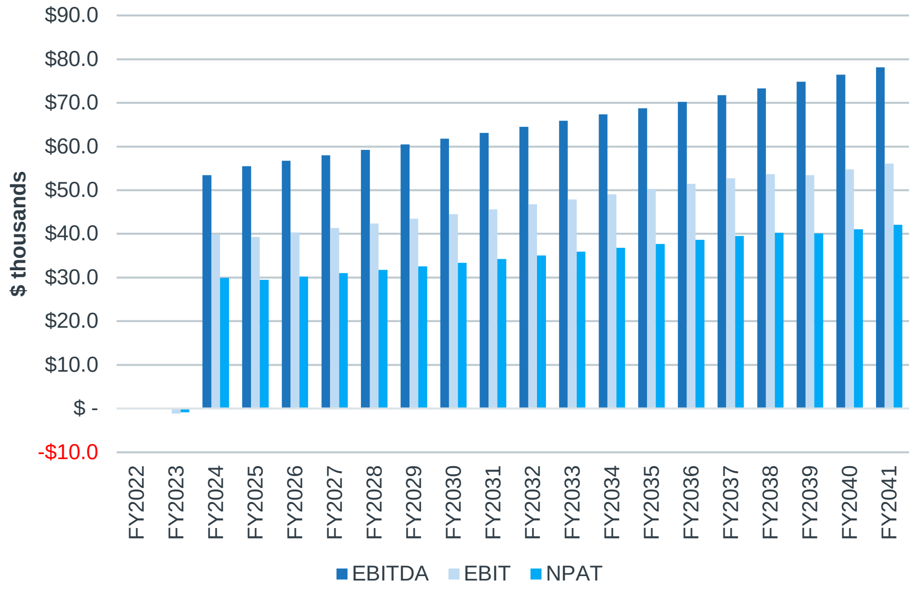
Soybean

The key guiding outcomes of the financial analysis for a 39.3ha farm are:

- The anticipated initial capital investment for a rotational cropping farm is $3.4 million – including, land clearing and water allocation ($932,474), irrigation infrastructure and equipment ($2.2 million), production equipment ($148,470), and storage and other infrastructure ($113,336). This includes water allocation of $771,056 at an assumed cost of $1,500 per ML (RFM, 2021).
- Assuming the crop rotation with soybean is wheat, the break-even point for the example soybean farm, at the current assumed price of $594 per tonne is June 2024. Under this scenario, the assumed price for wheat is $421 per tonne.
- The soybean farm will return positive discounted cash flows intermittently over the evaluation period, with the first positive discounted cash flow incurred in FY2024.
- The long-term growth rate for agricultural farm values is 12.5%, with an internal rate of return for agricultural investments of 12.8%, the net present value (NPV) of the example farm is zero. The terminal value of the example farm with rotational cropping at the conclusion of the analysis (FY2041) is $27.0 million (undiscounted).

By FY2041 the net profit after tax (NPAT) of the farm is estimated to be $42,070 and the EBITDA is estimated to be $78,111. This shows that the impact of both depreciation and tax expenses have a significant impact to the profitability of the farm for the landholder.

Figure ES. 25. Soybean Operating Profit (FY2022 – FY2041)



Source: AEC.

To understand the value of the farm investment, a discounted cashflow (DCF) has been calculated. 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 Central Queensland, which is 12.5% (HTW, 2022).

With an NPV of the farm at $0 the implied internal rate of return is 12.8%. The terminal value of the example farm with rotational cropping at the conclusion of the analysis (FY2041) is $27.0 million (undiscounted). The return implies that the investment will exceed the long-term growth rate in value over time and is a commercially viable investment.

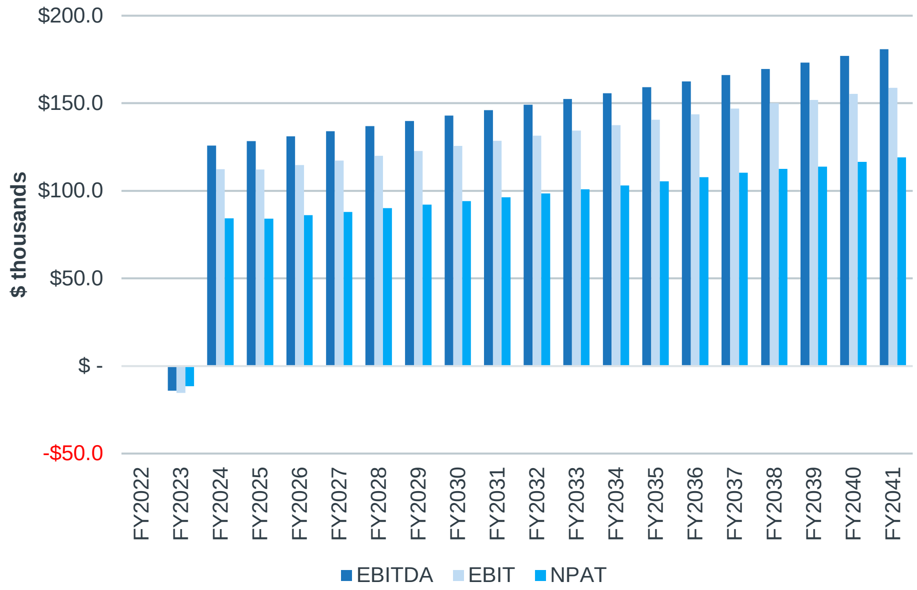
Chickpea

The key guiding outcomes of the financial analysis for a 62.7ha farm are:

- The anticipated initial capital investment for a rotational cropping farm is $4.8 million – including, land clearing and water allocation ($1.0 million), irrigation infrastructure and equipment ($3.6 million), production equipment ($148,470), and storage and other infrastructure ($118,488). This includes water allocation of $771,056 at an assumed cost of $1,500 per ML (RFM, 2021).
- Assuming the crop rotation with chickpea is wheat, the break-even point for the example chickpea farm, at the current assumed weighted average price of $828 per tonne is August 2023. Under this scenario, the assumed price for wheat is $421 per tonne.
- The chickpea farm will return positive discounted cash flows from FY2024, with negative discounted cash flows in FY2036 which correspond with the capital replacement program.
- The long-term growth rate for agricultural farm values is 12.5%, with an NPV of the farm at $0 the implied internal rate of return is 12.9%. The terminal value of the example farm with rotational cropping at the conclusion of the analysis (FY2041) is $37.4 million (undiscounted).

By FY2041 the NPAT of the farm is estimated to be $119,119 and the EBITDA is estimated to be $180,843. Figure ES. 26 shows that the impact of both depreciation and tax expenses have a significant impact to the profitability of the farm for the landholder.

Figure ES. 26. Chickpea Operating Profit (FY2022 – FY2041)



Source: AEC (2022).

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 Central Queensland, which is 12.5% (HTW, 2022).

With an NPV of the farm at $0 the implied internal rate of return is 12.9%. The terminal value of the example farm with rotational cropping at the conclusion of the analysis (FY2041) is $37.4 million (undiscounted). The return implies that the investment will exceed the long-term growth rate in value over time and is a commercially viable investment.

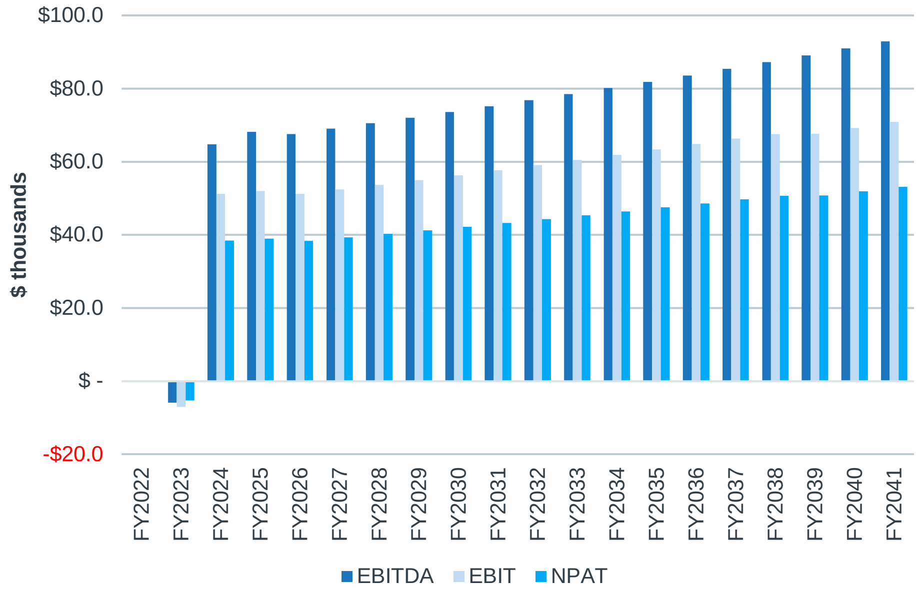
Mungbean

The key guiding outcomes of the financial analysis for a 54.5ha farm are:

- The anticipated initial capital investment for a rotational cropping farm is $4.4 million – including, land clearing and water allocation ($995,364), irrigation infrastructure and equipment ($3.1 million), production equipment ($148,470), and storage and other infrastructure ($118,488). This includes water allocation of $771,056 at an assumed cost of $1,500 per ML (RFM, 2021).
- Assuming the crop rotation with mungbean is wheat, the break-even point for the example mungbean farm, at the current assumed weighted average price of $929 per tonne is December 2023. Under this scenario, the assumed price for wheat is $421 per tonne.
- The mungbean farm will return positive discounted cash flows from FY2024, with intermittent negative discounted cash flows which correspond with the capital replacement program.
- The long-term growth rate for agricultural farm values is 12.50%, with an NPV of the farm at $0 the implied internal rate of return is 12.7%. The terminal value of the example farm with rotational cropping at the conclusion of the analysis (FY2041) is $34.9 million (undiscounted).

By FY2041 the NPAT of the farm is estimated to be $53,171 and the EBITDA is estimated to be $92,913. Figure ES. 27 shows that the impact of both depreciation and tax expenses have a significant impact to the profitability of the farm for the landholder.

Figure ES. 27. Mungbean Operating Profit (FY2022 – FY2041)



Source: AEC (2022).

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 Central Queensland, which is 12.50% (HTW, 2022).

With an NPV of the farm at $0 the implied internal rate of return is 12.7%. The terminal value of the example farm with rotational cropping at the conclusion of the analysis (FY2041) is $34.9 million (undiscounted). The return implies that the investment will exceed the long-term growth rate in value over time and is a commercially viable investment.

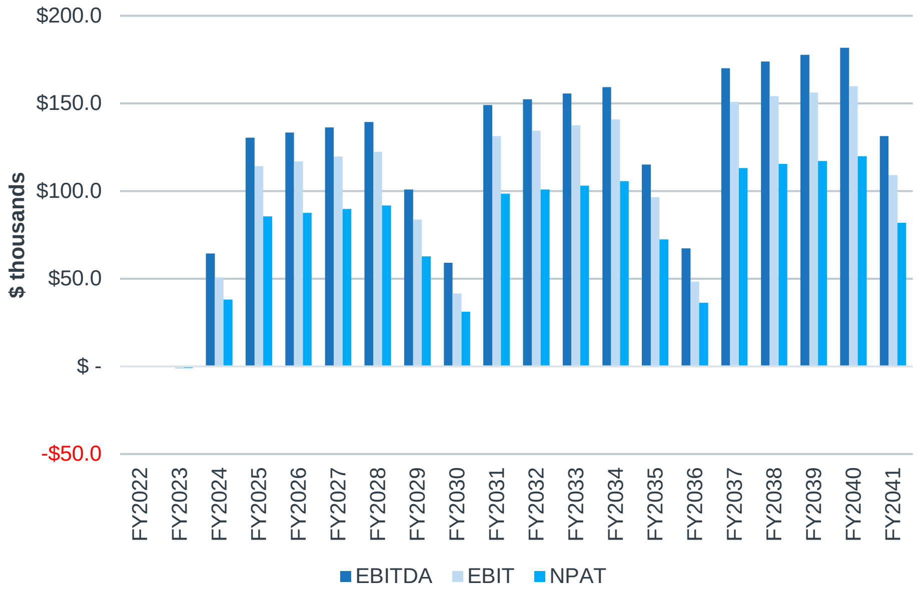
Lucerne

The key guiding outcomes of the financial analysis for a 48.0ha farm are:

- The anticipated initial capital investment for a rotational cropping farm is $1.1 million – including, land clearing and water allocation ($1.1 million), irrigation infrastructure and equipment ($4.6 million), production equipment ($148,470), and storage and other infrastructure ($118,488). This includes water allocation of $771,056 at an assumed cost of $1,500 per ML (RFM, 2021).
- Assuming the crop rotation with lucerne is wheat, the break-even point for the example lucerne farm, at the current assumed weighted average price of $6.80 per bale is November 2023. Under this scenario, the assumed price for wheat is $421 per tonne.
- The lucerne farm will return positive discounted cash flows from FY2024.
- The long-term growth rate for agricultural farm values is 12.5%, with an NPV of the farm at $0 the implied internal rate of return is 13.4%. The terminal value of the example farm with rotational cropping at the conclusion of the analysis (FY2041) is $46.1 million (undiscounted).

By FY2041 the NPAT of the farm is estimated to be $81,873 and the EBITDA is estimated to be $131,307. Figure ES. 28 shows that the impact of both depreciation and tax expenses have a significant impact to the profitability of the farm for the landholder.

Figure ES. 28. Lucerne Operating Profit (FY2022 – FY2041)



Source: AEC.

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 Central Queensland, which is 12.5% (HTW, 2022)

With an NPV of the farm at $0 the implied internal rate of return is 13.4%. The terminal value of the example farm with rotational cropping at the conclusion of the analysis (FY2041) is $546.1 million (undiscounted). The return implies that the investment will exceed the long-term growth rate in value over time and is a commercially viable investment.

ECONOMIC IMPACT

Investment in a farm enterprise will have an economic contribution to the Fitzroy region, and more broadly Central Queensland. Economic modelling in this section estimates the economic activity supported by the farm establishment and operations. Input-Output modelling is used to examine the direct and flow-on[2] activity expected to be supported within the Rockhampton local government area (LGA).

Soybean

Initial capital investment of the farm is anticipated to cost approximately $2.7 million, not including the purchase of land and the purchase of water entitlements (both of which are not contributing factors of the economic impact), or the impact of price escalation over time. Capital investment and operation of the farm is anticipated to directly contribute to $1.9 million in industry output (i.e. revenues) to local businesses within the Rockhampton LGA.

A further $1.2 million in industry output is estimated to be supported in the catchment's economy through flow-on activity, including $0.7 million in production induced (i.e. supply chain) activity and $0.5 million through household consumption induced activity (i.e. expenditure of households within the local economy as a result of a lift in household incomes).

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

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

Impact	Output ($M)	Gross Regional Product ($M)	Incomes ($M)	Employment (FTEs)
Direct	$1.9	$0.8	$0.6	8
Production Induced	$0.7	$0.3	$0.2	2
Consumption Induced	$0.5	$0.3	$0.2	2
Total	**$3.1**	**$1.4**	**$1.0**	**12**

Note: Figures may not add due to rounding.
Source: ABS (2012), ABS (2017b), ABS (2021b, c and d), AEC.

Chickpea

Initial capital investment of the farm is anticipated to cost approximately $4.1 million, not including the purchase of land and the purchase of water entitlements (both of which are not contributing factors of the economic impact), or the impact of price escalation over time. Capital investment and operation of the farm is anticipated to directly contribute to $3.0 million in industry output (i.e. revenues) to local businesses within the Rockhampton LGA.

A further $1.8 million in industry output is estimated to be supported in the catchment's economy through flow-on activity, including $1.0 million in production induced (i.e. supply chain) activity and $0.8 million through household consumption induced activity (i.e. expenditure of households within the local economy as a result of a lift in household incomes).

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

Impact	Output ($M)	Gross Regional Product ($M)	Incomes ($M)	Employment (FTEs)
Direct	$3.0	$1.2	$1.0	12
Production Induced	$1.0	$0.5	$0.3	4
Consumption Induced	$0.8	$0.5	$0.2	3
Total	**$4.8**	**$2.2**	**$1.5**	**19**

Note: Figures may not add due to rounding.
Source: ABS (2012), ABS (2017b), ABS (2021b, c and d), AEC.

Mungbean

Initial capital investment of the farm is anticipated to cost approximately $3.6 million, not including the purchase of land and the purchase of water entitlements (both of which are not contributing factors of the economic impact), or the impact of price escalation over time. Capital investment and operation of the farm is anticipated to directly contribute to $2.6 million in industry output (i.e. revenues) to local businesses within the Rockhampton LGA.

A further $1.6 million in industry output is estimated to be supported in the catchment's economy through flow-on activity, including $0.9 million in production induced (i.e. supply chain) activity and $0.7 million through household consumption induced activity (i.e. expenditure of households within the local economy as a result of a lift in household incomes).

Table ES. 4. Economic Activity Supported by a Mungbean Enterprise, Rockhampton LGA

Impact	Output ($M)	Gross Regional Product ($M)	Incomes ($M)	Employment (FTEs)
Direct	$2.6	$1.1	$0.8	10
Production Induced	$0.9	$0.4	$0.3	3
Consumption Induced	$0.7	$0.4	$0.2	3
Total	**$4.2**	**$1.9**	**$1.3**	**16**

Note: Figures may not add due to rounding.
Source: ABS (2012), ABS (2017b), ABS (2021b, c and d), AEC.

Lucerne

Initial capital investment of the farm is anticipated to cost approximately $5.0 million, not including the purchase of land and the purchase of water entitlements (both of which are not contributing factors of the economic impact), or the impact of price escalation over time. Capital investment and operation of the farm is anticipated to directly contribute to $3.6 million in industry output (i.e. revenues) to local businesses within the Rockhampton LGA.

A further $2.2 million in industry output is estimated to be supported in the catchment's economy through flow-on activity, including $1.2 million in production induced (i.e. supply chain) activity and $1.0 million through household consumption induced activity (i.e. expenditure of households within the local economy as a result of a lift in household incomes).

Table ES. 5. Economic Activity Supported by a Lucerne Enterprise, Rockhampton LGA

Impact	Output ($M)	Gross Regional Product ($M)	Incomes ($M)	Employment (FTEs)
Direct	$3.6	$1.5	$1.2	14
Production Induced	$1.2	$0.5	$0.4	4
Consumption Induced	$1.0	$0.5	$0.3	4
Total	**$5.8**	**$2.6**	**$1.8**	**22**

Note: Figures may not add due to rounding.
Source: ABS (2012), ABS (2017b), ABS (2021b, c and d), AEC.

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GLOSSARY OF TERMS

Term	Definition
AANZFTA	ASEAN Australia New Zealand Free Trade Agreement
ACIAR	Australian Centre for International Agricultural Research
AEC	AEC Group Pty Ltd
AFIA	Australian Fodder Industry Association
ANSB	Australian National Soybean Breeding
AUSFTA	Australia-United States FTA
CAGR	Compound annual growth rate
CET	Common External Tariff
CPTPP	Comprehensive and Progressive Agreement or Trans-Pacific Partnership
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAF	Department of Agriculture and Fisheries
EBIT	Earnings before interest and tax
FTA	Free Trade Agreement
FY	Financial year
GCC	Gulf Cooperation Council
GM	Genetically Modified
GRDC	Grains Research and Development Corporation
Ha (ha)	Hectares
HTW	Herron Todd White
KAFTA	Korea-Australia Free Trade Agreement
Km	Kilometres
KORUS-FTA	United States-Korea Free Trade Agreement
MFN	Most Favoured Nation
ML	Megaliters
NAFTA	Northern American Free Trade Agreement
non-GMO	Non genetically modified
NPAT	Net Profit After Tax
NPBT	Net Profit Before Tax
NSW	New South Wales
NSW DPI	New South Wales Department of Primary Industries
QLD	Queensland
RCEP	Regional Comprehensive Economic Partnership
RFM	Rural Funds Management
RLEM	Red legged Earth Mite
ROCE	Return on Capital Employed
RWGP	Rookwood Weir Grants Program
USMCA	United States-Mexico-Canada Agreement
WAR	Winter activity rating

1. INTRODUCTION

1.1 BACKGROUND

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

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

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

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

Rockhampton Regional Council and Advance Rockhampton are co-ordinating the Rookwood Weir 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 soybeans, chickpeas ad mungbeans.

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 soybeans, chickpeas and mungbeans 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 forward looking estimates based on publicly available information, engagement with key stakeholders and where available, additional non-public data supplied by the respective industry associations and market players. The analysis also includes commentary on the growing conditions and requirements for commercial soybean, chickpea and mungbean 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 as one of four 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 includes a chapter for soybeans, chickpeas and mungbeans and lucerne, with the report structured as follows for each commodity:

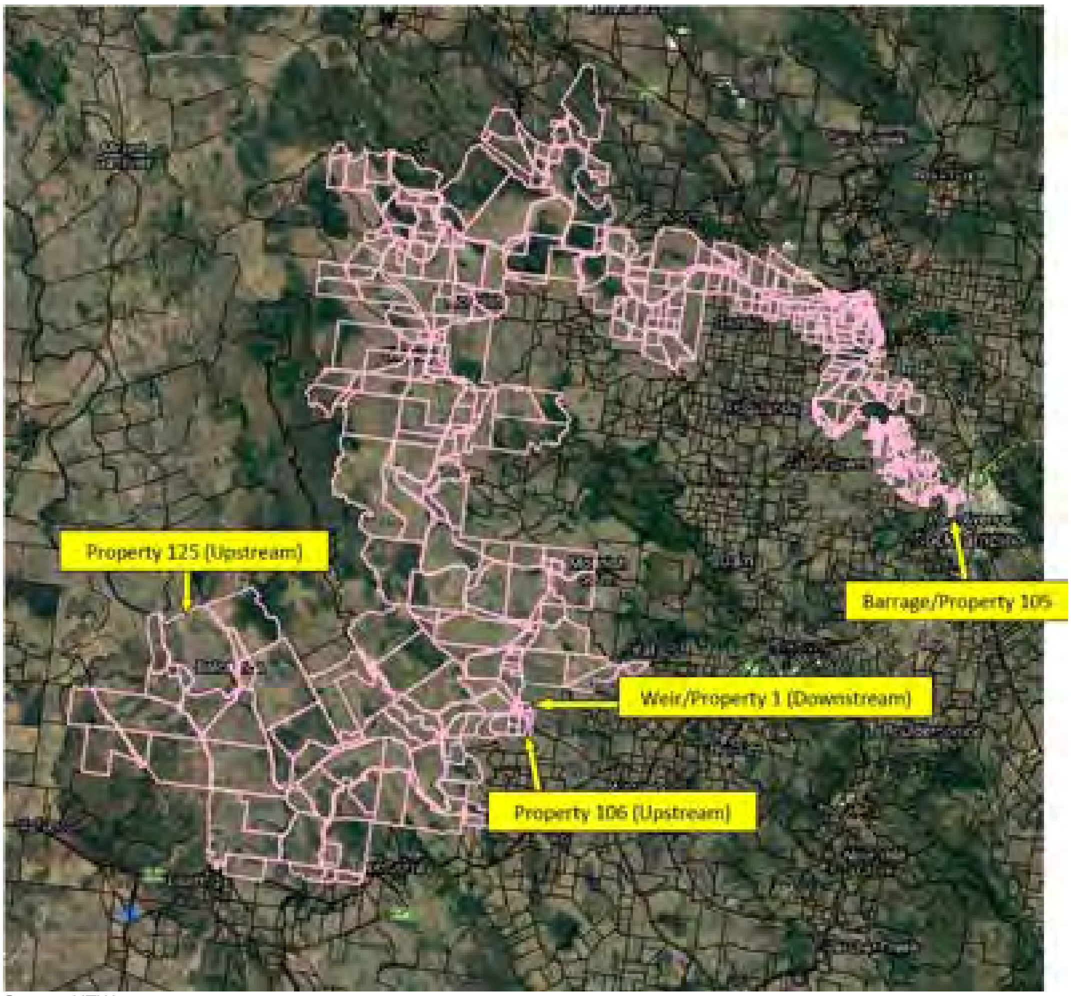
Source: AEC.

1.4 ROOKWOOD WEIR CATCHMENT AREA

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

The Rookwood Weir Catchment Area, for the purpose of our assessment, has been defined as the property holdings 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



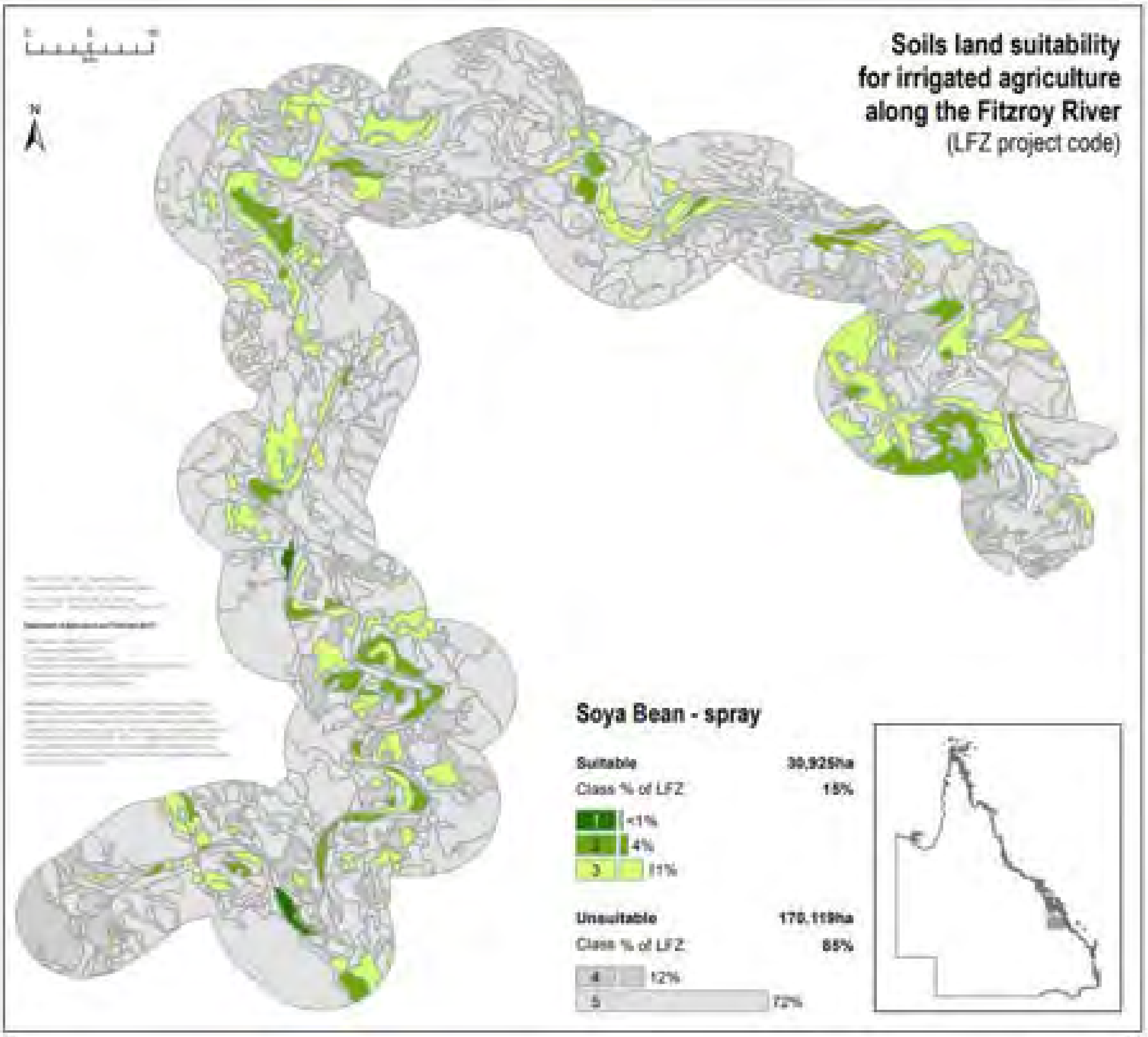
Source: HTW.

1.4.1 Land Suitability for Legume Production

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

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

Figure 1.2. Land Suitability for Soybean, Fitzroy River

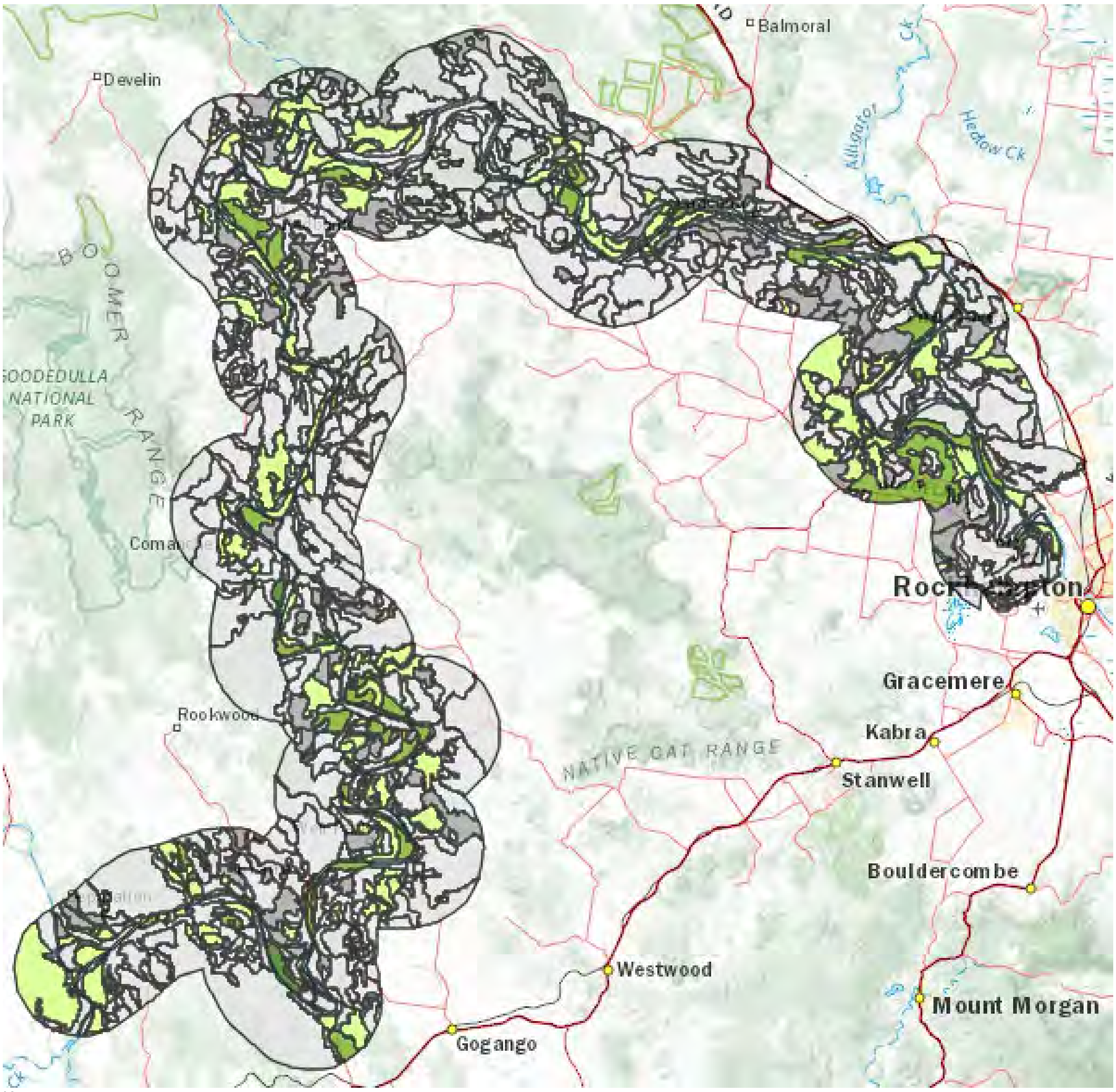


Source: Queensland Government (2021).

Based on the identified area, the maximum suitable land area that could be used to produce soybeans using spray irrigation is 30,925 hectares, of which, around 9,169 hectares was identified as Class 1 or Class 2 agricultural land. The majority of this land contains vertosols and cracking clay soils that are suitable for soybean production, with good water holding and nutrient storage capacity.

However, when taking into account the land's slope, another critical element in assessing crop suitability, the total land available for soybeans reduces to approximately 23,253 hectares (HTW, unpublished).

Figure 1.3. Land Suitability for Chickpea, Fitzroy River



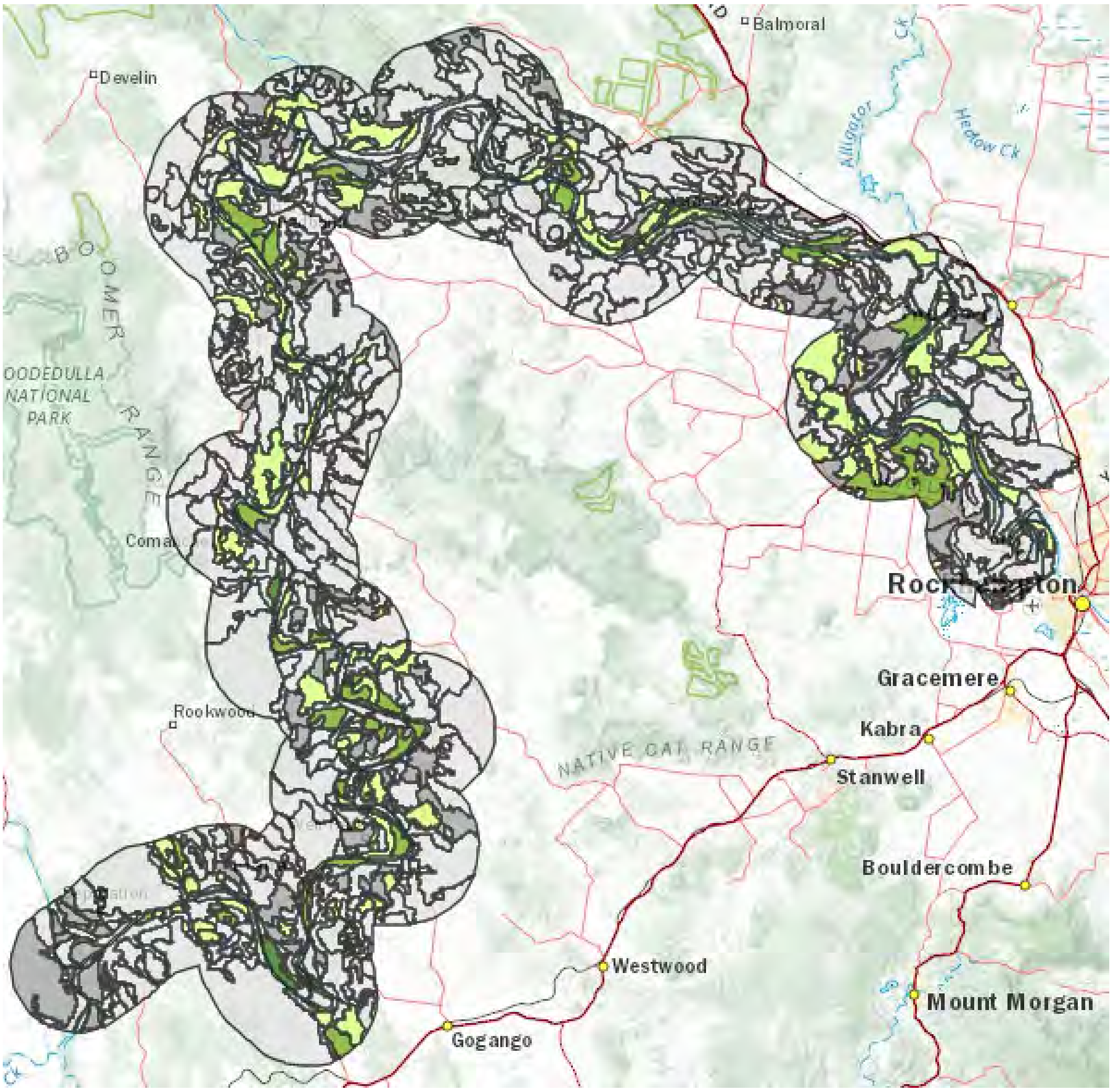
Key:

- Class 1—Suitable land with negligible limitations (dark green)
- Class 2—Suitable land with minor limitations (mid green)
- Class 3—Suitable land with moderate limitations (light green)
- Class 4—Marginal land which is presently unsuitable due to severe limitations (dark grey)
- Class 5—Unsuitable land with extreme limitations (light grey)

Source: DAF (2022)

When taking into account the land's slope, another critical element in assessing crop suitability, the total land available for chickpeas reduces to approximately 28,417 hectares (HTW, unpublished).

Figure 1.4. Land Suitability for Mungbeans, Fitzroy River



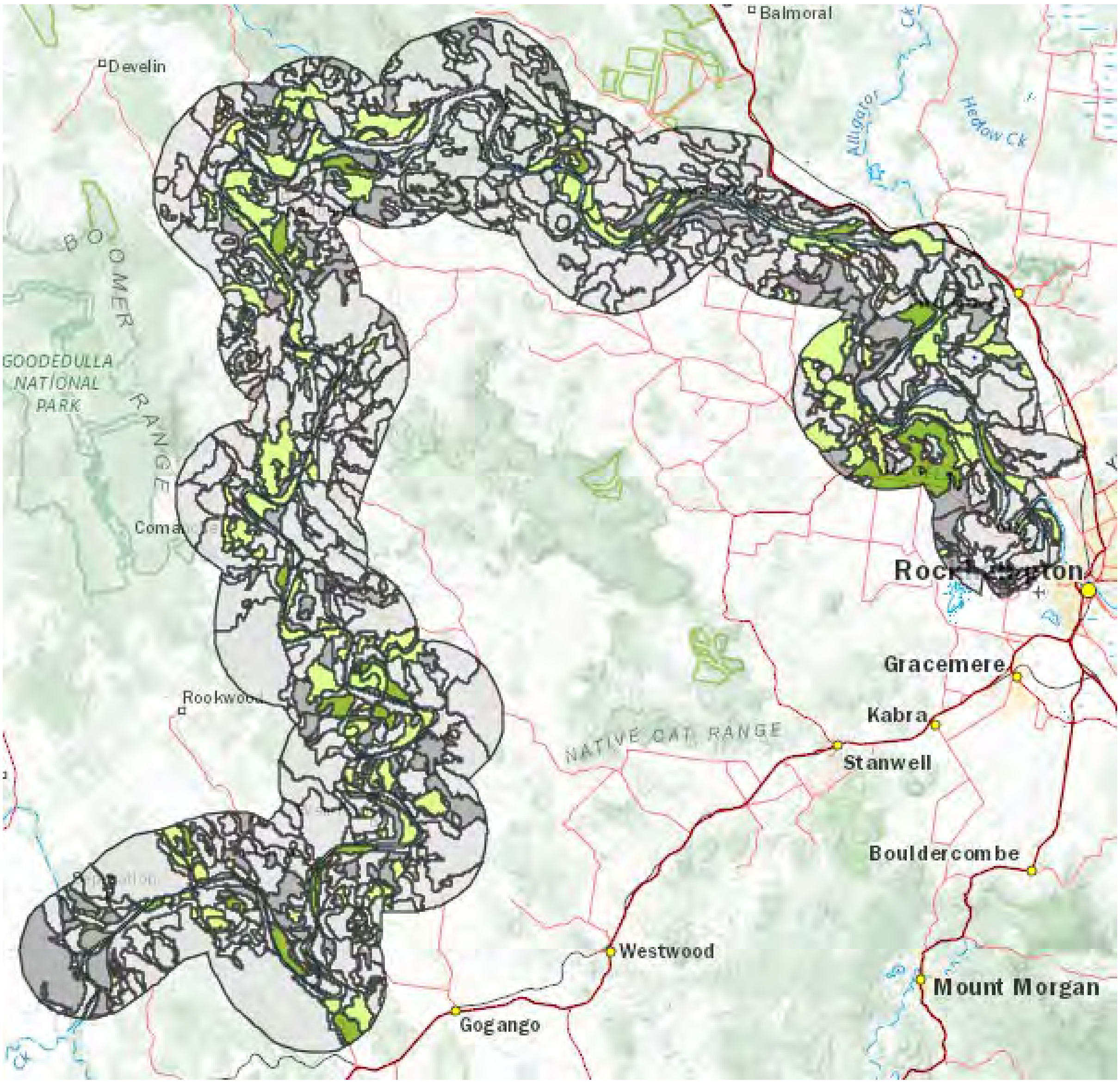
Key:

- Class 1—Suitable land with negligible limitations (dark green)
- Class 2—Suitable land with minor limitations (mid green)
- Class 3—Suitable land with moderate limitations (light green)
- Class 4—Marginal land which is presently unsuitable due to severe limitations (dark grey)
- Class 5—Unsuitable land with extreme limitations (light grey)

Source: DAF (2022)

When taking into account the land's slope, another critical element in assessing crop suitability, the total land available for mungbeans reduces to approximately 23,079 hectares (HTW, unpublished).

Figure 1.5. Land Suitability for Lucerne, Fitzroy River



Key:

- Class 1—Suitable land with negligible limitations (dark green)
- Class 2—Suitable land with minor limitations (mid green)
- Class 3—Suitable land with moderate limitations (light green)
- Class 4—Marginal land which is presently unsuitable due to severe limitations (dark grey)
- Class 5—Unsuitable land with extreme limitations (light grey)

Source: DAF (2022)

When taking into account the land's slope, another critical element in assessing crop suitability, the total land available for lucerne reduces to approximately 23,079 hectares (HTW, unpublished).

2. SOYBEANS

2.1 INTRODUCTION

Soybean is classed as an oilseed and it has been used in China for over 5,000 years as a food and component of pharmaceuticals (AgriFutures, 2011). Today, soybean consumption around the world is primarily driven by the crushing industry, which produces soybean meal and soybean oil.

Soybean meal is primarily used for animal feed and with the growing demand for meat products, the consumption of soybean meal is likely to increase. The growth in soybean meal will likely be more modest compared to historical years due to the slowdown in demand from China from improved feeding efficiencies and lower protein meal feed rations (OECD-FAO, 2021b).

Globally, there is an increase in consumer preferences for healthier foods, driving the demand for soybean derivatives such as soy milk and soy oil (Research and Markets, 2022). Additionally, the demand for dairy alternatives have been driving the soybean market (EMR, 2021).

Historically, global soybean production has been growing at substantial rates, increasing by more than six-fold to reach a total of 353.5 million tonnes in 2020. Growth is expected to soften through to 2030 with production estimated to total 411.1 million tonnes.

Although soybean is a native legume to East Asia, global production is dominated by Brazil and the United States of America (USA). Combined, these two countries accounted for 66.3% of global production in 2020 with this share expected to remain constant into 2030. Brazil and the USA also dominate the export market, accounting for 85.7% of total global exports in 2020. Although the USA and Brazil are significant producers and exporters of soybean, their product is largely suited for crushing.

Australia's production volumes are dwarfed by that of the USA and Brazil, with Australia accounting for 0.005% of total production in 2020. In 2020, Australia produced 17,288 tonnes of soybeans with strong growth in production expected to 2030, reaching an estimated 44,097 tonnes (OECD-FAO, 2021a). Although Australia is a relatively small player in the global market, Australia holds a unique position by producing non-GMO soybeans.

There is growing demand from Asian countries including Japan, Indonesia, Taiwan and Singapore for Australian food-grade soybeans (Soy Australia, 2015). The largest suppliers to these countries for food grade soybeans is the USA and Canada (Soy Australia, 2015). Australia does have an opportunity to increase its export market share by offering a premium non-GMO product.

With higher transport costs from the COVID-19 pandemic and further devaluation of the exchange rate, there is expected upward pressure on prices over the next 12 months. Based on continued supply impacts associated with the pandemic and the interest cycle in the USA, Europe and Asia, similar increases are likely to occur in Australia before a return to historical levels occurs.

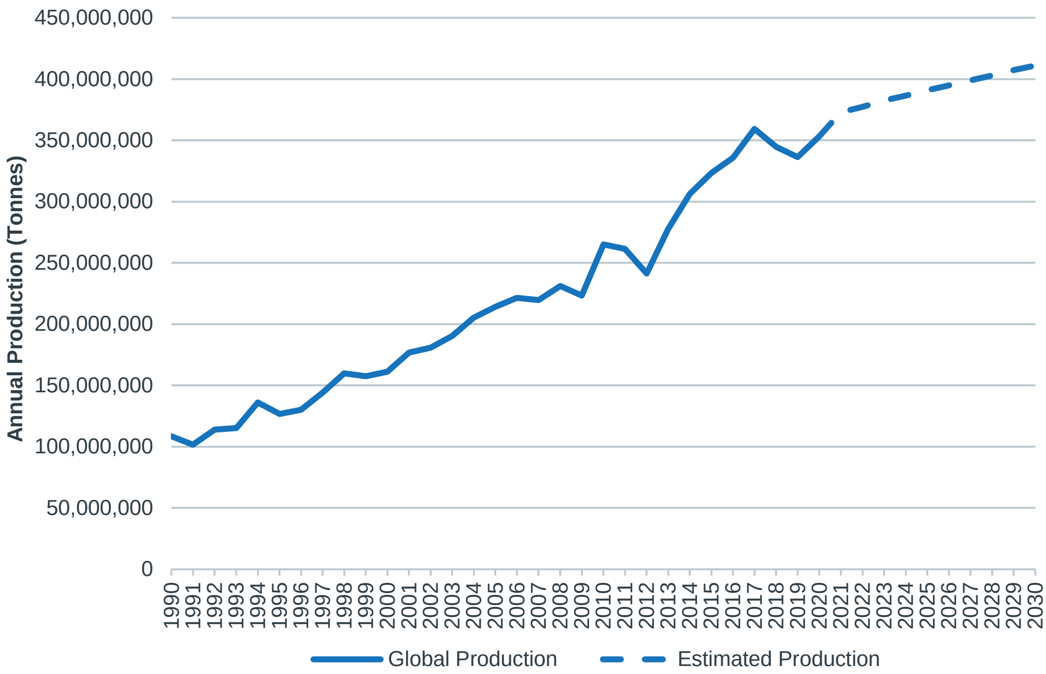
2.2 OVERVIEW OF THE GLOBAL MARKET

2.2.1 Global Production

Global soybean production has been growing by an average annual rate of 4.0% per annum from 1990 to 2020, to reach a total of 353.5 million tonnes in 2020. On the global scale, soybean production experienced a rather sharp increase from 2012 to 2017, increasing by a total of 118.2 million tonnes over the five-year period. This increase was largely driven by a ramp up in production of both Brazil and the USA.

Projections from the *OECD-FAO Agriculture Outlook 2021-2030* indicate that soybean production could increase by an average annual rate of 1.5% from 2020 to 2030. Soybean production is estimated to reach a total of 411.1 million tonnes in 2030. The growth in production to 2030 will largely be driven by an increase in yields, accounting for three quarters of production growth (see Figure 2.2 below).

Figure 2.1 Global Soybean Production, 1990 to 2030

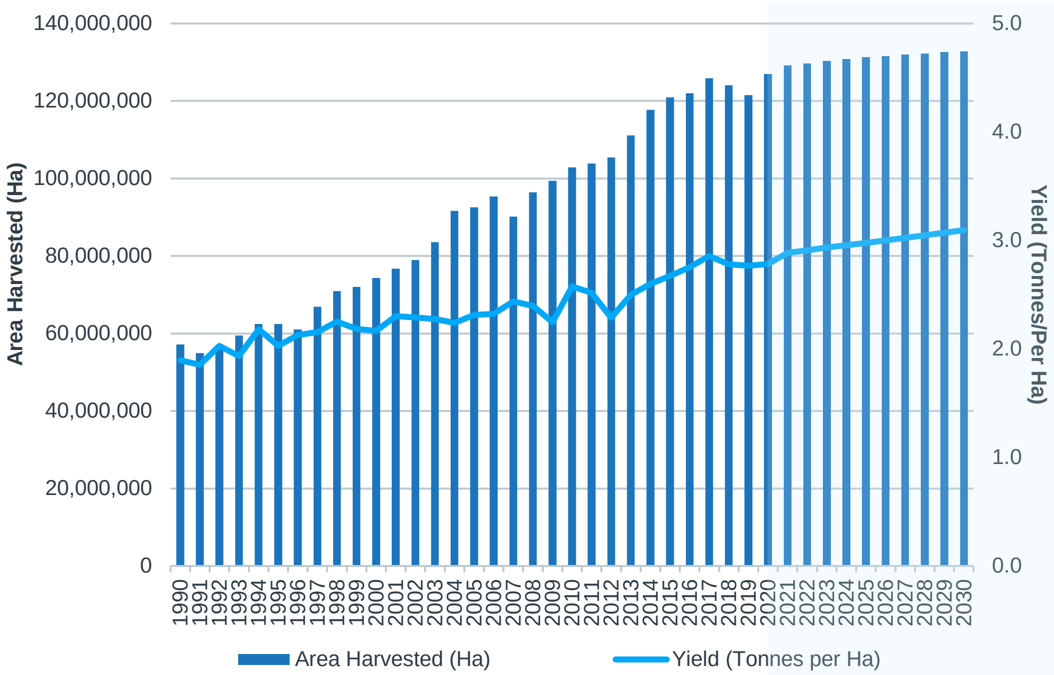


Source: FAOSTAT (2022), OECD-FAO (2021a).

Historically, the soybean harvested area has grown substantially, increasing by 2.7% on average per annum from 1990 to 2020. The harvested area is projected to increase by 0.5% on average per annum (equating by an increase of 5.9 million Ha over the 10-year period). In 2030, it is estimated that the harvested area will total 132.8 million Ha.

Soybeans are a fast-growing crop, providing the potential for double cropping production. The *OECD-FAO Agriculture Outlook 2021-2030* identifies that a large portion of the increase in additional harvested area will be a result of double cropping soybean with wheat in Argentina and maize in Brazil (OECD-FAO, 2021b).

Figure 2.2. Global Area Harvested & Yield, 1990 to 2030



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

2.2.2 Major Producers

In 2020, Brazil was the largest producer of soybeans on the global scale with production totalling approximately 121.8 million tonnes. The second largest producer of soybeans in 2020 was the USA (112.5 million tonnes), followed by Argentina (48.8 million tonnes).

The section below provides more detail about soybean production in Brazil, the USA and Argentina.

Table 2.1. Top 10 Producers of Soybeans, 2019 and 2020

Country	2019		2020	
	Tonnes	Proportion	Tonnes	Proportion
Brazil	114,316,829	34%	121,797,712	34%
USA	96,667,090	29%	112,549,240	32%
Argentina	55,263,891	16%	48,796,661	14%
China	18,100,000	5%	19,600,000	6%
India	13,267,520	4%	11,226,000	3%
Paraguay	8,520,350	3%	11,024,460	3%
Canada	6,145,000	2%	6,358,500	2%
Russia	4,359,956	1%	4,307,593	1%
Bolivia	2,990,845	1%	2,829,356	1%
Ukraine	3,698,710	1%	2,797,670	1%
Other	12,998,800	4%	12,176,142	3%
Total	**336,328,991**	100%	**353,463,334**	100%

Note: Top 10 producers in 2020.
Source: FAOSTAT (2022).

Brazil

Soybeans were initially introduced to Brazil in the early 1880s from the USA and the cultivars that were initially tested were prone to blooming early (Cattelan, A, & Dall'Agnol, A., 2018). This led to the development of unsatisfactory yields as the cultivars were adapted to climates with temperatures near or higher than 30 degrees Celsius. The growing conditions of the USA cultivars meant that until 1980, production of soybean was restricted to the South of Brazil, which is largely a subtropical region (Cattelan, A, & Dall'Agnol, A., 2018). Cultivars were adapted to account for lower altitudes in tropical climates and expansion began to the Midwest and then towards the centre north (Cattelan, A, & Dall'Agnol, A., 2018).

From 1990 to 2020, soybean production in Brazil has experienced rapid growth, increasing by an average annual rate of 6.2%. From 1990, production has increased by more than seven-fold to reach a total of 121.8 million tonnes in 2020.

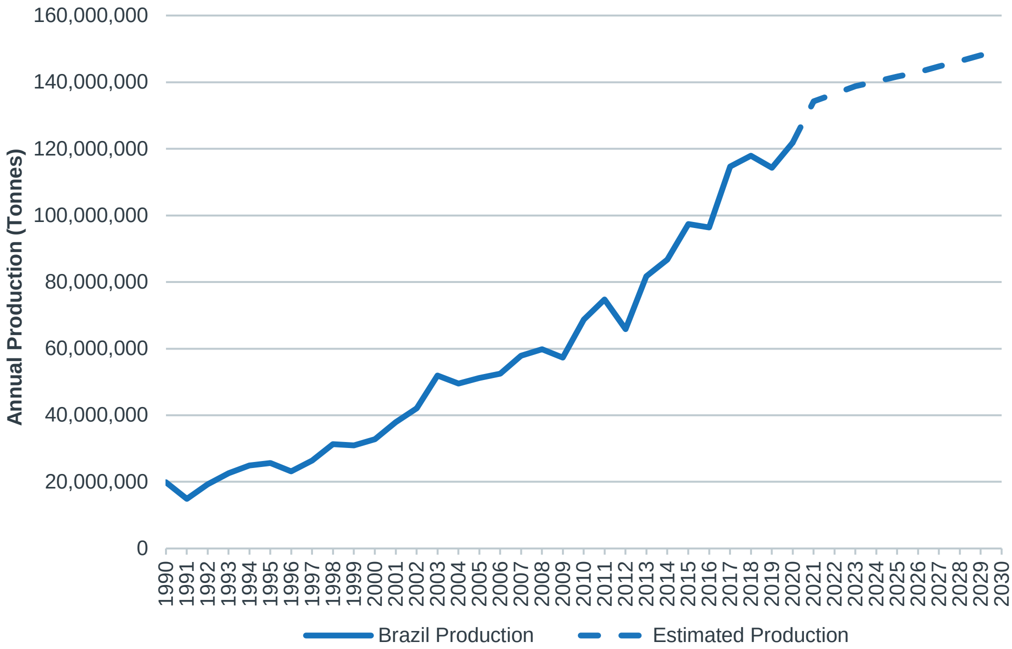
The growth in soybean production in Brazil has trumped that of the USA, who has historically been the largest producer on the global scale. In recent years, currency has impacted the competitiveness of soybeans in the global market. The depreciation of the Brazilian real relative to the USA dollar has provided advantages for Brazil, particularly in the export market (Colussi, J., & Schnitkey, G., 2021). Brazil has several competitive advantages in soybean production, including (Linden, J, 2012):

- A tropical climate encourages and allows the potential for double cropping with other commodities such as maize, sorghum and cotton
- Underutilised land
- Government resources for agricultural research
- Private sector seed research.

Brazil is expected to maintain its position as the largest global producer of soybeans, with production expected to increase by 2.1% on average per annum from 2020 to 2030. In 2030, it is estimated that production will reach a total of 149.3 million tonnes.

Production in Brazil is expected to be stronger than the USA (Brazil's largest competitor), in part due to the potential for increased cropping intensity.

Figure 2.3. Soybean Production in Brazil, 1990 to 2030

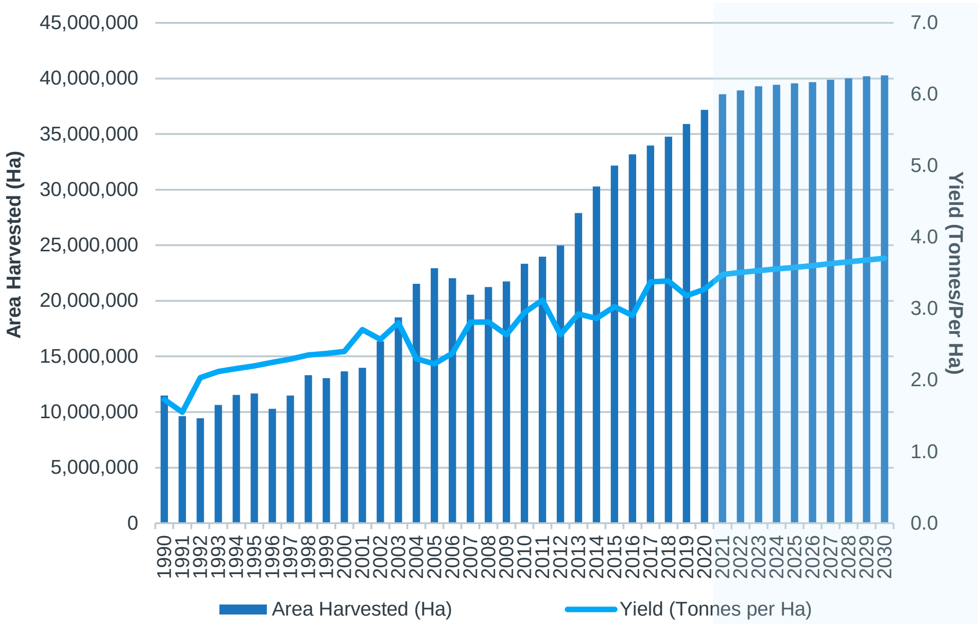


Source: FAOSTAT (2022), OECD-FAO (2021a).

By 2030, it estimated that the total area harvested for soybeans in Brazil will total 40.3 million tonnes. Expansion in soybean area in Brazil over the next 10 years is projected to result from (Colussi, J., & Schnitkey, G., 2021):

- Currently underutilised pasturelands, which are planned to be converted to soybean production
- Soybeans planted in new agricultural frontiers
- Soybeans replacing other lower-value crops in current agricultural area
- The increased utilisation of irrigation, opening additional areas for soybean production.

Figure 2.4. Area Harvested & Yield (Brazil), 1990 to 2030



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

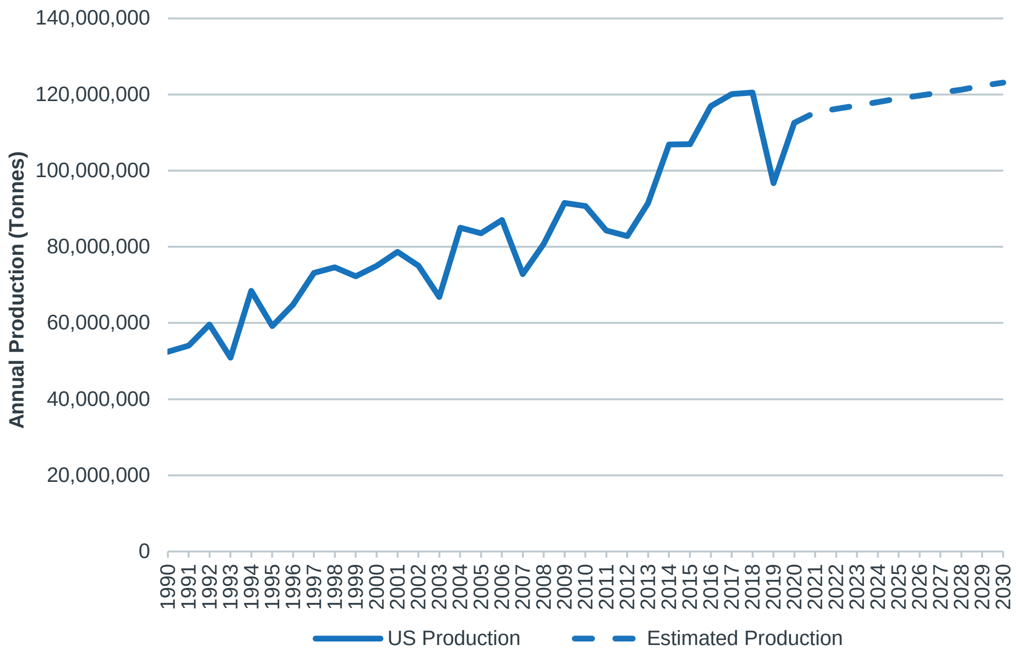
The USA

Historically, the USA has been the largest producer of soybeans on the global scale, until 2019 where Brazil took precedence as the number one producer. From 1990 to 2020, soybean production in the USA has experienced an average annual growth rate of 2.6% to reach a total of 112.5 million tonnes in 2020.

From 2018 to 2019, production in the USA declined by approximately 23.8 million tonnes to reach a six year low of 96.7 million tonnes. The lower production in 2019 was impacted by a number of factors including the above average rainfalls that pushed planting timeframes later in the year (US Soy, 2019). By the end of May 2019, it was reported that the USA had only planted little under 30% of the soybean crop, compared to 74% planting the year before (US Soy, 2019). The typical planting window for soybeans in the USA is from April through to June, however, with many areas receiving nearly double the typical rainfall, fields were saturated and the planting window was pushed back.

Compared to historical growth of soybean production in the USA, growth is projected to soften to 2030. From 2020 to 2030, production is projected to increase by an average annual rate of 0.9% per annum, reaching 123.1 million tonnes. Projected growth in the USA is lower than projected growth in Brazil.

Figure 2.5. Soybean Production in the USA, 1990 to 2030



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

Major soybean producing states in the USA are highlighted in the figure below. Illinois and Iowa are the key soybean producing states in the USA, with a significant portion of land area used for production.

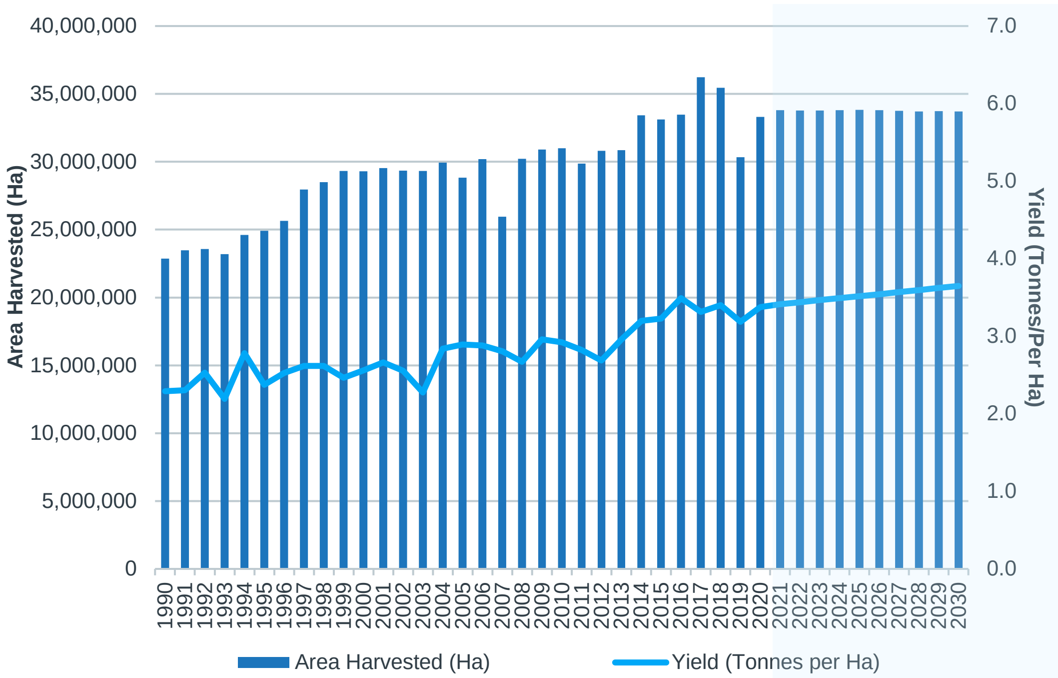
Figure 2.6. Soybean Producing States in the USA

Source: USDA (2019a).

Harvested area in the USA experienced significant decline from 2018 to 2019, decreasing by 5.1 million Ha. As stated previously, this decline was due to the significant rains, pushing back planting windows later in in the year. In 2020, it was estimated that the total harvested area in the USA was 33.3 million Ha, while harvested area in Brazil was estimated to total 37.2 million Ha.

From 2020 to 2030, the harvested area is projected to increase by little over 402,000 Ha. This growth is negligible compared to that of Brazil, which is projected to increase by 3.1 million Ha over the same period of time.

Figure 2.7. Area Harvested & Yield (US), 1990 to 2030



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

Argentina

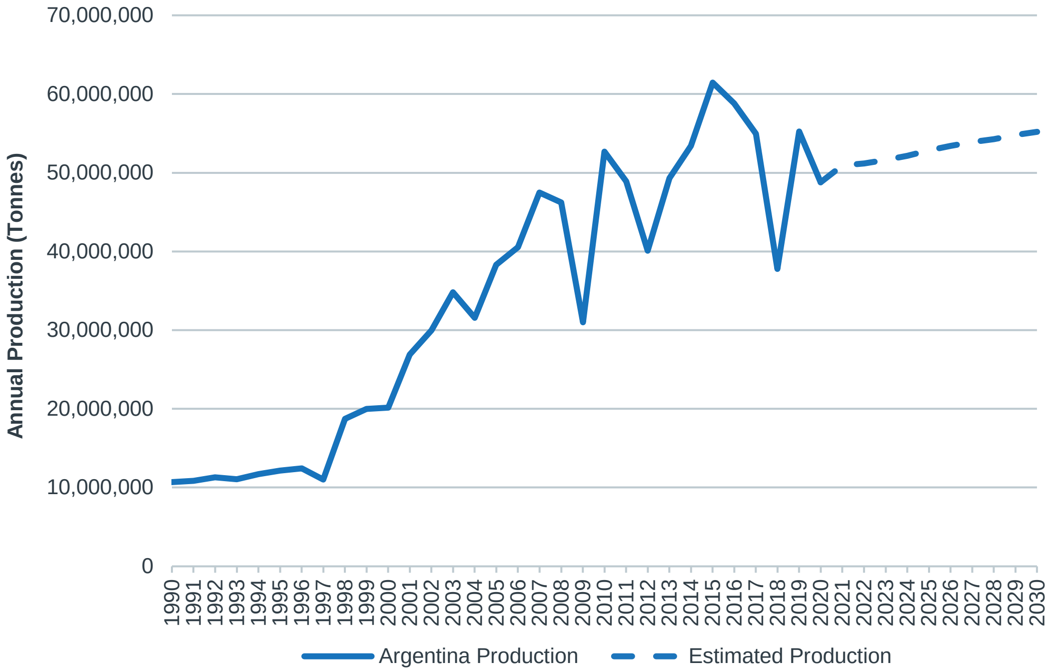
From 1990 to 2020, soybean production in Argentina has experienced rapid growth, increasing by an average annual rate of 5.2%. From 1990, production has more than quadrupled to reach a total of 48.8 million tonnes in 2020. This growth was driven primarily throughout the early 2000s as there was a commodity boom (Dialogo Chino, 2021).

Over the 30-year analysis period, production peaked in 2015 at 61.4 million tonnes. From this peak in production, soybean production experienced a significant decline over the following years to reach 37.8 million tonnes in 2018. Over the period of three years, production declined by 23.7 million tonnes, which was largely driven by agronomic pressures and increased competition from alternative crops including maize, wheat and sunflower (USDA, 2016a).

In 2018, harvested area increased while production and yield declined (see Figure 2.9 below), which was due to a lack of rain combined with high temperatures and heat waves during early 2018 (Bert, F, de Estrada, M., Naumann, G., Negri, R., Podesta, G., de los Milagros Skansi, M., Spennemann, P., & Quesada, M., 2021). The drought that occurred in late 2017 and early 2018 had significant impacts on summer crops, including soybean and maize (Bert, F., de Estrada, M., et al, 2021).

Unlike the USA, Argentina is projected to experience strong growth to 2030, increasing by an average annual rate of 1.2% from 2020 to 2030. This growth equates to an increase of 6.4 million tonnes of soybeans over the 10-year period to reach 55.2 million tonnes in 2030.

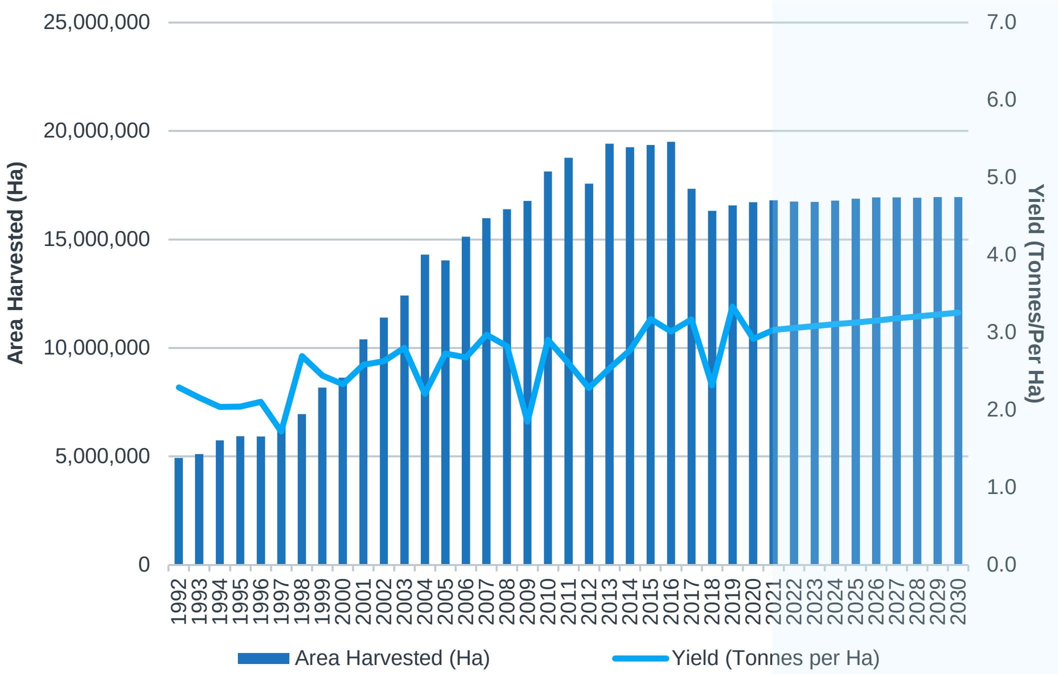
Figure 2.8. Soybean Production in Argentina, 1990 to 2030



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

The increase in production in Argentina is estimated to largely result from an increase in productivity. Harvested area is projected to increase by little over 50,000 Ha to 2030, while yield productivity is projected to increase from 2.9 tonnes per Ha in 2020 to 3.3 tonnes per Ha in 2030.

Figure 2.9. Area Harvested & Yield (Argentina), 1990 to 2030

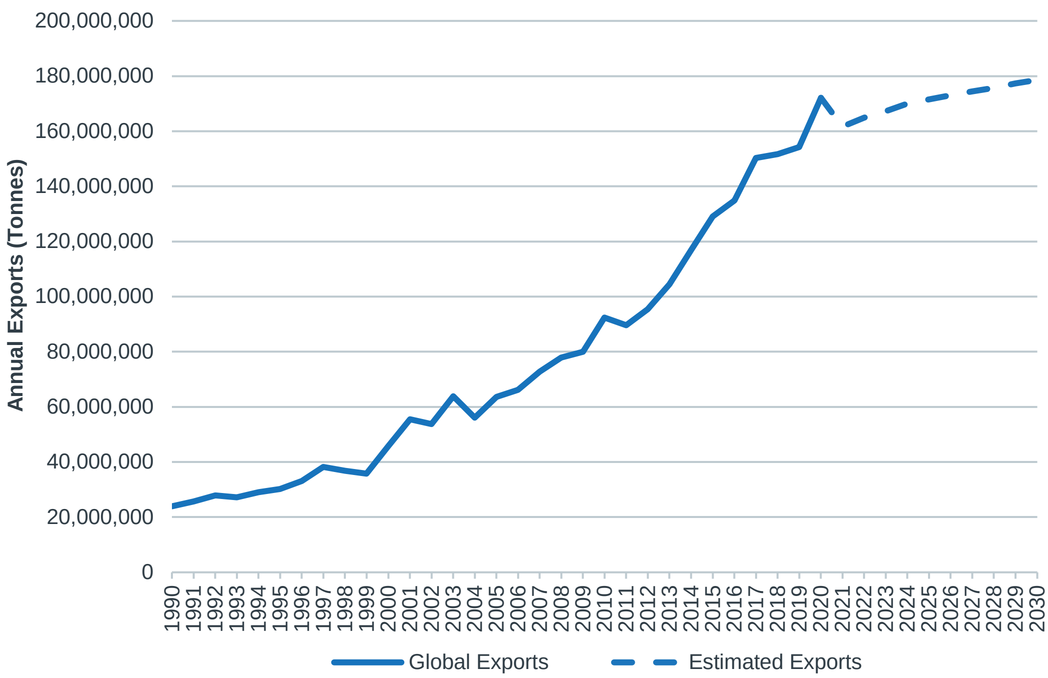


Source: FAOSTAT (2022), OECD-FAO (2021a).

2.2.3 Major Exporters

Global exports of soybean have experienced an average annual growth rate of 6.8% since 1990, totalling 172.1 million tonnes in 2020. It is projected that soybean exports will increase by 0.4% per annum from 2020 to 2030, reaching a total of 178.6 million tonnes in 2030.

Figure 2.10. Global Soybean Exports, 1990 to 2030



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

Historically, the largest exporter of soybeans on the global scale was the USA, until 2017 when Brazil emerged as the largest exporter. Similar to global production, Brazil has experienced rapid growth in soybean exports (growing by an average annual rate of 10.8% from 1990 to 2020). In 2020, it was estimated that Brazil exported a total of 82.9 million tonnes of soybeans.

Brazil's emergence as the largest global exporter is a result from (USDA, 2019b; Colussi, J., & Schnitkey, G., 2021):

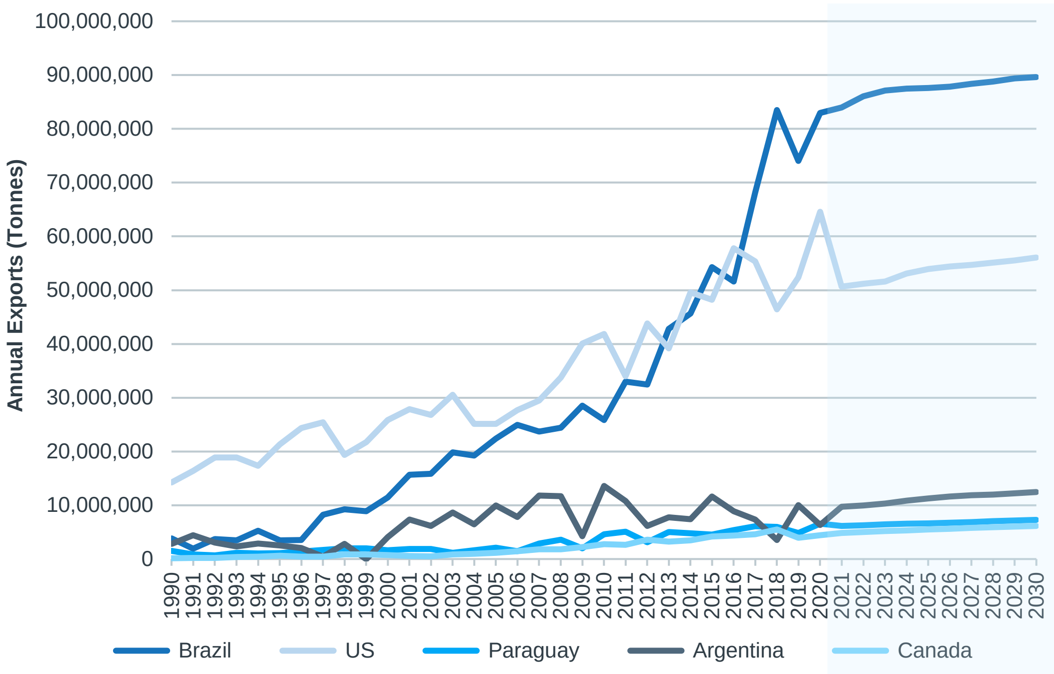
- Increase in production resulting from available land, double cropping and logistical improvements. In the last 10 years, there has been a significant investment in transport infrastructure including roads, railways and waterways. From 2000 to 2010, soybeans that were transported by truck declined from 75% to 67%; rail increased from 20% to 24%; and shipping increased from 5% to nearly 9%.
- Lower production costs in Brazil driven by differences in land rent and the opportunity cost of farm labour. These drivers increased competitiveness between the two countries, with production costs in Brazil totalling $839 USD per Ha while costs in the USA are estimated to total $1,095 USD per Ha on average.

From 2018 to 2019, Brazil experienced a decline in soybean exports of 9.4 million tonnes. The decline was off the back of increasing soybean prices, higher domestic demand and lower inventories (World Grain, 2019). Projections indicate that soybean exports from Brazil will increase by 0.8% on average per annum over the period of 10 years to reach 89.6 million tonnes in 2030.

The second largest exporter in 2020 was the USA, exporting an estimated 64.6 million tonnes. In 2018, soybean exports from the USA experienced a decline to reach a four year low of 46.4 million tonnes. The drop in exports resulted from rising trade tensions between the USA and China, which initially started in 2018. In July 2017, China imposed a 25% tariff on USA soybean imports, resulting in a 23.5 million tonne decline of USA soybean exports to China from 2017 to 2018 (FAOSTAT, 2022). Throughout 2019 and 2020, USA soybean exports to China were once again one the rise, totalling 34.7 million tonnes in 2020 (FAOSTAT, 2022).

The third largest exporter of soybeans on the global scale was Paraguay, exporting an estimated 6.6 million tonnes of soybean in 2020. In 2020, Paraguay exported approximately 60.0% of total production for the year. Of important note, approximately 76.0% of the total exports from Paraguay in 2020 was destined for Argentina.

Figure 2.11. Top Five Global Exporters of Soybeans, 1990 to 2030

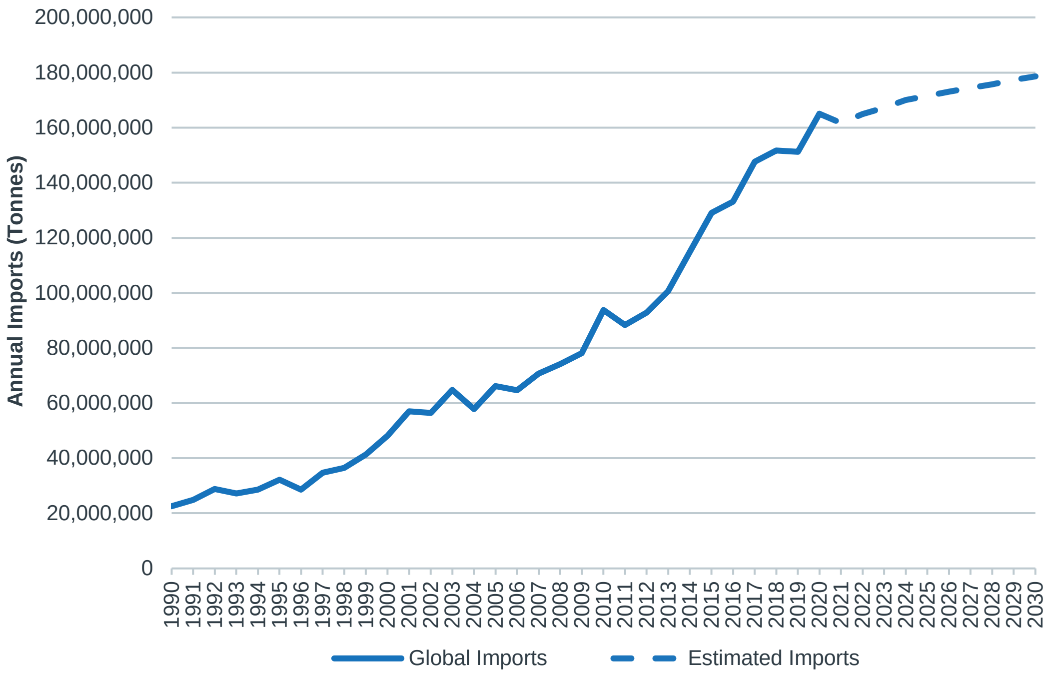


Note: Top five exporters in 2020.
Source: FAOSTAT (2022), OECD-FAO (2021a).

2.2.4 Major Importers

Global imports of soybeans have experienced an average annual increase of 6.9% since 1990, totalling 165.0 million tonnes in 2020. It is projected that soybeans imports will increase by 0.8% per annum from 2020 to 2030, reaching a total of 178.6 million tonnes in 2030.

Figure 2.12. Global Soybean Imports, 1990 to 2030



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

China emerged as the largest importer of soybeans in the early 2000s, with demand for imports experiencing a significant increase. From 1990 to 2020, soybean imports in China have experienced an average annual increase of 47.6%.

In 2020, China accounted for 60.8% of total global soybean imports, importing a total of 100.3 million tonnes. Of important note, China is also the fourth largest producer of soybeans globally, however, their domestic production is not sufficient to meet demand. Resources such as land in China are limited and to produce the quantities required to meet demand would be a difficult task (CGTN, 2019). China was more focused on producing crops that deliver higher net returns including corn, rice and vegetables (USDA, 2019b).

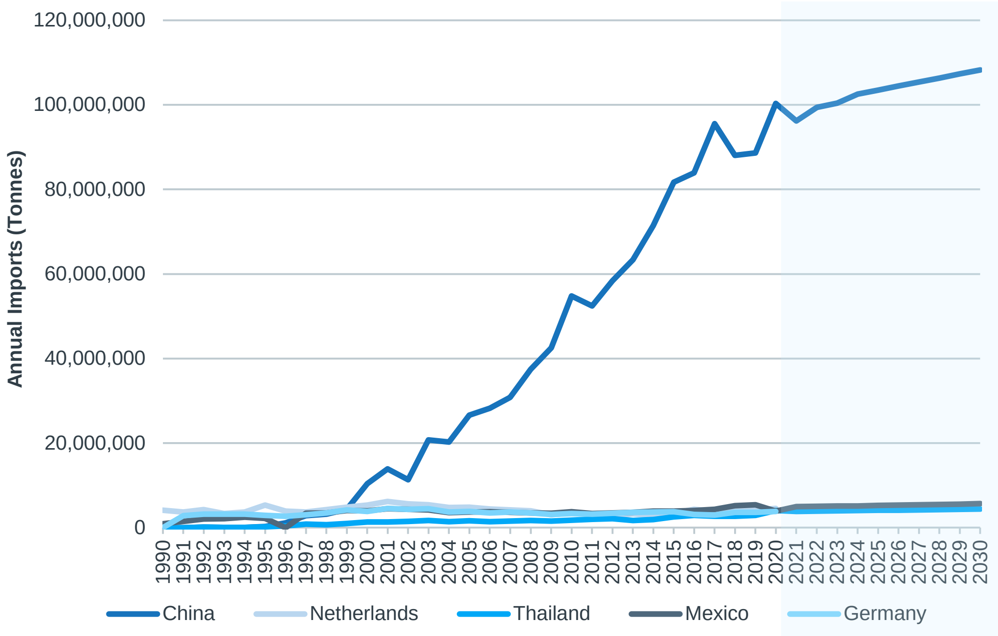
On average from 2010 to 2020, China sourced 53.0% of total soybean imports from Brazil, followed by 33.3% from the USA. China's soybean imports from Brazil experienced significant increase from the 2000s, growing by an average annual rate of 18.6% per annum to 2020. Over the period of 20 years, imports from Brazil increased over 60-fold to total 64.3 million tonnes in 2020. Brazilian soybeans are more attractive to the market in China over USA soybeans due to price advantages and higher protein content, which is suited well for animal feed producers (Reuters, 2018).

Chinese imports of soybeans are largely to support the country's agriculture demand for animal feed, particularly for pigs. In 2018, China's soybean imports experienced a decline due to the outbreak of the African Swine Flu, which saw a significant decline in the country's pig production. China's pig herd is on the road to recovery, with only small outbreaks in October 2020 and January 2021, which has had little impact on the overall industry and subsequent demand for soybeans (ABARES, 2021).

With a significant reliance on imports to satisfy domestic demand, soybeans present a significant supply-chain security and food risk. It was reported that China produced 16.4 million tonnes of soybean in 2021 and have ambitions to raise production by 40% by 2025, to total an estimated 23.0 million tonnes (SCMP, 2022). The projected increase in production volumes will still be dwarfed by import volumes.

In 2030, it is projected that China's soybean imports will increase to 108.2 million tonnes (or approximately 0.8% on average per annum). This projected growth in imports is significantly lower than what has been recorded in the past.

Figure 2.13. Top Five Global Importers of Soybeans, 1990 to 2030



Notes:

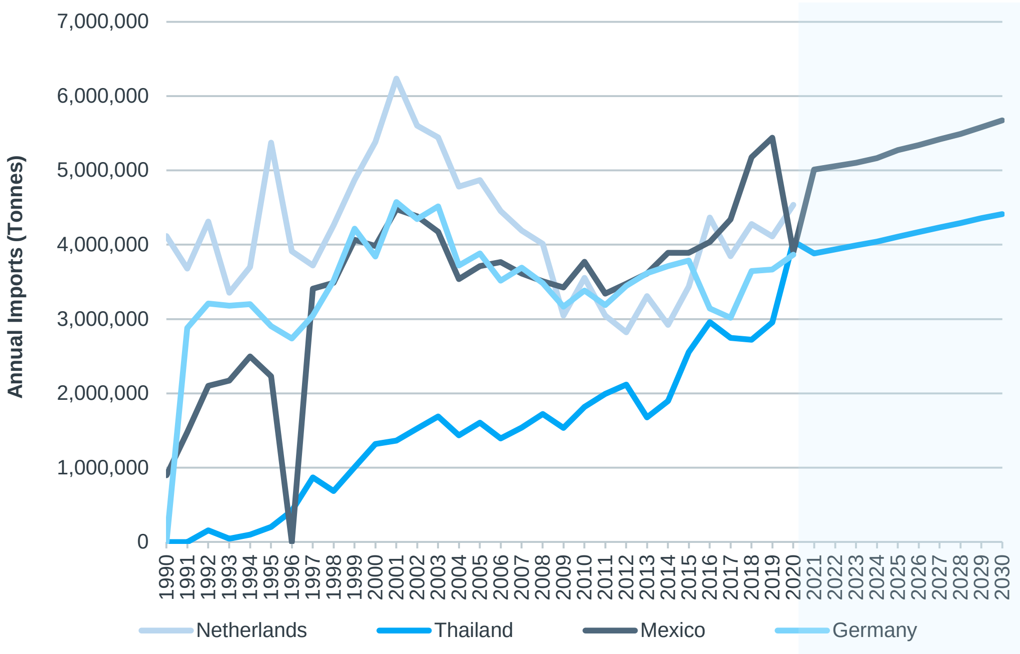
- Top five importers in 2020.
- No projected data available for Germany or the Netherlands.

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

The second largest importer of soybeans in 2020 was the Netherlands, importing a total of 4.5 million tonnes. Soybeans are crucial for the oils and fat industry, the animal feed industry and the food and grocery industry (COE-Resources, 2015). Reports suggest that around one third of soybeans imported into the Netherlands are re-exported to other countries, with the remainder being processed into soybean meal for animal feed and soy oil for human consumption (CBS, 2020).

In 2020, Netherlands sourced approximately 51.7% of total imports from Brazil. The second largest supply market for Netherlands is the USA, with imports from the USA accounting for 34.9% of total imports in 2020. The Netherlands is vulnerable to geopolitical developments for the trade flow of soybeans as they have high import dependence and limited options for alternative sourcing or substitution (COE-Resources, 2015).

Figure 2.14. Remaining Top Four Largest Soybean Importers, 1990 to 2030



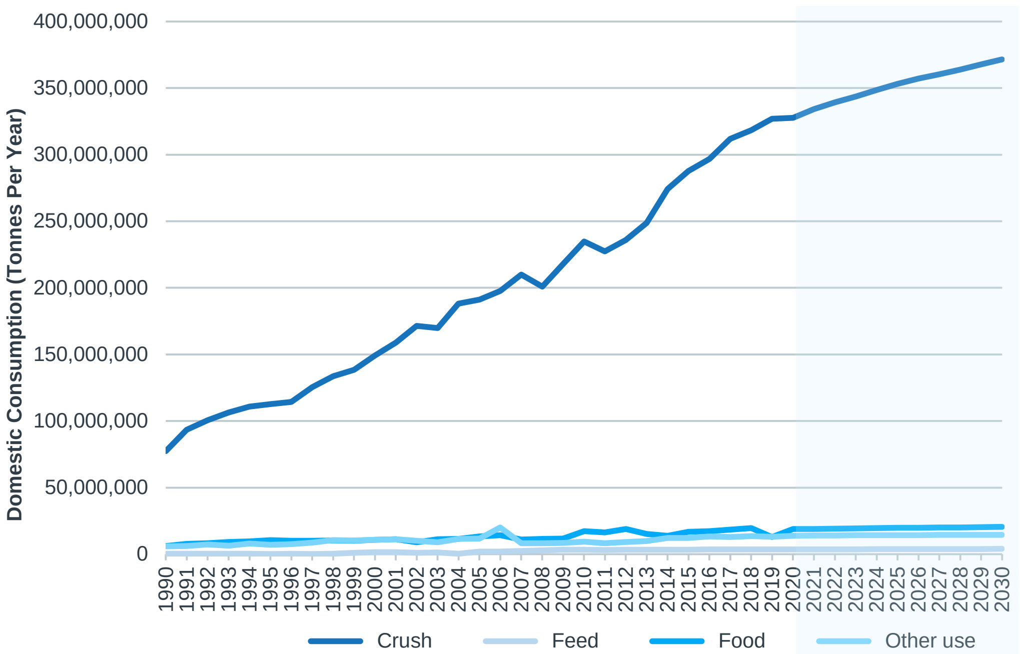
Note: No projection data is available for Germany or the Netherlands.
Source: FAOSTAT (2022), OECD-FAO (2021a).

2.2.5 Global Consumption

The *OECD-FAO Agricultural Outlook 2021-2030* highlights the consumption of soybean from 1990 to 2030, split by consumption type (crush, feed, food, biofuel use and other use). In 2020, it was estimated that 90.0% of total global consumption of soybean was for crush purposes. The second largest consumption of soybean in 2020 was for food purposes, accounting for 5.2% of total global consumption.

Soybean meal is a major source of protein and is largely used for animal feed across the globe. Consumption of crushed soybean (including soybean meal and soybean oil) has increased by 4.9% on average per annum from 1990 to 2020.

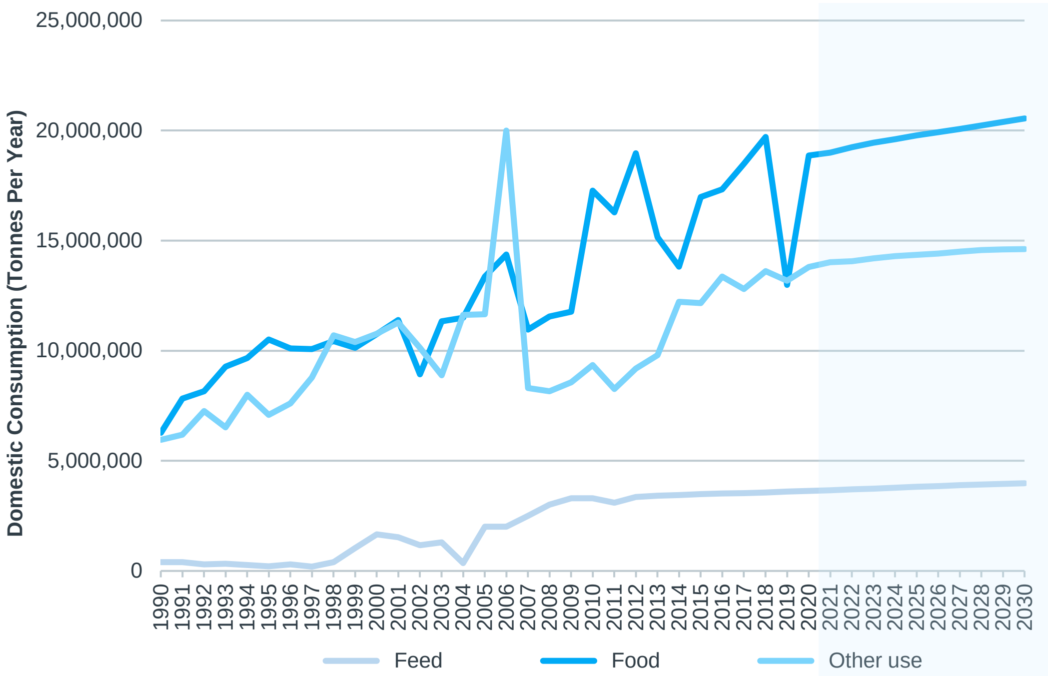
Figure 2.15. Global Soybean Consumption, 1990 to 2030



Source: OECD-FAO (2021a), IMF (2022), OECD (2022).

In 2020, global food consumption was estimated to total 18.9 million tonnes and is projected to increase to 20.5 million tonnes in 2030. The decline in consumption in 2019 coincides with the two-year decline in global production over 2018 and 2019 (23 million tonne production decline from 2017 to 2019) as there is a tightening of the supply and demand situation. Additionally, the COVID-19 pandemic and subsequent lockdowns have impacted on the consumption of soybeans for the purposes of food (FAO, 2020).

Figure 2.16. Global Soybean Consumption, 1990 to 2030



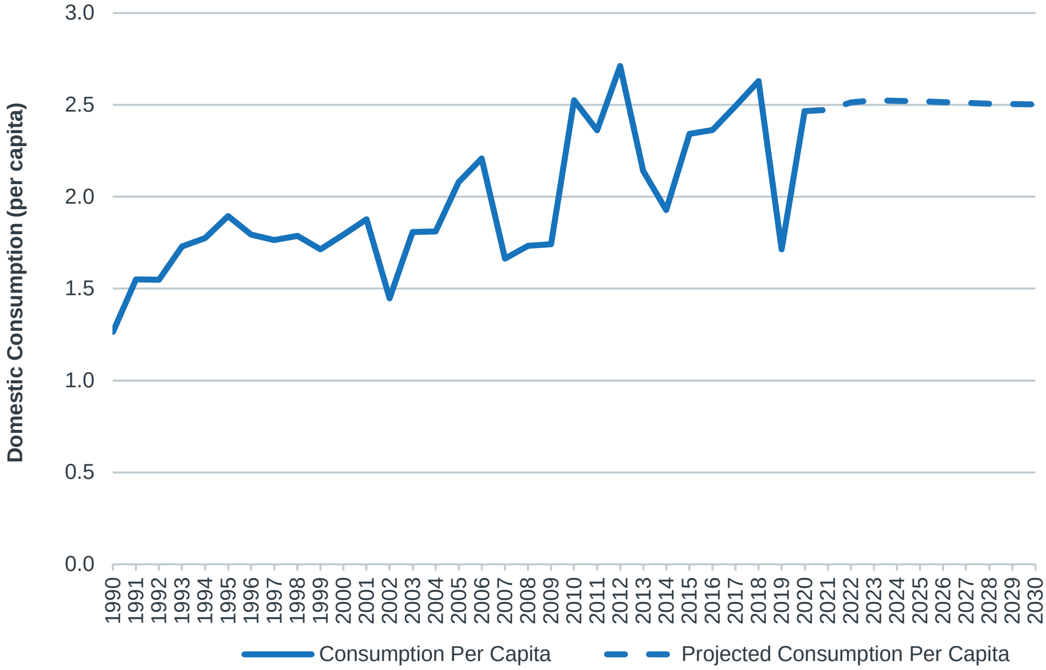
Source: OECD-FAO (2021a), IMF (2022), OECD (2022).

China is the largest consumer of soybeans, with total consumption estimated at 116.6 million tonnes in 2020 (including crush, feed, food, biofuel use and other use) (OECD-FAO, 2021a; USDA FAS, 2022). This far outweighs consumption of other countries, alone representing a 32.0% share of global consumption for the year (USDA FAS, 2022). The strong growth in Chinese consumption is attributable to growth in its use as an input of animal feed for chicken and pigs (of which, livestock numbers are high) and in the culinary market (for use in numerous ingredients such as soy sauce, cooking oil and tofu) (Caixin Global, 2019).

The USA currently sits as the second largest consumer of soybeans with 63.4 million tonnes in 2020 (OECD-FAO, 2021a; USDA FAS, 2022).

Consumption estimates per capita have been developed based on the total food consumption listed above and historical and projected population estimated identified by IMF (2022) and OECD (2022). In 2020, it was estimated that consumption of soybean totalled 2.5 kilograms per capita. As population increases, this is projected to remain at 2.5 kilograms per capita in 2030. As stated above, the volatility in consumption in FY2020 coincides with the tightening of the supply and demand situation and the COVID-19 related lockdowns.

Figure 2.17. Consumption Per Capita, 1990 to 2030 (Kilograms Per Capita)



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

2.2.6 Growth Markets for Soybean

Soybean consumption is primarily driven by the crushing industry, which produces soybean meal and soybean oil. As stated previously, soybean meal is primarily used for animal feed and with the growing demand for meat products, the consumption of soybean meal is likely to increase. Growth in soybean meals will likely be softer compared to historical years, largely due to the slowdown in demand from China due to improved feeding efficiencies and lower protein meal feed rations (OECD-FAO, 2021b).

Additionally, soybean derivatives (such as soy milk and soy oil) are in demand due to consumer preferences for healthier foods (Research and Markets, 2022). The rising consumer preferences around health consciousness and demand for dairy alternatives are driving growth in the soybean market (EMR, 2021).

Europe is a key market for non-GMO and high-protein soybean meal. Historically non-GMO soybean meal to Europe has been supplied by Brazil, however, Brazil is losing market share to European and Indian non-GMO products (Cotecna, 2021). There has also been a reduction in non-GMO soybean production in Brazil in recent years, reducing from 5% of total production in FY2018 to only 2% of total production in FY2021 (Poterra Foundation, 2021).

China continues to be a key growth market for soybeans. Its primary use will be for animal feed and other agricultural functions as it begins to ramp up its recovery of livestock production and rebuilding of the national pig herd in the short to medium term. Imports to the country are projected to grow by 0.8% to 108.2 million tonnes by 2030. While this represents a lower level of growth from the previous decade, it will continue to account for the vast majority of world soybean imports throughout the next decade.

Another growing market for soybeans on the global scale is Mexico. Imports to the country grew by 5.0% per annum from 1990 to 2020, with projections to increase further in the next few years. The drivers of this are mostly also attributable to an increased demand from animal feed. Since a large proportion of Mexican oilseed crushing occurs domestically, crushing processors are also a strong contributor to demand (World Grain, 2020).

2.3 THE AUSTRALIAN SOYBEAN INDUSTRY

2.3.1 Cultivars

With soybean growing regions in Australia spanning a wide range of latitudes and climates across the country, a range of varieties have been developed to suit these respective environments. Each variety has unique appearance attributes, yield expectations and disease immunity. According to the Australian Oilseeds Federation, there are over 25 varieties currently produced for commercial purposes across Australia, as highlighted in the table below.

Table 2.2. Major Australian Soybean Varieties

Variety	Main Growing Region	Soybean Hilum Colour
A6785	Southern QLD and Northern NSW	Buff
Bidgee	Southern NSW	Clear
Bunya	Southern QLD and Northern NSW	Clear
Cowrie	Northern and Inland NSW	Clear
Curringa	Southern NSW and Northern VIC	Buff
Djakal	Southern NSW and Northern VIC	Buff
Empyle	Southern NSW	Buff
Fraser	Southern QLD	Clear
Hale	Inland NSW	Black
Hayman	Tropics to Northern NSW	Clear
Intrepid	Inland NSW	Black
Ivory	Inland NSW	Clear
Jabiru	Southern QLD	Buff
Kuranda	Tropics to Southern QLD	Clear
Leichhardt	Tropics	Brown
Manta	Coastal Northern NSW	Black
Moonbi	Northern NSW	Clear
Oakey	Southern QLD	Clear
Poseidon	Coastal Northern NSW	Black
PR 443	Coastal Northern NSW	Clear
Richmond	Southern QLD and Northern NSW	Clear
Soya 791	Southern QLD and Northern NSW	Buff
Snowy	Southern NSW and Northern VIC	Clear
Stuart	Tropics	Light Grey
Surf	Coastal Northern NSW	Clear
Warrigal	Southern QLD and Northern NSW	Clear
Zeus	Coastal Northern NSW	Black

Source: Soy Australia (undated), GRDC (2016).

In an attempt to develop new varieties that will benefit all sectors of the soybean supply chain in Australia, the Australian National Soybean Breeding (ANSB) Program established in a joint venture between CSIRO, NSW DPI and funded by GRDC. Key objectives of the program are to develop soybean varieties with wider adaptation, yield and agronomic traits and combine these traits with end-user requirements to improve linkages with commercial partners and the wider soybean industry (Soybean Australia, undated). With the introduction of such a program, a greater share of the higher value culinary market can be captured.

Soy Australia has been granted the license to make available specific varieties of soybeans that arise from the ANSB including Kuranda, Mossman and new Nunya, which all have an end point royalty of $8 per tonne (excl. GST) (Soy Australia, 2020). Additionally, Moonbi, Bunya and Snowy have a royalty of $7 per tonne while Stuart has a royalty of $5 per tonne. (Soy Australia, 2020).

While nearly all soybean varieties are highly suitable for end use in the crushing industry for agricultural applications, only select varieties can be utilised for human consumption. This is because edible grade soybeans require higher levels of quality, with strict standards in regard to size, colour and protein levels. As such, only clear or pale coloured hilum varieties are accepted. Soybean varieties with a dark coloured hilum can only be sold for crushing purposes as the colour is not critical to the output (GRDC, 2016).

Soybeans that do not satisfy the superior quality required for soy milk and other high-end culinary applications, but still meet other quality specifications for colour, protein and size, are eligible to be sold into the edible flour market (GRDC, 2016).

Table 2.3. End Market Suitability of Australian Soybean Varieties

Variety	Crush/Full Fat	Flour Milling	Soy Milk	Culinary
A6785	High	Medium	Medium	Low
Bidgee	High	High	High	High
Bunya	High	High	Medium	High
Cowrie	High	High	Medium	Medium
Curringa	High	High	Medium	Medium
Djakal	High	High	Medium	Medium
Empyle	High	Medium	Medium	Medium
Fraser	High	High	Low	Low
Hale	High	Low	Not Suitable	Not Suitable
Hayman	High	High	Medium	High
Intrepid	High	Low	Not Suitable	Not Suitable
Ivory	High	High	Low	Low
Jabiru	High	High	Medium	Low
Kuranda	High	High	Medium	Medium
Leichhardt	High	Low–Medium	Low	Low
Manta	High	Low	Not Suitable	Not Suitable
Moonbi	High	High	Medium	Medium
Oakey	Medium	Medium	Not Suitable	Not Suitable
Poseidon	High	Low	Not Suitable	Not Suitable
PR 443	High	High	Medium	Medium
Richmond	High	High	Medium	Medium
Soya 791	High	High	High	Medium
Snowy	High	High	High	High
Stuart	High	High	Medium	Medium
Surf	High	High	Medium	Low
Warrigal	High	High	Medium	Low
Zeus	High	Low	Not Suitable	Not Suitable
Classification	Low	Medium	High	Not Suitable

Source: Soy Australia (undated).

2.3.2 Australian Soybean Production

Up until the early 1990s, around 75% of the Australian soybean crop was crushed for meal and oil, with a third of this going into full fat meal for intensive livestock. The remaining quarter of production accounted mostly for human consumption and small quantities kept for planting seed, with very little quantity for export.

Since the turn of the millennium, there has been a decline in the crush and full fat segments and an increasing share allocated to human consumption and sold in export markets. In FY2009, both crush and full fat accounted for just over half of total production in Australia, with around 35% for human consumption and 10% bound for export (Soy Australia, 2011). The main contributor to this shift has been higher available returns from culinary markets, facilitated by availability of new varieties targeted at producing higher quality product (Soy Australia, 2015).

In Australia, soybean is a valuable summer crop that is largely grown in rotation for both cereal and sugarcane farming (Soy Australia, 2011). Due to the rotational nature of the crop in Australia, soybean production is largely based on global commodity markets and weather conditions (Soy Australia, 2011). On the global scale, Australia is a very small producer, accounting for only 0.005% of total global production in 2020.

From 1990 to 2020, soybean production in Australia has been experiencing a declining trend, decreasing by an average annual rate of 4.9% per annum. Over the 30-year analysis period, soybean production has been rather volatile. Production experienced a peak in 1999 at a total of 107,179 tonnes, declining to a low of 9,212 tonnes in 2003.

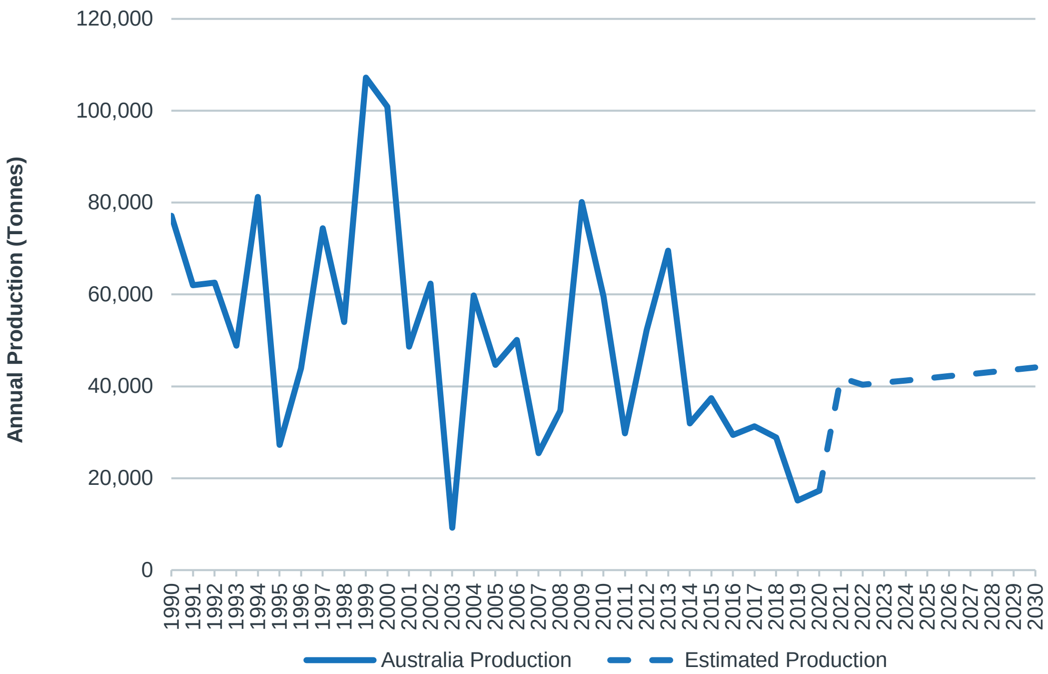
The extreme low recorded in 2003 is largely attributable to drought-like conditions experienced across Queensland, New South Wales and Victoria. According to BOM, rainfall decile ranges were at their lowest on record across major growing regions in New South Wales and Victoria from April 2002 to January 2003 (BOM, 2020), severely halting production. In addition, Cyclone Beni hit parts of Queensland in early February, causing significant damage to agricultural crops and public infrastructure (Harden Up, 2003).

Drought conditions throughout 2017 to 2019 saw a marked decline in the Australian soybean crop over the years, decreasing from 31,336 tonnes in 2017 to 15,136 tonnes in 2019. Production more than halved, impacting farmers and processors who make products from soy milk, tofu, soy flour and tempeh (Soy Australia, 2019). The competition for soybeans placed increasing price pressure on the market, increasing the attractiveness for growers.

Australian soybeans are unique in the market, holding a position of non-GMO and specifically suited for food and drink processing (Soy Australia, 2019). Advantages of Australian soybeans include (pbAgrifood, 2021):

- Non-GMO product. For example, growers in the USA expected a price premium of USD $1.71 in 2021 and USD $1.91 in 2022 (USSEC, 2021). The report highlights that in the USA, “the non-GMO premiums on export side are somewhat soft relative to selling to local processor and offer little drive for farmer to plant something new/different” (USSEC, p. 20 2021).
- Varieties are appropriate for the culinary market
- Quicker shipping times to the Asia-Pacific than key exporters including Brazil and the USA.

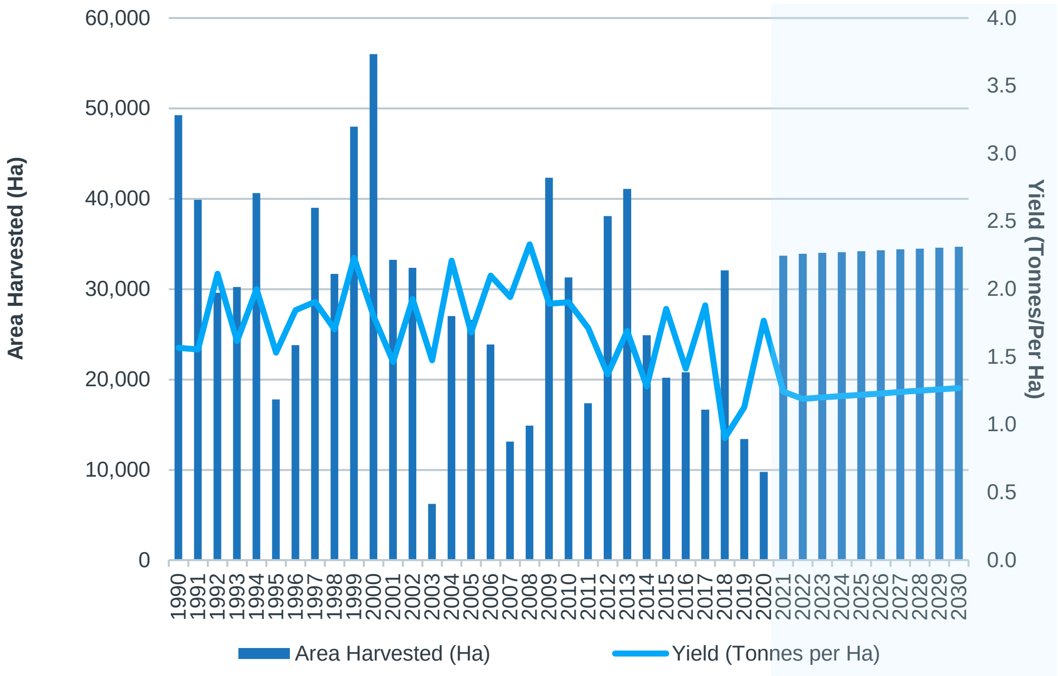
Figure 2.18. Australian Soybean Production, 1990 to 2030



Source: ABARES (2022a), OECD-FAO (2021a).

The volatile production volumes over the years are reflective of the change in harvested area from 1990 to 2020. By 2030, it is projected that the harvested area in Australia will total 34,700 Ha with a yield return of 1.27 tonnes per Ha.

Figure 2.19. Area Harvested & Yield (Australia), 1990 to 2030



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

2.3.2.1 Key Growing Areas

Production

Soybeans have been commercially grown in Australia since the 1950s, however, it was not until the mid to late 1970s when the industry reached notable levels of production. Soybean crops have been adapted across various regions and climates within Australia, with key growing area highlighted in the table below.

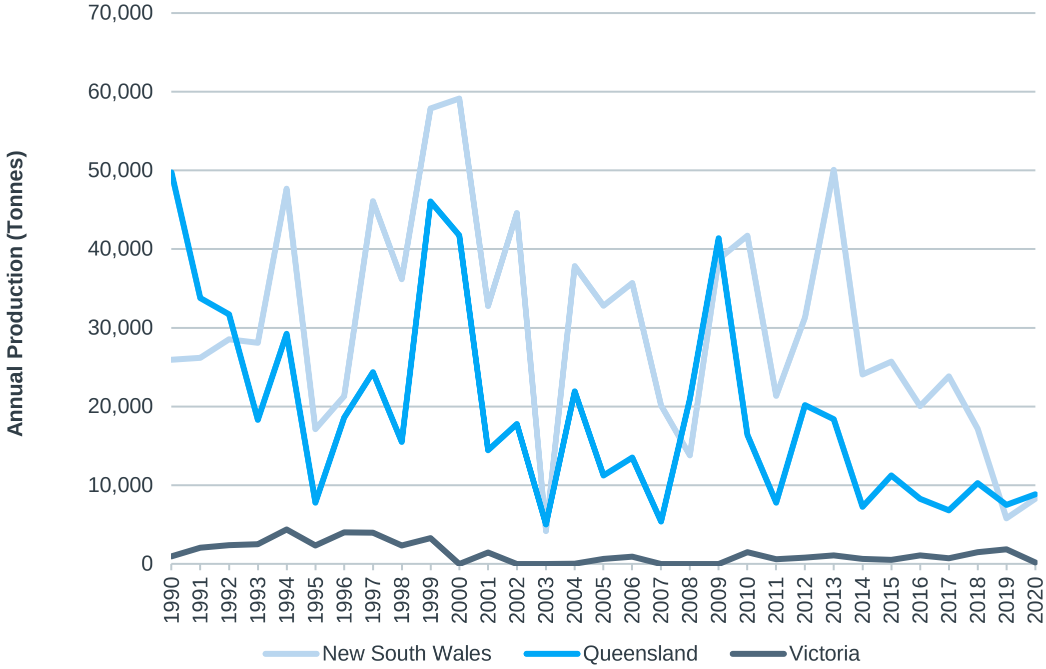
Table 2.4. Australian Soybean Growing Regions and Climates

State	Region
Tropical	
Queensland	• Far North Coastal (Atherton Tablelands) • Central Coastal (Mackay, Burdekin) • Central Highlands • Wide Bay Burnett
Western Australia	• Kimberley (Ord River)
Northern Territory	• Douglas-Daly (Daly River)
Subtropical	
Queensland	• Darling and Western Downs • Lockyer and Brisbane Valleys
New South Wales	• North Coast
Inland Irrigated	
New South Wales	• Northern Tablelands (Naomi and Gwydir Rivers) • Central (Lachlan and Macquarie Rivers) • Riverina (Murrumbidgee River)
Victoria	• Northern Victoria (Murray River)

Source: Soy Australia (2011).

Historically, New South Wales has been the largest producer of soybeans on average. Production experienced significant decline from 2017 to 2019 (largely due to the drought impacts), with production volumes now in line with Queensland. In 2020, Queensland was the largest producer of soybeans (accounting for 51.1% of total production), followed by New South Wales (47.8% of total production) and Victoria (1.1% of total production).

Figure 2.20. Australian Soybean Production by State, 1990 to 2020



Note: States and Territories not included do not produce soybeans.
Source: ABARES (2022a).

Seasonality

The table below provides an indication on the planting, harvest and growing seasons in key climates throughout Australia. The planting month for tropical and subtropical regions are in December while inland irrigated area planting is over the months of November and December.

Table 2.5. Soybean Harvest Season by Growing Region

Region	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Tropical						P	G	G	G	G	H	
Subtropical						P	G	G	G	H		
Inland Irrigated					P	P, G	G	G	G, H	H		

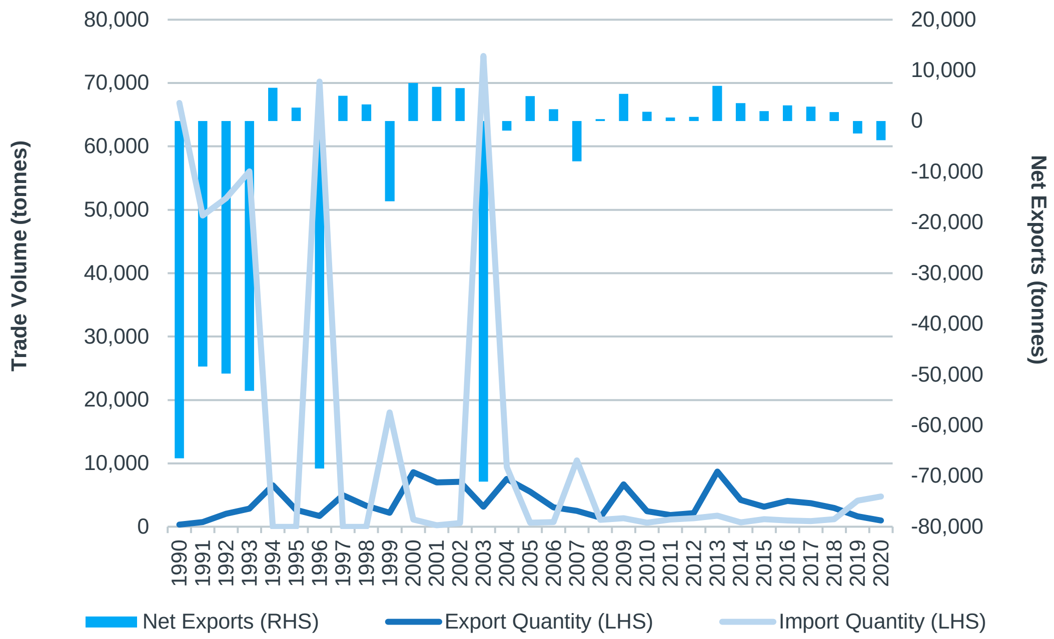
Note: P = Planting, G = Growing, H = Harvest
Source: GRDC (2016).

2.3.3 Australia's Trade Balance

Australia is not a large exporter or importer of soybeans on the global scale. On average, from 2010 to 2020, Australia was listed as the 48th largest exporter of soybeans and the 90th largest importer of soybeans in the world.

Over the years, Australia has experienced volatility in trade balance and has changed between a net importer and a net exporter. In 2020, Australia was a net importer of soybeans, with imports totalling 4,785 tonnes and exports totalling 1,011 tonnes. This indicated that in 2020, demand for soybeans in Australia was greater than domestic production volumes.

Figure 2.21. Australia's Trade Balance



Notes: RHS = Right hand side, LHA = Left hand side.
Source: FAOSTAT (2022), ABARES (2022a).

2.3.4 Soybean Prices in Australia

In the second quarter of 2021, soybean prices reached AUD $752 per tonne, one of the highest prices that has been achieved over the past 20 years. Towards the end of 2021, there was a slight downward revision on prices to AUD $671 per tonne, however, these were still much higher than what has been experienced in the past.

A major contributing factor to the increase in price has been China's recovery from the African Swine Flu and its resulting increased demand for soybean imports. Additional factors include (USDA, 2021c):

- Tight supplies on the global market, with large Chinese purchases from Brazil causing ending stocks to reach 20-year lows. Low stock in Brazil and the USA placed upward pressure on prices.
- Increase in price of USA corn, which is a key complimentary commodity to soybean within agricultural applications.

The price movement throughout 2020 also correlates with the COVID-19 supply chain issues for exports and imports on the global scale. Price projections provided by ABARES (2022a) highlight that price could decrease from FY2022 to FY2027 to reach an estimated AUD $493 per tonne. Soybean prices are forecast to experience gradual decline due to growth in global soybean production, which is expected to be greater than demand (ABARES, 2022b). Additionally, it is expected that supply chains will return to normal by FY2027.

Table 2.6. Assumed Exchange Rate (USD to AUD)

Year	Average USD/AUD
FY2022	$1.38
FY2023	$1.30
FY2024 Onwards	$1.30

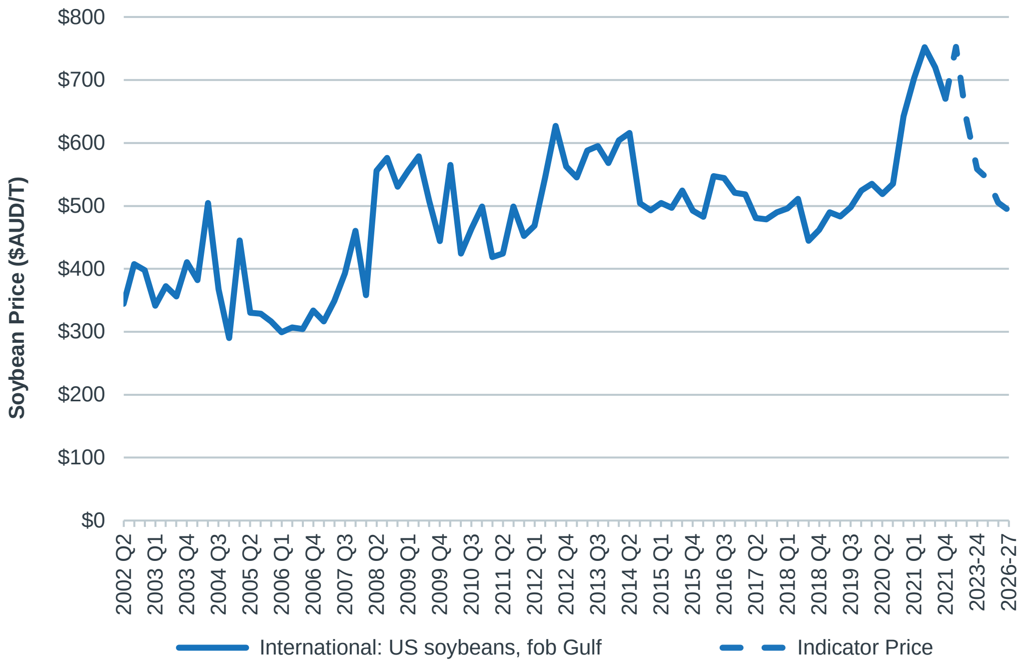
Notes:

- Future prices have been converted from USD to AUD based on spot exchange rate forecasts provided by NAB until December 2024.
- Average annual exchange rates over the financial year.

Source: NAB (2022).

The USA 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.

Figure 2.22. Soybean Prices ($/tonne)



Notes:

- Future prices have been converted from USD to AUD based on spot exchange rate forecasts provided by NAB until December 2024. Prices from 2024-25 to 2026-27 are assumed to have the same currency conversion as FY2024.
- Forecast years are identified on a different timescale
- FOB prices.

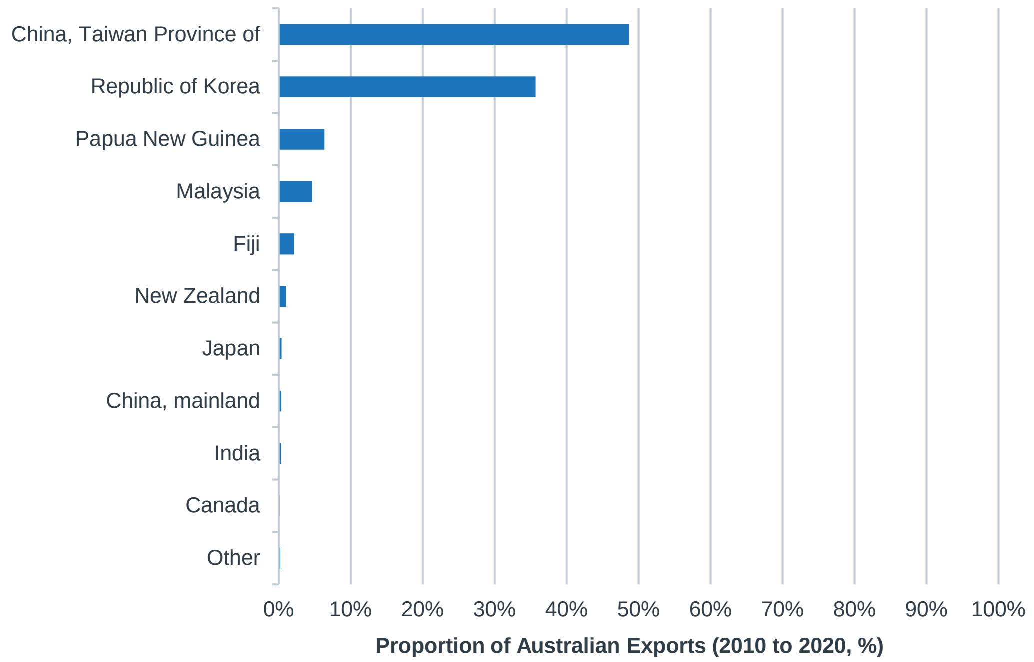
Source: ABARES (2022a), NAB (2022).

2.3.5 Australia's Key Markets

From 2010 to 2020, Taiwan was Australia's largest export market for soybeans, accounting for an average of 49% of Australia's total exports.

The Republic of Korea was Australia's second largest export market for soybeans, accounting for an average of 36% of exports from 2010 to 2020.

Figure 2.23. Key Exports Markets for Australian Soybeans (Top 10), 2010 to 2020



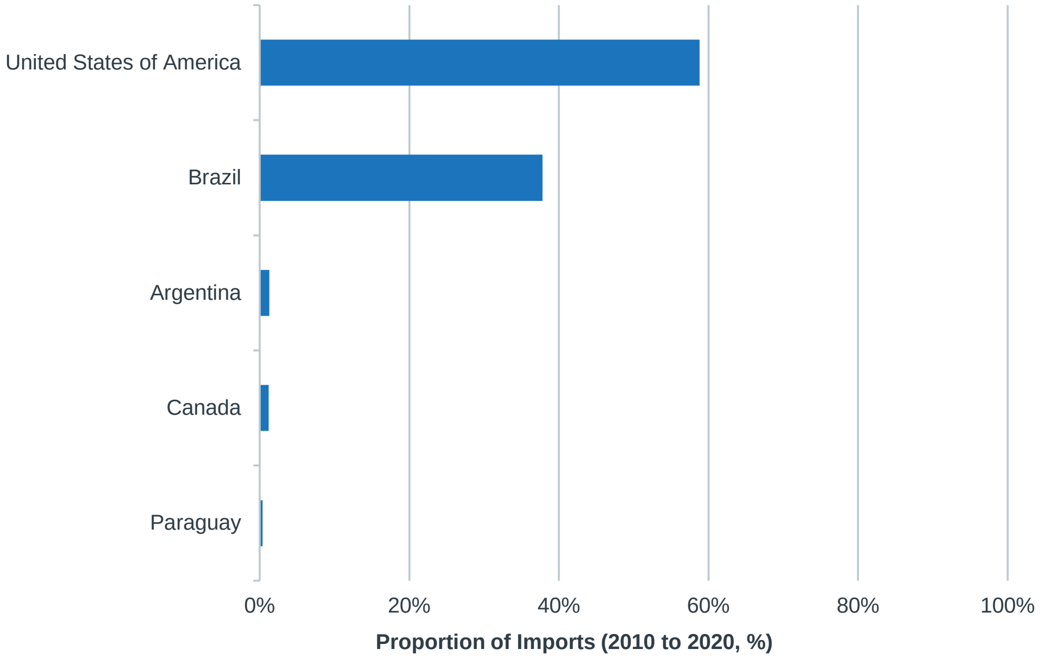
Source: FAOSTAT (2022).

Taiwan

From 2010 to 2020, Australia was largely reliant on Taiwan for the export of soybeans, however, Taiwan source majority of their soybeans from the USA and Brazil. Australian soybeans only accounted for 0.1% of total soybean imports into Taiwan (on average from 2010 to 2020).

The largest source of soybeans in Taiwan was from the USA, accounting for 58.8% of total imports on average from 2010 to 2020. The second largest source of soybean in Taiwan was from Brazil, accounting for 37.8% of total imports on average from 2010 to 2020.

Figure 2.24. Soybean Imports to Taiwan, 2010 to 2020



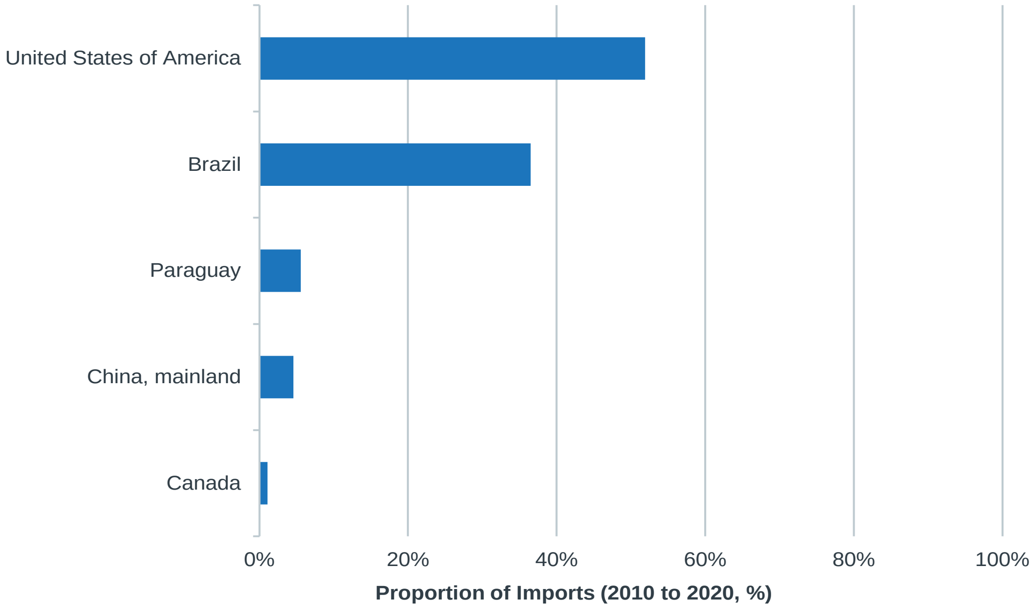
Source: FAOSTAT (2022).

South Korea

The largest source of soybeans in South Korea was from the USA, accounting for 51.9% of total imports on average from 2010 to 2020. The second largest source of soybean in South Korea was from Brazil, accounting for 36.5% of total imports on average from 2010 to 2020.

From 2010 to 2020, Australia was largely reliant on South Korea for the export of soybeans, however, the country sources majority of their soybeans from the USA and Brazil. Australian soybeans only accounted for 0.1% of total soybean imports into South Korea (on average from 2010 to 2020).

Figure 2.25. Soybean Imports to South Korea, 2010 to 2020

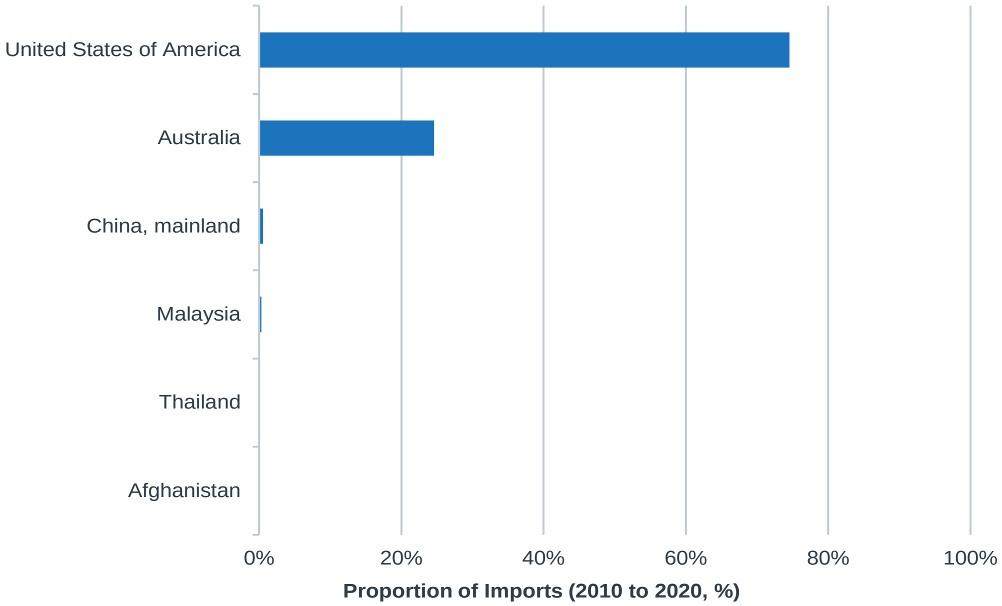


Source: FAOSTAT (2022).

Papua New Guinea

From 2010 to 2020, Papua New Guinea sourced majority of their soybeans from the USA, accounting for 74.5% of total imports. Australia was the second largest supplier, accounting for 24.6% of total imports.

Figure 2.26. Soybean Imports to Papua New Guinea, 2010 to 2020

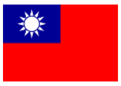


Source: FAOSTAT (2022).

2.4 MARKET VIABILITY ANALYSIS

The commodity outlook identified three key priority markets that are Australia's largest soybean export markets. The three key markets that were identified in the commodity outlook are listed below:

Taiwan



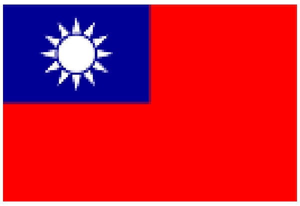
South Korea

Papua New Guinea

The market viability analysis provides a snapshot of each key market that has been identified for soybeans. This snapshot includes:

- Market depth and maturity
- Market access considerations (access to Free Trade Agreements)
- Economic strength, market growth and consumer capacity to pay
- Political stability and financial risk.

Taiwan



Soybean production in Taiwan is minimal due to a number of factors including the lack of available farmland, the competitiveness of imports and the predominance of rice and other crops (USDA, 2021a). The largest markets which supply Taiwan are the USA and Brazil, both accounting for 94.2% of total soybean imports in 2020.

Food and agricultural products from the USA have a strong reputation among Taiwan's consumers for high-quality and competitive prices (USDA, 2019d). Taiwan is an important trading partner for the USA, representing the 9th largest goods trading partner for the USA in 2020 (USTR, 2020). The strong relations are highlighted by Taiwan increasing soybean imports from the USA when China placed tariffs on USA soybeans.

Population & 2050 Forecast 2021: 23.5 million 2050: 22.0 million	GDP 2020: $28,358 per capita (USD) 2026: $44,979 per capita (USD)
In FY2020, 96% of soybean demand was from international markets	9th largest soybean importer in 2020, importing 2.6 million tonnes

Note: Population forecasts have been estimated based on population projections by IMF and OECD.
Source: IMF (2022), World Bank (2022), OECD (2022), Statista (2022), USDA (2021a), FAOSTAT (2022).

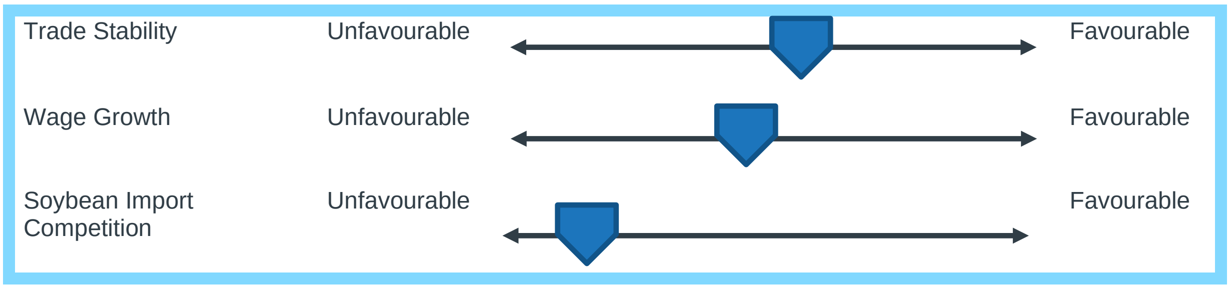
Market Access Consideration

- Australia currently has no Free Trade Agreements (FTAs) with Taiwan; however, it is a most favoured nation (MFN) where tariffs do not apply for soybeans. For flours and meals of genetically modified soybeans, a 3% tariff applies under MFN.
- Key markets that supply Taiwan with majority of their soybeans include the USA, Brazil, Canada and Argentina. These countries are also listed as MFNs, with no applied tariffs for soybean exports.
- From the beginning of February until the end of April 2022, the Taiwanese Government removed the 5% business tax on imported soybeans to help reduce the input costs for livestock farmers who use soybean as animal feed (Austrade, 2022a). Demand for soybeans is likely to increase while this temporary reduction is in place.

Australian Soybeans in Taiwan

Although Taiwan is Australia's largest export market for soybeans[3], Taiwan is not reliant on Australian imports to satisfy domestic demand. The soybean market in Taiwan is dominated by both Brazil and the USA, with Australia only accounting for 0.06% of the country's soybean imports on average from 2010 to 2020.

Of important note, Australian soybean exports to Taiwan experienced a relatively sharp increase from 2020 to 2021 increasing from an estimated $708,000 to $3.1 million (Austrade, 2022a).



South Korea

In 2020, it was estimated that the soybean crop is South Korea totalled nearly 81,000 tonnes (0.02% of total global production). Cultivation area for soybeans has fluctuated over the years, declining from 80,031 Ha in 2013 to 55,300 Ha in 2021 (USDA, 2021b).

Since 2018, the Korean Government has maintained a purchasing price of 4,500 won/kg, however, wholesale domestic prices have been higher (USDA, 2021b). This higher domestic price is discouraging for farmers to sell their crop under the government purchasing program (USDA, 2021b). The higher market prices have led to a sharp decline in Government purchases, purchasing only 1% of the contractual 44,298 tonnes in 2020 and 0.8% of the government purchasing plan (USDA, 2021b).

Population & 2050 Forecast 2021: 51.8 million 2050: 47.7 million	GDP 2020: $31,631 per capita (USD) 2026: $44,611 per capita (USD)
Consumption of soybeans is estimated to total 1.7 million tonnes in 2030, with crush accounting for 98.4% of total consumption	Imported 1.3 million tonnes of soybean in 2020

Source: OECD (2022), World Bank (2022), Statista (2022), OECD-FAO (2021a).

Market Access Consideration

- When the KAFTA agreement was implemented, Korea set up a duty-free quota of Australian identity-preserved soybeans of 500 tonnes in 2014. This quota has increased by 50 tonnes each year and will reach a limit of 1,000 tonnes from 2024 onwards (USDA, 2019c). Any exports below this quota are tariff free, however, there are tariff implications if this quota is exceeded.
- Under the KAFTA, the tariff for Australian soybean oil, oil cake and feeding exports into Korea will decrease to a maximum of 243.5% of 478 won/kg from January 2023 onwards. Soybeans for bean sprouts and other purposes have no tariff implications under the KAFTA agreement.
- Key competitor tariffs and quotas are as follows:
  - o USA – under the KORUS-FTA, Korea set-up a tariff free quota of 10,000 tonnes in 2012 for identity-preserved soybeans, increasing to 20,000 tonnes in 2013 and 25,000 tonnes in 2014. From 2015 onwards,

[3] On average from 2010 to 2020.

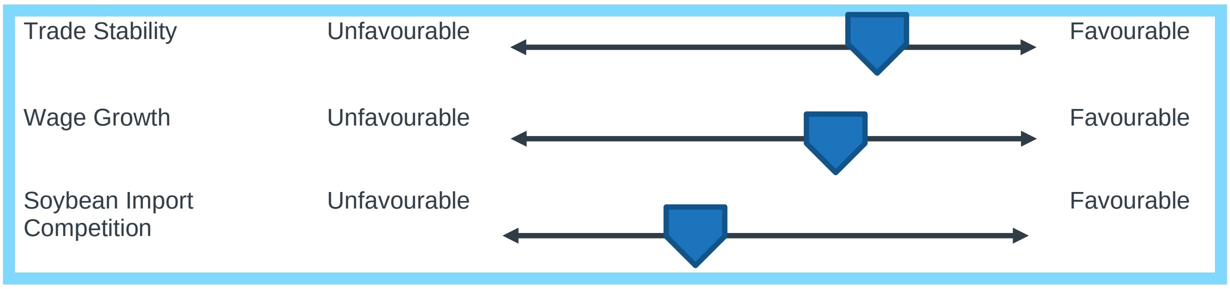
the tariff free quota grows by 3% annually in perpetuity (USDA, 2021c). Korean tariffs for soybean crushing and crude soybean oil are 0% (Baylis, K., Coppess, J., & Xie, Q., 2017).

- Brazil – a large market for soybeans into South Korea, however, Brazil has largely been a market for soybean for crushing (USDA, 2021b).

Australian Soybeans in South Korea

Although Australia is a small market for soybeans, there is a competitive advantage with Australia producing non-GMO and/or organic soybeans. Large soybean markets for South Korea, including the USA and Brazil mainly supply GMO soybeans which are used for cooking oil and animal fodder.

This is one of the most important criteria for food manufacturers in South Korea, as non-GMO soybeans can be used to create products such as tofu and soy milk (Deloitte, 2017). Australia's main non-GMO competitor is Canada, which is a larger soybean market for South Korea (Deloitte, 2017). In FY2020, the largest supplies to South Korea for food grade soybeans were the USA (219,120 tonnes), China (42,112 tonnes), Canada (19,397 tonnes), Russia (10,364 tonnes) and Australia (145 tonnes) (USDA, 2021b).



Papua New Guinea

Papua New Guinea is not a producer of soybeans and is solely reliant on soybean imports to meet domestic demand. This is largely due to deficiencies in several macronutrients of Papua New Guinea soil that are critical for growing soybeans (PNGUT, 2000), as well as the predominance of other crops on domestic farmland such as sweet potato and yams (FAO, 1995). The largest markets which supply Papua New Guinea are the USA and Australia, together accounting for 99.1% of total soybean imports on average from 2010 to 2020.

Population & 2050 Forecast 2021: 9.0 million 2050: 16.8 million	GDP 2020: $2,757 per capita (USD) 2026: $3,556 per capita (USD)
Does not produce soybeans domestically	Imported 43 tonnes of soybean in 2020

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

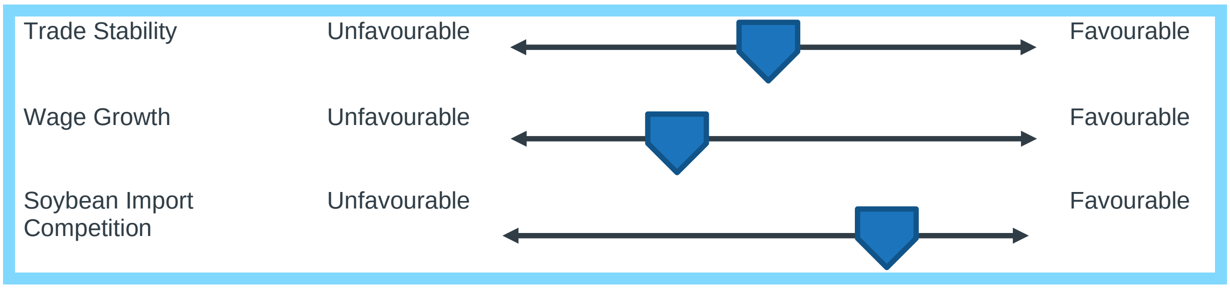
Market Access Consideration

- Australia is Papua New Guinea's largest development partner and it is also Australia's closet neighbour. In 2020, the Papua New Guinea-Australia Comprehensive Strategic and Economic Partnership was signed to advance relations between the two countries over the next 10 years. This partnership will see bilateral relations and support between the two nations increase.
- Australian soybean exports to Papua New Guinea have no tariff implications under the MFN duties. These duties also apply for the USA.
- Under the MFN duties, exports of soybean oil to Papua New Guinea incur a 25% tariff.

Australian Soybeans in Papua New Guinea

While not completely reliant on Australia, Papua New Guinea is a strong demander of Australian soybeans, accounting for just under a quarter of the country's soybean imports on average from 2010 to 2020.

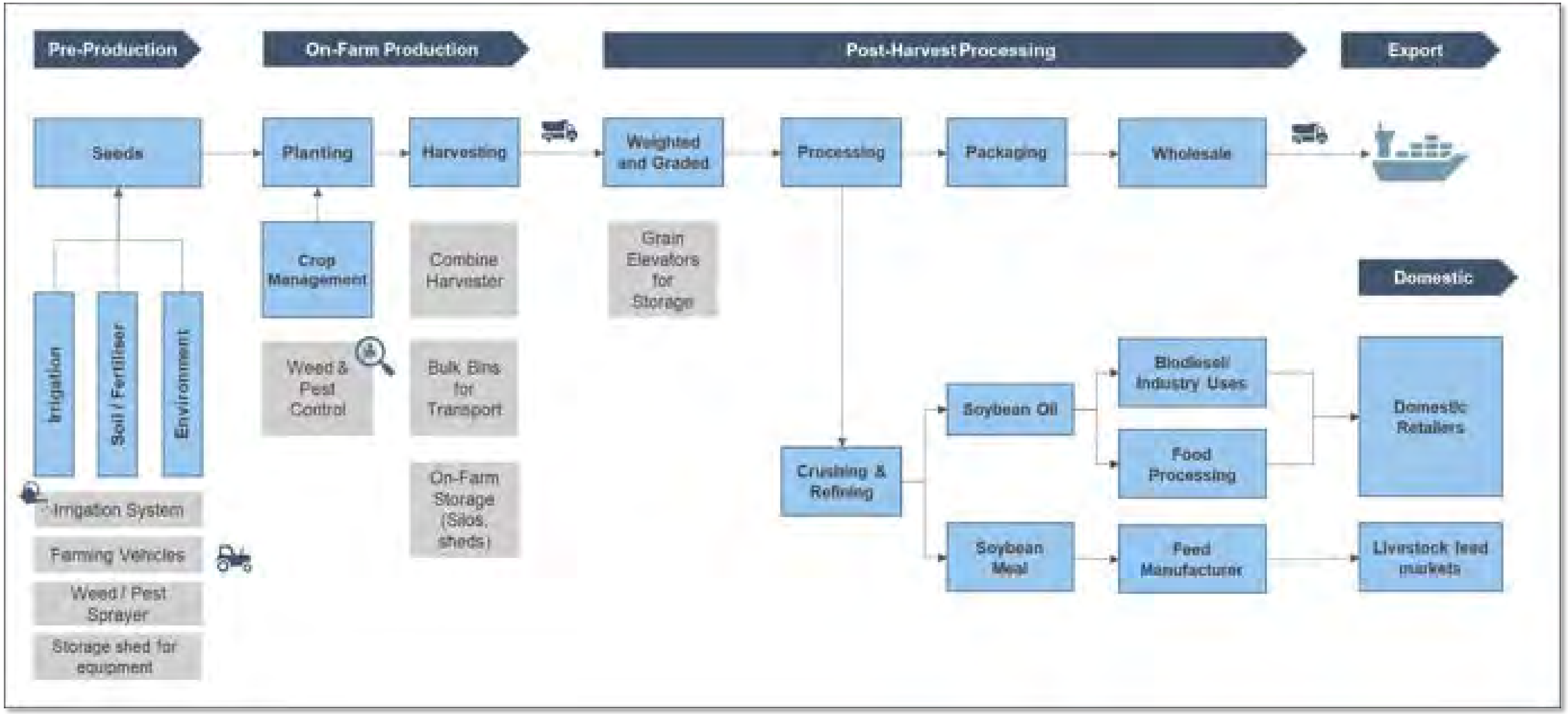
Australia also holds a competitive advantage in this market with transport advantages and a potential non-GMO offer that is not able to be matched by the major competitors (i.e., the USA, which mainly supplies GMO soybeans to the global market). Whether Australia improves its supply position to Papua New Guinea will be dependent on whether Papua New Guinea is prepared to match the price point to other Australian export markets.



2.5 SOYBEAN SUPPLY CHAIN ANALYSIS

The figure below introduces a high-level supply chain analysis to investigate the activities and processes involved in producing soybeans within the Central Queensland region. To understand this process to identify potential industry constraints or opportunities for the region at each point of the supply chain.

Figure 2.27. Soybean 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 crop establishment, prior to the planting of seeds. Equipment and infrastructure required for crop establishment for soybeans include:

- An irrigation system, irrigation equipment and soil moisture monitoring equipment
- Boom sprayers for herbicide and insecticide application
- Tractors and vehicles
- Cultivation equipment
- Seeders/disc drills or row crop planters
- Combine harvesters (headers)
- Chaser bins and grain trucks.
- Grain elevators/silos for on-farm storage.

Some or all of the operations required to produce a soybean crop can be carried out by contractors, which may alleviate some capital investment in the significant amount of equipment required for crop production.

On-Farm Production

Soybeans are a summer crop and are considered to be ideal with rotations in broadleaf (legumes, canola, sunflower) and grass crops (maize, wheat, sugarcane) (GRDC, 2016a). Soybeans as a rotational crop can be beneficial as a number of uses including soybeans grown for grain, used for forage, hay or silage, or incorporated as a green manure (GRDC, 2016a). Seeds are sown into soil using conventional seed drills.

The first indication of imminent harvest is once the green leaves start to turn yellow, and the pods start to change from a green to yellow, and through to a mature brown colour (generally between 18 to 20 weeks). Spots on the outside of the pods are a natural part of the maturing process. It is important to commence harvesting when seed moisture levels reach 16% because harvesting at 12-13% moisture causes more grain loss and seed cracking (Queensland Government, 2008).

Growers may wish to desiccate the crop prior to harvest to dry out the whole crop and minimise immature grain in the harvest. Soybeans are ready for desiccation when 90% of pods are yellow and are sprayed with a robust rate of glyphosate or diquat, and allowing sufficient time for the crop to dry down before commencing harvest (at least four to seven days). Once the desiccant is applied, the leaves will drop off the crop and the stems will brown out.

Soybeans are harvested using combine harvesters (headers). After harvesting, farmers can store their product on farm, or transport their product to a processing facility directly after harvest. The ideal bulk seed storage is a cone based, aerated, sealable silo that is painted white, or is located out of direct radiant heat of the sun. Automatic aeration controllers will usually provide the most reliable results for cooling grain temperatures.

Post-Harvest Processing

The majority of soybeans are sold into the processing or refining grade. After harvesting, farmers can store their soybean on farm, or transport their product to a processing facility after harvest. At the processing facility, they are then weighed, screened, gravity-graded, de-stoned, colour sorted and passed over by magnets and metal detectors, depending on the processor (Bean Growers Australia, 2021).

There are two main markets for soybeans – crushing grade grain for oil and culinary grade grain for the edible trade. Soy meal for stockfeed is a by-product of the crushing process (Queensland Government, 2008). Soybean oil is primarily consumed as vegetable oil or processed further into products such as margarine and mayonnaise. It can also be refined into oils used in the biofuels industry.

Soybeans delivered for processing may also be stored and dried to reduce moisture content, depending on the end use. Under the National Agricultural Commodity Marketing Assoc. (NACMA) standards the maximum for crushing beans is 13% and the maximum for edible beans is 12%. The moisture content of soybeans to be stored on-farm should not exceed 12%.

The maximum safe temperatures for drying soybean seed will depend on both the likely end use of the soybeans and the seed moisture content of the sample prior to drying. The table below provides a guide to maximum safe drying temperatures.

Table 2.7. Maximum safe drying temperatures

Maximum temperature (Celsius)	Initial seed-moisture content		
	14%	16%	18%
Planting seed	65	60	55
Edible trade	37	37	37
Crushing	80	70	80

Source: Sugar Research (2019).

Australian Oilseeds Federation Inc. (AOF) develops Quality and Trading Standards for the Australian oilseeds industry. The standards are revised annually and published on the AOF website. Three standards are issued for soybeans, which includes:

- **CSO 6: Edible Milling Grade**, which applies to edible soybeans comprising clean, sound, whole soybeans of light hilum varieties suitable for milling into flour.
- **CSO 7: Edible Manufacturing Grade**, appliable to edible soybeans comprising clean, sound, whole soybeans of light hilum varieties suitable for manufacturing such as the production of tofu, tempeh, soymilk, etc.
- **CSO 8: Crushing**, a general trade standard for all edible soybeans that are suitable for oilseed crushing, full fat soymeal production and other applications. These can be dark or light hilum varieties.

All the above Trading Standards include details of required nutrient and quality parameters (protein, moisture, test weight, germination, etc.) allowable foreign matter limits, defective seed limits and unacceptable contaminants such as weed seeds. The standards are not mandatory.

Export Markets

In addition, all exporters of soybeans are required to follow the conditions for export, as detailed in the Manual of Importing Country Requirements (Micor) maintained by DAWE.

Table 2.8 outlines the export requirements for soybeans for processing and consumption. The below markets are all non-protocol markets, i.e. countries whereby there is no agreement with Australia prescribing the export requirements, generally making these countries easier to export to than protocol markets. No protocol markets are listed on Micor.

Table 2.8. Export Requirements of Soybeans for Processing and Consumption

Country	Import Permit	Phytosanitary Certificate	Treatment / Fumigation Requirements
End Use - Processing			
Malaysia	Yes	Yes	No
New Zealand	Yes	Yes	No
Thailand	No	Yes	No
End Use - Consumption			
Malaysia	Yes	Yes	No
Mexico	Yes	Yes	No
Fiji	Yes	Yes	No
New Caledonia	Yes	Yes	Yes

Country	Import Permit	Phytosanitary Certificate	Treatment / Fumigation Requirements
New Zealand	Yes	Yes	No
Thailand	No	Yes	No

Source: Micor.

Domestic Market

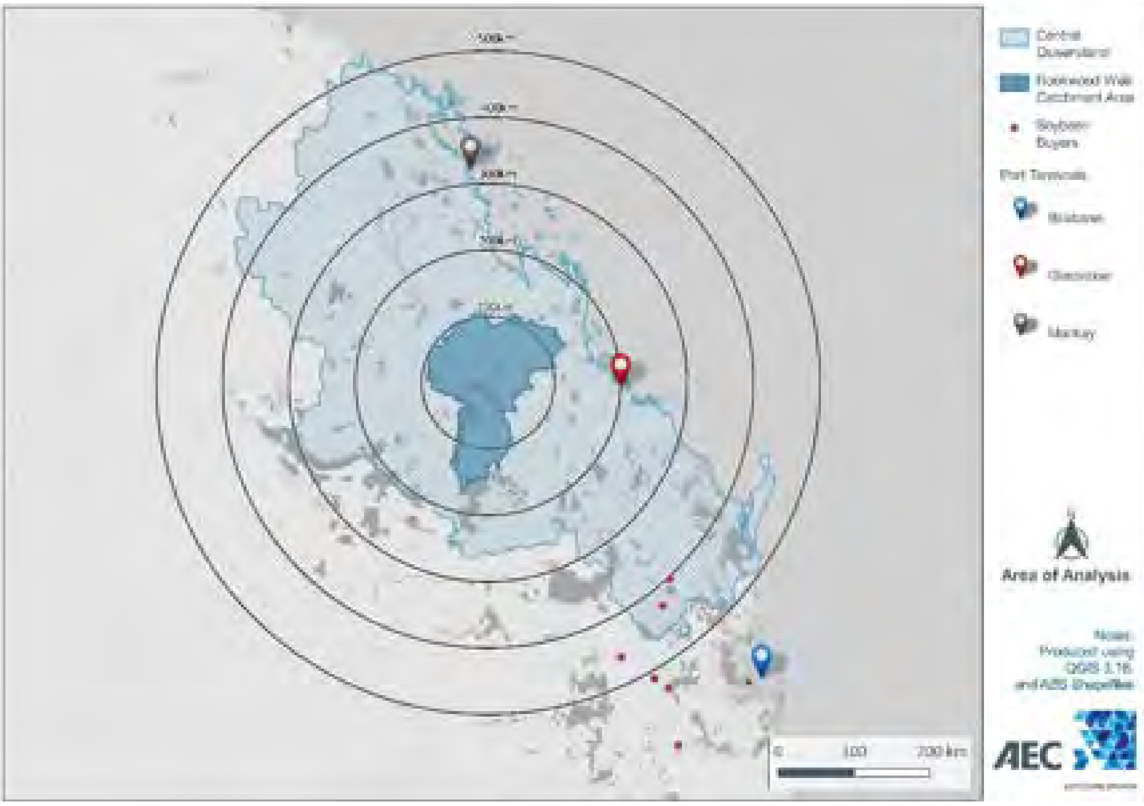
Domestic uses for soybeans include bean sprouts, tofu, oils, and flour and protein products. These products are generally sold via supermarkets and health stores. As identified in earlier sections, Australia was a net importer of soybeans in 2020.

2.5.1 Infrastructure Requirements and Gaps in Central Queensland

Soy Australia produces a 'Marketing Guide for Growers' (Soy Australia, 2015), which outlines the buyers of Australian soybeans. These buyers are shown in Figure 2.28, and include:

- **Riverina Stockfeeds** – purchases crushing grade soybeans for use in the manufacturing of full fat soybean meal. The company has four sites in Queensland, including two in Warwick, Murgon and Oakey.
- **PBAgrifood** – trades in a variety of commodities for both domestic and international markets including human consumption soybeans for milling and manufacture (tofu and milk) and full fat crushing soybeans. PBAgrifoods is based in Toowoomba.
- **Soya Feeds –** processors of white hilum soybeans and other grains for stockfeed. Based in Dalby.
- **Bean Growers Australia** – buyer of soybeans for human consumption and processing. Supplies to domestic and international markets. Based in Kingaroy.
- **North Queensland Tropical Seeds** – specialises in the production, gradin, processing and wholesaling of premium quality tropical pasture seeds, legumes and grains. Based in Walkamin.

Figure 2.28. Buyers of Soybeans, Queensland



Source: AEC.

The majority of these buyers are located approximately 400 – 500km from the Catchment, closer to the Port of Brisbane. However, soybeans are able to utilise existing grain infrastructure (similar to infrastructure for chickpeas and mungbeans).

If soybeans were to be selected as a commodity for the Rookwood Weir Catchment Area, it is anticipated that a processing facility may be required to be established within the region if the scale of production increases. Soybeans will need to be transported to the processing establishments near the Port of Brisbane, however there may be higher transport costs associated with the longer distance. There may be additional cost efficiencies though as there is a shorter distance to port.

2.6 COMPETITITVE ANALYSIS AND MARKET OUTLOOK

2.6.1 Key Exporters and Importers

The figure below provides a snapshot of the top five exporters and importers of soybeans in the global market. The top five exporters accounted for 95.8% of total soybean exports in 2020, while the top five importers accounted for 70.7% of total soybean imports in 2020.

The export market for soybeans is dominated by Brazil and the USA, which alone, accounted for 85.7% of total exports in 2020.

Figure 2.29. Major Exporters and Importers of Soybean

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

2.6.2 Australia's Competitive Advantages

While only a small player in the global soybean market, Australia possesses some competitive advantages to other major suppliers, including (Deloitte, 2017):

- Closer proximity and lower shipping times to Asian markets, which are responsible for the majority of global demand
- Competitive tariffs and free trade agreements relative to larger market participants
- Better performance of certain varieties of Australian soybeans in soy milk and culinary applications when compared with USA and Canadian soybeans
- Exclusive production of non-genetically modified (non-GMO) soybeans, which are required for human consumption
- International reputation for high quality produce
- Outstanding food safety records and compliance

Aside from domestic consumption which feeds most of Australia's end-market uses, the largest threats to demand for Australia's soybean product is Taiwan, given Australia exports almost half of its entire production to the island nation. Canada is Australia's only major competitor in the market for non-GMO soybeans.

Although the USA and Brazil are significant producers and exporters of soybean, their product is largely suited to soybean for crushing.

2.6.3 Future Growth Markets for Australia

South Korea represents a key growth market for Australian soybeans. Soybeans are a traditional part of the South Korean diet and demand is very stable, with approximately seven times the amount imported as are produced domestically. South Koreans also have a strong preference for non-GMO soybeans, purchasing these over genetically modified (GM) beans "wherever possible" (Deloitte, 2017). With only around 20% of imported product used for food production, there lies opportunities to increase exports to the region.

Papua New Guinea is another potential growth market for Australian soybeans, with imports from Australia accounting for around a quarter of the country's total imports on average from 2010 to 2020. Given the country does not undertake any domestic production, opportunities exist for Australia to market itself as a supplier of high-quality product with lower shipping times due to its proximity to the country.

Indonesia could also represent a growth market for Australian soybeans in the culinary market, with roughly 95% of its domestic consumption on average over the last five years for food use (USDA, 2022). While over 90% of the country's supply is sourced from the USA, favourable trade agreements and the superior quality product from Soy Australia's national breeding program demonstrates the potential for growth in the region.

There is also growing demand from other Asian countries including Japan, Taiwan and Singapore for Australian food grade soybeans (Soy Australia, 2015). The largest suppliers to these countries for food grade soybeans is USA and Canada (Soy Australia, 2015). Australia has an opportunity to increase its export market share by offering a premium non-GMO product.

As stated previously, the soybean market in Taiwan is largely dominated by the USA, accounting for 58.8% of total imports on average from 2010 to 2020. The strong relationship, particularly with soybeans is highlighted in 2018, when China placed tariffs on USA soybeans. Over the year from 2017 to 2018, Taiwanese imports of USA soybeans grew by over 870,000 tonnes.

With the ongoing trade tensions between the USA and China, the importance of Taiwan for soybean will likely increase. Majority of soybean exports from the USA are GMO soybeans, while Australia exports non-GMO soybeans. In FY2020, it was estimated non-GMO soybean imports to Taiwan totalled 88,000 tonnes, of which 61% was supplied from Canada and 35% was supplied from the USA (USDA, 2021a). Australia's opportunity lies in the export of non-GMO soybeans to Taiwan, offering a premium product in the market. Of important note, Australia has a competitive advantage for shipping to Taiwan over Canada and the USA.

2.6.4 SWOT Analysis of Australian Soybean Production

Table 2.9 outlines the strengths, weaknesses, opportunities and threats of the Australian soybean industry, which may be of relevance to potential growers of soybean crops in the Rookwood Weir Catchment Area.

Table 2.9. SWOT Analysis – Australian Soybean Production

Strengths	Weaknesses
• Australian soybeans are non-GMO, which international markets place a premium on • Australian soybeans are generally considered to be of high quality • Soybeans can perform particularly well as a rotational crop.	• Australia is a higher cost producer of soybeans compared to other major producers, especially in South America • Australia possesses a very small market share of soybean exports (less than 1%) • Little incentive or price support is available to Australian farmers as low total production levels are insufficient to meet tariff-free quotas in certain importing countries • Australia's main competitor in the non-GMO market, Canada, produces substantially more product in comparison to Australia.
Opportunities	**Threats**
• Continued rollout of the Australian National Soybean Breeding program, generating increased yield opportunity and capturing a greater share of the high-value culinary market • Ending stocks of major global producers such as Brazil at historic lows, allowing alternative producers to cater for any residual demand within the market • Recently established FTAs between Australia and countries within the Asia-Pacific to spur increases in trade • Ability to highlight and market the non-GMO status of Australian soybeans to provide a clear competitive advantage over major suppliers • Many growing regions and high land availability within the country promoting strong feasibility for increased production • Roadmap in place by Oilseeds Australia to plug the gap between current domestic production and demand of local soybean purchasers.	• Logistical challenges as a result of COVID-19 • Historical experience of Australian shipments of soybeans being downgraded from culinary grade, reducing export value • Sustained low reliance of Taiwan on Australian product may impact future supply to the market • Entering of trade agreements between key export markets of Australia and other suppliers with notable cost advantages.

Source: AEC.

2.7 SOYBEAN 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 soybean production is 197ha. With water entitlement restrictions and a conservative water use assumption, the total sustainable land available for farm development (i.e. planted area) is estimated to be 39.3ha.
- The anticipated initial capital investment for a rotational cropping farm is $3.4 million – including, land clearing, infrastructure and equipment, water entitlements, and planting. This includes water allocation at an assumed cost of $1,500 per ML (RFM, 2020).
- Assuming the crop rotation with soybean is wheat, the break-even point for the example soybean farm, at the current assumed price of $594 per tonne is June 2024. Under this scenario, the assumed price for wheat is $421 per tonne.
- The soybean farm will return positive discounted cash flows over the evaluation period, with the first positive discounted cash flow incurred in FY2024.
- The long-term growth rate for agricultural farm values is 12.5%, with an internal rate of return for agricultural investments of 12.8%, the net present value (NPV) of the example farm is zero. The terminal value of the example farm with rotational cropping at the conclusion of the analysis (FY2041) is $27.0 million (undiscounted).

2.7.1 Approach

The commercial and financial feasibility of an average soybean farm 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 capital investment required, operating costs, and the anticipated revenue over the 20-year time frame. The following sections detail the following:

- Farm establishment
- Farm operations
- Financial feasibility (including sensitivity analysis).

2.7.1 Crop Rotation

The financial analysis is undertaken for the purposes of growing soybean as a primary commodity. In modelling the financial feasibility of soybean in the Rookwood Weir Catchment Area, the farm has been assumed to be a monoculture farm, farming soybean, with a single crop rotation in the off season of spring wheat.

Further details are provided in Appendix E.

2.7.2 Rookwood Weir Water Availability

The Rookwood Weir Scheme allows for a maximum 500ML water allocation for agricultural landholders. Soybean irrigation in the Central Queensland region reportedly requires, on average, 5.5ML of water per annum per Ha (Mace, et al, 2012). Wheat irrigation in the Central Queensland region 5.2ML of water per annum per Ha (Harris, et al, 2012). Appendix A discusses soybean water requirements and growing environment in more detail.

Under the assumption this water is provided with a conservative 84% reliability and 10.7ML per ha per year is required for both wheat and soybean production, the maximum sustainable growing area in the Rookwood Weir Catchment Area is estimated to be 39.3ha.

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 2.10.

Table 2.10. Land Availability, by Water Reliability

60% Reliability	84% Reliability	100% Reliability	No Water Allocation Cap
28.0 ha	39.3 ha	46.7 ha	197 ha

Note: Total land available considers the soil suitability of soybean only and does not factor the rotation crop.
Source: HTW, AEC.

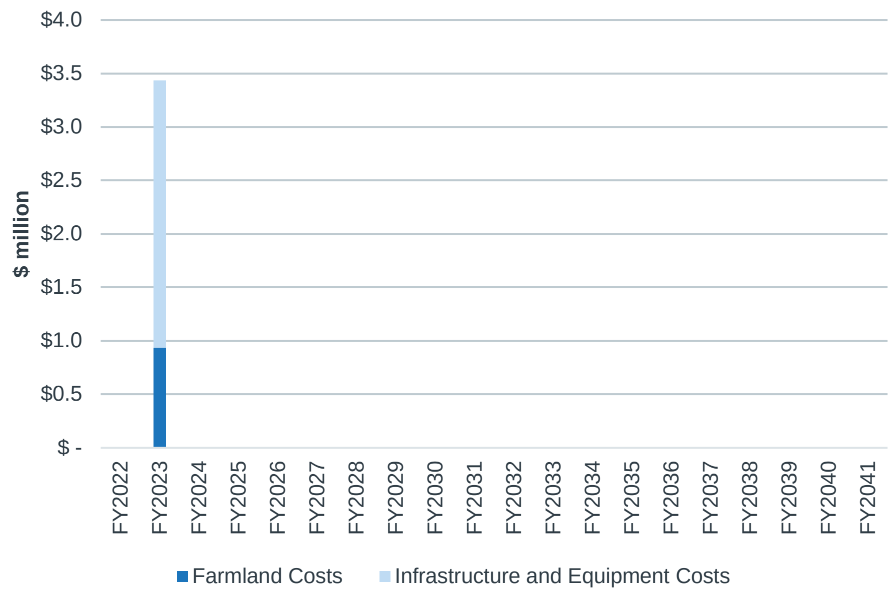
The outcome of the scenario analysis is presented below in Section 2.7.5.1.

2.7.3 Rotational Cropping Capital Investment

2.7.3.1 Farm Establishment

Rotational cropping farm establishment requires three key capital investments, the land, the on-farm infrastructure and associated equipment (including storage), and the crop. For the purpose of analysis, it is assumed the landholder already owns the land and the majority of the initial investment occurs across four months, starting 1 January 2023. For the 39.3ha farm, the initial capital investment is $3.4 million ($87,375/ha), not including the cost of planting.

Figure 2.30. Farm Establishment Costs, Not Including Planting Costs (FY2022 – FY2041)



Source: AEC, HTW

Farmland Costs

Farmland costs include the cost of land clearing, and the water entitlements. Total farmland costs per farm are estimated to be $932,474, including:

- **Water entitlement** – 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
- **Land clearing** – it is assumed the land will need to be cleared and prepared for farm establishment. Total land clearing is estimated to be $161,417 in nominal terms.

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.

For the example farm, the infrastructure and equipment will cost an estimated $2.4 million. This investment includes the following:

- **Irrigation infrastructure and equipment** – this assumes the irrigation method will be centre pivots and includes the necessary pumps, pipes, centre pivots and soil monitoring equipment. Overall irrigation equipment will cost an estimated $2.2 million.
- **Production equipment** – equipment and machinery included in the production of crops include the cultivation and harvesting equipment. Total production equipment expense is anticipated to cost $148,470.
- **Storage and other infrastructure** – this asset group includes storage facilities for the harvested crop and any relevant grain elevators, as all as general storage sheds. This asset group is estimated to cost $113,336.

All infrastructure and equipment costs are assumed to be a combination of new and second-hand equipment with costs quoted from sites such as Farm Machinery Sales (https://www.farmmachinerysales.com.au/items/), Farm Tender (https://www.farmtender.com.au/), and John Deer (https://www.deere.com.au/en/).

Further details are outlined in Appendix E.

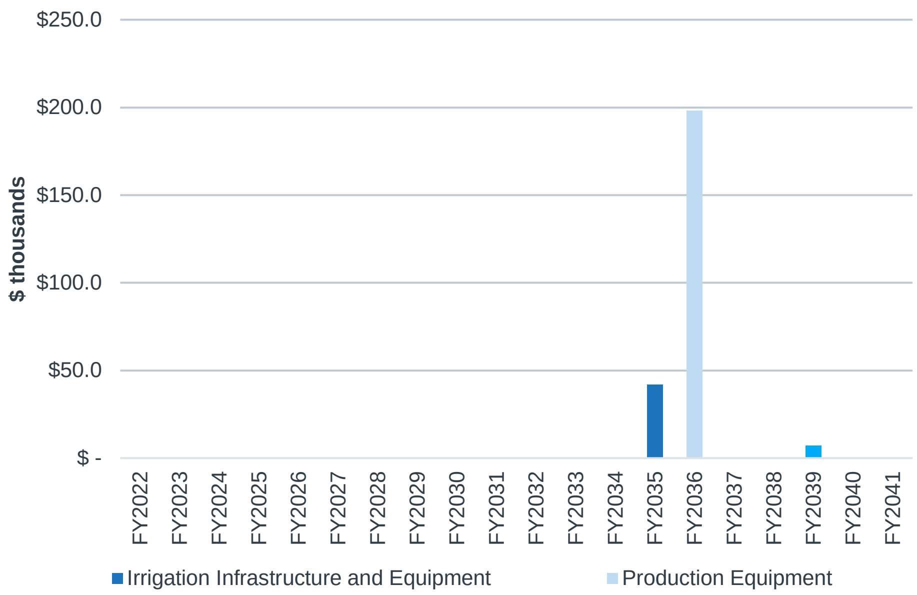
2.7.3.2 Planting Costs

Planting costs are on ongoing capital investment incurred twice a year – once for soybean, and once for wheat. It is assumed the first sowing will occur in 2024 (FY2025) as the soil will need at least 12 months to rest after clearing. Based on planting costs published by DAF (2020d & e), soybean is anticipated to costs $53.70/ha and wheat is anticipated to cost $59.78/ha in FY2021 real terms.

2.7.3.3 Asset Renewal

As general farming equipment, harvesting and spraying equipment, farm vehicles and irrigation equipment all have useful lives less than the evaluation period, they will be replaced at the expiration of their useful lives. The replacement capital expense is assumed to be consistent with the cost structure and drivers of the initial investment. There is an anticipated additional $247,415 required to maintain operational farm assets over the evaluation period. This expense is show in Figure 2.31.

Figure 2.31. Total Asset Renewal (FY2022 – FY2041)

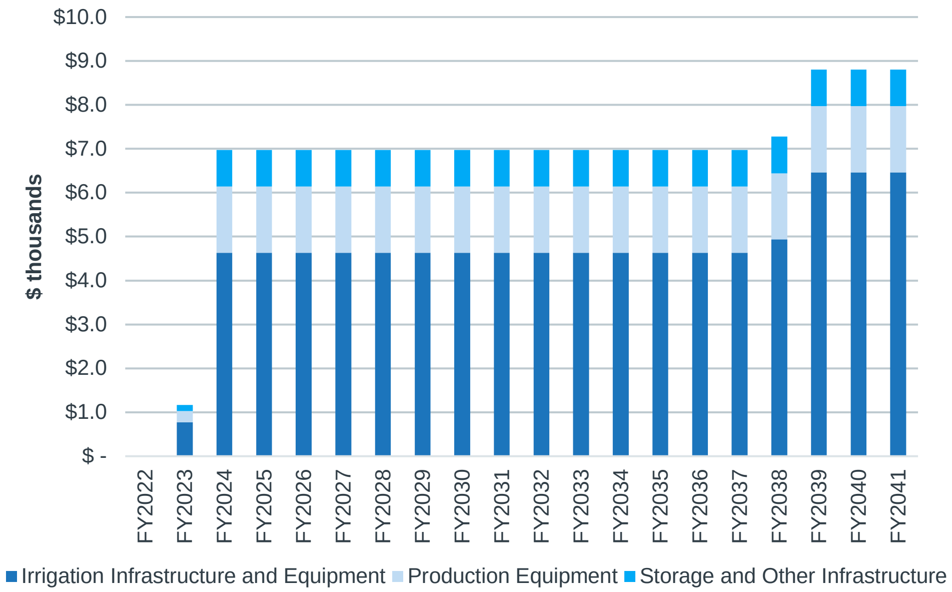


Source: AEC.

2.7.3.4 Depreciation and Amortisation of Assets

The capital investment required to establish the farm form the depreciable asset base of the farm. The total depreciation and asset write-off expense over the evaluation period is shown in Figure 2.32.

Figure 2.32. Total Depreciation Expense (FY2022 – FY2041)



Source: AEC.

Treatment of each asset type is outlined in Appendix E.

2.7.4 Soybean Operations

2.7.4.1 Operating Structure

The operating structure of the farm enterprise gives consideration to the ownership and management of the farm as well as the sources of funding for the enterprise.

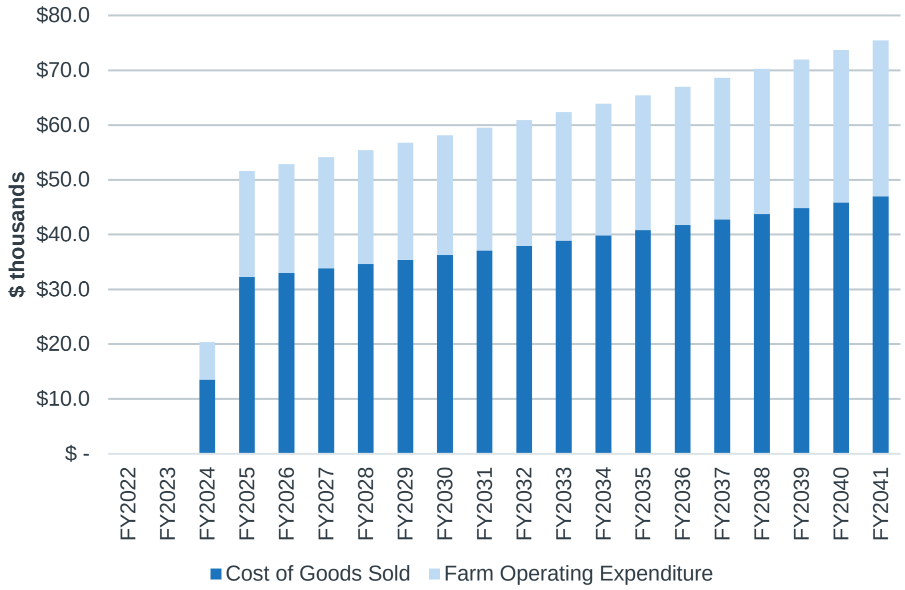
Establishment of the example farm requires significant investment to cover the capital requirements and the operating shortfall. There are number of high-level assumptions which guide the investment sources as a part of this analysis which are detailed in more detail in Appendix E.

2.7.4.2 Soybean Operating Costs

Farm operating costs have been estimated based on 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 2.33 below.

The cost of goods sold (COGS) account for approximately 62.4% of total operating costs, over the 20-year evaluation period. The COGS include costs such as packing, harvesting and materials.

Figure 2.33. Total Operating Costs (FY2022 – FY2041)



Source: AEC.

Operating costs pertaining to soybean and wheat production are presented in Appendix E.

2.7.4.3 Farm Revenue

The farm revenue consists of the operating income associated with the sale of both soybeans and wheat, pursuant to the crop's grade. For the purposes of analysis, it is assumed all soybean and wheat harvested have the following yield and price expectations.

Table 2.11. Price and Yield, by Commodity

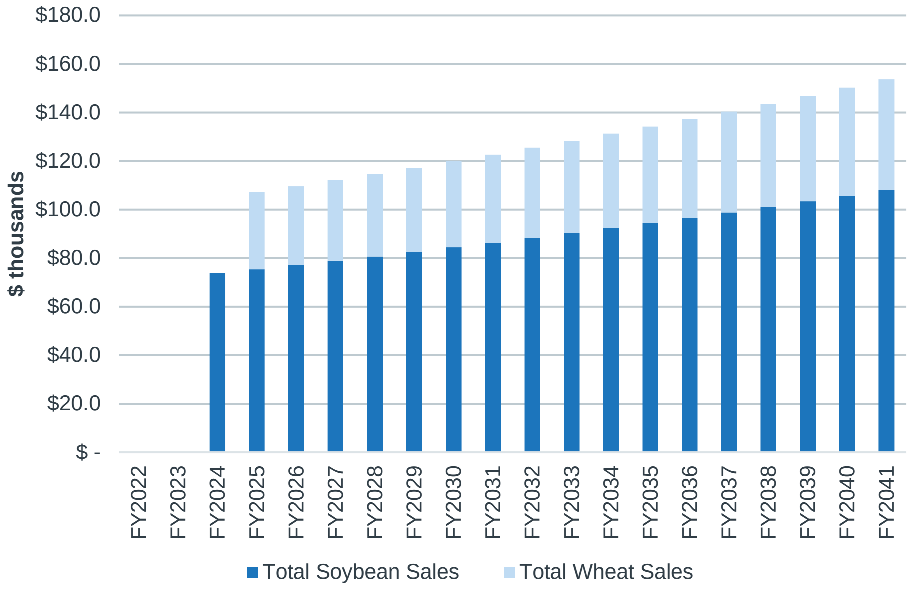
Commodity	Yield	Price
Soybean	3.0tonnes/ Ha	$594/ tonne
Wheat	1.8tonnes/ Ha	$421/ tonne

Source: ABARES (2022), DAF (2020c&d), NAB (2022).

Prices used for soybean is the five-year forecast produced by ABARES (refer to section 2.3 for more detail on soybean prices), and the price used for wheat is the average FY2021 price (ABARES, 2022).

The forecasted revenue for both soybean and wheat are shown in Figure 2.34. This forecast shows total soybean revenue exceeds total wheat revenue. The soybean revenue over the 20-year evaluation accounts for 71.3% of all farm revenue.

Figure 2.34. 20-year Revenue Forecast (FY2022 – FY2041)



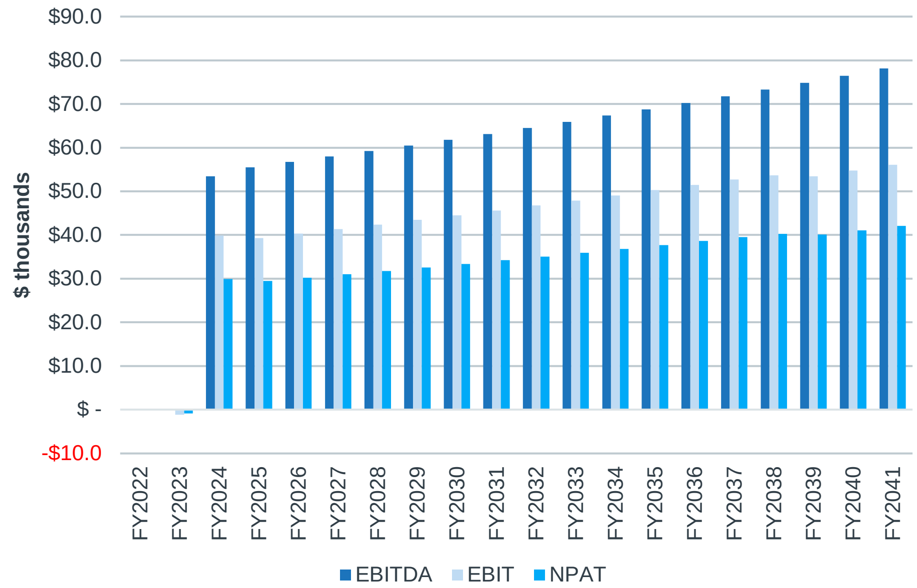
Source: AEC.

2.7.5 Financial Feasibility

The example farm in the Rookwood Weir Catchment Area is expected to return a positive earnings before interest, tax, depreciation and amortisation (EBITDA) across all years in the evaluation. The operating breakeven month for the example farm modelled is June 2024. This shows the price point for both soybean and wheat are sufficient to recover the total COGS.

By FY2041 the net profit after tax (NPAT) of the farm is estimated to be $42,070 and the EBITDA is estimated to be $78,111. Figure 2.35 shows that the impact of depreciation and tax expenses have a significant impact to the profitability of the farm for the landholder, with $36,041 of the total EBITDA required to cover these costs (in FY2041).

Figure 2.35. Farm Operating Profit (FY2022 – FY2041)



Source: AEC.

To understand the value of the farm investment, a DCF has been calculated. 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 Central Queensland between 2014 and 2021, which is 12.5% (HTW, 2021).

With an NPV of the farm at $0 the implied internal rate of return is 12.8%. The terminal value of the example farm growing soybean at the conclusion of the analysis (FY2041) is $27.0 million (undiscounted).

The example soybean farm is estimated to start incurring positive discounted cash flows intermittently from FY2025. Over the evaluation period there are a couple of years which are anticipated to have a negative discounted cash flow due to the required capital replacement.

The internal rate of return is above the growth rate estimated for the region, as such, the example soybean farm represents a commercially viable investment.

2.7.5.1 Sensitivity Analysis

It can be concluded that the profitability of a soybean enterprise is contingent of the scale of the farm. the enterprise is in the positive NPAT position under a soybean only scenario (76.4ha farm) and with no water allocation restrictions (197ha farm).

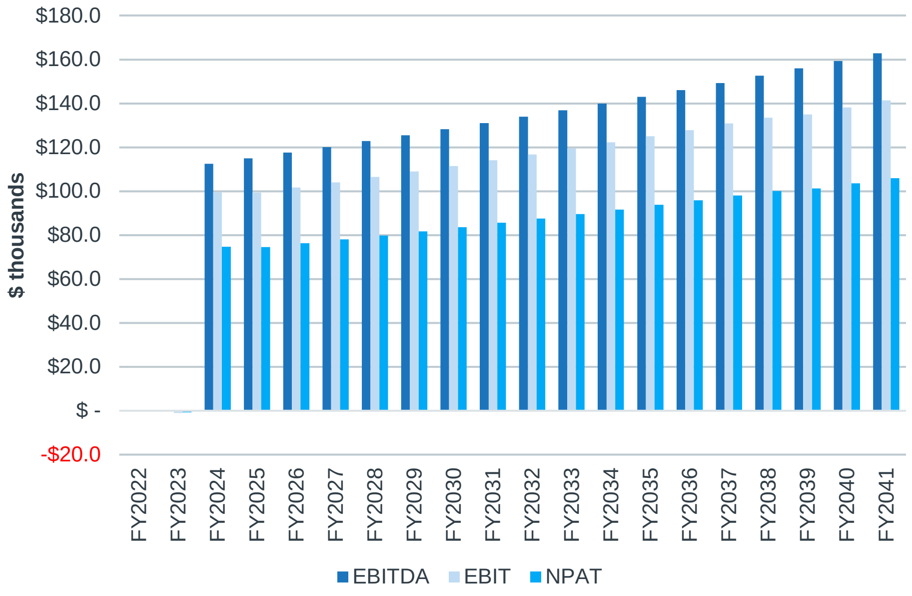
Crop Rotation Sensitivity

Figure 2.36 shows the farm operating profit when soybean is the only crop farmed in the Rookwood Weir Catchment Area. Removing wheat has a multitude of impacts:

- Lower total water is required on an annual basis. This will enable farms to increase their farmed area as the average farm size is 197ha and under the rotational cropping system, the planted area is 39.3ha. A soybean only farm will allow the landholder to farm 76.4ha.
- There is a marginal decrease in capital investment. This decrease relates only to on-farm storage for the wheat. Operationally, the impact of this is a slightly adjusted depreciation expense.
- Without a grain (or similar) crop, the farm is likely to experience an increased need for fertiliser to balance the soil nutrients. Similarly, the farm will likely have increased operating expenses associated with encouraging topsoil stability (to reduce the risk of erosion and increase water use efficiency). These costs have not been accounted for in the following profitability assessment.

A soybean only farm of 76.4ha, is expected to return a positive NPAT position from FY2024 and reach an NPAT position of $106,000 by FY2041.

Figure 2.36. Soybean Operating Profit (FY2022 – FY2041)



Source: AEC.

Farmland Growth Rate Sensitivity

Historical growth rates are not always reflective of future growth rates. Recent land sales activity is a key driver on recent land value uplift, with the growth rate for rural property estimated to be 12.5% for the Central Queensland region. As land sales and value growth may not continue to grow with equal rates of the historical rates, sensitivity of the growth rate used to determine the terminal value of the example farm has been undertaken.

Rural Bank (2021) published the average Queensland rural land value long term growth rate of 8.8% (calculated over 20 years). Using this conservative growth rate and the IRR of 12.8%, the terminal value of a soybean farm in the Rookwood Weir Catchment Area is $1.9 million with an investment NPV of negative $2.3 million.

With a growth rate of 8.8% and an NPV of the farm at $0 the implied internal rate of return is 9.3%. The terminal value of the example farm at the conclusion of the analysis (FY2041) is $15.0 million (undiscounted), ultimately showing a commercially feasible investment.

Table 2.12. NPV and Terminal Value, by IRR at 8.8% Growth Rates

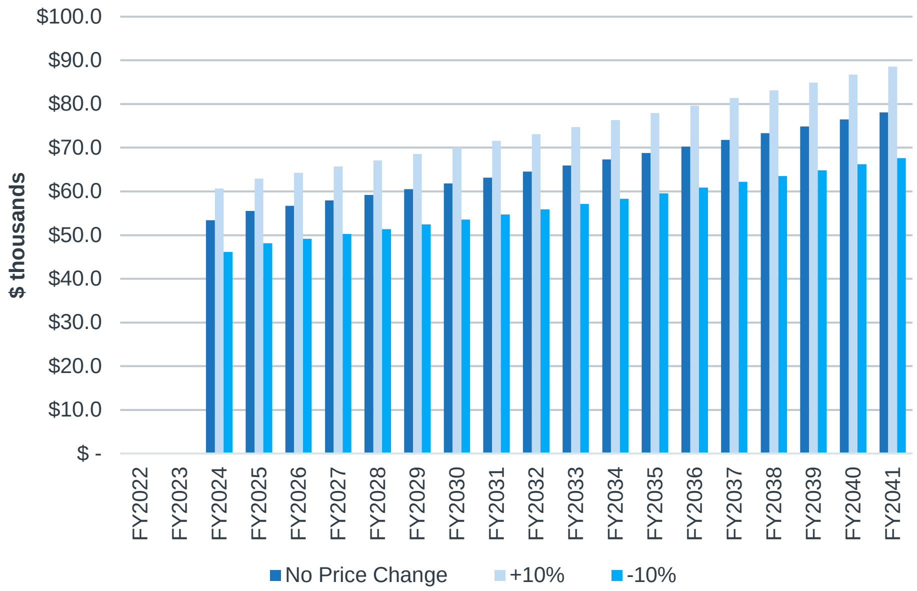
IRR	Net Present Value	Undiscounted Terminal Value
IRR at 12.8%	-$2.3 million	$1.9 million
IRR at 9.3%	$0.0 million	$15.0 million

Source: AEC

Price Sensitivity

To account for external price pressure on future soybean 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.

Figure 2.37. Price Impact on Profitability (EBITDA) (FY2022 – FY2041)



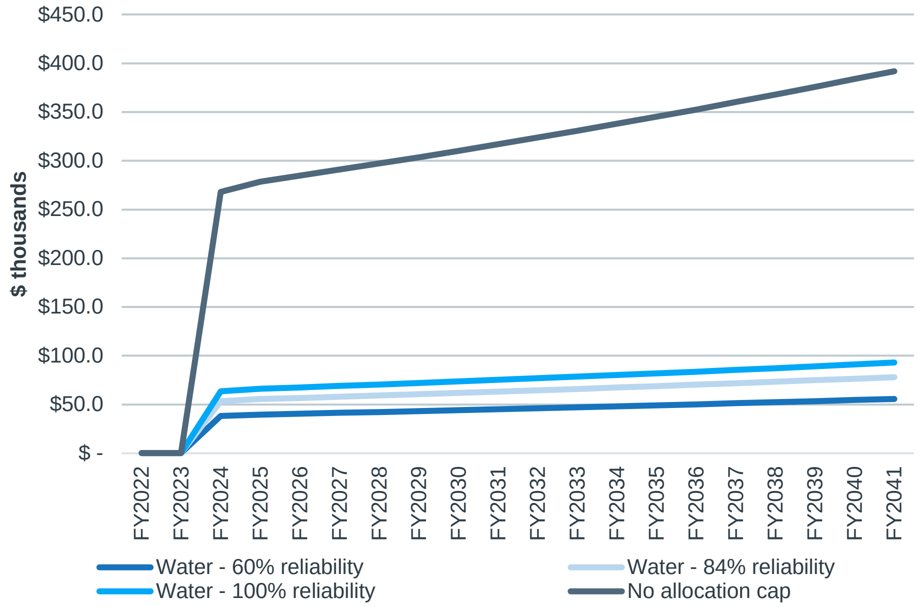
Source: AEC.

Water sensitivity

Water availability has a relatively linear relationship with the profitability of the example farm 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 farm.

The total water required in the no allocation cap is 2,108ML. The no allocation cap scenario is the only scenario to see the example farm reach a positive operating surplus ratio. The variance in revenue is presented in the figure below.

Figure 2.38. 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 farm establishment timing. In practice, by increasing the available land there may be an increased time required to establish the farm. Under the No allocation cap scenario the land farmed will increase from 37.4ha to 197ha, a significant increase, just over five times larger.

2.7.6 Economic Impact

Investment in a farm 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 farm establishment and operations.

Input-Output modelling is used to examine the direct and flow-on[4] 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 F.

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

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 (e.g., Gross Regional Product (GRP)) defines a true net economic contribution and is subsequently the preferred measure for assessing economic impacts.
- **Income –** Measures the level of wages and salaries paid to employees of the industry under consideration and to other industries benefiting from the project.
- **Employment –** Refers to the part-time and full-time employment positions generated by the economic stimulus, both directly and indirectly through flow-on activity, expressed in full time equivalent (FTE) positions. [5]

The economic contribution of the example farm enterprise in the Rookwood Weir Catchment Area is presented in Table 2.13.

Initial capital investment of the farm is anticipated to cost approximately $2.7 million, 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 farm is anticipated to directly contribute to $1.9 million in industry output (i.e. revenues) to local businesses within the Rockhampton LGA.

A further $1.2 million in industry output is estimated to be supported in the catchment's economy through flow-on activity, including $0.7 million in production induced (i.e. supply chain) activity and $0.5 million through household consumption induced activity (i.e. expenditure of households within the local economy as a result of a lift in household incomes).

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

- A $1.4 million contribution to GRP including $0.8 million directly
- 12 FTE jobs (including 8 FTE jobs directly), paying a total of $1.0 million in wages and salaries ($0.6 million directly).

Table 2.13. Economic Activity Supported by a Soybean Farm Enterprise, Rockhampton LGA

Impact	Output ($M)	Gross Regional Product ($M)	Incomes ($M)	Employment (FTEs)
Direct	$1.9	$0.8	$0.6	8
Production Induced	$0.7	$0.3	$0.2	2
Consumption Induced	$0.5	$0.3	$0.2	2
Total	**$3.1**	**$1.4**	**$1.0**	**12**

Note: Figures may not add due to rounding.
Source: ABS (2012), ABS (2017b), ABS (2021b, c and d), AEC.

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

3. CHICKPEAS

3.1 INTRODUCTION

There are two main varieties of chickpea available on the market, Desi and Kabuli. The Desi chickpea is known for its smaller angular seeds with various colouring from brown to light brown and fawn. This type of chickpea is largely known for its use in dhal. The Kabuli grouping is larger and rounder in size. The chickpeas are white-cream in colour and are primarily used whole. This grouping is the preferred chickpea throughout the Mediterranean region.

The demand for chickpeas is growing, particularly with the rising awareness of health benefits combined with the trend of substituting meat options for vegetarian alternatives (EMR, 2022a). The largest market for chickpeas on the global scale is India. In 2020, India was the largest producer of chickpeas, largest importer and fourth largest exporter. It is unlikely that the demand from the Indian subcontinent will diminish in the near future, however, the tariff applications are likely to remain a feature of this market. Currently, the tariffs for chickpeas in India stand at 60% for Desi chickpeas and 40% for Kabuli chickpeas. The tariffs implemented over 2017 and 2018 were to support domestic production and domestic pricing in India.

The primary producer of chickpeas on the global scale is India, accounting for 73.7% of total production in 2020. Production of chickpeas in India dwarf volumes achieved by every other country, however, Australia is relatively competitive in the export market. It is estimated that only 1% of chickpeas in Australia are consumed domestically, with the remainder being exported to international markets, including India, Bangladesh and Pakistan (GRDC, 2017). The large exportable surplus of chickpeas in Australia places the country as the largest global exporter in 2020.

Of significant note, production in Central Queensland (as defined in Figure 3.18) accounted for over half of Australia's total production in 2020. Varieties have been adapted for the Central Queensland climate over the years, including PBA Seamer, PBA Pistol and Moti, which are all Desi chickpeas (GRDC, 2016b). In 2011, the PBA Pistol variety was introduced as a replacement for Moti and the variety is well adapted to the shorter growing season of the region (Pulse Australia, 2016b).

Demand for Australian chickpeas are estimated to be strong throughout the coming years, with ABARES forecasting production to reach a peak of 1.1 million tonnes in 2022. Over the year, there has already been strong demand from Bangladesh particularly in the lead up to Ramadan which begins at the start of April and ends at the beginning of May.

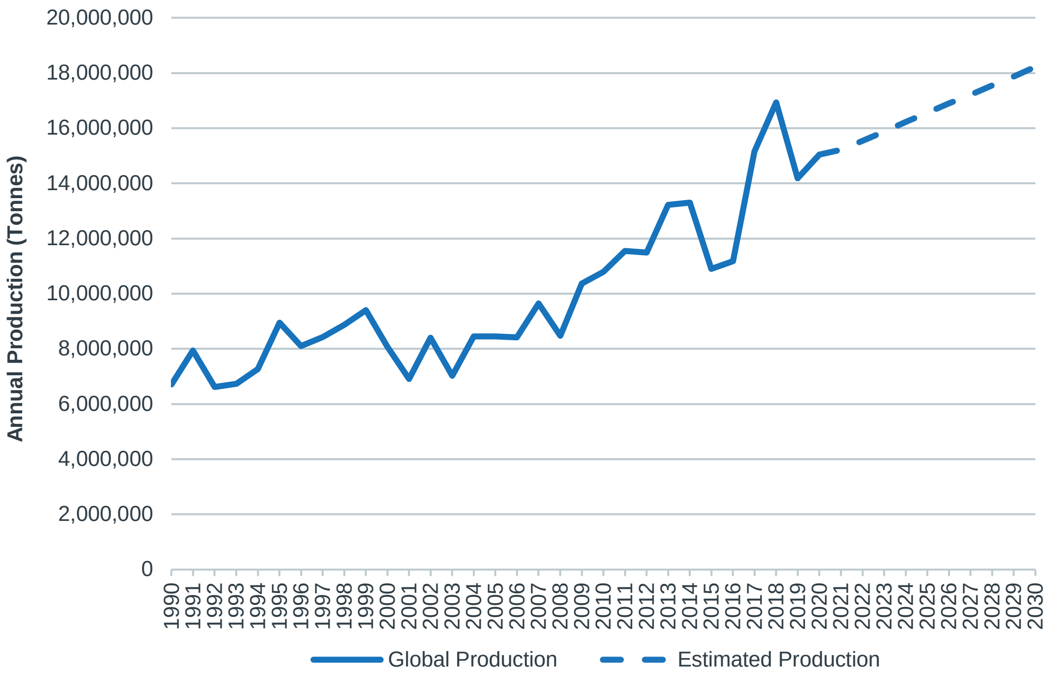
3.2 OVERVIEW OF THE GLOBAL MARKET

3.2.1 Global Production

In 2020, global chickpea production totalled 15.0 million tonnes, having increased by an average annual rate of 2.7% per annum from 1990. Global production experienced relatively strong growth over 2016 and 2017, largely driven by production in Australia and India.

Projections from the *OECD-FAO Agriculture Outlook 2021-2030* indicate that global pulse production could increase by an average annual rate of 1.9% from 2020 to 2030. Applying the average growth per annum to 2020 chickpea production estimates, highlights that chickpea production could reach 18.2 million tonnes in 2030. There are reports that suggest chickpea production could experience stronger growth over the short term increasing by an average rate of 4% to 6% over the next four to five years (Krishi Jargan, 2021).

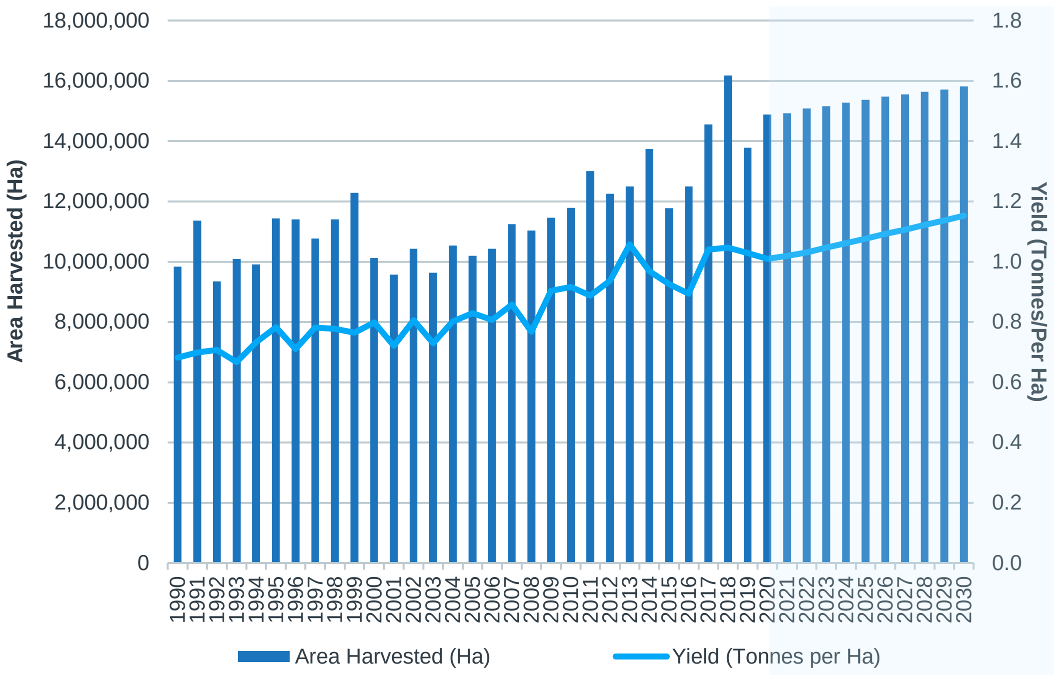
Figure 3.1. Global Production of Chickpeas, 1990 to 2030



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

Historically, the chickpea harvested area has grown by an average of 1.4% per annum from 1990 to 2020 to reach 14.9 million Ha in 2020. If the chickpea harvested area grows in line with the global harvested area for pulse production, then in 2030 the harvested area could reach 15.8 million Ha.

Figure 3.2. Global Area Harvested & Yield, 1990 to 2030



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

3.2.2 Major Producers

India has always been the most prominent producer of chickpeas on the global scale. In 2020, India produced 11.1 million tonnes of chickpeas, accounting for approximately 74% of the total global production. The second largest producer of chickpeas in 2020 was Turkey (630,000 tonnes), followed by Pakistan (497,608 tonnes) and Myanmar (481,668 tonnes).

The section below provides more detail about chickpea production in India, Turkey and Pakistan.

Table 3.1. Top 10 Global Producers of Chickpeas, 2019 and 2020

Country	2019		2020	
	Tonnes	Proportion	Tonnes	Proportion
India	9,937,990	70%	11,080,000	74%
Turkey	630,000	4%	630,000	4%
Pakistan	446,584	3%	497,608	3%
Myanmar	499,438	4%	481,668	3%
Ethiopia	435,193	3%	457,319	3%
Russia	506,166	4%	291,133	2%
Australia	205,130	1%	235,165	2%
Iran	195,487	1%	226,595	2%
US	282,910	2%	193,820	1%
Mexico	202,846	1%	125,823	1%
Other	842,705	6%	818,705	5%
Total	**14,184,449**	**100%**	**15,037,836**	**100%**

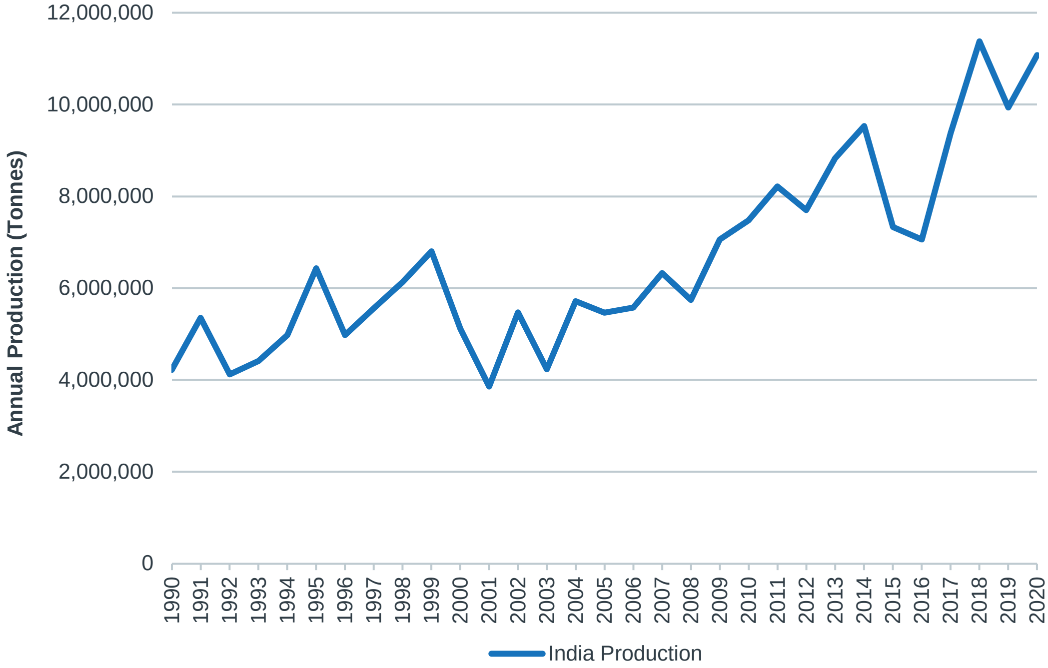
Note: Top 10 producers in 2020.
Source: FAOSTAT (2022), ABARES (2022a).

India

From 1990 to 2020, chickpea production in India has experienced strong growth, increasing by an average annual rate of 3.3%. From 1990, production has more than doubled to reach a total of 11.1 million tonnes in 2020, representing 73.7% of total global production.

From 2014 to 2017, chickpea production experienced relatively sharp decline, reducing from 9.5 million tonnes to 7.1 million tonnes. The decline in production was due to the drought impacting India in FY2016 (Reliefweb, 2016). In FY2015, India had a 12% rainfall deficit with impacts being exaggerated by a 14% shortfall in the following year (Reliefweb, 2016). In 2005, it was estimated that over 75% of the India chickpea crop was rainfed, with the remainder being irrigated (KPR Vittal, Masood Ali, G Ravindra Chary, GR Maruthi Sankar, T Srijaya, M. Udaya Bhanu, YS Ramakrishna and JS Samra, 2005).

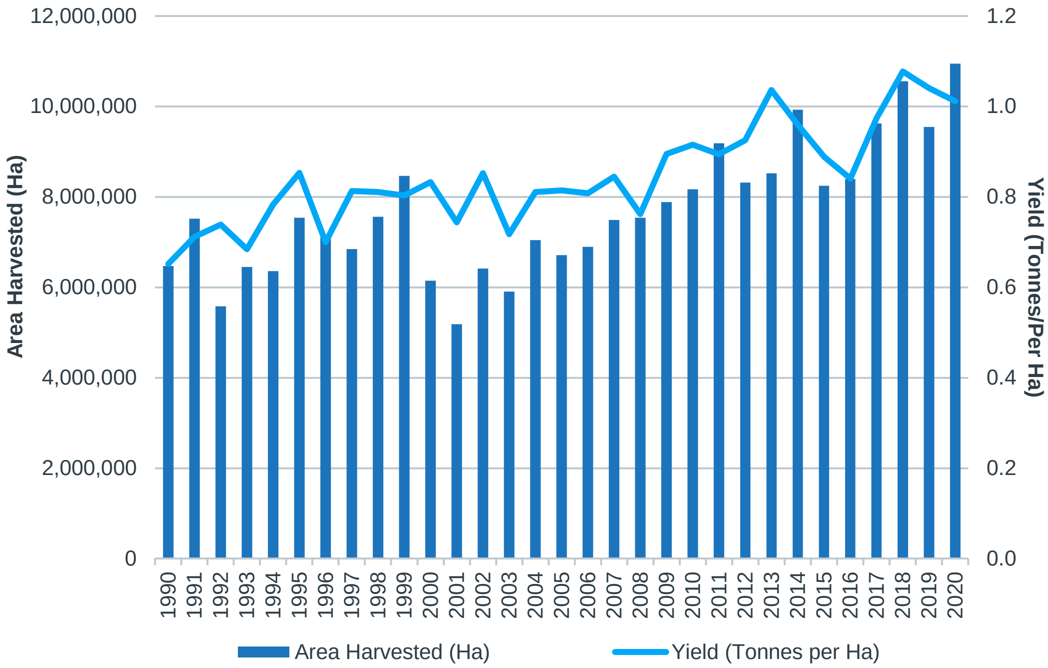
Figure 3.3. Chickpea Production in India, 1990 to 2020



Source: FAOSTAT (2022).

Historically, the chickpea harvested area has increased by an average of 1.8% per annum from 1990 to 2020 to reach 10.9 million Ha. Chickpea yield has also experienced an increase over the years, growing from an estimated 0.7 tonnes per Ha in 1990 to 1.0 tonnes per Ha in 2020. Of important note, yield declined significantly from 2013 to 2016, largely due to the impacts of drought in India.

Figure 3.4. Area Harvested & Yield (India), 1990 to 2020



Source: FAOSTAT (2022).

Turkey

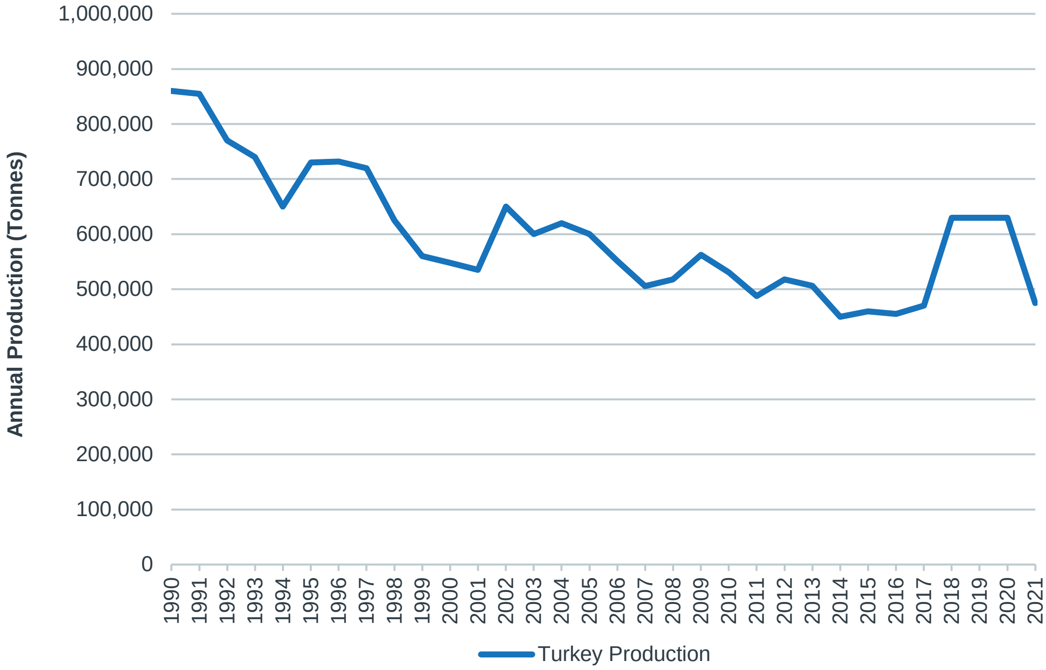
From 1990 to 2020, chickpea production in Turkey has been on the decline, decreasing by an average annual rate of 1.0% per annum. In 1990, production was estimated to total 860,000 tonnes which has subsequently declined to reach 475,000 tonnes in 2021.

The decline in production is being met with an increase in chickpea imports, as highlighted in Figure 3.10. Over the years, Turkey has been experiencing a decline in total pulse production, which could be attributed to inconsistent rainfall and severe harmattan[6] weather related conditions (Ertuk, A., & Gul, M, 2018).

From 2017, chickpea production experienced an increase due to an increase in the planted area. In 2021 chickpea production once again experienced a decline, decreasing by 24.6% largely due to the impact of a drought (The Western Producer, 2021). This drought was severe and impacted not only chickpeas, but a number of other agricultural commodities including wheat (World Grain, 2022).

The largest chickpea producing areas in Turkey include Konya, Corum, Karaman and Yozgat in Central Anatolia (USDA, 2016b). In South and West Anatolia, chickpeas are grown largely grown in Mersin, Antalya, Kutahya and Usak (USDA, 2016b).

Figure 3.5. Chickpea Production in Turkey, 1990 to 2021

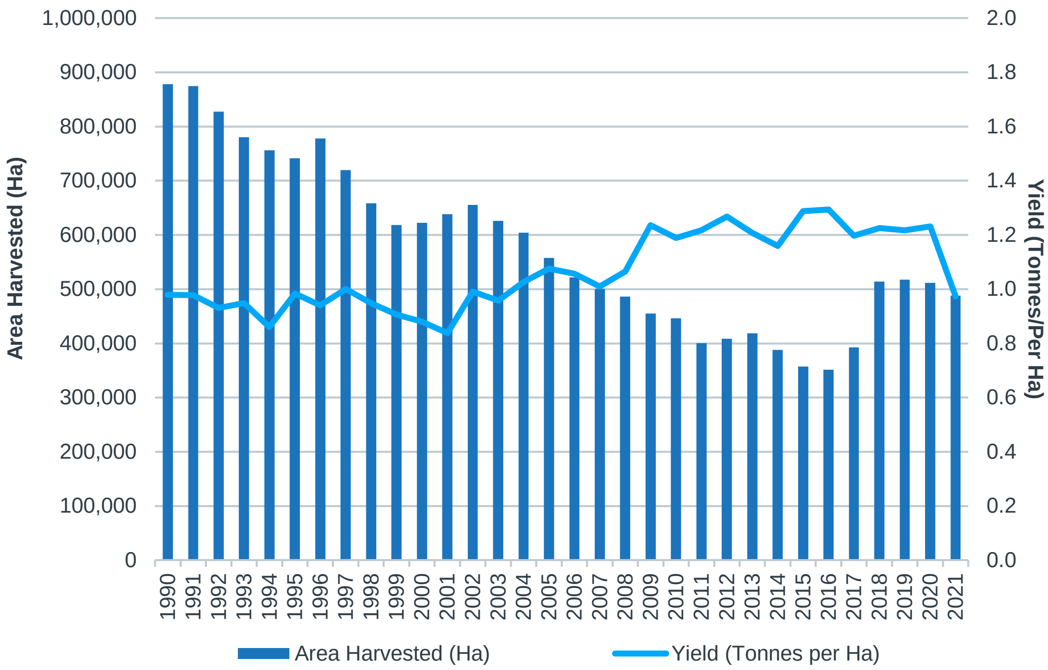


Source: Turkish Statistical Institute (2021).

Historically, the chickpea harvested area has declined by an average of 1.8% per annum from 1990 to 2021 to reach 487,886 Ha. The area harvested has largely declined from 1990 to reach a low of 351,687 Ha in 2016.

[6] Brings desert-like conditions.

Figure 3.6. Area Harvested & Yield (Turkey), 1990 to 2021



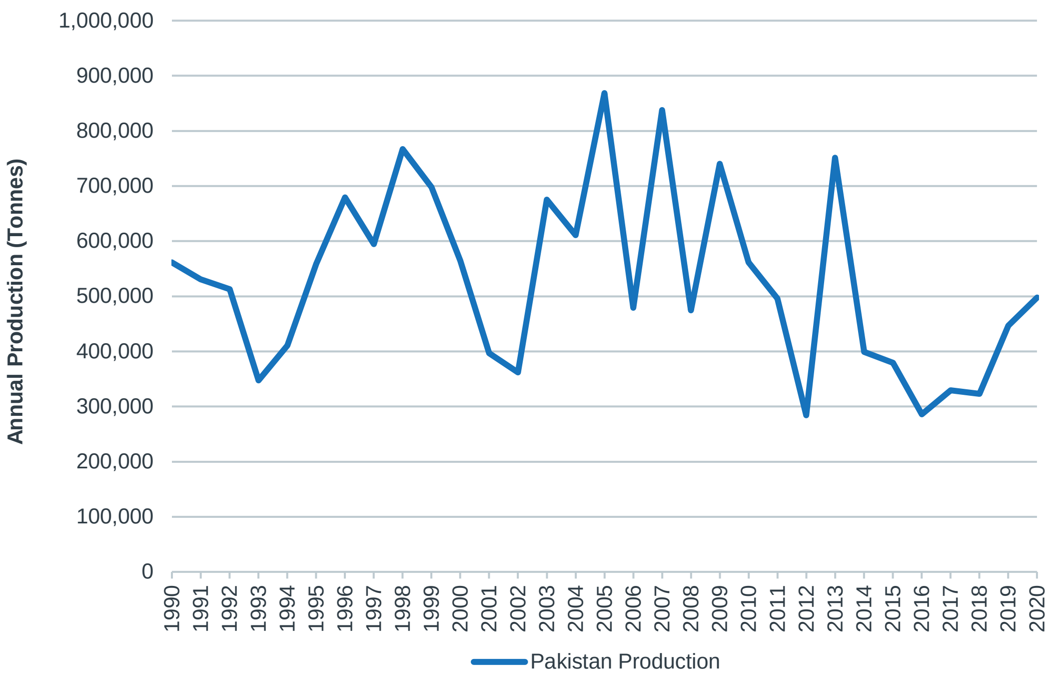
Source: Turkish Statistical Institute (2021).

Pakistan

Production of chickpeas in Pakistan has been relatively volatile over the years, with many peaks and troughs over time. The volitively of production stems for the countries reliance on rainfall to cultivate chickpeas (Khan, O.Z., Naseer, A., Shahbaz, M., Akhtar, S., Faisal, M., Mushtaq, K., 2017). Over 80% of chickpeas are growth in Thal where the regions are dry and have low soil productivity (AARI, undated; Khan, O.Z., et al., 2017).

From 1990 to 2020, chickpea production in Pakistan has been on the decline, decreasing by an average annual rate of 0.4% per annum. In 2020, chickpea production reached a total of 497,608 tonnes.

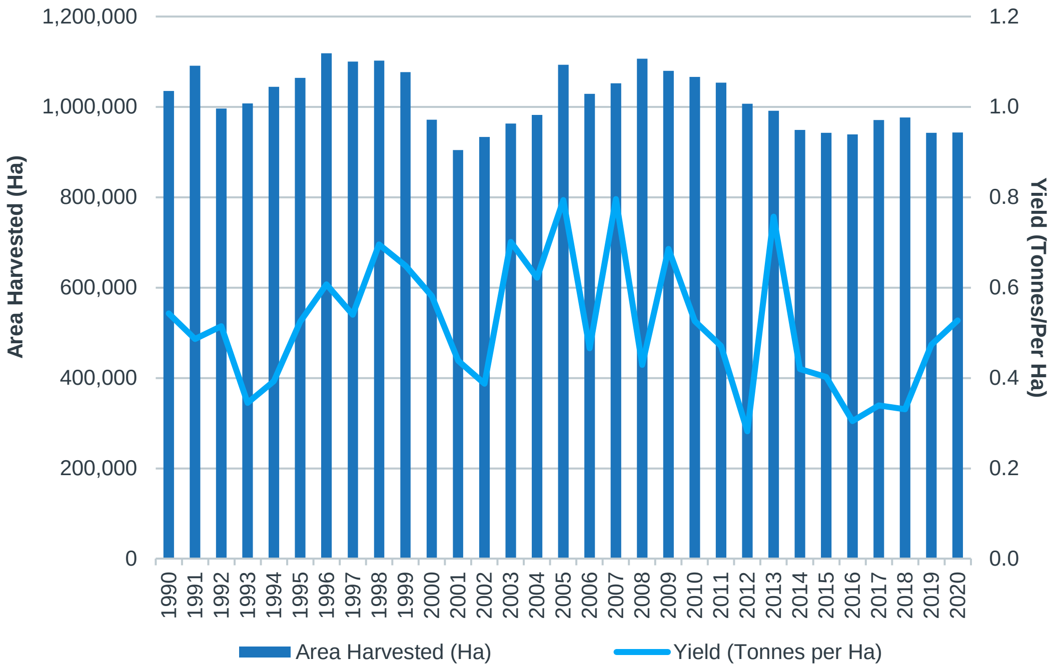
Figure 3.7. Chickpea Production in Pakistan, 1990 to 2020



Source: FAOSTAT (2022).

In 2020, it was estimated that the total area harvested was 943,860 Ha, resulting in a yield productivity of 0.5 tonnes per Ha. This yield productivity is significantly lower than what was achieved in both India and Turkey throughout 2020 (1.0 tonnes per Ha and 1.2 tonnes per Ha respectively).

Figure 3.8. Area Harvested & Yield (Pakistan), 1990 to 2020



Source: FAOSTAT (2022).

3.2.3 Major Exporters

From 1990 to 2020, exports of chickpeas have experienced an average annual growth of 4.8% per annum to reach 1.9 million tonnes in 2020.

The majority of the chickpeas grown in Australia are for exports to international markets including India, Bangladesh and Pakistan (FAOSTAT, 2022). The largest exporter of chickpeas in the global market in 2020 was Australia, with exports estimated to total 349,325 tonnes, despite Australian production totalling 235,165 tonnes in 2020. Given chickpeas can be stored post-harvest, there is often a discrepancy each year between the quantity sold and the quantity produced.

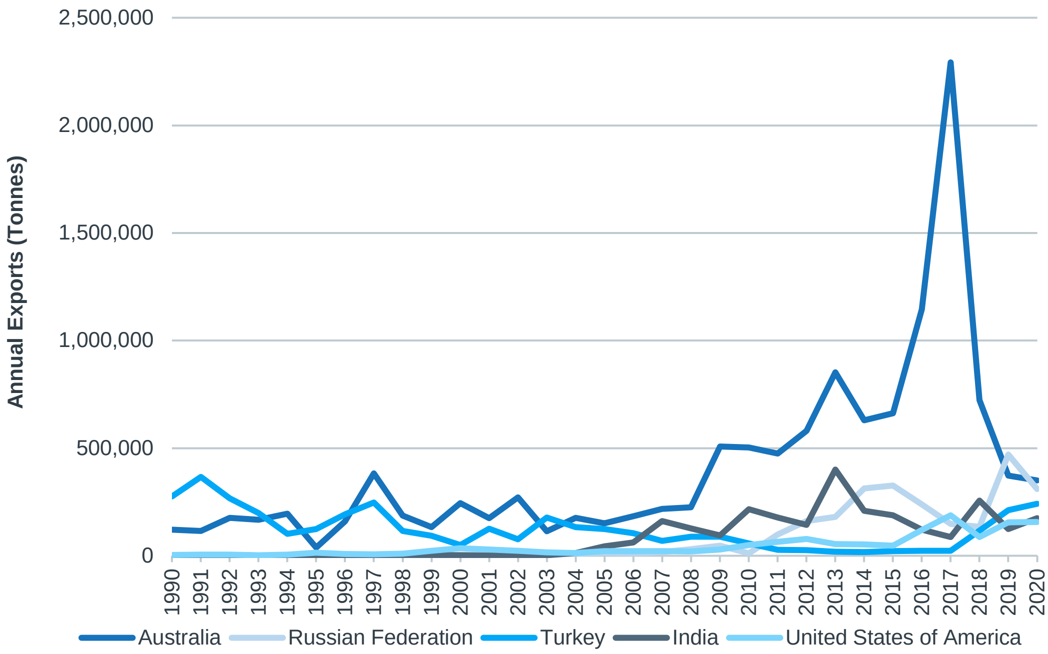
Of important note Australia experienced a significant spike from 2014, with exports peaking at a total of 2.3 million tonnes in 2017 (ABARES, 2022a). The increase in exports was largely driven by lower production in India from drought impacts and the increasing demand for imports. From 2014 to 2017, chickpea exports to India increased by over one million tonnes.

Based on data provided by FAOSTAT, Russia emerged as an exporter of chickpeas in 1999 and was identified as the second largest exporter in 2020. In 2020, the largest export market for Russian chickpeas was Pakistan, accounting for 45.5% of total exports. The second largest export market for Russia in 2020 was India at 22.6% of total exports, followed by Turkey at 16.6% of total exports (FAOSTAT, 2022).

With the Russian invasion in Ukraine many western countries have placed sanctions on many agricultural commodities from Russia. Pakistan, India and Turkey have not formally implemented any sanctions on Russia, meaning chickpea exports from Russia will likely be largely unaffected.

Of important note, Turkey was the third largest exporter of chickpeas in 2020, the third largest importer and also the second largest producer. In October 2021, the Turkish Government introduced a ban on chickpea exports which originated from Turkey to support domestic prices and help ease inflation (Pulse Pod, 2022). Turkey is focused on re-exporting chickpeas from different origins including Russia, Ukraine and some Asian and American origins (Pulse Pod, 2021;2022).

Figure 3.9. Top Five Major Exporters of Chickpeas, 1990 to 2020



Notes:

- Top five largest exporters in 2020.
- ABARES export data for Australia differs from what is reported in FAOSTAT. The above graph is reflective of the information provided by ABARES.
- FAOSTAT's detailed trade matrix does not record exports for Russia from 1990 to 1998.

Source: FAOSTAT (2022), ABARES (2022a).

3.2.4 Major Importers

From 1990 to 2020, exports of chickpeas have experienced an average annual growth of 5.3% per annum to reach 1.8 million tonnes in 2020.

In 2020, the largest importer of chickpeas was India, importing a total of 305,838 tonnes. Chickpea imports to India have been experiencing an average annual increase of 2.2% per annum from 1990 to 2020. Imports experienced a peak in 2017 at 1.4 million tonnes, of which 91.9% was supplied from Australia. This spike in imports was largely driven by a decline in domestic production over 2015 and 2016.

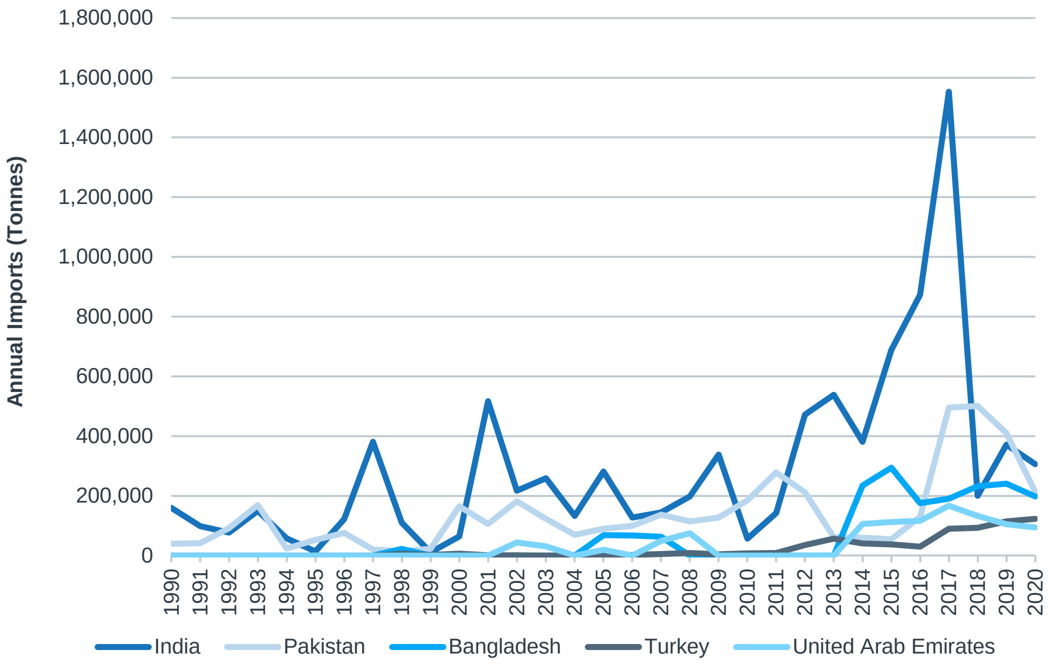
To support local farmers and protect domestic prices, India has imposed significant tariffs on chickpeas throughout 2017 and 2018. In December 2017, India initially introduced a 30% tariff on imports of chickpeas to restrict the flow of imports from producers in Australia and Canada (Business Insider, 2018). In February 2018, the tariff increased once again to 40% (Business Insider, 2018). The third and final increase in tariffs was realised in March 2018, with the tariff for Desi chickpeas totalling 60% while Kabuli chickpeas remained at 40% (Grain Central, 2019).

The implementation of the tariff resulted in a drop in India's chickpea imports, which were primarily sourced from Australia. The tariff increased the cost of export to India by 60% for Desi chickpeas within a short period of time, significantly impacting the sustainable profit of farmers.

Pakistan was the second largest importer of chickpeas in 2020, importing 212,992 tonnes. This import volume dropped to 68,040 tonnes in 2021 (Com Trade, 2022). The variance in imports from Pakistan is reflective of the volatile production due to the country's reliance on rainfed production. In 2021, Australia was Pakistan's largest supplier of chickpeas. Imports of Australian chickpeas totalled 24,927 tonnes in 2021, representing 36.6% of total imports for the year.

The third largest of chickpeas in 2020 was Bangladesh, importing around 197,645 tonnes. The domestic demand for chickpeas in Bangladesh exceeds domestic supply and the deficit is met through imports. The largest chickpea supplier to Bangladesh in 2020 was Australia, accounting for 89.3% of total imports. This was followed by India (8.9% of total imports) and the UAE (0.8% of total imports).

Figure 3.10. Top Five Major Importers of Chickpeas, 1990 to 2020



Notes:

- Top five largest importers in 2020.
- FAOSTAT detailed trade matrix does not have import data for Pakistan from 2013 onwards. Therefore, the import from 2014 to 2020 reflects Com Trade data.
- FAOSTAT's detailed trade matrix does not record imports for Bangladesh from 1990 to 1997, 1999 to 2004 and 2008 to 2013. Similarly, data is not recorded for the UAE from 1990 to 2001, 2004, 2006 and 2009 to 2013.

Source: FAOSTAT (2022), Com Trade (2022).

3.2.5 Global Consumption

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

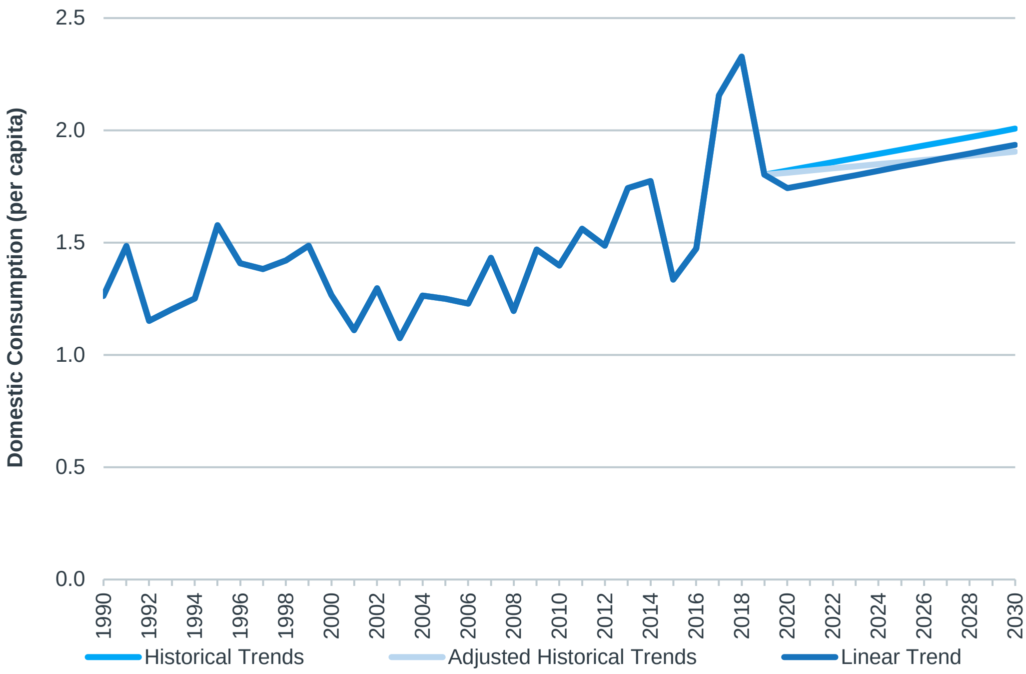
Initial estimates of consumption per capita have been developed based on:

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

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

Based on the historical trend volumes, consumption could total approximately 2.0 kilograms per capita in 2030.

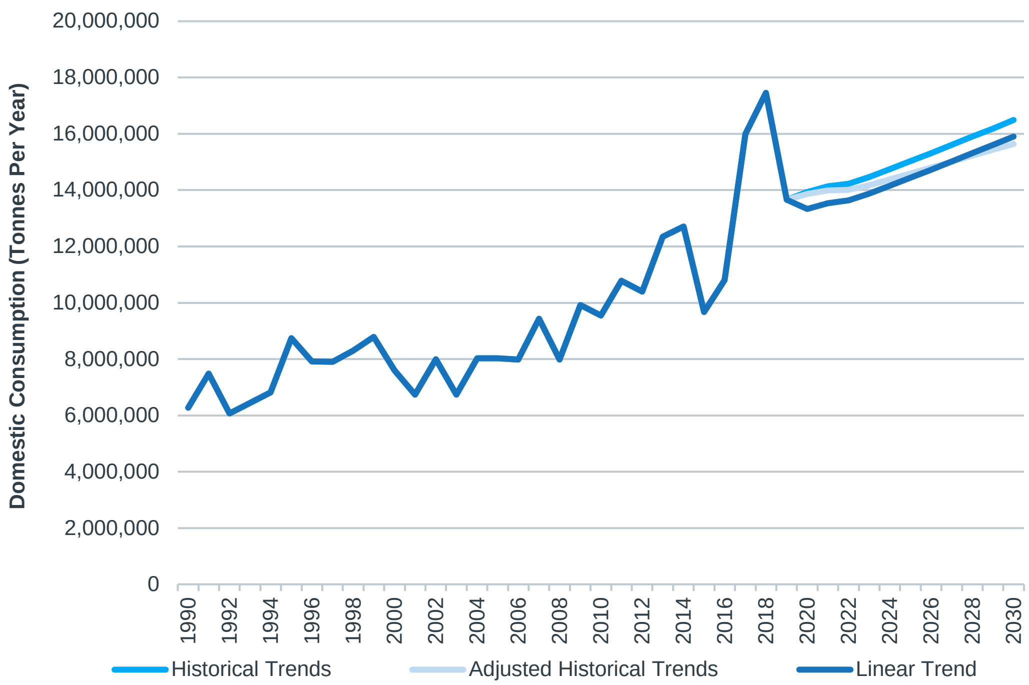
Figure 3.11. Consumption Per Capita, 1990 to 2030 (Kilograms Per Capita)



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

Based on historical trends, it is estimated that domestic consumption of chickpeas could grow from an estimated 41.1 million tonnes in 2021 to 16.5 million tonnes in 2030.

Figure 3.12. Consumption, 1990 to 2030 (Tonnes)



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

3.2.6 Growth Markets for Chickpeas

The demand for chickpeas is growing, particularly with the rising awareness of health benefits combined with the trend of substituting meat options for vegetarian alternatives (EMR, 2022a). It is unlikely that the demand from the Indian subcontinent will diminish in the near future, however, the tariff applications are likely to remain a feature of this market (GRDC, 2018). In India, vegetarians comprise a large portion of the population, driving substitutions for meat productions (GRDC, 2018). The tariffs will continue demand for local production and likely be a deterrent for international competitors, adding around 60% to costs of production.

Turkey is becoming more and more reliant on chickpea imports over the years due to declining production. In 2020, Turkey was the third largest importer of chickpeas on the global scale, with imports increasing by over 16-fold from 2010 to 2020. This equated to an average annual growth rate of 32.2% on average to reach a total of 123,274 tonnes in 2020. The largest suppliers of chickpeas to Turkey in 2020 was Russia (accounting for 33.9% of total imports), Mexico (33.8%) and India (8.4%) (FAOSTAT, 2022).

Pakistan is another key market for chickpeas, with highly volatile domestic production. Where there are production deficits (primarily due to dry conditions), Pakistan seeks to fill the deficit from imports. In 2021, Australia was Pakistan's largest supplier of chickpeas. This market provides opportunities for Australian chickpea exports.

3.3 THE AUSTRALIAN CHICKPEA INDUSTRY

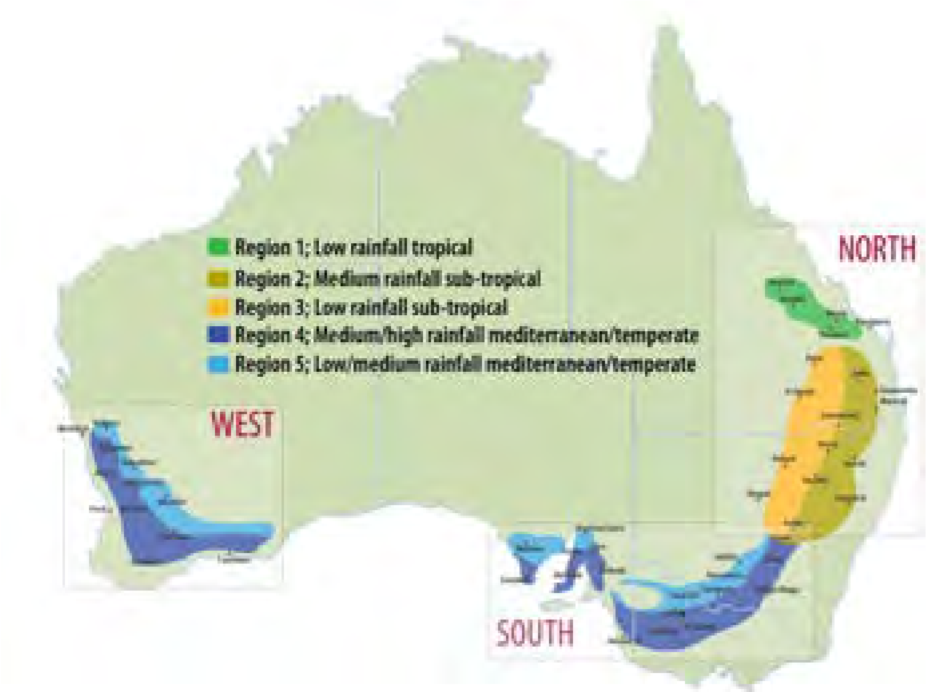
3.3.1 Cultivars

There are two main groups of chickpeas in Australia, the Desi chickpea and the Kabuli chickpea. Each chickpea has different seed size, colour, shape, different growth requirements and different markets (GRDC, 2016b). A description of each group (GRDC, 2016b):

- Desi chickpeas: The Desi grouping are small angular seeds, ranging in colour from brown to light brown and fawn. These chickpeas and most favoured in the Asian countries and are normally dehulled and split to obtain dhal.
- Kabuli chickpeas: The Kabuli grouping is larger and rounder in size. The chickpeas are white-cream in colour and are primarily used whole. This grouping is the preferred chickpea throughout the Mediterranean region.

The national chickpea production area has been categorised into five different categories based on rainfall and geographic location as highlighted below.

Figure 3.13. Key Growing Regions in Australia



Source: Pulse Australia (2020).

Kabuli chickpea varieties are listed in the table below. The varieties that are marked with an asterisk are subject to the Plant Breeder's Rights (PBR), which are rights that give the breeder exclusive control over the variety for a period of 20 years (Seednet, 2021).

Table 3.2. Kabuli Chickpea Varieties

Kabuli Varieties	Release Date	Production region
Very Large Varieties (9-11 mm)		
Kimberly Large*	2008	West (Ord)
Macarena	1984	North (Central Queensland) and West (Ord)
Large Varieties (8-10 mm)		
PBA Magnus*	2020	South and North
Kalkee	2012	North and South
Nafice*	2005	South
Bumper*	1998	North
Medium Varieties (7-9 mm)		
PBA Royal*	2019	South and North
PBA Monarch*	2013	South and North
Genesis™ 114	2010	North and South
Almaz*	2005	South
Kaniva	1980s	South
Small Varieties (6-8 mm)		
Genesis™ 079	2010	South
Genesis™ 425	2006	South
Genesis™ 090	2005	South

Note*: Protected by Plant Breeder's Rights (PBR).
Source: Pulse Australia (2020).

Desi chickpea varieties are listed in the table below.

Table 3.3. Desi Chickpea Varieties

Desi Varieties	Release Date	Production region
Medium Varieties		
CBA Captain*	2020	North, South and West
PBA Drummond*	2018	North (Central Queensland)
PBA Seamer*	2016	North
PBA Maiden*	2013	South and West
Ambar*	2013	West and South
Neelam*	2013	West and South
PBA Striker*	2012	South and West
PBA Boundary*	2011	North
PBA Pistol*	2011	North (Central Queensland)
PBA HatTrick*	2009	North
PBA Slasher*	2009	South and West
Genesis™ 836	2006	West and South
Kyabra*	2005	North
Moti*	2003	North (Central Queensland)
Jimbour	2001	North
Small Varieties		
Genesis™ 510	2008	West
Genesis™ 509	2008	South
Genesis™ 508	2005	South

Note*: Protected by Plant Breeder's Rights (PBR).
Source: Pulse Australia (2020).

In 2020, Australia launched a $30 million five-year breeding program that is working to expand chickpea production into central and southern New South Wales and Western Australia (GRDC, 2022). The first new chickpea variety released under the Chickpea Breeding Australia was CBA Captain in 2020 (GRDC, 2021).

3.3.2 Australian Chickpea Production

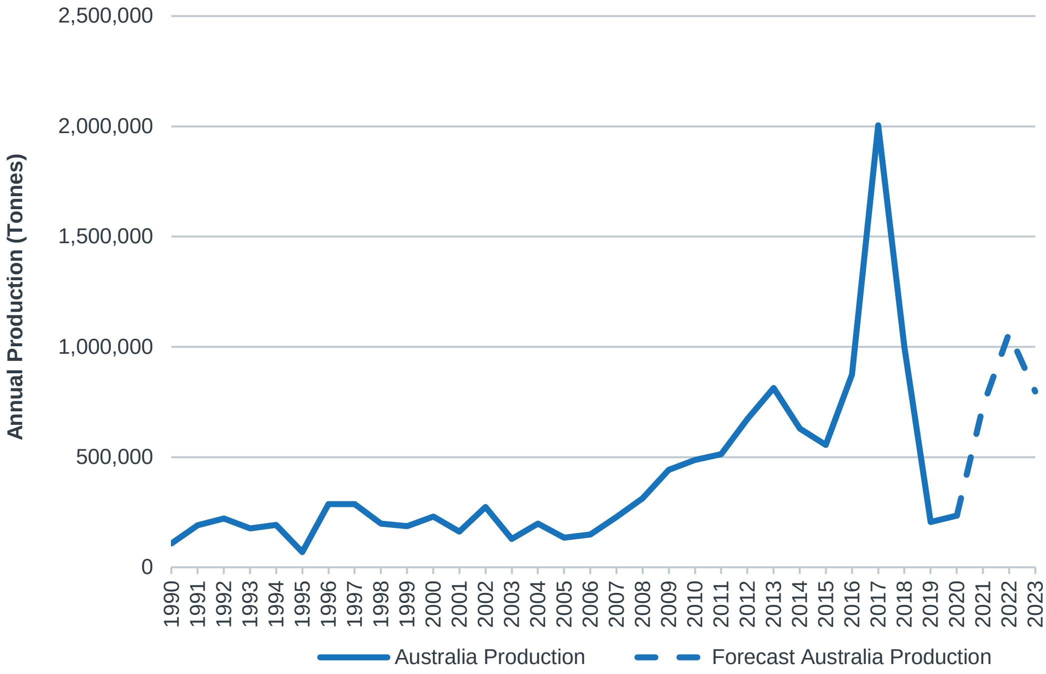
From 1990 to 2020, the production of chickpeas in Australia has experienced a 2.6% average annual increase to reach 235,165 tonnes. Australia experienced a spike in chickpea production from 2015, peaking at a total of 2.0 million tonnes in 2017. The increase in production was driven by a number of reasons, including:

- An increase in prices for chickpeas, providing an attractive profit for farmers compared to previous years (see Figure 3.20 below).
- An increase in demand from India, filling the chickpea demand deficit with an increase in imports.
- Almost perfect seasonal growing conditions across Australia in 2016 (Pulse Australia, 2016a). The ideal climate and weather conditions was combined with one of the largest recorded planted areas since 1990 at 1.1 million Ha.

The high prices, demand from India and the almost perfect seasonal conditions combined to create a perfect storm, driving chickpea production throughout 2016 and 2017. India's implementation of tariffs on chickpeas in 2017 and 2018 saw production decline, with costs increasing by 60% for Desi chickpeas. Additionally, production was low resulting from drought impacts, as discussed below.

Projections developed by ABARES highlights that chickpea production could reach 798,000 tonnes in 2023.

Figure 3.14. Australian Total Production of Chickpeas, 1990 to 2023

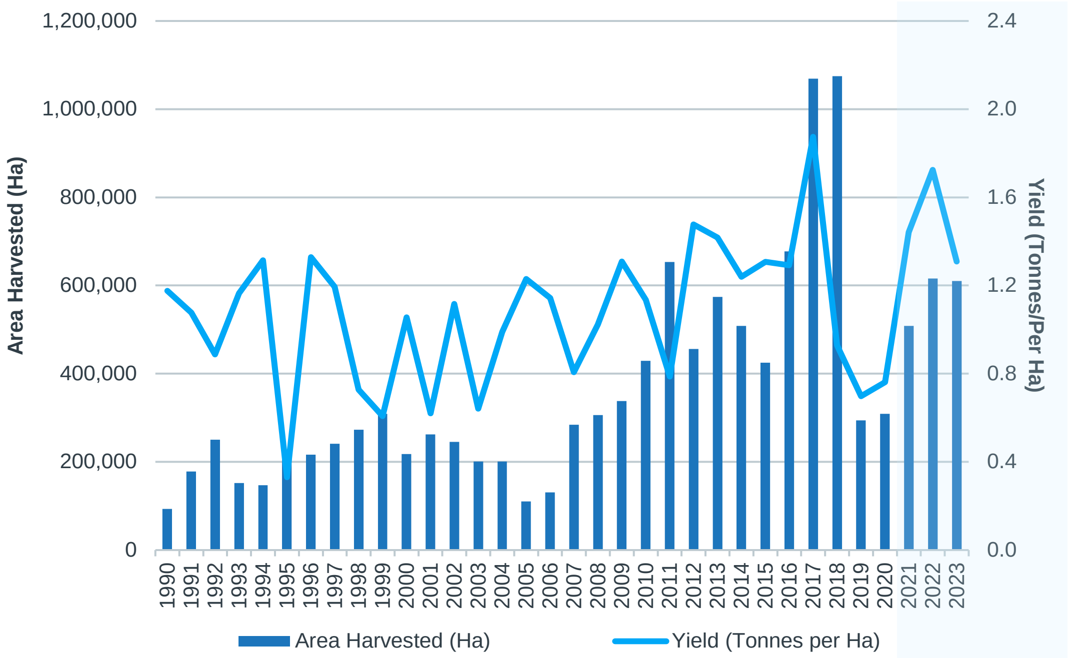


Source: ABARES (2022a).

Chickpea yield in Australia has shown volatility over the years, dipping to a low of 0.3 tonnes per Ha in 1995 and rising to a peak of 1.9 tonnes per Ha in 2017. In 2018, Australia experienced the largest chickpea plantings in the entire 30-year analysis period, however, yields were significantly low. The low yield resulted from significant rainfall deficits spanning from 2017 to 2019, particularly across New South Wales and Southern parts of Queensland (see Figure 3.16 below). Additionally, the rainfall deficiencies were largely experienced in the cooler seasons (BOM, 2020).

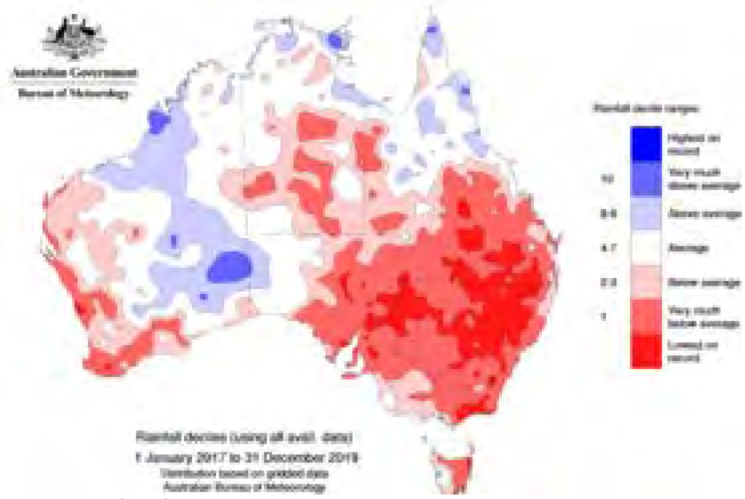
In 2023, it is projected that yields will total 1.3 tonnes per Ha.

Figure 3.15. Area Harvested & Yield (Australia), 1990 to 2020



Source: ABARES (2022a).

Figure 3.16. Rainfall Deciles January 2017 to December 2019



Source: BOM (2020).

3.3.2.1 Key Growing Areas

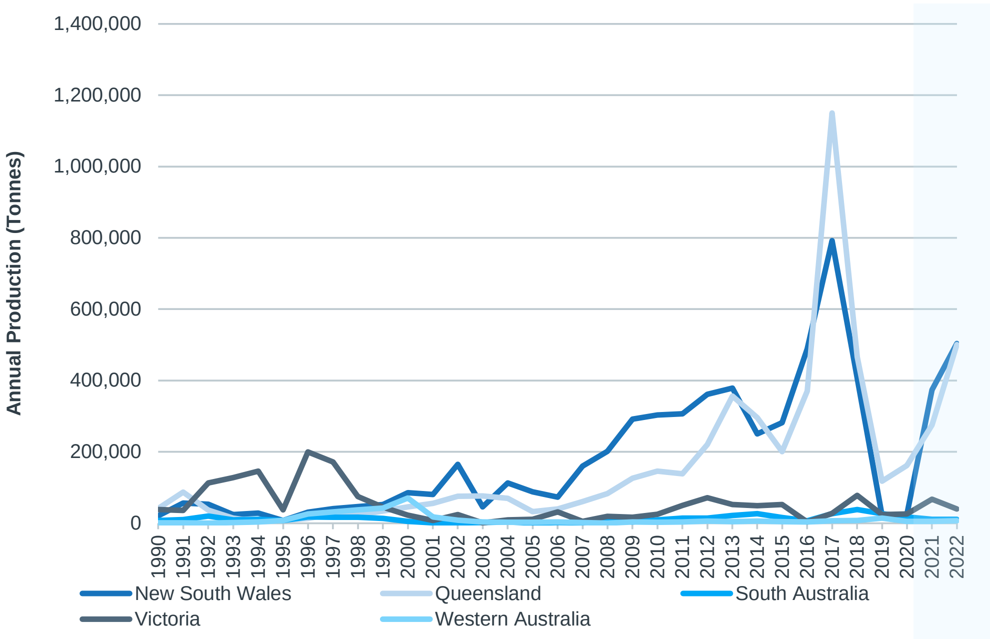
Production

On average, New South Wales has historically been the largest producer of chickpeas in Australia, with production totaling an estimated 374,000 tonnes in 2021.

In 2022, it is estimated that the chickpea crop will total 1.1 million tonnes, of which New South Wales is estimated to account for 47.7% and Queensland is estimated to account for 47.1%.

Major chickpea producing areas are highlighted in Figure 3.13 above.

Figure 3.17. Chickpea Production by State, 1990 to 2022



Source: ABARES (2022a).

Seasonality

Within the northern region as highlighted in Figure 3.13, chickpeas are largely planted over the months of April to June. The preferred chickpea planting times for districts within the northern, southern and western regions are highlighted in the tables below.

Table 3.4. Key Sowing Windows in the Northern Region

	April			May				June				July	
Region	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**
Central QLD													
Maranoa/ Balonne													
Western Downs													
Darling Downs													
Moree/ Narrabri													
Walgett/ Coonamble													
Liverpool Plains													
Central NSW (grey soil)													
Central NSW (red soil)													
	Marginal sowing time – increased costs and/or lower yields likely												
	Preferred sowing window												

Source: Pulse Australia (2016b).

Table 3.5. Key Sowing Windows in the Southern Region

	April			May				June				July	
Region	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**
South Australia/ Victoria													
<400 mm													
400-450 mm													
450-500 mm													
500-600 mm*													
Southern NSW													
<400 mm													
400-450 mm													
450-500 mm													
500-600 mm													
	Marginal sowing time – Marginal area or low disease risk area												
	Preferred sowing window – Ascochyta blight resistant varieties												
	Preferred sowing window – High disease risk areas or Ascochyta blight susceptible varieties												

Note*: Preferred sowing time for spring-sown chickpea in south-eastern Australia is August-September.
Source: GRDC (2017a).

Table 3.6. Key Sowing Windows in the Western Region

	April		May				June				July		
Region	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**
Western Australia													
Low rainfall													
Northern region													
Eastern region													
Central region													
Medium rainfall													
Southern region													
	Marginal sowing time – Marginal area or low disease risk area												
	Preferred sowing window – Ascochyta blight resistant varieties												
	Preferred sowing window – High disease risk areas or Ascochyta blight susceptible varieties												

Source: GRDC (2017a).

Central Queensland Chickpea Production

The optimal sowing timeframe in Central Queensland only spans for a period of two weeks over the end of April and beginning of May. Over time, there has been variety releases for specific growing regions, where Central Queensland specific varieties include PBA Seamer, PBA Pistol and Moti (GRDC, 2016b).

Research suggests that “many farms in Central Queensland have Phosphorous and Potassium concentrated in the topsoil and critically low levels in the subsoil. Plants cannot access these immobile nutrients when the topsoil is dry and this reduces productivity” (N Baxter, 2013 as cited in GRDC, p.168. 2016b).

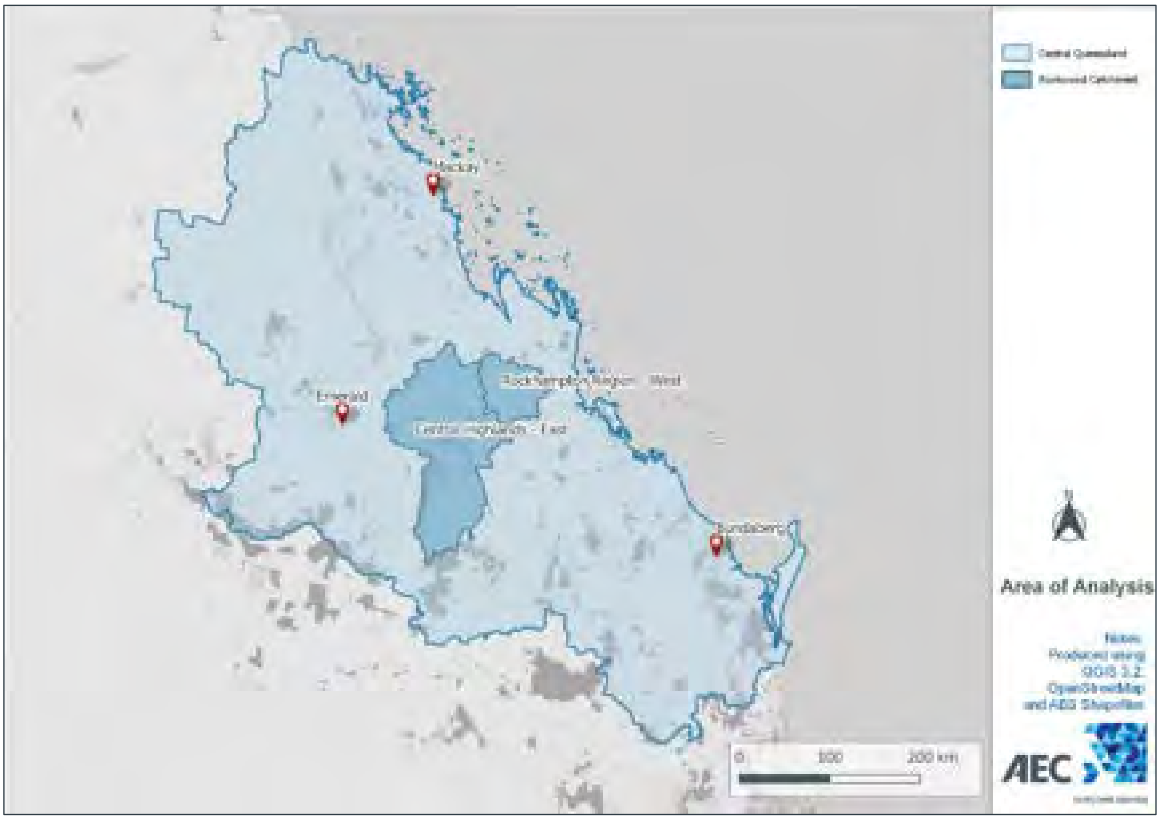
In FY2020, the Central Queensland region produced approximately 138,652 tonnes of chickpeas, representing 59.0% of total Australian production for the year.

Table 3.7. Central Queensland Chickpea Production, FY2020

Statistical Area 4	Hectares (Ha)	Production (t)
Mackay - Isaac - Whitsunday	56,717	67,604
Central Queensland	40,784	70,826
Wide Bay	367	222
Total	**97,868**	**138,652**

Source: ABS (2021).

Figure 3.18. Rookwood Weir Catchment Area and Central Queensland



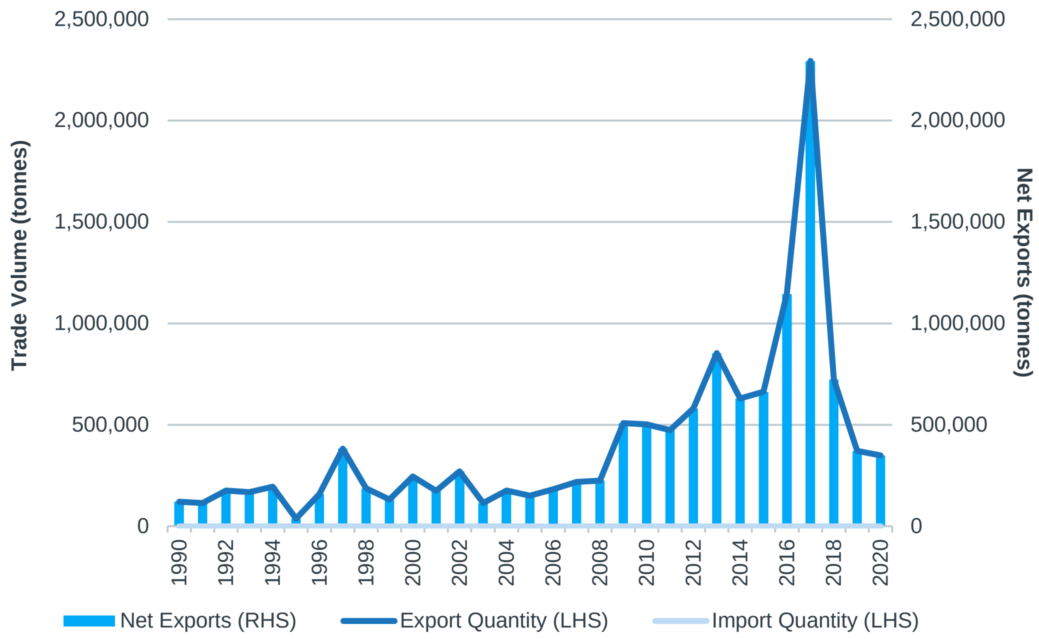
Note: For the purposes of this report, Central Queensland has been defined as the Mackay – Isaac – Whitsunday Statistical Area 4 (SA4), the Central Queensland SA4 and the Wide Bay SA4.
Source: AEC.

3.3.3 Australia's Trade Balance

Historically, Australia has been a significant net exporter of chickpeas. GRDC has estimated that Australia only consumes approximately 1% of chickpea production domestically, with the remainder being exported (GRDC, 2017).

With a large reliance on international markets for consumption, Australian chickpeas are sensitive to changes in export markets.

Figure 3.19. Australia's Chickpea Trade Balance, 1990 to 2020



Notes:

- ABARES export data for Australia differs from what is reported in FAOSTAT. The above graph is reflective of the information provided by ABARES.
- RHS = Right hand side, LHS = Left hand side.

Source: ABARES (2022a), FAOSTAT (2022).

It should be noted that there is an inconsistency in export and production numbers across available datasets. Whilst some of this can be explained through potential inventory carryover across reporting periods, there appears to be some data inconsistencies between various domestic and international datasets. As a result, extrapolations and analysis based on this information should consider these shortcomings.

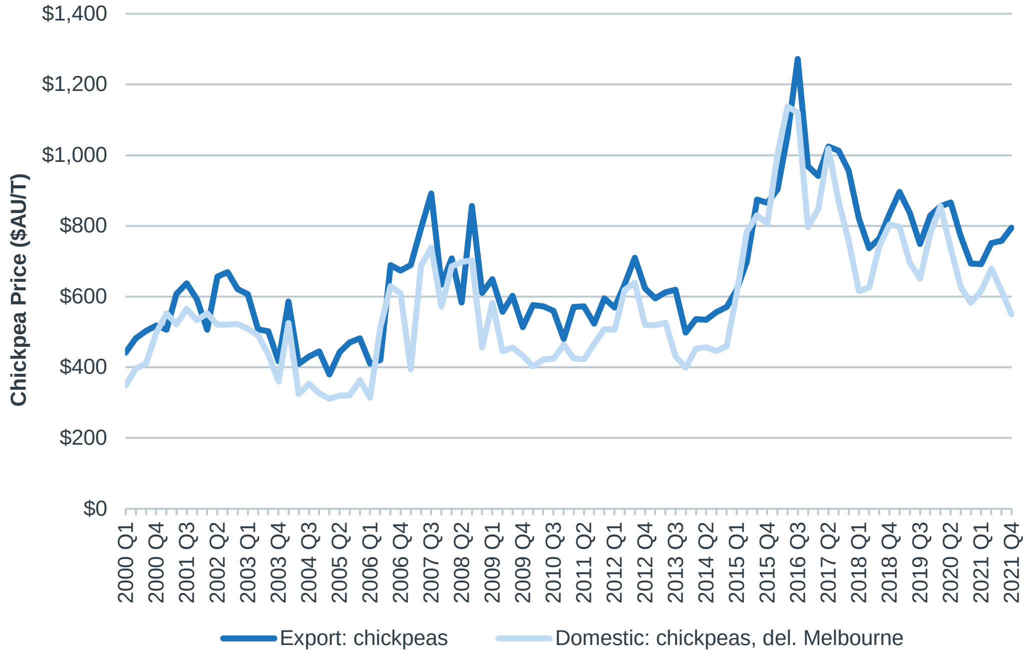
3.3.4 Chickpea Prices in Australia

In the fourth quarter of 2021, Australian prices for chickpeas totalled approximately AUD $550 per tonne in the domestic market and AUD $795 per tonne in the export market. With relatively low demand for chickpeas in Australia, the export market prices provide greater returns for growers.

Chickpea prices experienced a peak in the second quarter of 2016, reaching $1,272 per tonne for exported chickpeas. High prices were also experienced in the domestic market and led to an increase in plantings.

The USA 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.

Figure 3.20. Average Australian Chickpea Prices ($AUD/t)

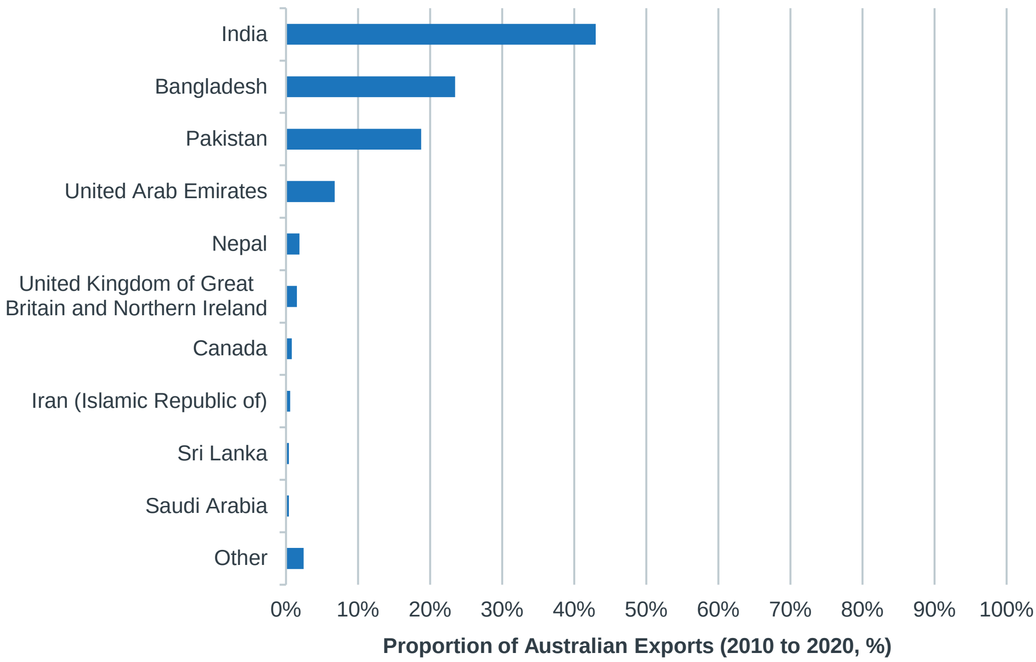


Source: ABARES (2022a).

3.3.5 Australia's Key Markets

From 2010 to 2020, India accounted for 43.0% of Australia's total chickpea exports. Bangladesh was Australia's second largest export market for chickpeas, accounting for an average of 23.5% of exports from 2010 to 2020.

Figure 3.21. Key Exports Markets for Australian Chickpeas (Top 10)

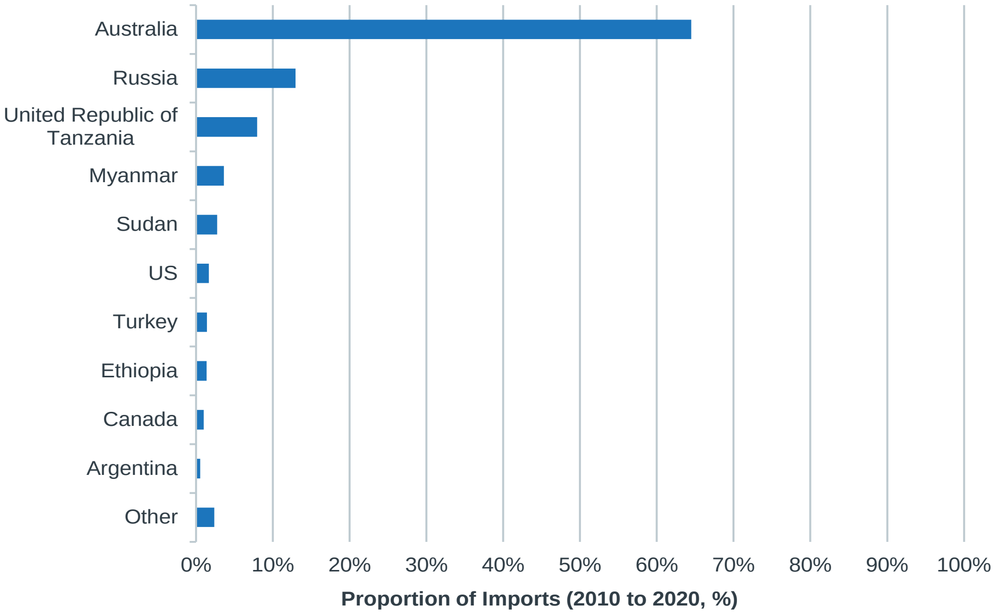


Note: ABARES export data for Australia differs from what is reported in FAOSTAT. The above graph is reflective of the information provided by FAOSTAT.
Source: FAOSTAT (2022).

India

The largest source of chickpeas in India was from Australia, accounting for 64.5% of total imports on average from 2010 to 2020. The second largest source of chickpeas in India was from Russia, accounting for 13.0% of total imports on average from 2010 to 2020.

Figure 3.22. Chickpea Imports to India, 2010 to 2020

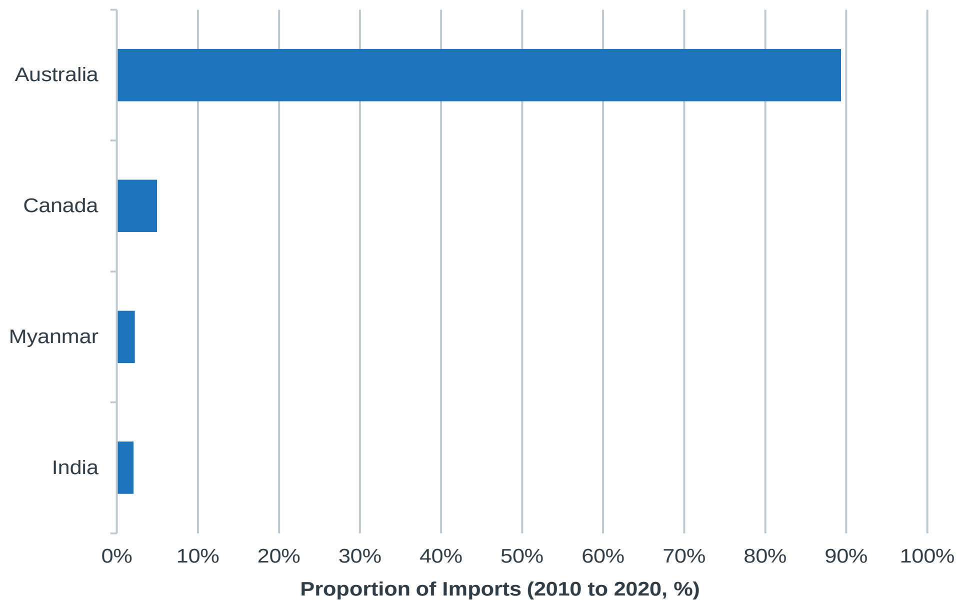


Note: ABARES export data for Australia differs from what is reported in FAOSTAT. The above graph is reflective of the information provided by FAOSTAT.
Source: FAOSTAT (2022).

Bangladesh

The largest source of chickpeas in Bangladesh was from Australia, accounting for 89.4% of total imports on average from 2010 to 2020. The second largest source of chickpeas in Bangladesh was from Canada, accounting for 5.0% of total imports on average from 2010 to 2020.

Figure 3.23. Chickpea Imports to Bangladesh, 2010 to 2020

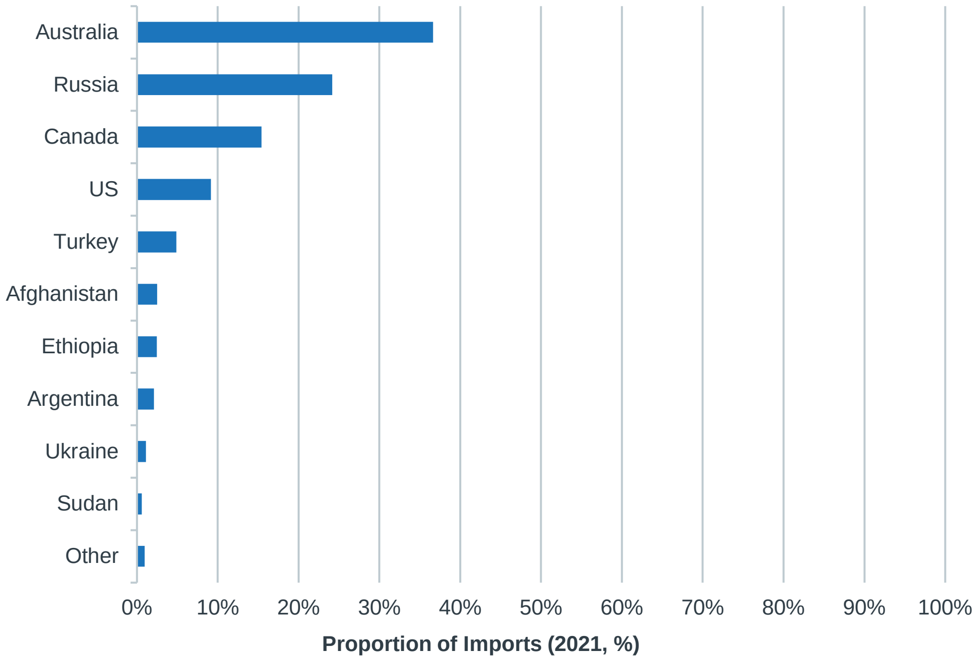


Note: ABARES export data for Australia differs from what is reported in FAOSTAT. The above graph is reflective of the information provided by FAOSTAT.
Source: FAOSTAT (2022).

Pakistan

The largest source of chickpeas in Pakistan was from Australia, accounting for 36.6% of total imports in 2021. The second largest source of chickpeas in Pakistan was from Russia, accounting for 24.2% of total imports in 2021.

Figure 3.24. Chickpea Imports to Pakistan, 2021



Source: Com Trade (2022).

3.4 MARKET VIABILITY ANALYSIS

The commodity outlook identified three key priority markets that are Australia's largest chickpea export markets. The three key markets that were identified in the commodity outlook are listed below:

The market viability analysis provides a snapshot of each key market that has been identified for chickpeas. This snapshot includes:

- Market depth and maturity
- Market access considerations (access to Free Trade Agreements)
- Economic strength, market growth and consumer capacity to pay
- Political stability and financial risk.

India

India is the largest chickpea producing country in the world, accounting for 73.7% of total production in 2020. Historically, India has been largely reliant on domestic production to support domestic demand. From 2014 to 2016, domestic chickpea production in India reduced by a total of 2.5 million tonnes, creating a deficit in supply.

To satisfy domestic demand, India began increasing imports rising from 381,315 tonnes in 2014 to 1.6 million tonnes in 2017.

To support domestic production and local farmers, the Indian Government implemented significant tariffs on chickpea imports over 2017 and 2018. This is analysed in more detail in the market access considerations below.

Population & 2050 Forecast 2021: 1.4 billion 2050: 1.6 billion	GDP 2020: $1,928 per capita (USD) 2026: $3,018 per capita (USD)
In 2020, India sourced 37.4% of total chickpea imports from Tanzania	Largest soybean importer in 2020, importing 305,838 tonnes

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

Market Access Consideration

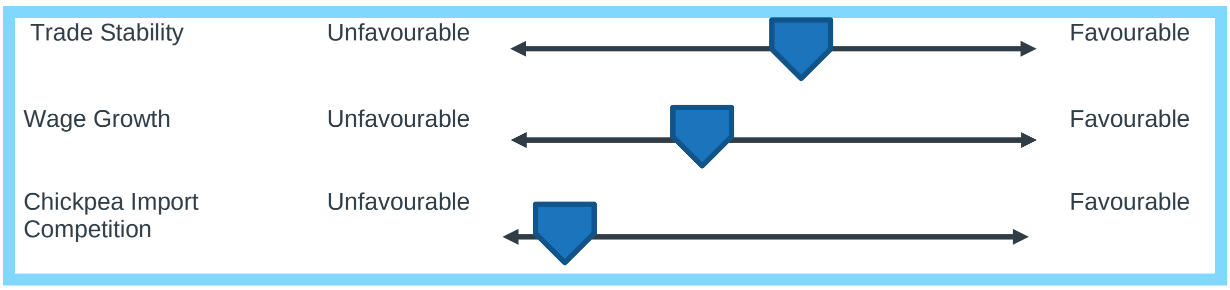
In December 2017, India initially introduced a 30% tariff on imports of chickpeas to restrict the flow of imports from producers in Australia and Canada (Business Insider, 2018). In February 2018, the tariff increased once again to 40% (Business Insider, 2018). The third and final increase in tariffs was realised in March 2018, with the tariff for Desi chickpeas totalling 60% while Kabuli chickpeas remained at 40% (Grain Central, 2019).

The implementation of the tariff resulted in a drop in India's chickpea imports, which were primarily sourced from Australia. The tariff increased the cost of export to India by 60% for Desi chickpeas within a short period of time, significantly impacting the sustainable profit of farmers.

Australian Chickpeas in India

Australia was the largest exporter of chickpeas on the global scale in 2020, positioning Australia as fill the demand deficit from India throughout 2014 to 2016. This increase in supply was primarily met from Australian chickpeas, which rose by 1.2 million tonnes over the period of three years (from 2014 to 2017) to reach 1.4 million tonnes in 2017.

After the tariff implications were announced the imports of Australian chickpeas dropped to little over 80,000 tonnes in 2018. Chickpea tariffs and lentil tariffs were imposed around the same time, with lentil tariffs being cut in 2021 from 33% to 11% (Austrade, 2022b). Tariff applications are likely to remain a feature of this market, however, this could change if chickpea stocks and domestic production are relatively low (GRDC, 2018). This market risk puts significant pressure on the industry to find alternative markets of equivalent value.



Bangladesh

In Bangladesh, the most common variety of chickpea is Desi, which is preferred over the Kabuli type (ICRISAT, 2017). The Desi chickpea is consumed in many different forms, including dried whole seed, roasted and puffed, split (dhal), flour, roasted and split and fresh green seed (ICRISAT, 2017).

It is reported that approximately 65-70% of Desi chickpea consumption was whole, with the remanding 30-35% consumed as dhal and flour (Doni & Company, 2017). Majority of the chickpeas consumed in Bangladesh is during Ramadan, accounting for 40-50% of annual demand (Doni & Company, 2017).

Population & 2050 Forecast 2021: 164.7 million 2050: 190.8 million	GDP 2020: $1,962 per capita (USD) 2026: $3,254 per capita (USD)
In 2020, Bangladesh sourced 89.3% of total chickpea imports from Australia	3rd largest chickpea importer in 2020

Notes:

- Population forecasts have been estimated based on population projections by IMF and OECD.
- ABARES export data for Australia differs from what is reported in FAOSTAT. The above graph is reflective of the information provided by FAOSTAT.

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

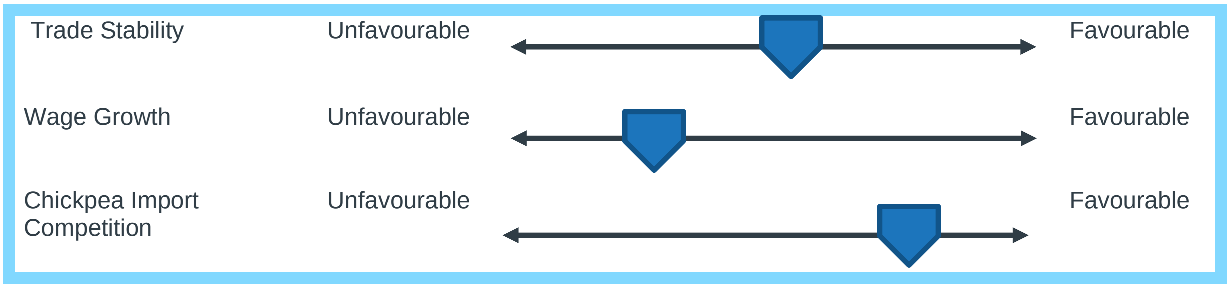
Market Access Consideration

- Under the MFN duties, there are no tariff implications for Australia chickpea exports to Bangladesh. Also under the MFN duties are key competitors, Canada, Myanmar and India.
- Chickpea exports to Bangladesh are required to be accompanied with an import permit and the shipment is to be free from pests, soil, weed seeds and extraneous material. A phytosanitary certificate is required when the permit specifically states the requirement, with treatments including on shore or in transit fumigation (DAWE, 2021).
- If stated on the import permit, shipments must be accompanied by a non-GMO certificate to ensure that the seed has not been genetically modified (DAWE, 2021).

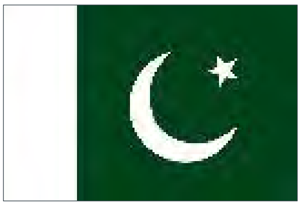
Chickpeas in Bangladesh

The production of chickpeas in Bangladesh has been on the decline reducing from 70,120 tonnes in 1990 to 4,942 tonnes in 2020 (FAOSTAT, 2022). This decline in production is largely due to the emphasis on production of staple cereals including rice, maize, wheat and other short duration growing oilseed crops (Rashid, A., Hossain, S., Deb, U., Charyulu, K., Shyam, M., Bantilan, C, 2014). The chickpea sowing times in Bangladesh are often pushed back due to the late harvest of rice and as a result the chickpea crop is exposed to heat stress (ICRISAT, 2017).

Bangladesh is largely reliant on chickpea imports from Australia to satisfy domestic demand. If production continues to decline in Bangladesh, Australia is in a position to fill this demand.



Pakistan



A large portion of chickpeas in Pakistan are grown in the Thal desert, with a significant portion of farms being reliant on rainfall. The crop in Pakistan is very reliant on the weather and with the increase in challenges from climate change, production has been rather volatile. Pakistan chickpea production has been impacted by either no rain, with the crop failing to germinate, or heavy rain damaging the standing crop (Dawn, 2021).

Consumers in Pakistan prefer the larger and lighter coloured Desi chickpea (Pulse Australia, 2015 a).

Population & 2050 Forecast 2021: 212.5 million 2050: 364.2 million	GDP 2020: $1,189 per capita (USD) 2025: $1,143 per capita (USD)
In 2021, Pakistan sourced 36.6% of total chickpea imports from Australia	2nd largest chickpea importer in 2020

Notes:
- Population forecasts have been estimated based on population projections by IMF and OECD.
- Forecast GDP per capita has been calculated based on 2025 total forecast GDP and projected population.

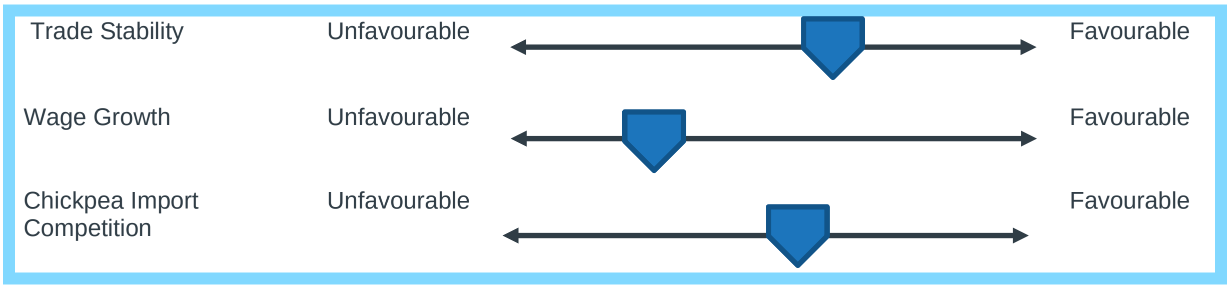
Source: OECD (2022), IMF (2022), Statista (2022), World Bank (2022), Com Trade (2022).

Market Access Consideration

- Under the MFN duties, there are 3% tariff implications for Australia chickpea exports to Pakistan. Also under the MFN duties are key competitors including Russia and Canada.
- Chickpea exports to Pakistan are required to be accompanied with an import permit and the shipment is to be free from pests, soil, weed seeds and extraneous material. A phytosanitary certificate is required when the permit specifically states the requirement (DAWE, 2022). In mid-2021, the Department of Plant Protection in Pakistan implemented methyl bromide fumigation of chickpeas (Austrade, 2021).
- If stated on the import permit, shipments must be accompanied by a non-GMO certificate to ensure that the seed has not been genetically modified (DAWE, 2021).

Chickpeas in Pakistan

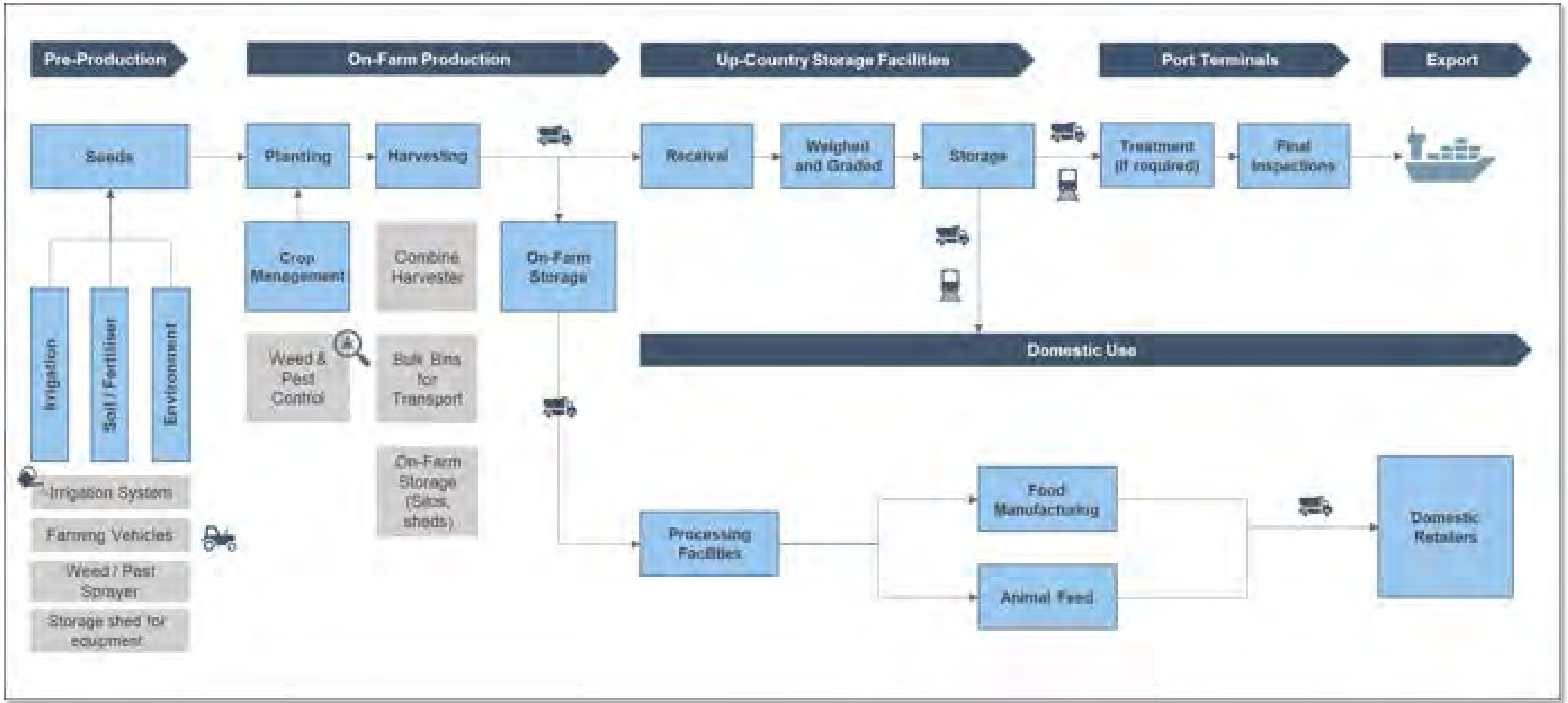
The variance in imports from Pakistan is reflective of the volatile production due to the country's reliance on rainfed production. In 2021, Australia was Pakistan's largest supplier of chickpeas. Imports of Australian chickpeas totalled 24,927 tonnes in 2021, representing 36.6% of total imports for the year.



3.5 CHICKPEA SUPPLY CHAIN ANALYSIS

The figure below introduces a high-level supply chain analysis to investigate the activities and processes involved in producing chickpeas within the Central Queensland region (refer to Figure 3.25). 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 3.25. Chickpeas 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 crop establishment, prior to the planting of seeds. Equipment and infrastructure required for crop establishment for chickpeas include:

- An irrigation system
- Soil and fertiliser (and fertiliser spreader)
- Weed and pest sprayers and safety equipment
- Tractors and vehicles, which includes a large tractor to operate Equipment and machinery for seeding and harvest
- On-farm storage facilities (including silos).

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

Chickpeas are a summer crop in Australia with sowing starting in autumn and harvesting typically occurring in spring and summer. Each season, farmers use seeds to plant their chickpea crops. Seeds can be purchased, or retained from the previous harvest season for sowing. Purchase of new seed is self-regulated by the Australian Seeds Federation.

A tractor with a seed drill attachment is used to plant the seeds evenly into the long rows of soil. Seeds can be treated with surface protectants prior to sowing in order to reduce the incidence of disease in growing crops.

When the chickpea plant reaches its final stage in the growing process, i.e. when the crop has dried to a golden yellow colour and there is no green visible on the plant, it is ready to be harvested. A combine harvesting machine is used to collect the ripe chickpea. The harvester is driven through the paddocks where it cuts the chickpeas, cleans and separates the seeds or kernels from the rest of the plant.

After harvesting, growers can store their chickpeas on farm, or move their chickpeas to an up-country storage facility directly after harvest or move their chickpeas direct to port for export or straight to a domestic user.

According to AEGIC (2021), industry experts estimate that the amount of grain stored in good-quality steel silos has doubled over the past five years, stored in facilities that can be gas-sealed, fumigated, or aerated. More than 80% of an average harvest can now be stored in permanent storage on-farm, particularly in New South Wales, Queensland and Victoria.

Although the cost of using smaller on-farm storage can be higher than the cost of the service provided by commercial grain handlers, depending on the type of farm storage and the nature of the commercial warehouse service provider, increased investment in farm storage can either increase or decrease a farmer’s supply chain costs. This comes with an increased risk to growers from adverse events when storing grain on-farm, as the risk is not transferred to a commercial service provider.

Storage and Processing Facilities

The majority of chickpeas destined for export is handled, stored and transported through the bulk grain handling system. This system comprises a network of up-country receival facilities that are connected by rail and road transport links to domestic users (typically feedlots and mills), or to port terminals for export. However, with the increasing popularity in on-farm storage, there have been ongoing reductions in the number of up-country receival sires operated by the main grain handling companies. Chickpeas delivered to commercial storage facilities are weighed and tested to determine the grade and quality. It is then stored with other product in the same bin grade.

Export Market

All exporters of chickpeas are required to follow the conditions for export, as detailed in the Manual of Importing Country Requirements (Micor) maintained by DAWE.

Table 3.8 outlines the export requirements for chickpeas for processing and consumption for a number of key markets. The below markets are all non-protocol markets, i.e. countries whereby there is no agreement with Australia prescribing the export requirements, generally making these countries easier to export to than protocol markets. No protocol markets are listed on Micor.

Table 3.8. Export Requirements of Chickpeas for Processing and Consumption

Country	Import Permit	Phytosanitary Certificate	Treatment / Fumigation Requirements
End Use - Processing			
Mauritius	Yes	Yes	Yes
Kenya	Yes	Yes	No
New Zealand	Yes	Yes	Yes
End Use - Consumption			
Afghanistan	No	Yes	No
India	No	Yes	Yes
Malaysia	No	No	No
New Zealand	No	Yes	Yes
Pakistan	Yes	Yes	Yes
Thailand	No	Yes	No
Turkey	No	Yes	No

Source: Micor.

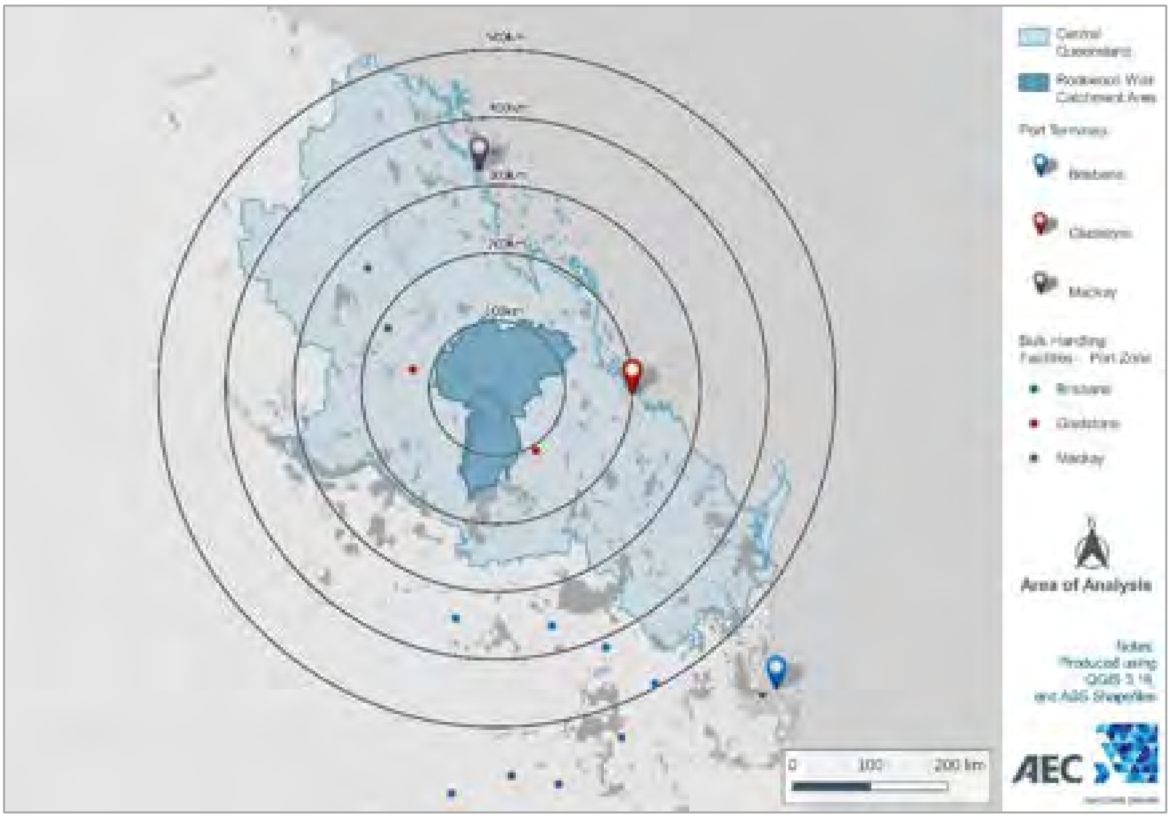
Domestic Market

Domestic demand for chickpeas represent a small proportion of overall Australian production (approximately 1%). Domestic uses for chickpeas include roasted and canned chickpeas for consumption, flours, and other value-added products. These products are generally sold via supermarkets and health stores.

3.5.1 Infrastructure Requirements and Gaps in Central Queensland

In Queensland, GrainCorp is the largest bulk handler of grains, with 15 country silos surrounding that accept chickpeas its port terminals in Brisbane, Mackay and Gladstone. Within the Rookwood Weir Catchment Area, there are six GrainCorp bulk receival sites which accept chickpeas, including three which are in the Gladstone port zone and three facilities in the Mackay port zone.

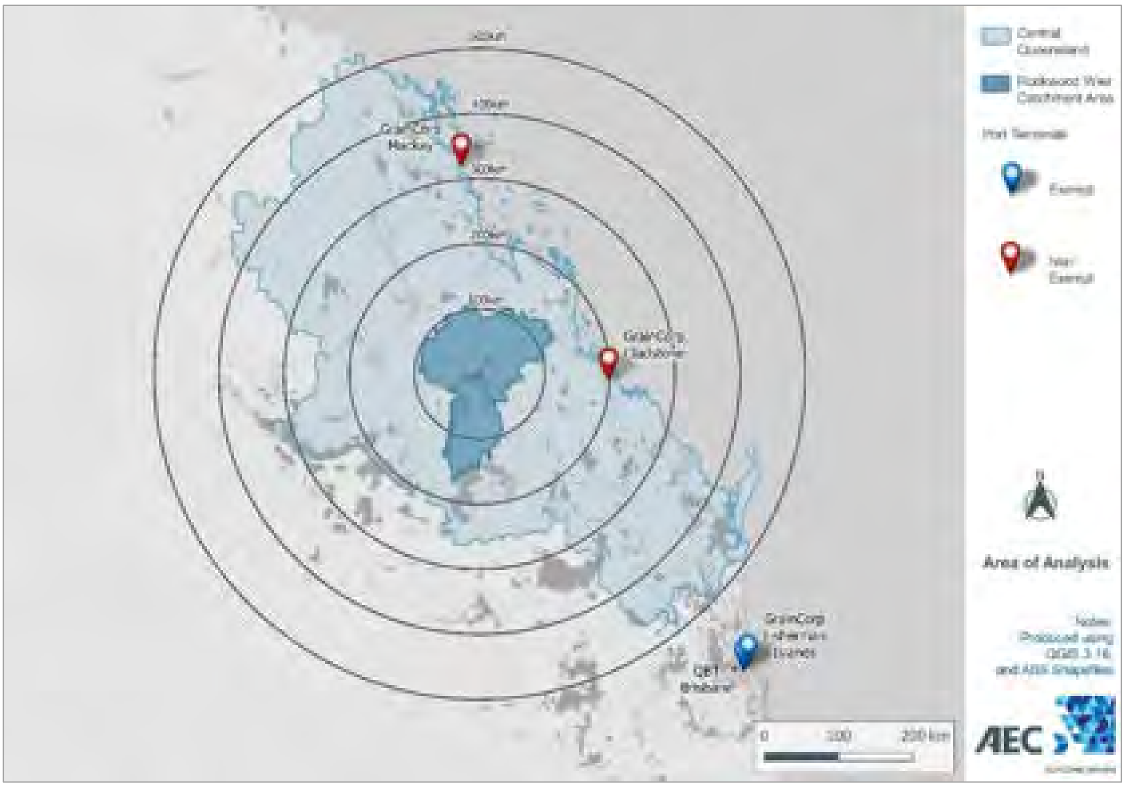
Figure 3.26. GrainCorp Bulk Handling Facilities & Port Terminal Locations, Queensland



Source: AEC.

The chickpeas are then transported by rail or road to the port terminals for export. There are four bulk grain export port terminal facilities in Queensland, illustrated in Figure 3.26. Three terminals are owned by GrainCorp (at Brisbane, Gladstone and Mackay) and one by Queensland Bulk Terminals (Brisbane).

Figure 3.27. Queensland Port Terminal Facilities, Bulk Grain



Source: AEC.

GrainCorp is the dominant bulk grain export service provider in Queensland, with 73% of bulk exports going through GrainCorp facilities in the 2020-21 shipping year (2019-20: 100%) and 92% of bulk exports going through GrainCorp since the beginning of the 2011-12 shipping year. No chickpeas were exported through QBT's facility in Brisbane in the 2020-21 shipping year.

Table 3.9 outlines the market share of the grain throughput by port terminal facility.

Table 3.9. Queensland Port Terminal Facility, Market Share of Grain Throughput

Port	Percentage Share of Grain Throughput			
	2020-21 Year	2019-20 Year	Since 2011-12	Since 2015-16
GrainCorp				
Fisherman Islands	60%	14%	56%	53%
Gladstone	3%	26%	17%	14%
Mackay	9%	60%	20%	15%
GrainCorp Total	73%	100%	92%	81%
Queensland Bulk Terminals - Brisbane	27%	0%	8%	19%

Notes:
- Includes all grains such as wheat, sorghum, barley, canola, chickpeas, faba beans, field peas, lentils, lupins and triticale.
- Queensland Bulk Terminals commenced operations under the Code in 2015-16.

Source: ACCC (2021).

If chickpeas were to be produced within the Rookwood Weir Catchment Area, farmers are well-placed to utilise the services at GrainCorp's receival sites, or alternatively, can implement on-farm storage facilities. GrainCorp's Gladstone port terminal is also the closest to the Rookwood Catchment, within a 200-kilometre radius.

In the 2020-21 shipping year, bulk exports at the Gladstone facility remained low at 47,000 tonnes, resulting in an annual capacity utilisation rate of 8% (ACCC, 2021), with wheat, sorghum and chickpeas exported by GrainCorp and JKI. As the maximum annual capacity for the Gladstone terminal is 600,000 tonnes, there appears to be significant capacity for additional bulk exports of chickpeas at the Gladstone terminal.

3.6 COMPETITITVE ANALYSIS AND MARKET OUTLOOK

3.6.1 Key Exporters and Importers

The table below provides a snapshot of the top five exporters and importers of chickpeas in the global market. The top five exporters accounted for 65.1% of total chickpea exports in 2020, while the top five importers accounted for 51.9% of total chickpea imports in 2020.

Both India and Turkey are highlighted in the top five importers and exporters for 2020.

Figure 3.28. Major Exporters and Importers of Chickpea

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

The table below provides an indication of key harvesting windows for pulses on the global scale. Australia and India's Kharif window for harvesting pulses (chickpeas) occurs from October to December. The Australian chickpea production is influenced by the (Pulse Australia, 2015 b):

- Harvest in Turkey, Canada and Pakistan where chickpeas are harvested before the Australian harvest.
- The outlook for the crop of the Indian sub-continent, which occurs largely during the Australian harvest period.

Table 3.10. Global Pulse Production

Country	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Australia												
Canada												
Turkey/Syria												
India (rabi)												
India (Kharif)*												
Pakistan												
Egypt												
EU (spring)												

Country	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
EU (winter)								Harvest	Harvest	Sowing	Sowing	Sowing
China (north)		Sowing	Sowing	Sowing					Harvest	Harvest		
China (south)				Harvest	Harvest				Sowing	Sowing	Sowing	
(light shading)	Sowing											
(dark shading)	Harvest											

Notes:

- Pulses include chickpea, field pea, lentil, lupin, fava bean.
- * Chickpeas

Source: Pulse Australia (2015b).

3.6.2 Australia's Competitive Advanatges & Key Competitors

Australia is a relatively large exporter of chickpeas on the global scale, with key competitive advantages including:

- Significant investment in research and development to improve heat resistance and widen production capability
- Ability for dryland and irrigated cropping unlike other key global producers such as Pakistan
- Bangladesh prefers Australian chickpeas due to high quality and timely availability right before Ramadan (Grain Central, 2020a)
- Closer proximity and lower shipping times to Australia's key markets (India, Bangladesh and Pakistan) than Canada and the USA
- Australia has a large exportable surplus of chickpeas due to low domestic demand
- International reputation for high quality produce

A key competitor for Australia's Desi chickpeas is the Canadian yellow field pea (Pulse Australia, 2015b). This product is a key competitor in the sub-continent market as when the price differential is large, consumers will substitute a portion of chickpea flour for filed pea (Pulse Australia, 2015b). On the global scale, Canada is the largest producer and exporter of yellow field pea (Pulse Australia, 2015b).

In Australia's key export markets (India, Bangladesh and Pakistan), Australia's key competitors include Canada, Russia and Myanmar.

3.6.3 Future Growth Markets for Australia

Bangladesh is a key future market for Australian chickpeas. Australia was the largest supplier of chickpeas to Bangladesh in 2020, accounting for 89.3% of total imports. The production of chickpeas in Bangladesh has been declining over the years, with production more focused on staple commodities including rice, maize and wheat. In January 2022, Bangladesh was highlighted as the largest market for Australian chickpeas with an import volume of 69,172 tonnes (of Australian chickpeas) for the month (Grain Central, 2022).

Pakistan is another key market for Australian chickpeas, with Australian chickpeas accounting for 36.6% of total chickpea imports for 2021. Over the year, Australia was the largest supplier to Pakistan exporting 24,927 tonnes. This was followed by Russia at 16,439 tonnes. It is currently uncertain how the Russia invasion on Ukraine will impact on chickpea exports to Pakistan, however, Pakistan currently do not have any sanctions in place on Russia.

In January 2022, Pakistan was highlighted as the second largest market for Australian chickpeas, with an export volume of 5,048 tonnes for the month (Grain Central, 2022). Pakistan was the third largest producer of chickpeas on the global scale in 2020, however, production is rather volatile as it is subject to rainfall volumes. With the increasing variance of rainfall, particularly over the coming years with climate change, Pakistan may have an increased reliance on chickpea imports.

3.6.4 SWOT Analysis of Australian Chickpea Production

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

Table 3.11. SWOT Analysis – Australian Chickpea Production

Strengths	Weaknesses
• Investment in R&D, with the $30 million breeding program. This aims to expand the geographic reach of production • Increasing awareness of health benefits and substitute for meat options • Australia known for quality produce • Dryland and irrigated production	• Increased price pressure in Australia due to falling exchange rates (until interest rates equalise) • Most of Australia's chickpea crop is exported, with the commodity being subject to fluctuations in the international market • No futures market unlike other cereal and oilseed markets. This makes forecasting prices more challenging
Opportunities	**Threats**
• Increase bilateral trade and Free Trade Agreements with key export markets • Import tariffs on chickpeas to India will decrease the countries reliance on imported produce and increase demand for domestic production. This has the potential to decrease the export potential of India to key markets including Bangladesh	• Logistical challenges as a result of COVID-19 • Continued Indian import tariffs for chickpeas, which is a significant market for Australia • Volatility in chickpea production in Pakistan, Australia's 3rd largest export market. This volatility of production being high and low impacts on demand for Australian chickpeas

Source: AEC.

3.7 CHICKPEA 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 chickpea production is 241ha. With water entitlement restrictions and a conservative water use assumption, the total sustainable land available for farm development (i.e. planted area) is estimated to be 62.7ha.
- The anticipated initial capital investment for a rotational cropping farm is $4.8 million – including, land clearing, infrastructure and equipment, and water entitlements. This includes water allocation at an assumed cost of $1,500 per ML (RFM, 2021).
- Assuming the crop rotation with chickpea is wheat, the break-even point for the example chickpea farm, at the current assumed weighted average price of $828 per tonne is August 2023. Under this scenario, the assumed price for wheat is $421 per tonne.
- The chickpea farm will return positive discounted cash flows from FY2024, with negative discounted cash flows in FY2036 which correspond with the capital replacement program.
- The long-term growth rate for agricultural farm values is 12.5%, with an NPV of the farm at $0 the implied internal rate of return is 12.9%. The terminal value of the example farm with rotational cropping at the conclusion of the analysis (FY2041) is $37.4 million (undiscounted).

3.7.1 Approach

The commercial and financial feasibility of an average chickpea farm 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 capital investment required, operating costs, and the anticipated revenue over the 20-year time frame. The following sections detail the following:

- Farm establishment
- Farm operations
- Financial feasibility (including sensitivity analysis).

3.7.2 Crop Rotation

The financial analysis is undertaken for the purposes of growing chickpea as a primary commodity. In modelling the financial feasibility of soybean in the Rookwood Weir Catchment Area, the farm has been assumed to be a monoculture farm, farming chickpea, with a single crop rotation in the off season of spring wheat.

3.7.3 Rookwood Weir Water Availability

The Rookwood Weir Scheme allows for a maximum 500ML water allocation for agricultural landholders. Chickpea irrigation in the Central Queensland region reportedly requires, on average, 1.5ML of water per annum per Ha (DAF, 2020a). Wheat irrigation in the Central Queensland region 5.2ML of water per annum per Ha (Harris, et al, 2012). Appendix B discusses chickpea water requirements and growing environment in more detail.

Under the assumption this water is provided with a conservative 84% reliability and 6.7ML per ha per year is required for both wheat and chickpea production, the maximum growing area in the Rookwood Weir Catchment Area is 62.7ha.

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 3.12.

Table 3.12. Land Availability, by Water Reliability

60% Reliability	84% Reliability	100% Reliability	No Water Allocation Cap
44.8 ha	62.7 ha	74.6 ha	241 ha

Note: Total land available considers the soil suitability of soybean only and does not factor the rotation crop.
Source: HTW, AEC.

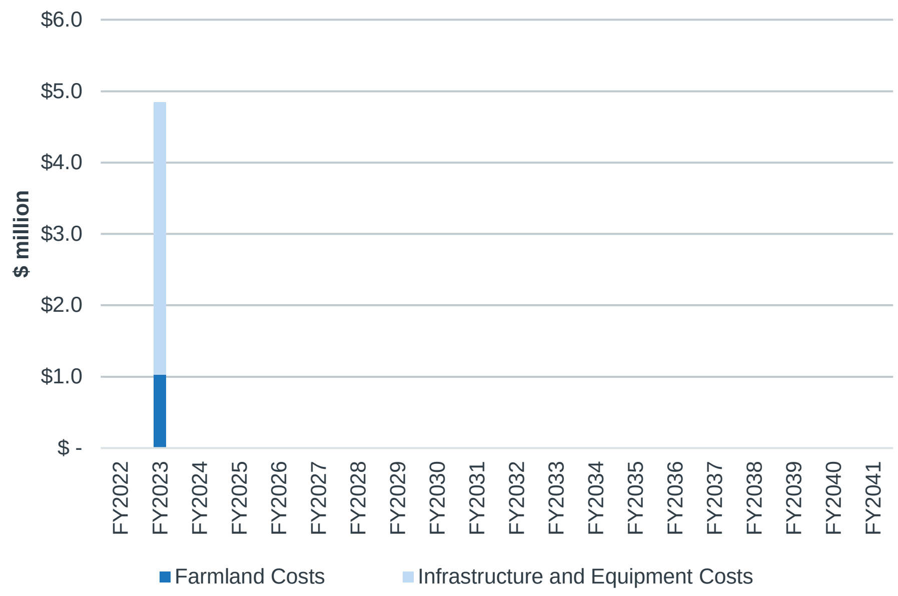
The outcome of the scenario analysis is presented below in Section 3.7.6.1.

3.7.4 Rotational Cropping Capital Investment

3.7.4.1 Farm Establishment

Rotational cropping farm establishment requires three key capital investments, the land, the on-farm infrastructure and associated equipment (including storage), and the horticultural crop. For the purpose of analysis, it is assumed the landholder already owns the land and the majority of the initial investment occurs across four months, starting 1 January 2023. For the 62.7ha farm, the initial capital investment is $4.8million ($77,272/ha), not including the cost of planting.

Figure 3.29. Farm Establishment Costs, Not Including Planting Costs (FY2022 – FY2041)



Source: AEC, HTW.

Farmland and Acquisition Costs

Farmland costs include the cost of land clearing, and the water entitlements. Total farmland costs per farm are estimated to be $1.0 million: including:

- **Water entitlement** – 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
- **Land clearing** – it is assumed the land will need to be cleared and prepared for farm establishment. Total land clearing is estimated to be $257,786 in nominal terms.

Infrastructure and Equipment Costs

On-farm infrastructure includes storage facilities, irrigation, and farming and harvesting equipment. The infrastructure and equipment investment are considered to be purchased or built in the same year of land development.

For the example farm, the infrastructure and equipment will cost an estimated $3.8 million. This investment includes the following:

- **Irrigation infrastructure and equipment** – this assumes the irrigation method will be centre pivots and includes the necessary pumps, pipes, centre pivots and soil monitoring equipment. Overall irrigation equipment will cost an estimated $3.6 million
- **Production equipment** – equipment and machinery included in the production of crops include the cultivation and harvesting equipment. Total production equipment expense is anticipated to cost $148,470.
- **Storage and other infrastructure** – this asset group includes storage facilities for the harvested crop and any relevant grain elevators, as all as general storage sheds. This asset group is estimated to cost $118,488.

All infrastructure and equipment costs are assumed to be a combination of new and second-hand equipment with costs quoted from sites such as Farm Machinery Sales (https://www.farmmachinerysales.com.au/items/), Farm Tender (https://www.farmtender.com.au/), and John Deer (https://www.deere.com.au/en/).

Further details are outlined in Appendix E.

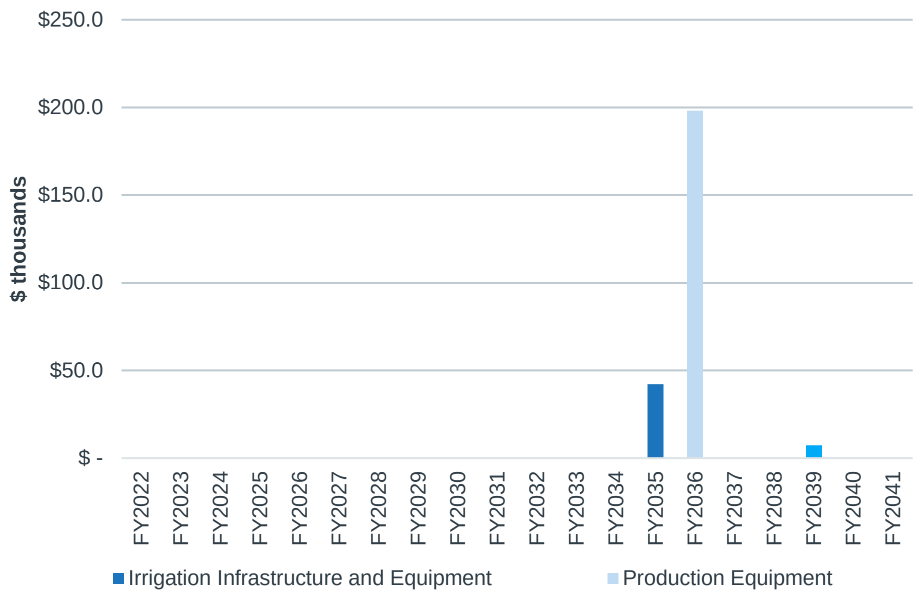
3.7.4.2 Planting Costs

Planting costs are on ongoing capital investment incurred twice a year – once for chickpea, and once for wheat. It is assumed the first sowing will occur in 2024 (FY2025) as the soil will need at least 12 months to rest after clearing. Based on planting costs published by DAF (2020a & e), chickpea is anticipated to costs $85.11/ha and wheat is anticipated to cost $59.78/ha in FY2021 real terms.

3.7.4.3 Asset Renewal

As general farming equipment, harvesting and spraying equipment, farm vehicles and irrigation equipment all have useful lives 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 $257,415 required to maintain operational farm assets over the evaluation period. This expense is show in Figure 3.30.

Figure 3.30. Total Asset Renewal (FY2022 – FY2041)

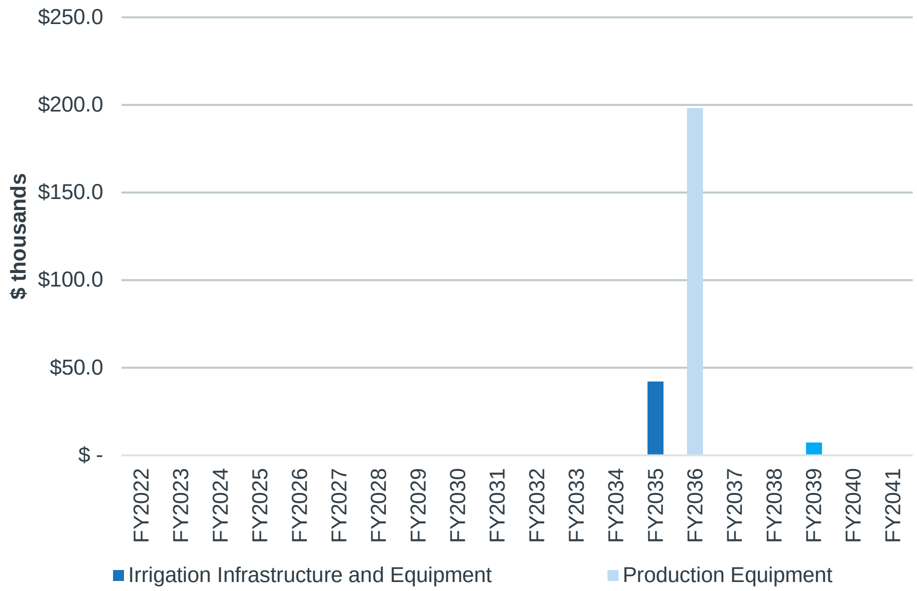


Source: AEC.

3.7.4.4 Depreciation and amortisation of assets

The capital investment required to establish the farm form the depreciable asset base of the farm. The total depreciation and asset write-off expense over the evaluation period is shown in Figure 3.31.

Figure 3.31. Total Depreciation Expense (FY2022 – FY2041)



Source: AEC (2022).

Treatment of each asset type is outlined in Appendix E.

3.7.5 Chickpea Operations

3.7.5.1 Operating Structure

The operating structure of the farm enterprise gives consideration to the ownership and management of the farm as well as the sources of funding for the enterprise.

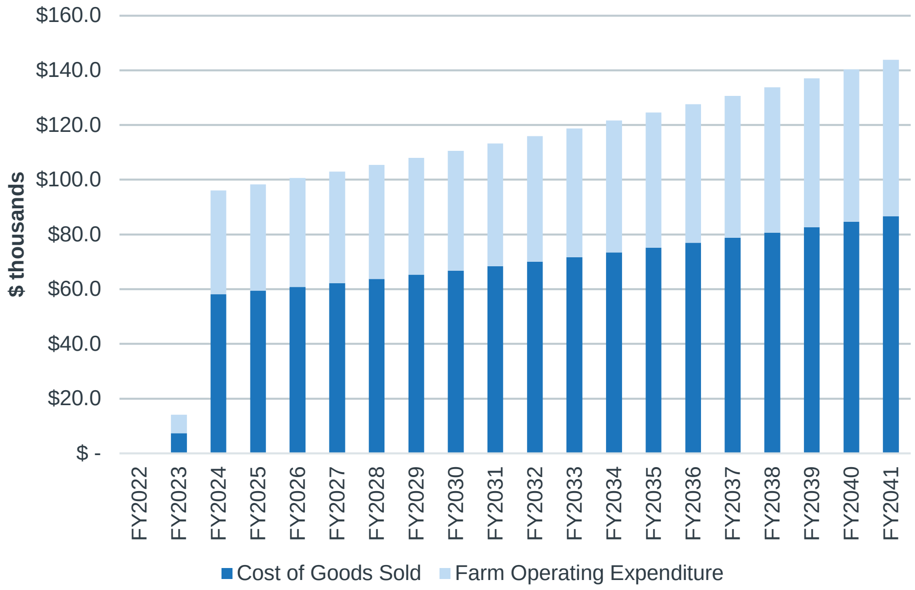
Establishment of the example farm requires significant investment to cover the capital requirements and the operating shortfall. There are a number of high-level assumptions which guide the investment sources as a part of this analysis which are detailed in more detail in Appendix E.

3.7.5.2 Chickpea Operating Costs

Farm 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 3.32.

The COGS account for approximately 60.3% of total operating costs, over the 20-year evaluation period. The COGS include costs such as packing, harvesting and materials.

Figure 3.32. Total Operating Costs (FY2022 – FY2041)



Source: AEC.

Operating costs pertaining to chickpea and wheat production are presented in Appendix E.

3.7.5.3 Farm Revenue

The farm revenue consists of the operating income associated with the sale of both chickpea and wheat, pursuant to the crop's grade. For the purposes of analysis, it is assumed all wheat and chickpea harvested have the following yield and price expectations.

Table 3.13. Price and Yield, by Commodity

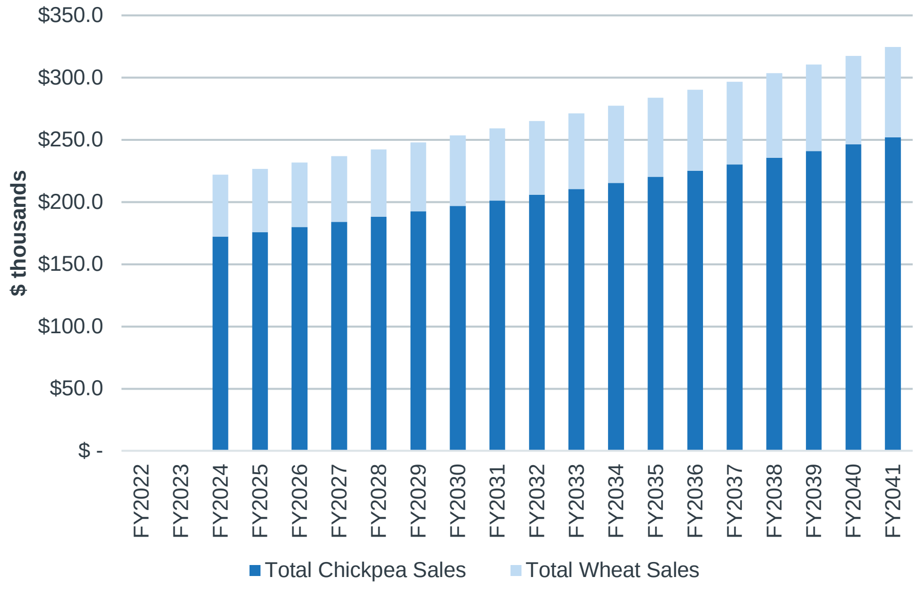
Commodity	Yield	Price
Chickpea	3.2tonnes/ Ha	$828/ tonne
Wheat	1.8tonnes/ Ha	$421/ tonne

Source: ABS (2021), ABARES (2022), DAF (2020a&d), NAB (2022).

Prices for chickpea is the average of the five-year forecast produced by ABARES (refer to section 3.3.4 for more detail on chickpea prices), and the price for wheat is the average FYY2021 price (ABARES, 2022).

The forecasted revenue for both chickpea and wheat are shown in Figure 3.33 This forecast shows total soybean revenue exceeds total wheat revenue. The chickpea revenue over the 20-year evaluation accounts for 77.6% of all farm revenue.

Figure 3.33. 20-year Revenue Forecast (FY2022 – FY2041)



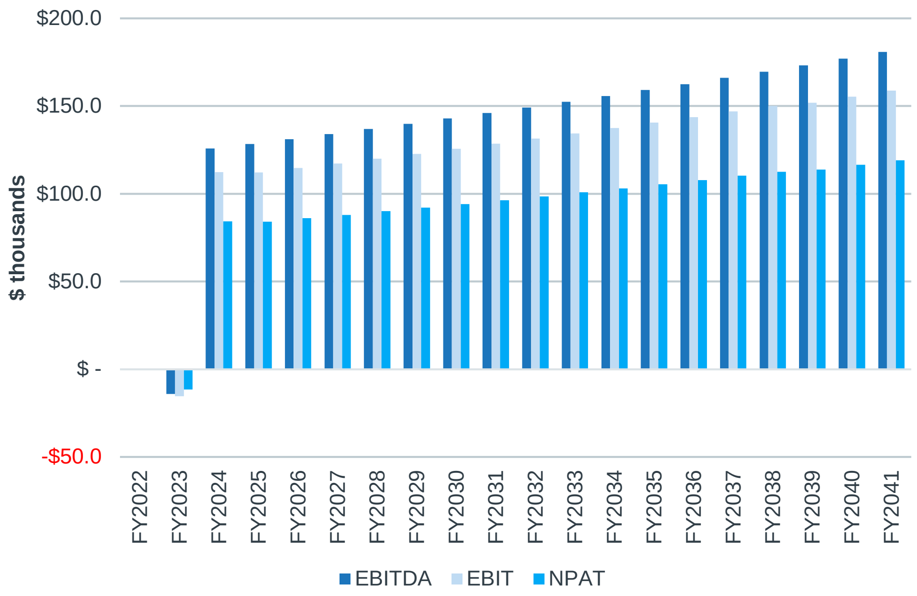
Source: AEC.

3.7.6 Financial Feasibility

The example farm in the Rookwood Weir Catchment Area is expected to return a positive EBITDA across all years in the evaluation, except for the first year of operation. The operating breakeven month for the example farm modelled is August 2023. This shows the price point for both chickpea and wheat are sufficient to recover the total COGS.

By FY2041 the NPAT of the farm is estimated to be $119,119 and the EBITDA is estimated to be $180,843. Figure 3.34 shows that the impact of depreciation and tax expenses have a significant impact to the profitability of the farm for the landholder, with $61,724 of the total EBITDA required to cover these costs (in FY2041).

Figure 3.34. Farm Operating Profit (FY2022 – FY2041)



Source: AEC.

To understand the value of the farm investment, a DCF has been calculated. 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 Central Queensland between 2014 and 2021, which is 12.5% (HTW, 2021).

With an NPV of the farm at $0 the implied internal rate of return is 12.9%. The terminal value of the example farm growing chickpeas at the conclusion of the analysis (FY2041) is $37.4 million (undiscounted).

The example chickpea farm is estimated to start incurring positive discounted cash flows from FY2024. Over the evaluation period there are a couple of years which are anticipated to have a negative discounted cash flow due to the required capital replacement.

The internal rate of return is above the growth rate estimated for the region, as such, the example chickpea farm represents a commercially viable investment.

3.7.6.1 Sensitivity Analysis

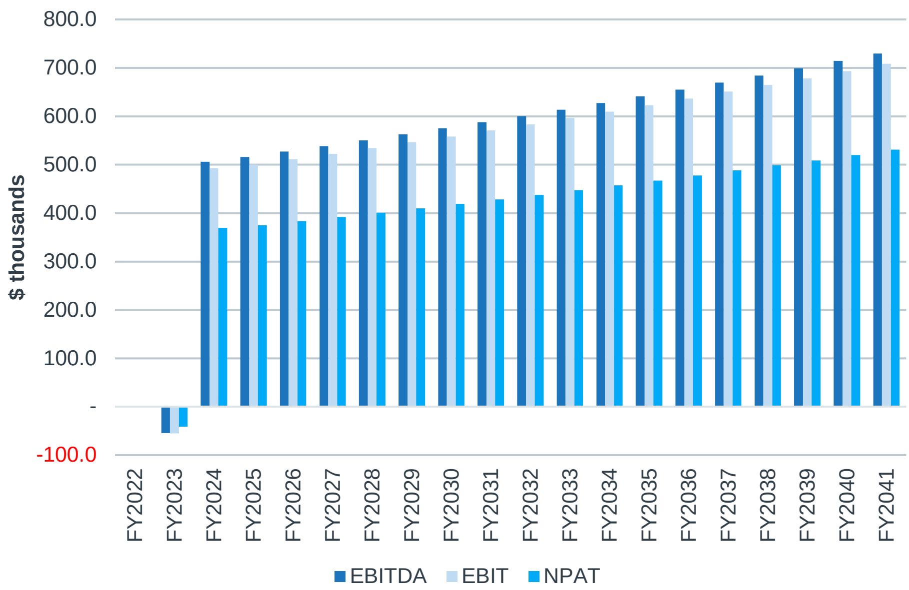
Crop Rotation Sensitivity

Figure 3.35 shows the farm operating profit when chickpea is the only crop farmed in the Rookwood Weir Catchment Area. Removing wheat has a multitude of impacts:

- Lower total water is required on an annual basis. This will enable farms to increase their farmed area as the average farm size is 241ha and under the rotational cropping system, the planted area is 62.7ha. A chickpea only farm will allow the landholder to farm all 241ha available.
- There is a marginal decrease in capital investment. This decrease relates only to on-farm storage for the chickpeas. Operationally, the impact of this is a slightly adjusted depreciation expense.
- Without a grain (or similar) crop, the farm is likely to experience an increased need for fertiliser to balance the soil nutrients. Similarly, the farm will likely have increased operating expenses associated with encouraging topsoil stability (to reduce the risk of erosion and increase water use efficiency). These costs have not been accounted for in the following profitability assessment.

A chickpea only farm of 241ha, is expected to return an NPAT of $531,384 by FY2041, where the EBITDA in the same year is $729,974.

Figure 3.35. Chickpea Operating Profit (FY2022 – FY2041)



Source: AEC.

Farmland Growth Rate Sensitivity

Historical growth rates are not always reflective of future growth rates. Recent land sales activity is a key driver on recent land value uplift, with the growth rate for rural property estimated to be 12.5% for the Central Queensland region. As land sales and value growth may not continue to grow with equal rates of the historical rates, sensitivity of the growth rate used to determine the terminal value of the example farm has been undertaken.

Rural Bank (2021) published the average Queensland rural land value long term growth rate of 8.8% (calculated over 20 years). Using this conservative growth rate and IRR of 12.9%, the terminal value of a chickpea farm in the Rookwood Weir Catchment Area is $3.4 million with an investment NPV of negative $3.0 million.

With a growth rate of 8.8% and an NPV of the farm at $0 the implied internal rate of return is 9.5%. The terminal value of the example farm at the conclusion of the analysis (FY2041) is $20.8 million (undiscounted), ultimately showing a commercially feasible investment.

Table 3.14. NPV and Terminal Value, by IRR at 8.8% Growth Rates

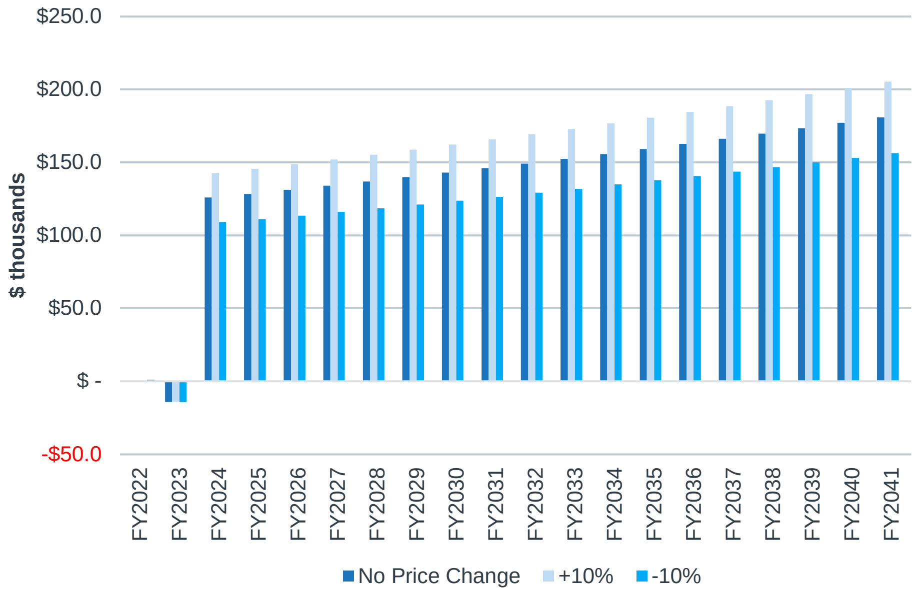
IRR	Net Present Value	Undiscounted Terminal Value
IRR at 12.9%	-$3.0 million	$3.4 million
IRR at 9.5%	$0.0 million	$20.8 million

Source: AEC

Price Sensitivity

To account for external price pressure on future chickpea 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.

Figure 3.36. Price Impact on Profitability (EBITDA) (FY2022 – FY2041)



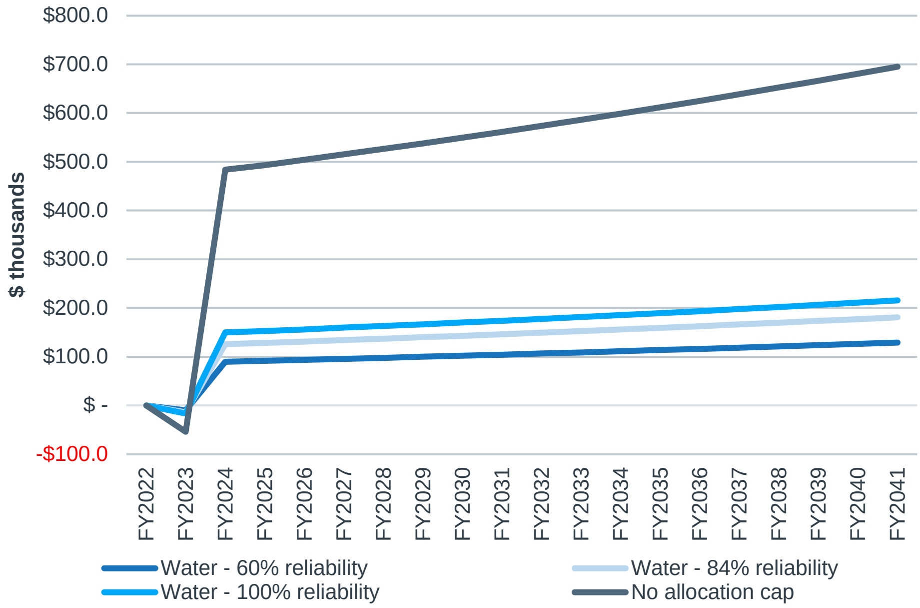
Source: AEC.

Water sensitivity

Water availability has a relatively linear relationship with the profitability of the example farm 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 farm.

The total water required in the no allocation cap is 1,615ML and under the scenario the example farm have a positive operating surplus ratio. The variance in revenue is presented in the figure below.

Figure 3.37. 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 farm establishment timing. In practice, by increasing the available land there may be an increased time required to establish the farm. Under the No allocation cap scenario, the land farmed will increase from 51.9ha to 241ha, a significant increase, just less than four times larger.

3.7.7 Economic Impact

Investment in a farm enterprise will have an economic contribution to the Fitzroy region, and more broadly Central Queensland. The economic contribution of the example farm in the Rookwood Weir Catchment Area is presented in Table 3.15 and has been estimated using IO modelling (for further details, refer to Appendix F).

Initial capital investment of the farm is anticipated to cost approximately $4.1 million, not including the purchase of land and the purchase of water entitlements (both of which are not contributing factors of the economic impact), or the impact of price escalation over time. Capital investment and operation of the farm is anticipated to directly contribute to $3.0 million in industry output (i.e. revenues) to local businesses within the Rockhampton LGA.

A further $1.8 million in industry output is estimated to be supported in the catchment's economy through flow-on activity, including $1.0 million in production induced (i.e. supply chain) activity and $0.8 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 $2.2 million contribution to GRP including $1.2 million directly
- 19 FTE jobs (including 12 FTE jobs directly), paying a total of $1.5 million in wages and salaries ($1.0 million directly).

Table 3.15. Economic Activity Supported by a Chickpea Farm Enterprise, Rockhampton LGA

Impact	Output ($M)	Gross Regional Product ($M)	Incomes ($M)	Employment (FTEs)
Direct	$3.0	$1.2	$1.0	12
Production Induced	$1.0	$0.5	$0.3	4
Consumption Induced	$0.8	$0.5	$0.2	3
Total	**$4.8**	**$2.2**	**$1.5**	**19**

Note: Figures may not add due to rounding.
Source: ABS (2012), ABS (2017b), ABS (2021b, c and d), AEC.

4. MUNGBEANS

4.1 INTRODUCTION

Mungbeans are also known as moong or green gram and belong to the legume family. It was thought that the mungbean originated from the Indian subcontinent, where it was belived to be domesticated as early as 1500 BC (Feedipedia, 2015). Today, the mungbean commodity is consumed as a part of the staple diet in India.

Mungbeans have a number of different uses including feed for both livestock or for human consumption. The mungbean can be eaten whole, made into flour, porridge, bread or be processed to make starch noodles (Feedipedia, 2015). Mungbeans which are split can also be used to create dhal (Feedipedia, 2015).

Mungbeans are sold in three main grades, including sprouting, cooking and processing (GRDC, 2014). Most of Australia's mungbean production (approximately 80%) is utilised in the processing market, with only a very small proportion achieving price premiums in the sprouting grade (less than 10% of all mungbean produced) (GRDC, 2014). For cooking, sprouting and No 1 Processing classifications the mungbeans must be bright in colour with no discolouration, staining, dust or wrinkles (GRDC, 2014).

Both 2020 and 2021 were favourable years for mungbeans production in Australia, reaching approximately 100,000 tonnes per annum (information based on industry consultation). Based on the planted area, 2022 was set to be Australia's largest production year ever, achieving well over 150,000 tonnes of mungbeans (information based on consultation). The major flooding events which have occurred throughout the beginning of the year will downgrade this estimation due to crop loss with constant inundation in some areas. It is expected that there will be a loss of yield in the crop in terms of crop ripeness and physical loss of production due to waterlogging (information based on consultation).

Australia is a key competitor of mungbeans on the global scale, being recorded as the third largest exporter in 2020. Australia's key export markets are India, Vietnam and China and the key competitors for these markets is largely Myanmar. Australia does have a competitive advantage with strong protocols for hygiene, delivering conistently high quality mungbeans.

Overall, publicly available information on mungbean production and trade is limited. The Food and Agriculture Organisation of the United Nations does not report data for mungbeans, and as a result the information in this chapter differs from what has been reported for both soybeans and chickpeas. Any gaps in available information have been discussed with the Australian Mungbean Association and recorded as appropriate.

International trade data by country was only found to be available on the United Nations Comtrade Database. The mungbean data for international trade data has been defined as *beans of the species vigna mungo (l.) hepper or vigna radiata (l.) wilczek, shelled, whether or not skinned or split, dried*. This includes green gram legumes (mungbeans) and black gram legumes (close relative to mungbeans), however, section 4.2.3, 4.2.4 and 4.4 make reference to mungbeans.

4.2 OVERVIEW OF THE GLOBAL MARKET

4.2.1 Global Production

The global area dedicated to mungbean production was estimated at 7.3 million Ha and production was estimated to total 5.3 million tonnes per annum[7] (ACIAR, 2022). Based on consultation with the Mungbean Industry Association, it has been identified that this estimate of global production is high and is likely to be the global maximum achieved in recent years. It was estimated that India and Myanmar each accounted for approximately 30% of production while China accounted for approximately 16%, followed by Indonesia which was estimated to account for 5% (ACIAR, 2022). It is reported that global mungbean productivity was quite low at 0.73 tonnes per

[7] The year for reference has not been specified from the source.

Ha, however, there is potential to increase this productivity by developing higher performing varieties (AVRDC, undated).

More recent information highlights that global mungbean production reached a volume of 2.6 million tonnes in 2018 (Insider, 2019).

The World Vegetable Centre highlights that mungbeans have significant potential due to the crops good source of protein and iron for human consumption and the crops tolerance to heat and drought stress (AVRDC, undated). International collaboration has been key in mungbean breeding research and in 2016 the International Mungbean Improvement Network (IMIN) was established with funding support from the ACIAR (AVRDC, undated).

4.2.2 Major Producers

The section below provides a more detailed overview of the largest mungbean producers on the global scale.

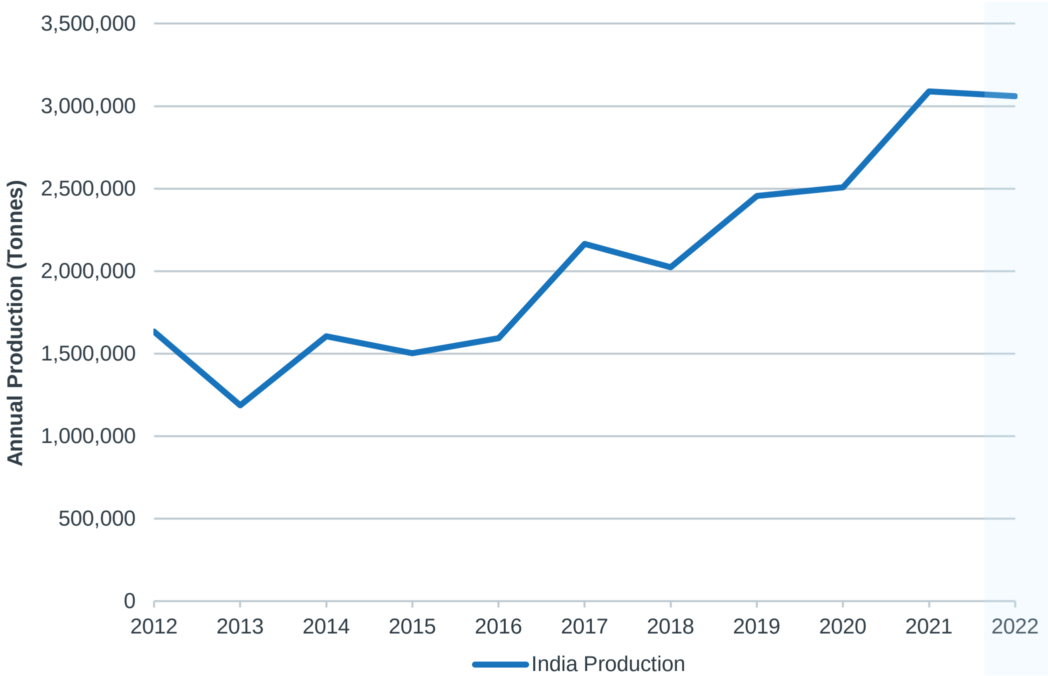
India

In India, mungbean is generally referred to as green gram and moong (Angrua, 2021). India is the largest producer of mungbeans on the global scale, with production estimated to total 2.5 million tonnes in the 2020 (Angrua, 2021). From 2012 to 2020, it is estimated that mungbean production grew by an average annual rate of 5.5% per annum.

Majority of the mungbean production in India occurs in the Kharif season, which is from July to October. In 2020, the Kharif growing season was estimated to account for 72.9% of total production while the Rabi season was estimated to account for the remaining 27.1% of total production.

In 2022, it is estimated that production of mungbeans could total 3.1 million tonnes, based on second advance estimated from India's Directorate of Economics and Statistics. Approximately 65.4% of this production is expected during the Kharif season and the remaining 34.6% during the Rabi season.

Figure 4.1. Mungbean Production in India, 2012 to 2022



Notes:

- Production is based on FY.
- Production data in 2021 and 2022 are rounded and were not available at a smaller level.

Source: DES, Ministry of Agri. & FW (2020, 2022).

The largest mungbean producing states in India in 2020 was Rajasthan, accounting for 51.9% of total production. The table below highlights the five largest producing states in India as of 2020 and estimated production over time.

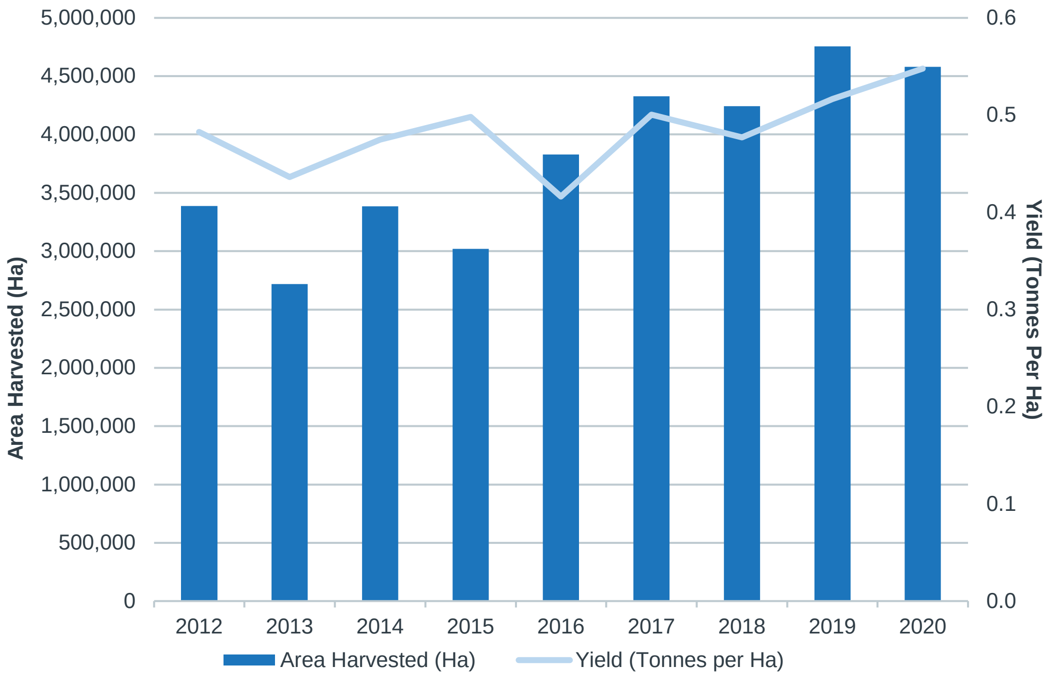
Table 4.1. Top Five Producing States, Tonnes

Tonnes	2016	2017	2018	2019	2020
Rajasthan	596,850	810,216	742,452	1,222,227	1,303,320
Madhya Pradesh	131,183	295,802	265,750	280,250	247,794
Karnataka	43,900	115,500	135,264	142,573	141,062
Bihar	94,359	119,876	125,676	118,450	110,054
Gujarat	67,000	84,000	84,716	49,146	104,113

Note: Largest producing states as of FY2020.
Source: DES, Ministry of Agri. & FW (2020).

From 2012 to 2020, the area under mungbean cultivation grew by 3.8% on average per annum to reach 4.6 million Ha. In 2020, it was estimated that mungbean yield in India totalled 0.5 tonnes per Ha.

Figure 4.2. Area Harvested & Yield (India), 2012 to 2020



Note: Production is based on FY.
Source: DES, Ministry of Agri. & FW (2020, 2022).

The *pulses revolution from food to nutritional security* report released by the Indian Government in 2018 highlights the potential additional harvested area for mungbeans and black gram. By 2030, it is estimated that an additional 3.9 million Ha of mungbeans and black gram could be planted. If yields remain at an average of 0.5 tonnes per Ha, the production of mungbeans and black gram could grow by an additional 1.9 million tonnes.

Table 4.2. Potential Additional Mungbean Production 2030

Potential Crops/Cropping System/Niches	Specific Areas	Potential Area (Million Ha)	Target Area 2030 (Million Ha)
Intercropping			
Mungbean with sugarcane (irrigated) and with cotton and millets (rainfed uplands)	Eastern, central and eastern UP, Bihar, MH, AP and Timelnadu	0.70	0.50
Catch Crops			
Mungbeans: Spring/summer	Western & central UP, Haryana, Punjab, Bihar, WB	3.00	2.00

Potential Crops/Cropping System/Niches	Specific Areas	Potential Area (Million Ha)	Target Area 2030 (Million Ha)
Rice Fallow			
Urdbean/mungbean	AP, Tamilnadu, Odisha, Karnataka	0.50	0.40
Kharif Fallow			
Urdbean/Mungbean	UP, Bundelkhad MP	1.20	1.00
Total	**-**	**5.40**	**3.90**

Note: Urdbean is also known as black gram.
Source: Government of India (2018).

China

It is estimated that mungbean production represents approximately 19% of the total legume production in China (Kousonsavath, C., & Vagneron, I, 2018). China has historically been a major producer of mungbeans on the global scale, particularly in the 1950s where 1.64 million Ha were dedicated to mungbean production, producing approximately 800,000 tonnes (Kousonsavath, C., & Vagneron, I, 2018). Mungbean yields were relatively low, reaching an estimated 188 kg per Ha due to the low use of inputs (Kousonsavath, C., & Vagneron, I, 2018).

Mungbean production was on the decline in China throughout the 1960 and 1970s, with the government directing their attention to other grain commodities including rice and soybean (Kousonsavath, C., & Vagneron, I, 2018). The decline stopped throughout the 1980s, with a significant improvement in production practices and high yielding varieties (Kousonsavath, C., & Vagneron, I, 2018). Mungbean yields experienced increase to 914 kg per Ha in 1986 and 1,154 kg per Ha in 2000 (Kousonsavath, C., & Vagneron, I, 2018). In the 2000s, mungbean production area totalled 772,000 Ha, resulting in production volumes of 891,000 tonnes (Kousonsavath, C., & Vagneron, I, 2018). The main growing mungbean provinces in 2000 were Jilin, Henan, Inner Mongolia and Shannxi (Kousonsavath, C., & Vagneron, I, 2018).

Mungbean production has been relatively volatile over the years in China, with production declining by approximately 50% in 2014, attributed to two main factors including poor weather conditions and less land availability for mungbeans (Kousonsavath, C., & Vagneron, I, 2018).

More recently, the USDA (2019e) has forecast mungbean production in FY2020 to total an estimated 650,000 tonnes, which is down one fifth from the previous year. There have been lower market prices which has discouraged plantings (USDA, 2019e). This is expected to be driven by border trade, predominately with Myanmar (USDA, 2019e). In August 2021, it was estimated that mungbean prices in Myanmar “averaged six yuan per kilogram, about twenty percent cheaper than domestic mungbeans” (USDA, p. 2, 2019e).

Pulse production in China receives no support from the Central Government, and challenges in production include (USDA, 2019e):

- Limited research
- Poor access to quality seeds
- Lack of improved varieties
- Limited planting and harvesting equipment.

There are three main cropping patterns in China, including (Li *et al,* 2017):

- Southern cropping patterns (including middle and lower Yangtze River regions): the mungbeans is sown in early June and harvest in mid to late August. The main cropping patterns for mungbeans include wheat, maize, cotton and sweet potato.
- Spring-sown areas in northern China (one crop per year): mungbeans are sown in late April to early May. Harvesting of the mungbean crop occurs in September. The main commodities with rotational cropping include mungbeans, millet, sorghum (maize). The crop can also be intercropped with millet, maize or sorghum.

- Summer-sown areas in northern China (two crops per year): the mungbean crop is sown in June and harvested in early September. With the summer-sown areas focusing on two crops per year, mungbeans are generally intercropped with wheat.

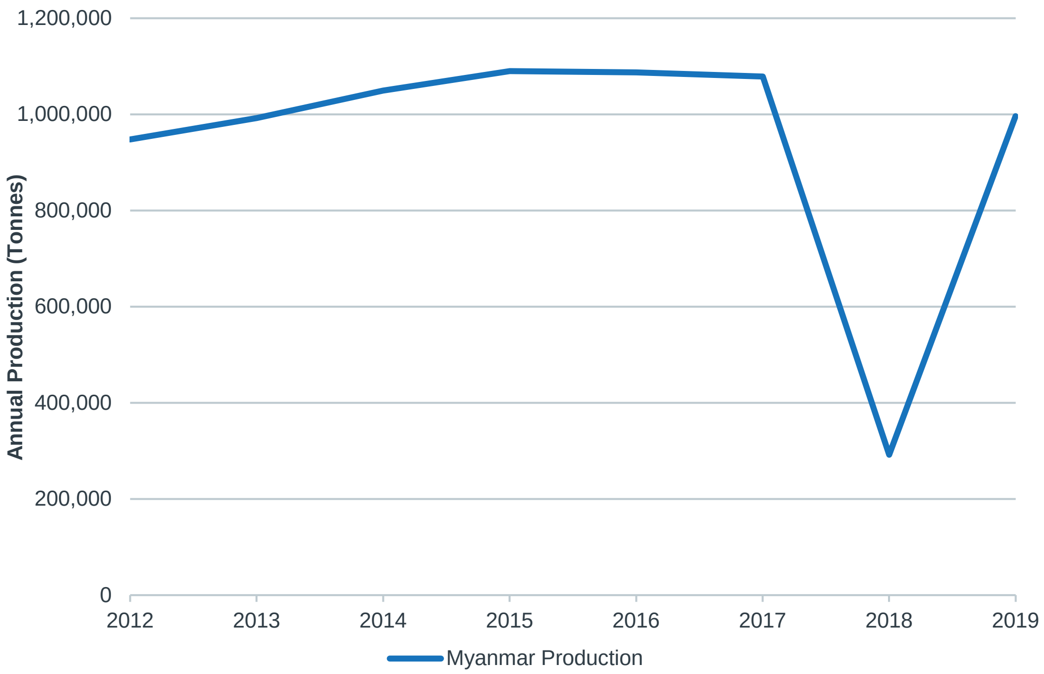
Myanmar

From 2012 to 2019, mungbean production in Myanmar has experienced an average annual growth rate of 0.7%. Information identified by the Myanmar Statistical Information Service (MMSIS) estimates production to total 996,279 tonnes in 2019. Mungbeans are increasingly becoming a crop for export in Myanmar (ACIAR, 2020c).

Over the seven-year period production experienced a peak in 2015 of 1.1 million tonnes, declining to a low of 291,919 tonnes in 2018. The decline in production over 2018 is reflective of the significant decline in harvested area. A report by Kousonsavath, C. and Vagneron, I (2018) has highlighted that Myanmar's pulse production was projected to decline in FY2018 with a farming shift to other crops including corn, soybean, dry season paddy and sesame. The shift in production stemmed from the Indian Governments import restrictions in mungbeans from 2017 (Kousonsavath, C., & Vagneron, I, 2018).

The largest constraining factor in Myanmar at the time of harvest is high labour costs and labour shortages (ACIAR, 2020a). These factors are also experienced in Bangladesh and Pakistan, due to traditional harvesting techniques of hand picking (ACIAR, 2020a). Hand harvesting accounts for 50% of production costs, as a result, ACIAR is funding research to evaluate the introduction of mechanical harvesting methods (ACIAR, 2020b).

Figure 4.3. Mungbean Production in Myanmar, 2012 to 2019



Note: The data reflects green gram production only.
Source: MMSIS (2020).

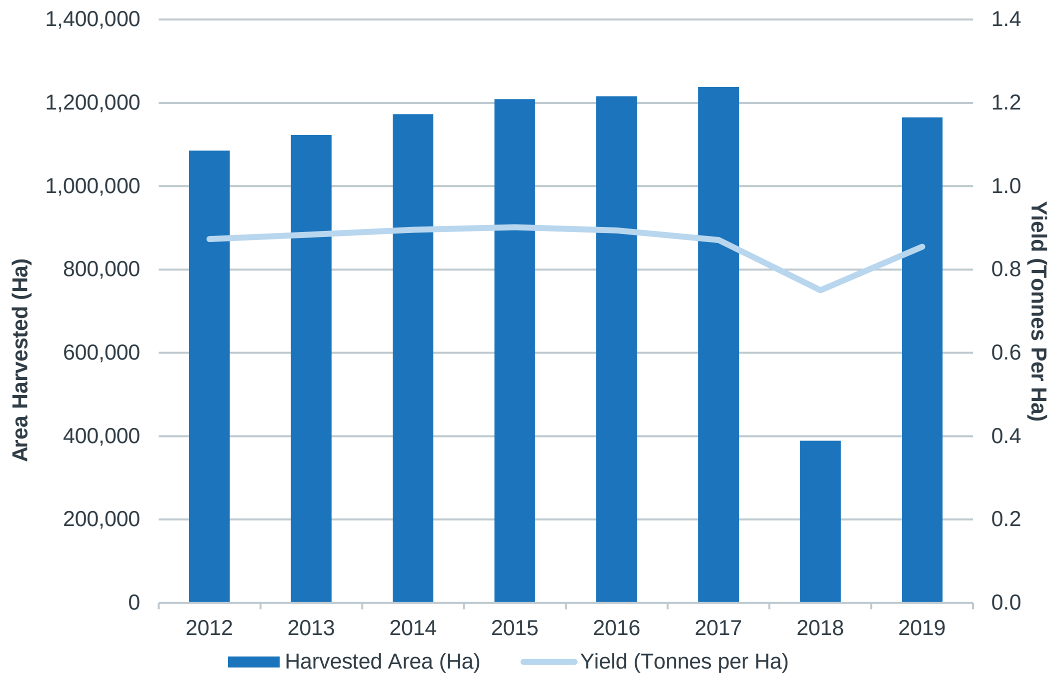
Historically, the mungbean harvested area has increased by an average of 1.0% per annum from 2012 to 2019 to reach 1.2 million Ha. In 2018, the area harvested experienced significant decline, decreasing to 389,186 Ha. Key mungbean producing states including the Yangon region and the Ayeyarwardy region had little to no production while the harvested area for states including the Bago region, Magway region and Mandalay region experienced significant decline in harvested area from the previous year.

Additionally in 2018, there was a relatively large difference in the sown area and the harvested area. In 2018, there was approximately 539,480 Ha of mungbeans sown but only 389,186 Ha were harvested.

In Myanmar, mungbeans have two key growing seasons (USDA, 2020):

- Winter season, starting in October with the harvest in February to April
- Rainy seasons, staring from July and August, with the harvest in November to January

Figure 4.4. Area Harvested & Yield (Myanmar), 2012 to 2019



Notes:
- The data reflects green gram production only.
- Acres converted to hectares.

Source: MMSIS (2020).

4.2.3 Major Exporters

From 2012 to 2020, global exports have experienced an average annual growth rate of 1.3% per annum to reach a total of 1.7 million tonnes in 2020.

Over the entire analysis period (2012 to 2020), Myanmar has been the largest exporter of mungbeans on the global scale. Exports in Myanmar have experienced an average annual decline of 1.3% to reach 1.1 million tonnes in 2020. Exports from Myanmar represented 65.8% of total global exports in 2020. India is the largest export market for Myanmar, however the Indian Government "regularly imposes stringent restrictions or complete bans on the imports of pulses to protect domestic farmers against competing supplies, or falling prices – e.g., in the case of bumper harvests" (Kousonsavath, C., & Vagneron, I. p. 16, 2018).

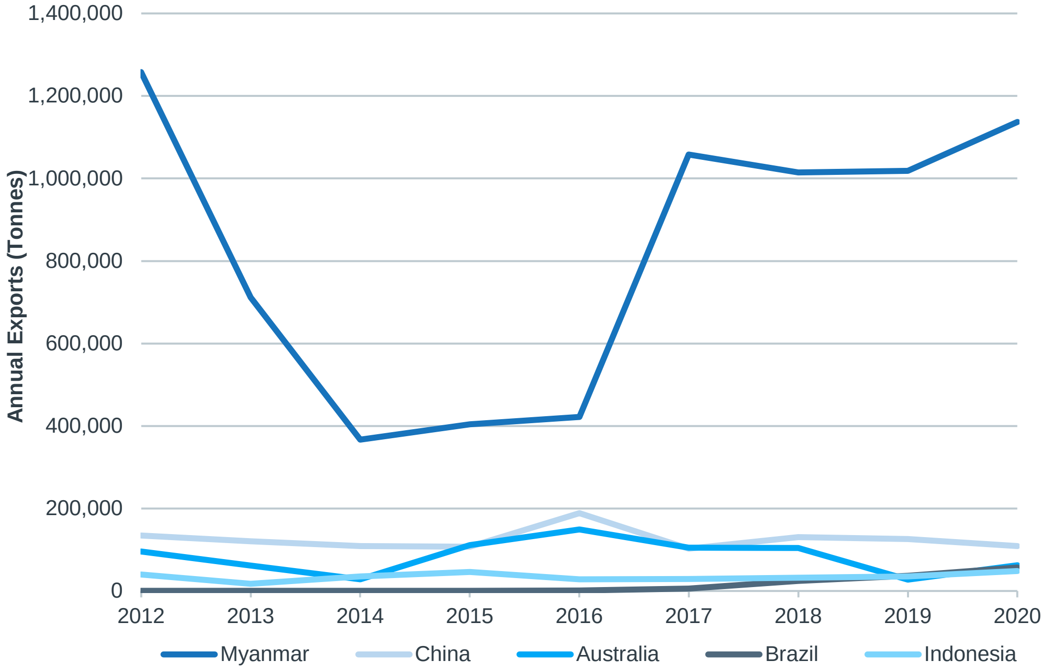
Mungbean exports from Myanmar experienced decline from 2012 to 2014, with exports decreasing by little over 890,000 tonnes in the period of two years. This was largely driven by the decline to India, with exports decreasing from 900,621 tonnes in 2012 to 41,675 tonnes in 2012 (Com Trade, 2022). Exports from Myanmar experienced a sharp increase from 2016 to 2017, driven by the rise in exports to India. Over the year, exports to India increased from 41,970 tonnes to 444,301 tonnes.

The second largest exporter of mungbeans in 2020 was China, exporting a total of 109,103 tonnes. In 2020, China's largest export market was Japan, accounting for 36.3% of total exports for the year. This was closely followed by Vietnam, accounting for 31.3% of total exports in 2020.

Of important note, Australia was the third largest exporter of mungbeans on the global scale, with exports totalling 62,190 tonnes in 2020. Australian mungbeans are regarded as the most hygienic and safest mungbeans available due to the strict measures the industry has taken to ensure the highest quality of supply (Australian Mungbean Association, undated c). Australia's mungbeans can take up to six months or more to grade, bag and export due to the export markets preference for delivery over an extended period (Australian Mungbean Association, undated c). Historically, key exports markets for Australian mungbeans include (Australian Mungbean Association, undated c):

- The Middle East – preference for large and small green beans
- The Indian Subcontinent – preference for large and small green beans
- Malaysia, Sri Lanka and Philippines – preferences for large green beans
- Taiwan – preference for dull seeded, Regur and large green beans
- USA and Canada – preference for sprouting, cooking beans, premium small beans and Regur
- United Kingdom (UK) and Europe – preference for sprouting, cooking beans, premium small beans, dull seeded and Regur.

Figure 4.5. Top Five Major Exporters of Mungbeans, 2012 to 2020



Note: Excluding re-exports.
Source: Com Trade (2022).

4.2.4 Major Importers

From 2012 to 2020, global imports have risen by an average annual rate of 2.5% per annum to reach a total of 1.2 million tonnes in 2020.

Over the entire analysis period (2012 to 2020), India has been the largest importer of mungbeans on the global scale. Imports to India have been declining over the nine-year period, decreasing by an average annual rate of 3.9% to reach an estimated 388,648 tonnes in 2020. In 2020, India represented 32.6% of total global mungbean imports. Of important note, India is the world's largest producer of mungbeans and the world's largest importer. This highlights the significant domestic demand for the pulse crop in India.

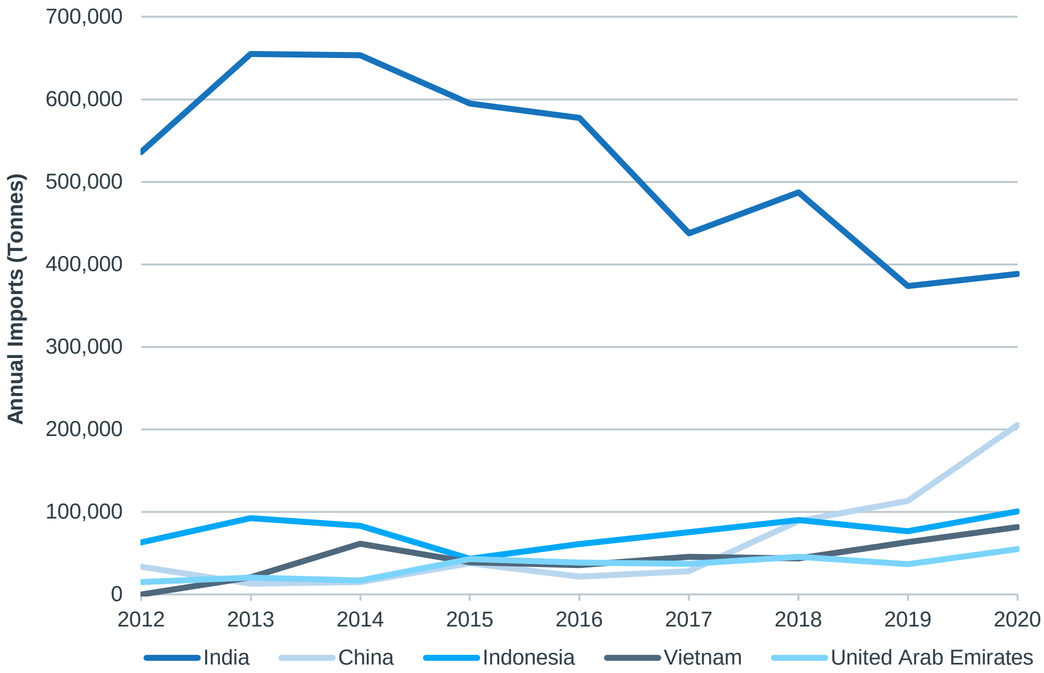
The majority of mungbeans to India in 2020 was supplied from Myanmar, accounting for 91.2% of total imports. As stated previously, Myanmar is one of the largest global producers of mungbeans and therefore has the quantity to satisfy demand from India. Myanmar also has proximity to market advantages, with the ability to transport commodities via road or port to India. The second largest source market to India in 2020 was Mozambique, accounting for 5.1% of total imports for the year.

The second largest importer of mungbeans in 2020 was China, with imports increasing by an average annual rate of 25.5% from 2012 to 2020. Over the nine-year period, mungbean imports to China have increased by over six-fold reaching 205,343 tonnes in 2020.

In 2020, China's largest supplier of mungbeans was Myanmar, with the country accounting for 28.3% of total imports in 2020. The second largest source market was Uzbekistan (accounting for 21.5% of total imports), followed by Australia (16.7% of total imports). Historically, Indonesia has also been a large supplier of mungbeans to the Chinese market.

Indonesia was the third largest importer of mungbeans in 2020, importing a total of 100,479 tonnes. Similar to India and China, Indonesia's largest mungbean supplier was Myanmar, accounting for 69.3% of total imports in 2020. The second largest supplier was Ethiopia, suppling 22.1% of total mungbean imports to Indonesia in 2020.

Figure 4.6. Top Five Major Importers of Mungbeans, 2012 to 2020



Note: Excludes re-imports.
Source: Com Trade (2022).

4.2.5 Global Consumption

Information on global consumption is limited and data is not available.

4.2.6 Growth Markets for Mungbeans

Mungbean production in Myanmar, Bangladesh and Pakistan could experience an increase over the coming years with ACIAR funded research to modernise production practices (ACIAR, 2020b). The research looks at supporting more efficient production and harvesting practices, switching from traditional methods of hand harvesting to mechanical methods. Hand harvesting accounts for 50% of production costs and the introduction of machinery will increase incomes of farmers significantly.

It is reported that the research may also support Myanmar in finding more suitable varieties for the sprout mungbean market in Europe (ACIAR, 2020b). The premium sprout mungbean market in Europe is strict around food hygiene and supply-chain traceability (ACIAR, 2020b). The market is also strict around quality expectations including appearance, consistency, taste and texture (ACIAR, 2020b). Of important note, grain importers in Europe reject mechanically harvested mungbean due to the higher percentage of grain which is more likely to be hardened and split (ACIAR, 2020b).

Generally, the demand for mungbean is rising due to a number of factors including (EMR, 2022 b):

- Rising demand for organic food products
- Awareness regarding health
- Substitutions for meat products.

Based on industry consultation, future key growth markets for Australia include southeast Asia, Philippines, Indonesia, Vietnam and China.

4.3 THE AUSTRALIAN MUNGBEAN INDUSTRY

4.3.1 Cultivars

Australian mungbeans are harvested mechanically while many international markets use traditional methods and hand harvest mungbeans (Australian Mungbean Association, undated b). As a result, Australian mungbeans compete with a product that has exceptional seed quality. The industry within Australia has developed varieties and management practices that are suited to quality mungbean production under mechanised systems.

The table below provides a summary of the key mungbean varieties, while Table C. 4 (page 199) highlights the varieties by grade classification. In 2020, Queensland Government plant breeders released Opal-AU, which is a more resistant variety to halo blight and powdery mildew (Australian Mungbean Association undated b). This will increase yield potentials, particularly in southern areas where the disease is more prevalent.

In the early 2000s, DAF released a National Mungbean Improvement Program and the Opal-AU is the sixth variety released since the program began (Grain Central, 2020b).

Mungbeans refer to mainly green seeded varieties, however, black gram is closely related to the mungbean species. The variety has a dull grey-black seed and usually more difficult to harvest as pods are set lower on the plant (Australian Mungbean Association undated b). The Regur black gram is more resistance to waterlogging that other mungbean varieties, however, this variety is not recommended in Central Queensland where the growth time for the crop is very short and any delay in maturity limits yield potential (Australian Mungbean Association, undated b).

Table 4.3. Mungbean Varieties

Varieties	Release Date	Colour	Production region
Large-seeded shiny green mungbean			
Opal-AU*	2020	Shiny green	North
Jade-AU*	2013	Shiny green	North
Crystal*	2008	Shiny green	North
Berken	1975	Shiny green	North
Small-seeded shiny green mungbean			
Celera II-AU*	2014	Shiny green	North
Green Diamond*	1997	Shiny green	North
Black gram (Mungo)			
Onyx-AU*	2017	Black	North
Regur	1975	Black	North
Large-seeded dull green mungbean			
Stain II*	2008	Dull green	North

Notes:

- *Protected by Plant Breeder's Rights (PBR).
- Production region definitions are provided in Figure 3.15..

Source: Pulse Australia (2020).

4.3.2 Australian Mungbean Production

Definitive mungbean production values for Australia are not currently available, however the figure below provides an indicative estimate of production from FY2015 to FY2021. The information listed in the figure below is based on information highlighted in Grain Central (2016), information from ABS (2017a) and consultation with the Australian Mungbean Industry Association.

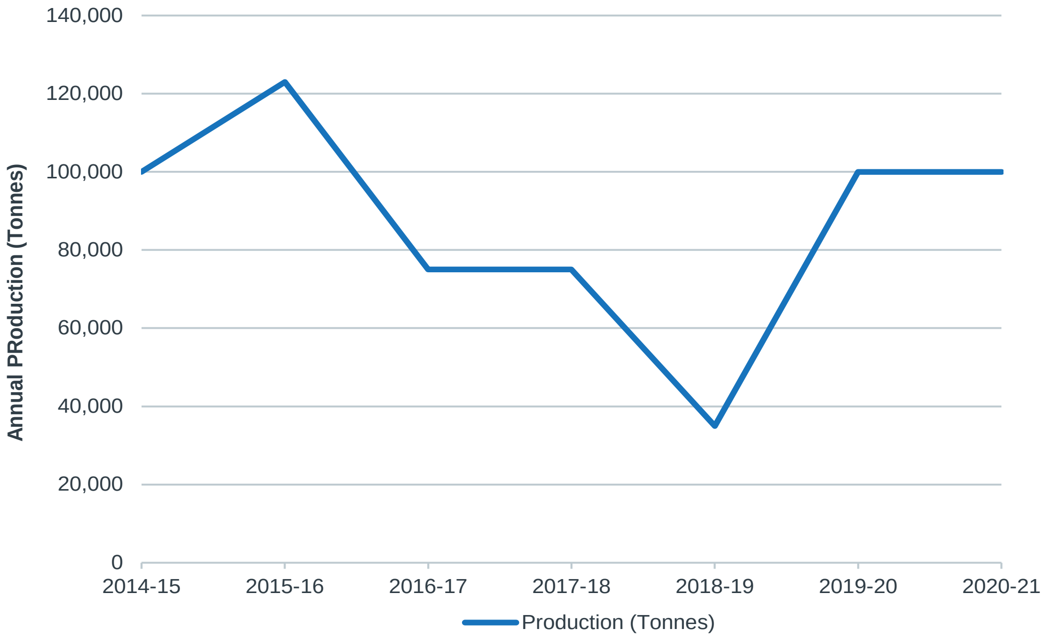
Of important note, data provided by the ABS indicates that mungbean production in FY2016 was estimated to total 122,953 tonnes. However, consultation with industry and information highlighted by ACIAR (2020d) and Grain Central (2016) suggests that production totalled approximately 150,000 tonnes.

Information highlighted in the Grain Central (2016) article highlights that mungbean production grew from 38,974 tonnes in FY2007 to 100,000 tonnes in FY2015. Consultation with the industry association suggested that production dropped to around 30,000 to 40,000 tonnes with import quotas implemented by India. With the import quotas on imports to India, Australia turned to China as a key market and production was on the rise with more confidence in end market destinations.

Both 2020 and 2021 were favourable years for mungbean production in Australia, reaching approximately 100,000 tonnes per annum (information based on consultation). Based on the planted area, 2022 was set to be Australia's largest production year ever, achieving well over 150,000 tonnes of mungbeans (information based on consultation). The major flooding events which have occurred throughout the beginning of the year will downgrade this estimation due to crop loss with constant inundation in some areas. It is expected that there will be a loss of yield in the crop in terms of crop ripeness and physical loss of production due to waterlogging (information based on consultation).

A report developed by Coriolis (2018) highlighted that there is a $70 million mungbean opportunity in the northwest Queensland. This report highlights that production in the northwest could be over 90,000 tonnes (Coriolis, 2018). Consultation with the Australian Mungbean Association highlights that Australia's export markets can confidently handle 100,000 tonnes per annum. If India was re-introduced to the market, removing import quotas and restrictions, then Australia could increase production to 200,000 tonnes to satisfy demand (Australian Mungbean Association consultation).

Figure 4.7. Estimated Australian Production



Notes:

- The above figures are based on information highlighted in a 2016 Grain Central article and on consultation with the Australian Mungbean Association. The above figures only provide an estimation of Australian mungbean production and may not reflect the exact production volumes for the year.
- The graph above reflects mid-point estimates provided in consultation with the Australian Mungbean Association, providing an indicative quantity.

Source: Grain Central (2016), ABS (2017a), consultation with the Australian Mungbean Association.

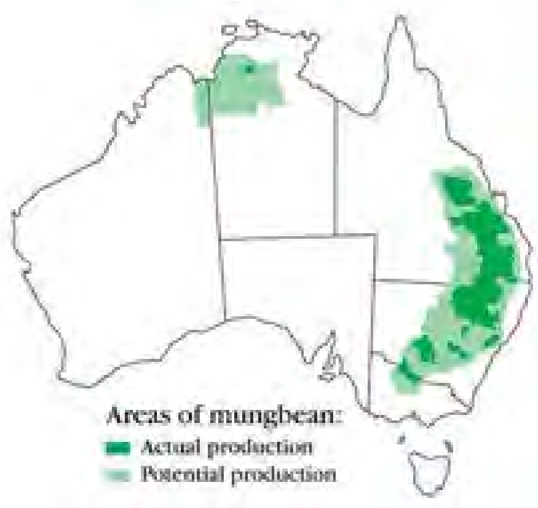
4.3.2.1 Key Growing Areas

Production

Current production is generally concentrated in Central Queensland, Southern Queensland and northern New South Wales (AgriFutures, 2017). Mungbean in Australia is predominately grown in the summer dominant rainfall areas in Queensland and northern New South Wales (AEGIC, 2021). Australia mostly produces large seeded mungbeans (shiny green in colour), with small volumes of large dull seeded, small shiny seeded and black gram (AEGIC, 2021).

The figure below provides a summary of actual production areas for mungbeans and potential production areas. Importantly, the Australian Mungbean Association have identified potential production in the Northern Territory where cropping is rather limited at this point in time. The CRCNA report identifies that the Northern Territory Farmer's Association has identified current mungbean production as 20 Ha, with potential expansion to 6,000 Ha (CRCNA, 2020).

Figure 4.8. Key Growing Areas



Source: Australian Mungbean Association (undated d).

Seasonality

There are two main planting seasons for mungbeans, the spring and the summer planting (the summer planting is more conventional) (GRDC, 2014). The following table provides planting windows for mungbeans in Queensland and northern New South Wales for an early spring plant and a late summary plant. Central Queensland has a larger sowing time than every other key region highlighted in the table.

Mungbean crops are a quick crop from planting to mature, only taking around 70 to 80 days depending on location and climate (Australian Mungbean association, undated b).

Figure 4.9. Planting Windows for Mungbeans in Queensland and northern New South Wales

Source: GRDC (2014).

Central Queensland Mungbean Production

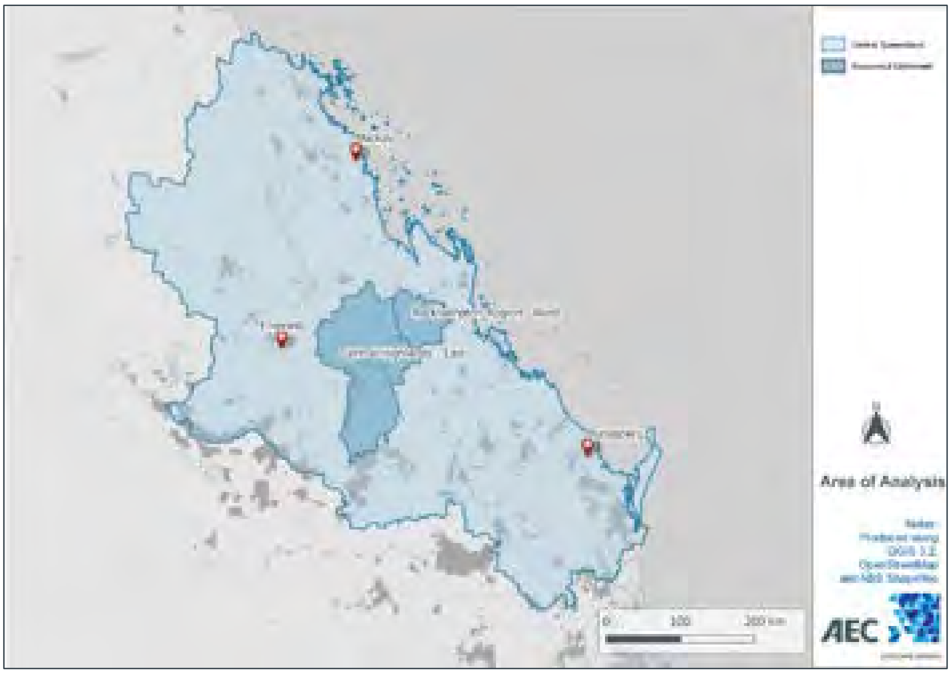
In FY2016, the Central Queensland region produced approximately 40,948 tonnes of mungbeans.

Table 4.4. Central Queensland Mungbean Production, FY2016

Region	Hectares (Ha)	Production (t)	Yield (Tonnes/Ha)
Mackay - Isaac - Whitsunday	3,890	3,950	1.0
Central Queensland	33,399	31,690	1.0
Wide Bay	4,304	5,307	1.2
Total	**41,593**	**40,948**	**1.0**

Note: The latest data available for the ABS agricultural commodities release was FY2016.
Source: ABS (2017a).

Figure 4.10. 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.

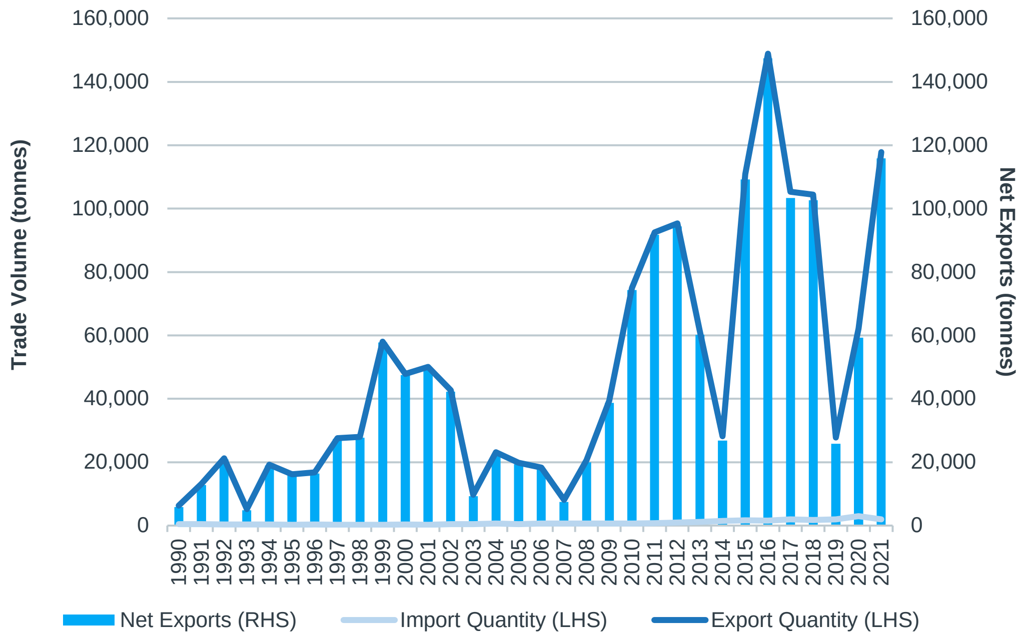
4.3.3 Australia's Trade Balance

Approximately 95% of Australia's mungbeans are exported to international markets, including the Indian subcontinent, Asia and North America (AEGIC, 2021). Australia has a high level of food safety for export protocols with a number of quality assurance systems in place to improve traceability (AEGIC, 2021). Before the mungbeans are exported, "the crop is graded, cleaned, bagged and packed into shipping containers" (AEGIC, p.9, 2021). Most of the Australian mungbean crop is destined for human consumption, with no further processing or heat treatment required (Australian Mungbean Association, undated c). Subsequently, these strict hygiene and food safety protocols are in place to ensure quality product that is backed by high health regulations.

To ensure high quality is achieved for export, the Department of Agriculture Quarantine regulations require mungbeans that are destined for export to be cleaned and packaged at registered processing establishments (AEGIC, 2021). There are also requirements for the commodity to be handled in accordance with the Australian Mungbean Association hygienic practice (AEGIC, 2021).

Australia has historically been a net exporter of mungbeans, with net exports estimated to total 115,853 tonnes in 2021.

Figure 4.11. Australia's Trade Balance, 1990 to 2021



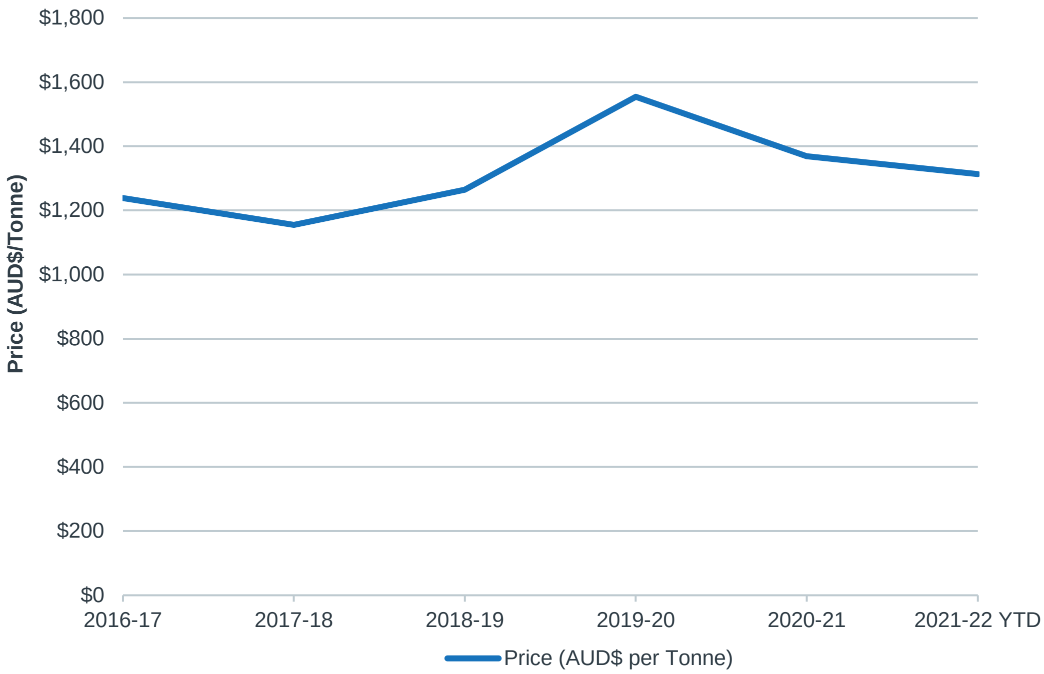
Note: Excluding re-exports and re-imports.
Source: Com Trade (2022).

4.3.4 Mungbean Prices in Australia

China and Myanmar are the two largest exporters of mungbeans on the global scale, with production and export volumes in these two countries having a large influence over price (GRDC, 2014). The harvest time of these two major competitors occurs when Australia is entering the planting phase and therefore information prior to planting is limited (GRDC, 2014). China's harvest occurs in September or November while Myanmar's harvest occurs in January or May and the size and quality of the crop in these countries dictates world pricing (GRDC, 2014).

Over the year from July 2021 to December 2021, Queensland export mungbean prices were estimated to total AUD$1,314 per tonne. Over the six-year analysis period, Queensland mungbean export prices peaked in FY2020, with prices estimated at AUD$1,554 per tonne.

Figure 4.12. Queensland Mungbean Prices ($/Tonne)



Notes:

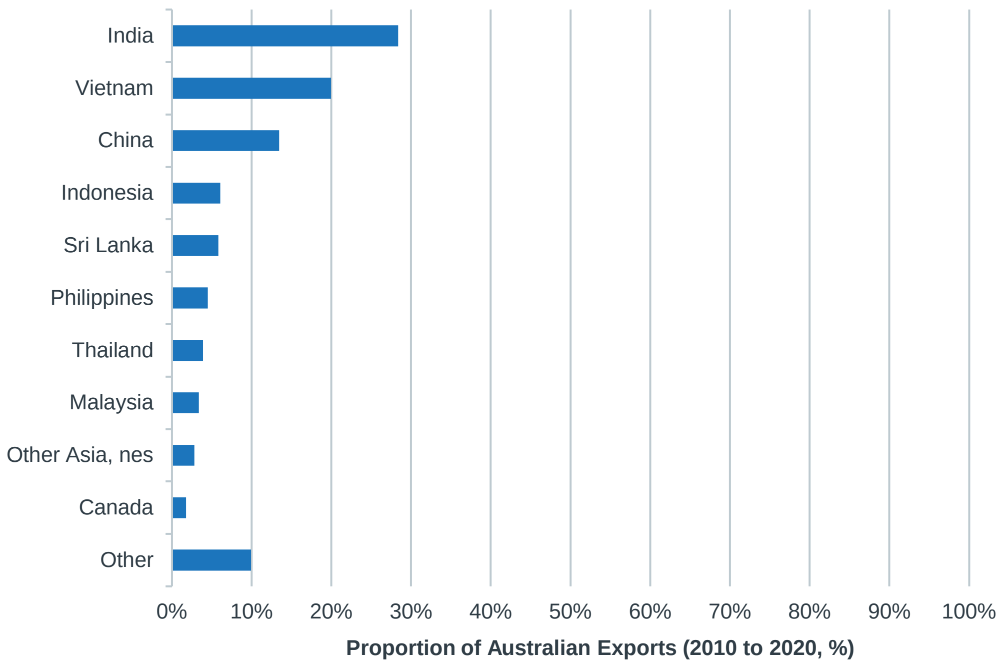
- Based on export data from Queensland
- Prices FOB (Free on Board).
- Latest data included is until the first of December 2021.

Source: ABS 2021, as cited in Pulse Australia (unpublished).

4.3.5 Australia's Key Markets

From 2010 to 2020, India accounted for 28.4% of Australia's total mungbean exports. Vietnam was Australia's second largest export market for mungbeans, accounting for an average of 20.0% of exports from 2010 to 2020.

Figure 4.13. Key Export Markets for Australian Mungbeans (Top 10)



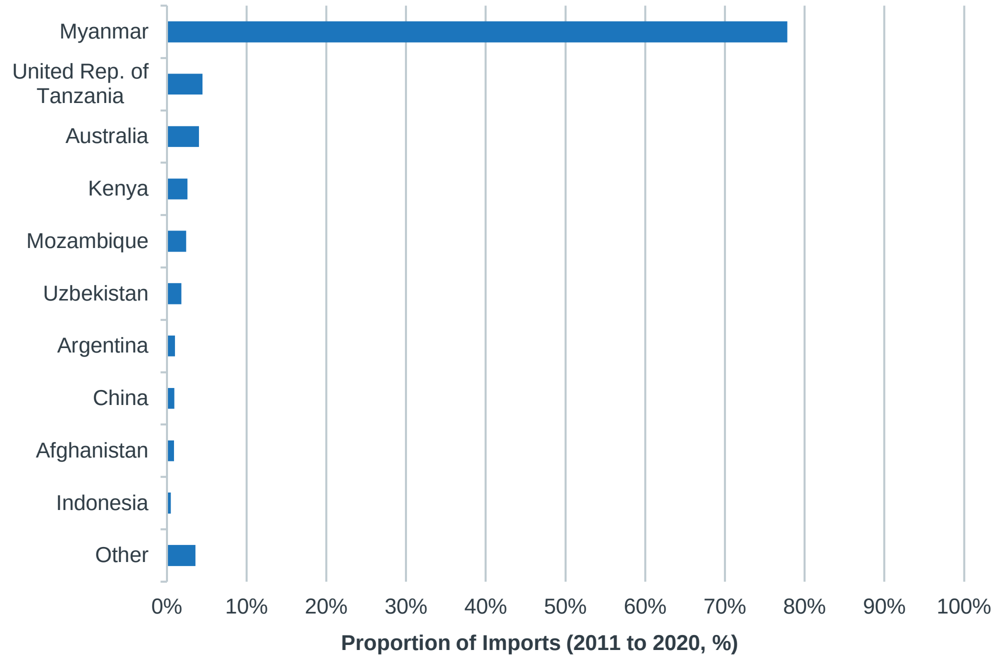
Source: Com Trade (2022).

India

The largest source of mungbean in India was from Myanmar, accounting for 77.8% of total imports on average from 2011 to 2020. The second largest source of mungbeans in India was from Tanzania, accounting for 4.5% of total imports on average from 2011 to 2020.

Of important note, Australia was India's third largest market for mungbeans, accounting for 4.0% of total imports on average from 2011 to 2020.

Figure 4.14. Mungbean Imports to India, 2011 to 2020

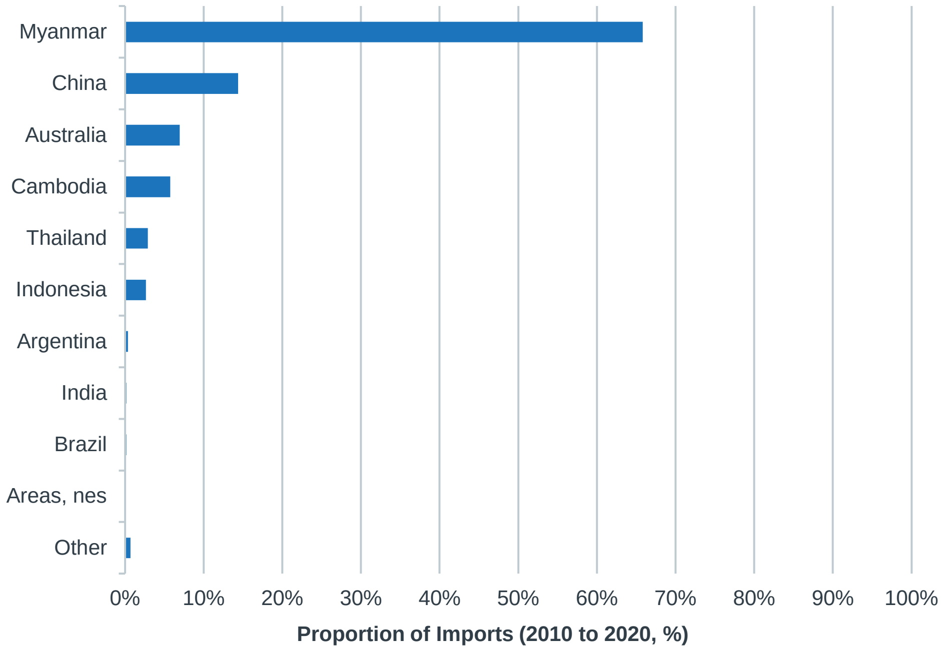


Note: No detailed trade data was available for 2010.
Source: Com Trade (2022).

Vietnam

The largest source of mungbeans in Vietnam was from Myanmar, accounting for 65.8% of total imports on average from 2010 to 2020. The second largest source of mungbeans in Vietnam was from China, accounting for 14.4% of total imports on average from 2010 to 2020.

Figure 4.15. Mungbean Imports to Vietnam, 2010 to 2020

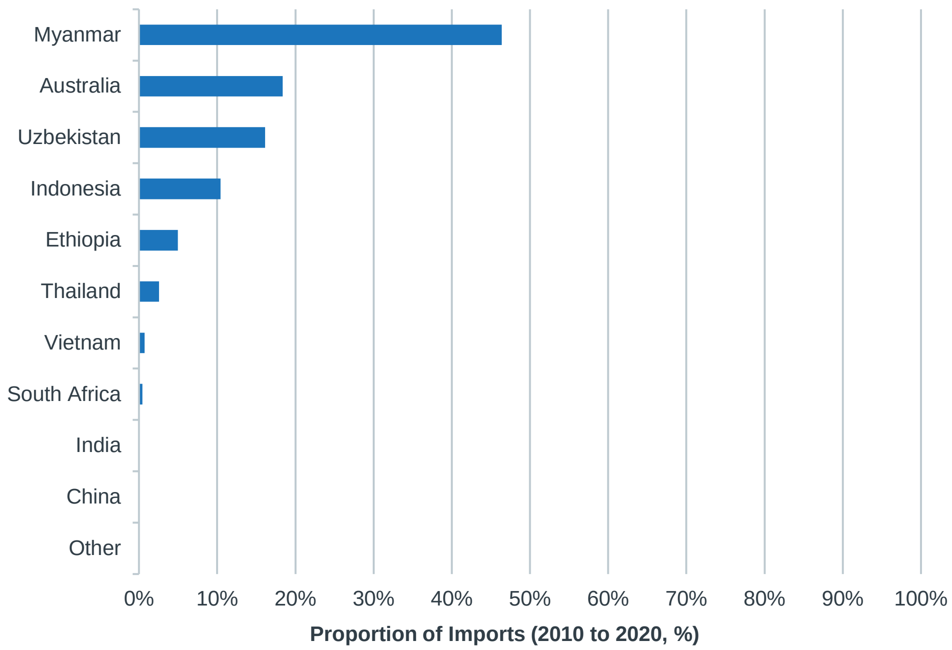


Source: Com Trade (2022).

China

The largest source of mungbeans in China was from Myanmar, accounting for 46.4% of total imports on average from 2010 to 2020. The second largest source of mungbeans in China was from Australia, accounting for 18.4% of total imports on average from 2010 to 2020.

Figure 4.16. Mungbean Imports to China, 2010 to 2020

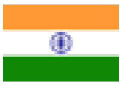


Source: Com Trade (2022).

4.4 MARKET VIABILITY ANALYSIS

The commodity outlook identified three key priority markets that are Australia's largest mungbean export markets. The three key markets that were identified in the commodity outlook are listed below:

India



Vietnam

China

The market viability analysis provides a snapshot of each key market that has been identified for mungbeans. This snapshot includes:

- Market depth and maturity
- Market access considerations (access to Free Trade Agreements)
- Economic strength, market growth and consumer capacity to pay
- Political stability and financial risk.

India

India is the largest producer and importer of mungbeans on the global scale. In 2020, India accounted for 32.6% of total global imports. This highlights the strong domestic demand compared to domestic supply.

India primarily sources mungbeans from Myanmar, accounting for 77.8% of imports on average from 2011 to 2020. Mungbean imports from Myanmar have experienced an average annual increase of 1.5% per annum from 2011 to 2020, while imports from Australia have declined by 41.7% per annum.

Population & 2050 Forecast 2021: 1.4 billion 2050: 1.6 billion	GDP 2020: $1,928 per capita (USD) 2026: $3,018 per capita (USD)
No.1 producer and No. 1 importer	Historical 150,000 tonne import quota

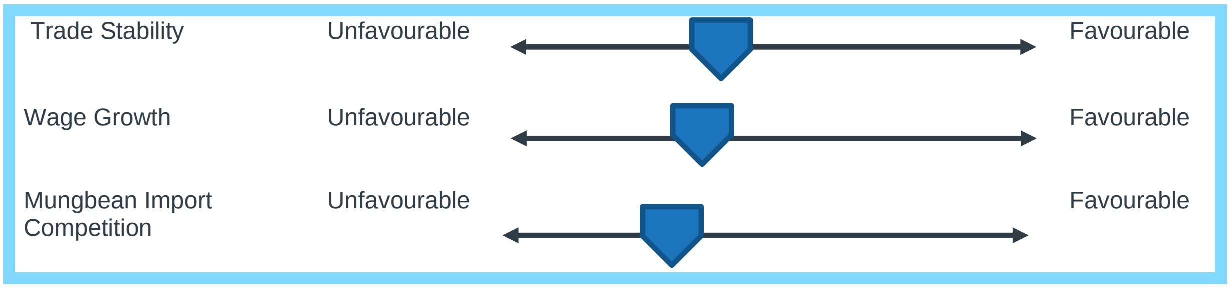
Source: OECD (2022), Statista (2022), World Bank (2022).

Market Access Consideration

- Each year, the Indian government releases import quota volumes for mungbeans–based on the domestic market including local supply and demand (USDA, 2021d). Over the last few years, the import quota has been relatively consistent at 150,000 tonnes (Australian Mungbean Association, 2020). In September 2021, the Indian Government temporarily removed import quota restrictions as unseasonal weather conditions impacted harvest (Austrade, 2022). The removal of restrictions is in place until the end of March 2022 (Austrade, 2022).
- Under the MFN duties, there are no import tariffs of mungbeans to India. The MFN nations include Australia and key competitors of Tanzania, Myanmar and Kenya.
- Import permits are not required for mungbeans to India, however, a phytosanitary certificate is required. Each shipment is required to be fumigated with methyl bromide (MICOR, 2021).

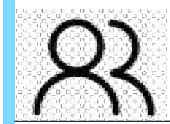
Mungbeans in India

The Australian Mungbean Association (2022) highlights that in recent times, the Indian market has been transitioning towards cheaper mungbeans from Africa. This has seen a decline in Australian mungbean exports to India, which peaked at 55,392 tonnes in 2016, declining to 144 tonnes in 2020 (Com Trade, 2022). The association highlights that there is potential for this to change in the future as supply from other markets decreases due to environmental constraints while domestic demand rises (Australian Mungbean Association, 2022).



Vietnam

In 2020, Vietnam was the fourth largest importer of mungbeans on the global scale, importing a total of 81,732 tonnes. As highlighted in Section 4.3.5, the largest supply market for mungbeans to Vietnam has been Myanmar (accounting for 65.8% of total imports to Vietnam from 2010 to 2020). China was the second largest supply market on average from 2010 to 2020, accounting for 14.4% of total imports to Vietnam.

	Population & 2050 Forecast 2021: 98.3 million 2050: 106.9 million	GDP 2020: $3,523 per capita (USD) 2026: $6,149 per capita (USD)
	4th largest importer in 2020	Australia accounted for 7.0% of Vietnams mungbean imports from 2010 to 2020

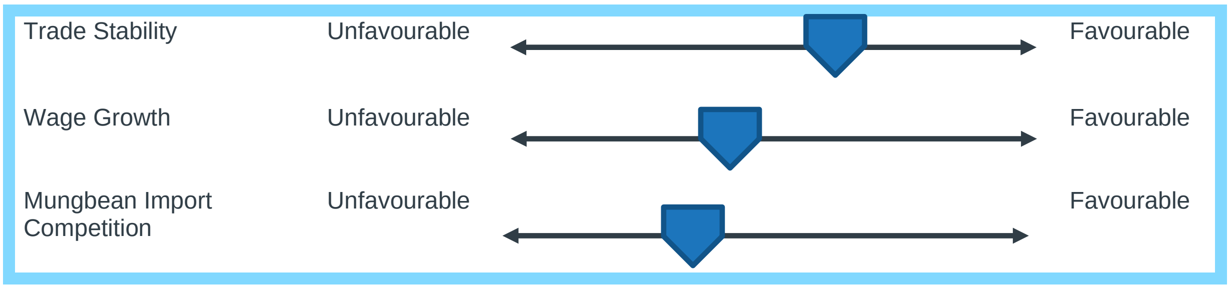
Notes: Population forecasts have been estimated based on population projections by IMF and OECD.
Source: OECD (2022), IMF (2022), Statista (2022), World Bank (2022).

Market Access Consideration

- Australia and Vietnam have a number of FTAs in place where there are no tariff implications for the export of mungbeans. Under the RCEP, CPTPP and AANZFTA, tariff implications for mungbeans currently stand at 0% for Australia.
- Other key suppliers for mungbeans to Vietnam, including Myanmar, China, Cambodia and Thailand do not have any tariff implications under the MFN duties.

Mungbeans in Vietnam

Consultation with the Australian Mungbean Association highlighted that Australia has large potential for growth of mungbeans into Vietnam, especially for the process of protein. Australia has a proximity to market competitive advantage to Asian markets, however, Myanmar which is Vietnams largest supplier has transport access via land.



China

In 2020, China was the second largest importer of mungbeans on the global scale, importing a total of 205,343 tonnes. The largest source of mungbeans in China was from Myanmar, accounting for 46.4% of total imports on average from 2010 to 2020. The second largest source of mungbeans in China was from Australia, accounting for 18.4% of total imports on average from 2010 to 2020.

Population & 2050 Forecast 2021: 1.44 billion 2050: 1.40 billion	GDP 2020: $10,4511 per capita (USD) 2026: $17,493 per capita (USD)
2nd largest importer in 2020	Australia accounted for 18.4% of Chinas mungbean imports from 2010 to 2020

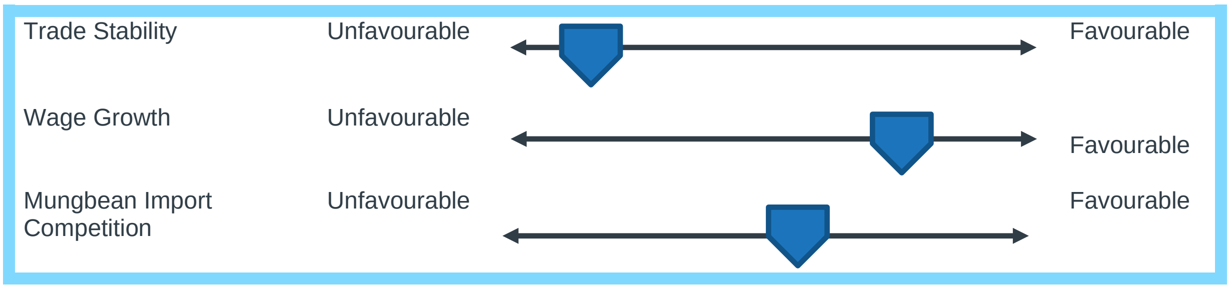
Source: OECD (2022), IMF (2022), Statista (2022), World Bank (2022).

Market Access Consideration

- Australia and China have a number of FTAs in place where there are no tariff implications for the export of mungbeans. Under the RCEP and CHAFTA, tariff implications for mungbeans currently stand at 0% for Australia. Mungbean seed exports to Vietnam are also 0% under MFN duties. For mungbeans which are classified under the 'other' category, there are no tariff implications under the CHAFTA agreement.
- Other key suppliers for mungbeans to China, including Myanmar, Uzbekistan and Indonesia, do not have any tariff implications under the MFN duties.

Mungbeans in China

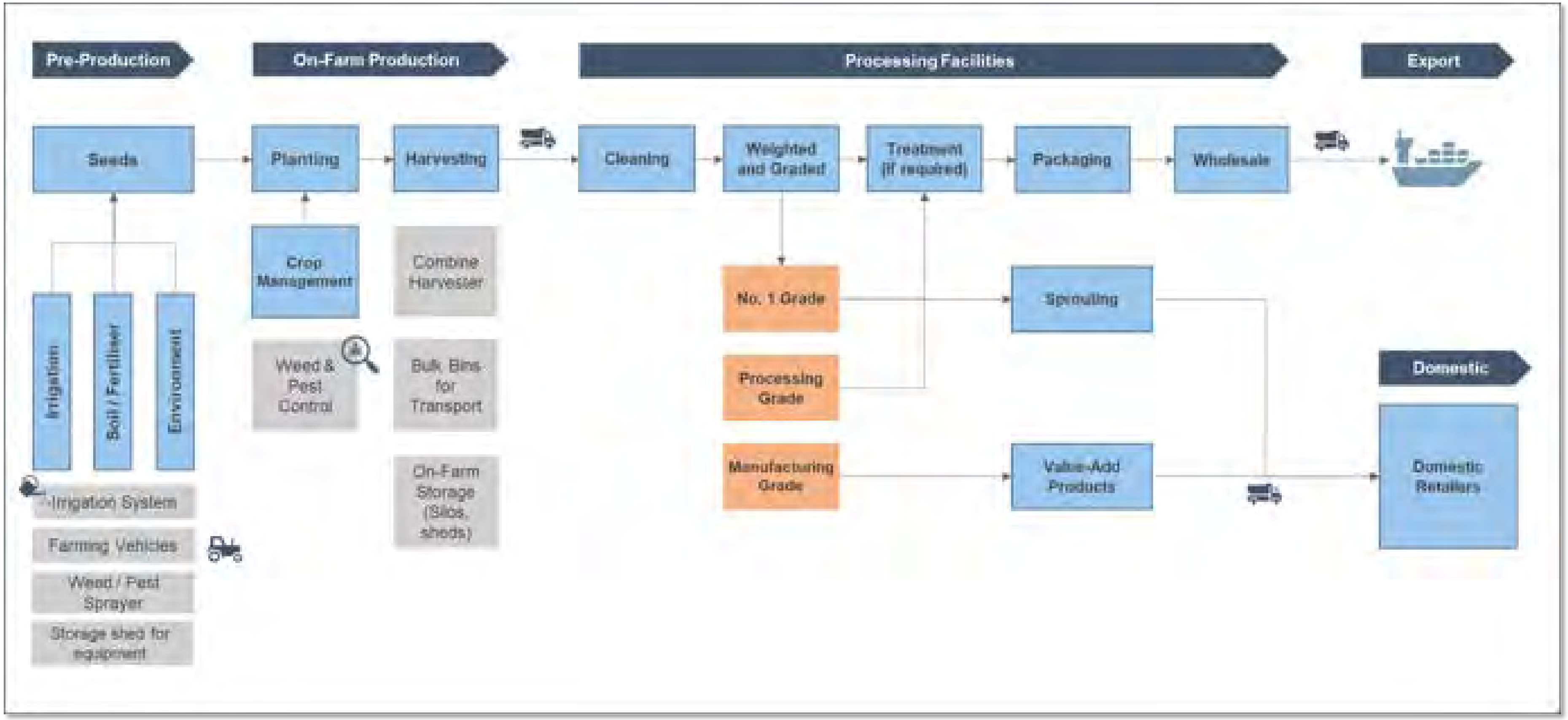
Consultation with the Australian Mungbean Association has highlighted that China is now a key market for Australian mungbeans, accounting for up to 80% of Australia's total production. China is Australia's biggest growth sector and is a key market for premium products. Additionally, with the graphic diversity of China's farming systems, the production of mungbeans is slowly beginning to decline, providing an opportunity for Australia to increase supply (Australian Mungbean Association consultation).



4.5 MUNGBEAN SUPPLY CHAIN ANALYSIS

The figure below introduces a high-level supply chain analysis to investigate the activities and processes involved in producing mungbeans within the Central Queensland region. To understand this process to identify potential industry constraints or opportunities for the region at each point of the supply chain.

Figure 4.17. Mungbean 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 crop establishment, prior to the planting of seeds. Equipment and infrastructure required for crop establishment for mungbeans include (Agrifutures, 2017):

- An irrigation system, irrigation equipment and soil moisture monitoring equipment
- Boom sprayers for herbicide and insecticide application
- Tractors and vehicles
- Cultivation equipment
- Seeders/disc drills or row crop planters
- Combine harvesters (headers)
- Chaser bins and grain trucks.
- Grain silos for on-farm storage.

Some or all of the operations required to produce a mungbean crop can be carried out by contractors, which may alleviate some capital investment in the significant amount of equipment required for crop production.

On-Farm Production

Mungbeans are a summer crop, taking 70 to 80 days from planting to maturity. Mungbean crops have a lower fertiliser requirement than other summer crop choices, and are a good crop to incorporate into the rotation because of the quick harvest period, allowing for more diversity and ability to manage agronomic risks, as well as better utlisation of farm machinery.

Planting of mungbeans should be restricted to one variety, unless harvest equipment and storage facilities can be thoroughly cleaned and maintained. Plantings of different varieties should be clearly separated, as varietal mixtures could impact the visual quality of mungbeans, and are unacceptable in the sprouting and cooking trade. Mungbeans are generally consumed with minimal or no processing so achieving food grade hygiene is critical.

Mungbeans are an indeterminate plant i.e. they produce flowers continuously, they may require desiccation prior to harvest to minimise immature grain in the harvest. Mungbeans are ready for desiccation when 80% to 90% of pods are brown to black, and are sprayed with a robust rate of glyphosate and allowing sufficient time for the crop to dry down before commencing harvest.

Mungbeans are harvested using combine harvesters (headers). After harvesting, farmers can store their mungbean on farm, or transport their product to a processing facility directly after harvest. Harvested mungbeans will continue to age and darken in storage which leads to quality deterioration over time. The ideal bulk seed storage is a cone based, aerated, sealable silo that is painted white, or is located out of direct radiant heat of the sun. Automatic aeration controllers will usually provide the most reliable results for cooling grain temperatures.

Processing

The majority of Australian mungbean crop is sold into the processing grade market. Less than 5% goes into the sprouting market. All Australian mungbeans are cleaned, gravity graded and bagged through registered processing plants.

Most mungbeans are cleaned, graded, bagged and marketed through Registered Processing Establishments because of their knowledge and understanding of the international marketplace. Prices may vary depending on appearance and quality. Grain quality standards are set for the following three main grades:

- No. 1 grade
- Processing grade

- Manufacturing.

They may also require fumigation for any live insects and drying to a consistent moisture content.

Export Markets

Mungbeans have very strict hygiene requirements as over 95% of Australian production is used for human consumption often with no further processing or heat treatment.

Mungbean exports are required by the Australian Quarantine and Inspection Services (AQIS) regulations to be cleaned and packaged at a Registered Processing Establishment, and handled in accordance with the Industry Code of Hygienic Practice. All products must be inspected by AQIS to ensure they meet with importing countries requirements and standards. Shipping containers must be of food quality standard and approved by AQIS approved personnel prior to loading. They may also require fumigation for any live insects and drying to a consistent moisture content.

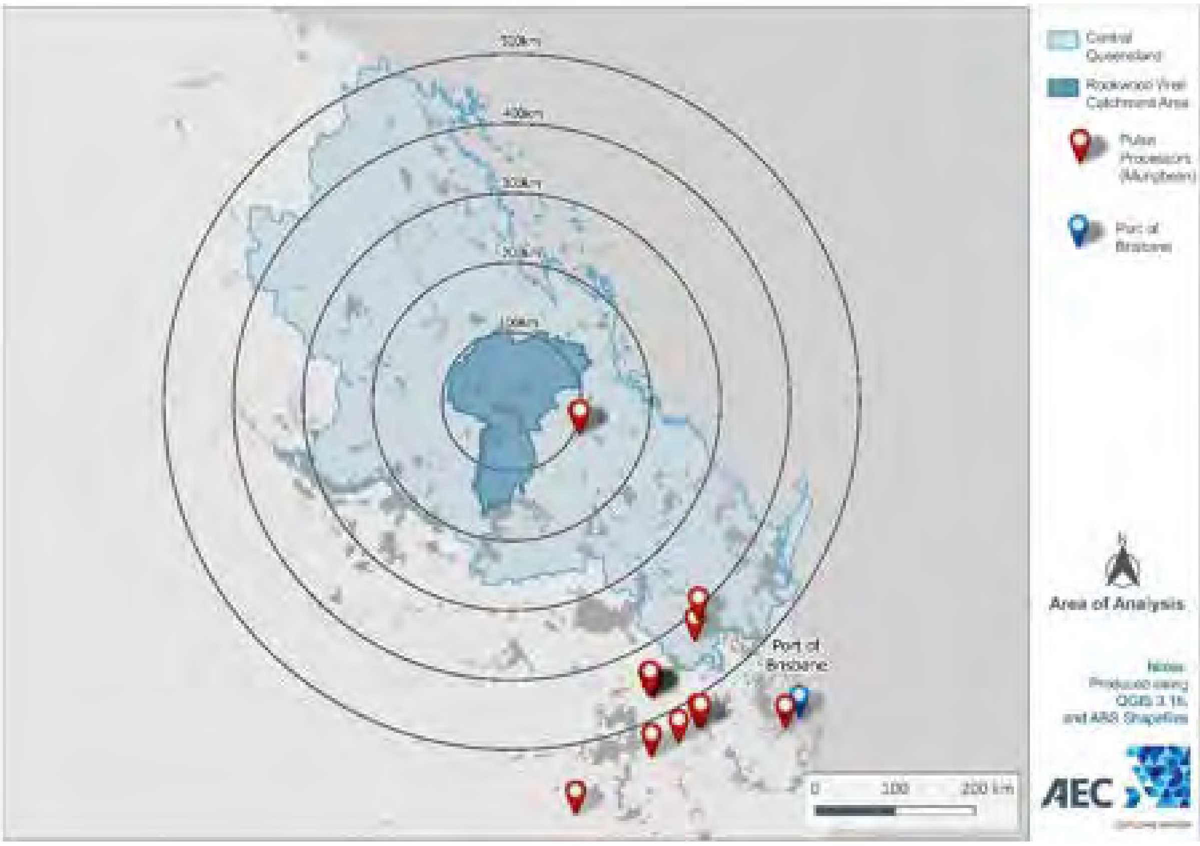
Domestic Market

Domestic demand for mungbeans represent a small proportion of overall Australian production (approximately 5%). Domestic uses for mungbean include bean sprouts, dried mung beans, and mungbean starch and protein products. These products are generally sold via supermarkets and health stores.

4.5.1 Infrastructure Requirements and Gaps in Central Queensland

All mungbean exports are required to be handled through Registered Processing Establishments, which are mainly located in southern Queensland. Registered Processing Establishments are illustrated in Figure 4.18.

Figure 4.18. Registered Processing Establishments



Source: AEC.

There is one processing facility within 100km of the Rookwood Weir Catchment (Allenden Seeds in Jambin, QLD), with the other facilities located approximately 400 – 500km from the Catchment, closer to the Port of Brisbane. The Allenden Seeds facility has over 6,000 tonnes of on-site storage (over 40 sealed silos), and large grading, packing and export sheds. If mungbeans were to be selected as a commodity for the Rookwood Weir Catchment Area, it is anticipated that the Allenden Seeds facility will service the Rookwood region, with a further processing facility required if the scale of mungbean production surpasses the processing capabilities at this plant. Mungbeans can also be transported to the processing establishments near the Port of Brisbane, however there may be higher transport costs associated with the longer distance. There may be additional cost efficiencies though as there is a shorter distance to port.

4.6 COMPETITIVE ANALYSIS AND MARKET OUTLOOK

4.6.1 Key Importers & Exporters

The figure below provides a snapshot of the top five exporters and importers of mungbeans in the global market. The top five exporters accounted for 81.3% of total mungbeans exports in 2020 (primarily driven by Myanmar), while the top five importers accounted for 69.6% of total mungbean imports in 2020.

Figure 4.19. Major Exporters and Importers of Mungbeans

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

Australia's Competitive Advantages

Australia has a number of competitive advantages in the global mungbean market, including:

- Close proximity to destinations in Asia, with some of the best shipping capabilities to Asia.
- Australia has good hygiene protocols surrounding mungbean exports, delivering consistently high-quality produce
- Australia has good agronomic practices for production
- Australia has good varieties of mungbean, which can yield relatively high productivity per Ha.

In the future, there will be an increasing focus on food certification and complying with internationally recognised food safety standards will be integral. Based on industry consultation, it is likely that the increasing focus on food safety and reliability will place a strain on countries such as Myanmar or Tanzania.

4.6.2 Australia's Key Markets

Australia is an emerging force in the global mungbean market, especially with increasing production and high quality and hygiene practices. The GRDC grow notes reports highlight those international markets prefer Australian mungbeans due to the consistency of quality (GRDC, 2014). The key markets and drivers for demand as outlined by GRDC are presented in the table below.

Table 4.5. Key International Markets and Drivers of Demand

Key Markets	Drivers of Demand
Philippines and Sri Lanka	• Quality requirements have increased • Prepared to pay a higher price for good quality • In Philippines, mungbeans are used for a replacement if vegetables are in short supply due to a wet summer season
Taiwan	• Imports predominately cooking mungbean, with some processing mungbean • "Demand increases during hot summers because the mungbean are used to make soup, which is considered a cooling food" (GRDC, 2014, p. 258) • Price driven market
India	• Is only a key market when domestic demand is not sufficient to meet supply • Purchases Celera, Regur and poor-quality processing mungbean
US/Canada	• Premium market for Celera, Regur and cooking mungbean • Net importer of mainly sprouting mungbean • No tolerance to cereal grains
Malaysia	• Market for low-quality cooking mungbean and a number of processing mungbean • Due to the country's close proximity Myanmar, the quantity exported to Malaysia is dependent on price
Japan	• Japan is a relatively small market for Australia • Imports sprouting mungbean primarily from China
Europe and the UK	• Key market for sprouting mungbean • UK has strong demand for Celera, Regur and cooking mungbean from India • Australian mungbean was linked to *Salmonella* outbreaks in the UK and Sweden in the past
Indonesia	• Indonesia was the third largest importer of mungbeans in 2020 • Largest source markets in 2020 include Myanmar, Ethiopia and Australia
Australia's Domestic Use	• In 2014, it was reported that Australia utilised approximately 3,000 tonnes of sprouting mungbean and cooking mungbean for domestic uses. Approximately 80% of this was for sprouting mungbean

Source: GRDC (2014).

4.6.3 SWOT Analysis of Australian Mungbean Production

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

Table 4.6. SWOT Analysis – Australian Mungbean Production

Strengths	Weaknesses
• Short duration crop, providing a quick turnaround for profitability • Strong protocols for hygiene, delivering consistently high quality mungbeans which are preferred in some markets. Australia has a high-quality niche • FTAs with key importers including Vietnam and China	• Increased price pressure in Australia due to falling exchange rates (until interest rates equalise) • Lack of registered herbicides for broadleaf weed management • Inconsistent supply of mungbeans from Australia • High cost of domestic grading and packing • Mungbeans are an opportunity crop and are just one option for a summer rotation crop
Opportunities	**Threats**
• Providing increased yield outcomes and increase the land area with the development of new varieties • Strong market demand for mungbeans, providing export opportunities • Temporary removal of import quotas to India, until the end of March 2022 • Mungbeans are not shipped in bulk and all products are processed, bagged and packaged for buyer specifications. To ship bulk mungbeans in containers will save costs	• Logistical challenges as a result of COVID-19 • Increasing competition with Myanmar exports • Export demand dictates price for growers, with low demand in the domestic market

Source: Australian Mungbean Association (2015), AEC.

4.7 MUNGBEAN 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 mungbean production is 197ha. With water entitlement restrictions and a conservative water use assumption, the total sustainable land available for farm development (i.e. planted area) is estimated to be 54.5ha.
- The anticipated initial capital investment for a rotational cropping farm is $4.4 million – including, land clearing, infrastructure and equipment, water entitlements, and planting. This includes water allocation at an assumed cost of $1,500 per ML (RFM, 2021).
- Assuming the crop rotation with mungbean is wheat, the break-even point for the example mungbean farm, at the current assumed weighted average price of $929 per tonne is December 2023. Under this scenario, the assumed price for wheat is $421 per tonne.
- The mungbean farm will return positive discounted cash flows from FY2024, with intermittent negative discounted cash flows which correspond with the capital replacement program.
- The long-term growth rate for agricultural farm values is 12.5%, with an NPV of the farm at $0 the implied internal rate of return is 12.7%. The terminal value of the example farm with rotational cropping at the conclusion of the analysis (FY2041) is $34.9 million (undiscounted).

4.7.1 Approach

The commercial and financial feasibility of an average mungbean farm 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 capital investment required, operating costs, and the anticipated revenue over the 20-year time frame. The following sections detail the following:

- Farm establishment
- Farm operations
- Financial feasibility (including sensitivity analysis).

4.7.2 Crop Rotation

The financial analysis is undertaken for the purposes of growing mungbean as a primary commodity. In modelling the financial feasibility of soybean in the Rookwood Weir Catchment Area, the farm has been assumed to be a monoculture farm, farming mungbean, with a single crop rotation in the off season of spring wheat. For the full wheat commodity analysis, please refer to the Advance Rockhampton Broadacre Commodity Report (published 2022).

Further details are provided in Appendix E.

4.7.3 Rookwood Weir Water Availability

The Rookwood Weir Scheme allows for a maximum 500ML water allocation for agricultural landholders. Mungbean irrigation in the Central Queensland region reportedly requires, on average, 2.5ML of water per annum per Ha (DAF, 2020c). Wheat irrigation in the Central Queensland region 5.2ML of water per annum per Ha (Harris, et al, 2012). Appendix C discusses mungbean water requirements and growing environment in more detail.

Under the assumption this water is provided with a conservative 84% reliability and 7.7ML per ha per year is required for both wheat and mungbean production, the maximum growing area in the Rookwood Weir Catchment Area is 54.5ha.

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 4.7.

Table 4.7. Land Availability, by Water Availability

60% Reliability	84% Reliability	100% Reliability	No Water Allocation Cap
39.0 ha	54.5 ha	64.9 ha	197 ha

Note: Total land available considers the soil suitability of soybean only and does not factor the rotation crop.
Source: HTW, AEC.

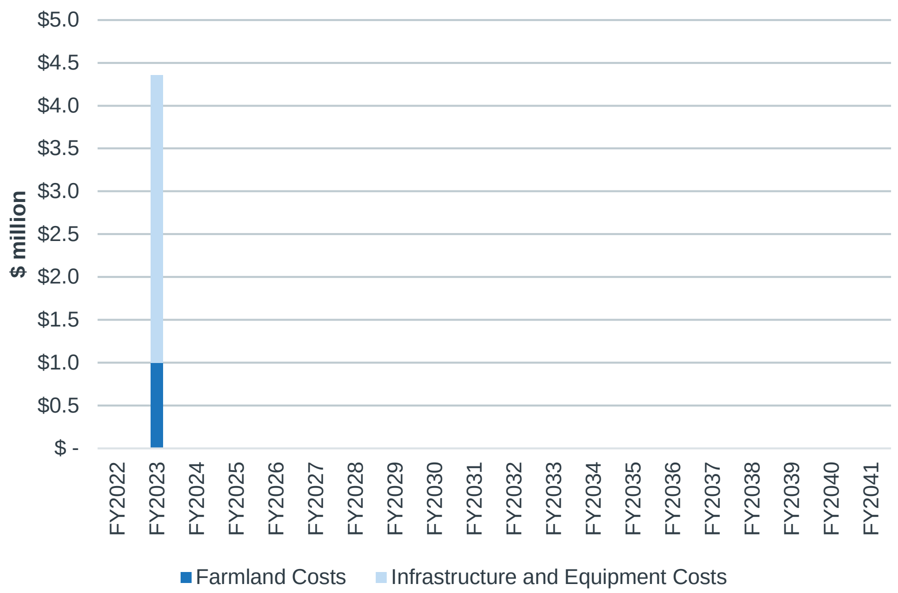
The outcome of the scenario analysis is presented below in 4.7.6.1.

4.7.4 Rotational Cropping Capital Investment

4.7.4.1 Farm Establishment

Rotational cropping farm establishment requires three key capital investments, the land, the on-farm infrastructure and associated equipment (including storage), and the horticultural crop. For the purpose of analysis, it is assumed the landholder already owns the land and the majority of the initial investment occurs across four months, starting 1 January 2023. For the 54.5ha farm, the initial capital investment is $4.4 million ($79,904/ha), not including the cost of planting.

Figure 4.20. Farm Establishment Costs, Not Including Planting Costs (FY2022 – FY2041)



Source: AEC, HTW.

Farmland Costs

Farmland costs include the cost of land clearing, and the water entitlements. Total farmland and acquisition costs per farm are estimated to be $995,364.

- **Water entitlement** – 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
- **Land clearing** – it is assumed the land, upon purchase, will need to be cleared and prepared for farm establishment. Total land clearing is estimated to be $224,307 in nominal terms.

Infrastructure and Equipment Costs

On-farm infrastructure includes storage facilities, irrigation, and farming and harvesting equipment. The infrastructure and equipment investment are considered to be purchased or built in the same year as the farmland costs.

For the example farm, the infrastructure and equipment will cost an estimated $3.4 million. This investment includes the following:

- **Irrigation infrastructure and equipment** – this assumes the irrigation method will be centre pivots and includes the necessary pumps, pipes, centre pivots and soil monitoring equipment. Overall irrigation equipment will cost an estimated $3.1 million.
- **Production equipment** – equipment and machinery included in the production of crops include the cultivation and harvesting equipment. Total production equipment expense is anticipated to cost $148,470.
- **Storage and other infrastructure** – this asset group includes storage facilities for the harvested crop and any relevant grain elevators, as all as general storage sheds. This asset group is estimated to cost $118,488.

All infrastructure and equipment costs are assumed to be a combination of new and second-hand equipment with costs quoted from sites such as Farm Machinery Sales (https://www.farmmachinerysales.com.au/items/), Farm Tender (https://www.farmtender.com.au/), and John Deer (https://www.deere.com.au/en/).

Further details are outlined in Appendix E.

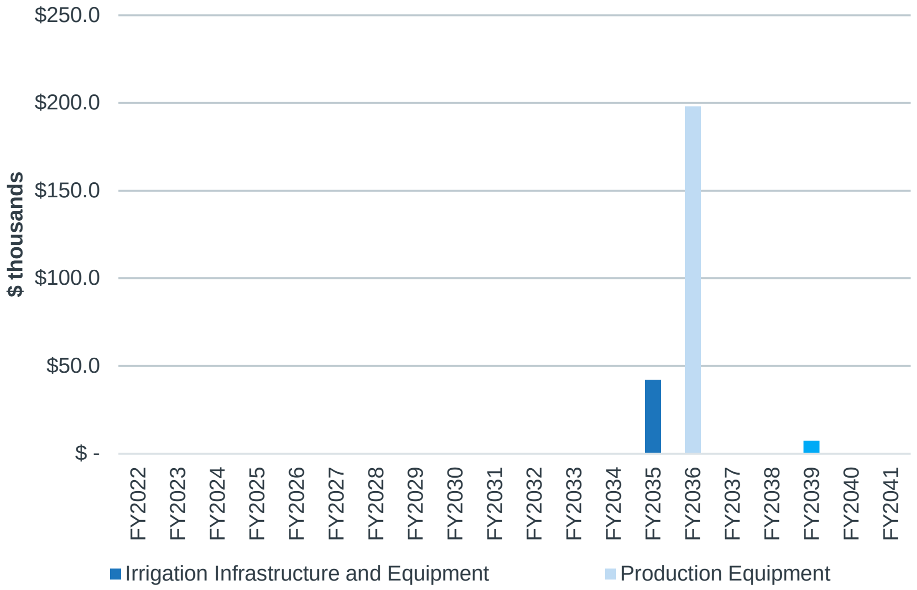
4.7.4.2 Planting Costs

Planting costs are an ongoing capital investment incurred twice a year – once for mungbean, and once for wheat. It is assumed the first sowing will occur in 2024 (FY2025) as the soil will need at least 12 months to rest after clearing. Based on planting costs published by DAF (2020c & e), mungbean is anticipated to costs $77.66/ha and wheat is anticipated to cost $59.78/ha in FY2021 real terms.

4.7.4.3 Asset Renewal

As general farming equipment, harvesting and spraying equipment, farm vehicles and irrigation 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 of the initial investment. There is an anticipated additional $247,415 required to maintain operational farm assets over the evaluation period. This expense is show in Figure 4.21.

Figure 4.21. Total Asset Renewal (FY2022 – FY2041)

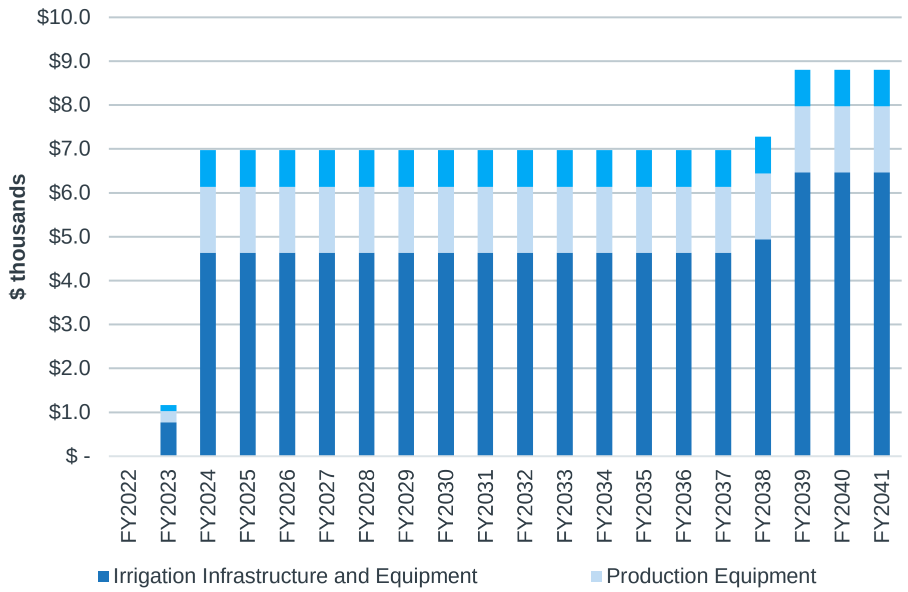


Source: AEC.

4.7.4.4 Depreciation and amortisation of assets

The capital investment required to establish the farm form the depreciable asset base of the farm. The total depreciation and asset write-off expense over the evaluation period is shown in Figure 4.22.

Figure 4.22. Total Depreciation Expense (FY2022 – FY2041)



Source: AEC (2022).

Treatment of each asset type is outlined in Appendix E.

4.7.5 Mungbean Operations

4.7.5.1 Operating Structure

The operating structure of the farm enterprise gives consideration to the ownership and management of the farm as well as the sources of funding for the enterprise.

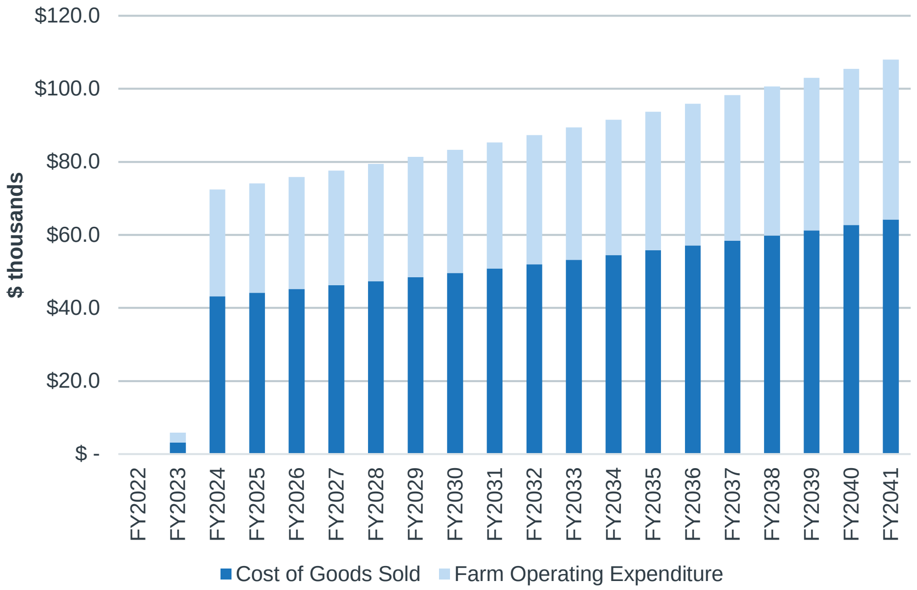
Establishment of the example farm requires significant investment to cover the capital requirements and the operating shortfall. There are number of high-level assumptions which guide the investment sources as a part of this analysis which are detailed in more detail in Appendix E.

4.7.5.2 Mungbean Operating Costs

Farm 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 4.23.

The COGS account for approximately 59.5% of total operating costs, over the 20-year evaluation period. The COGS include costs such as packing, harvesting and materials.

Figure 4.23. Total Operating Costs (FY2022 – FY2041)



Source: AEC.

Operating costs pertaining to wheat production are presented in Appendix E.

4.7.5.3 Farm Revenue

The farm revenue consists of the operating income associated with the sale of both mungbeans and wheat, pursuant to the crop's grade. For the purposes of analysis, it is assumed all wheat and soybean harvested have the following yield and price expectations.

Table 4.8. Price and Yield, by Commodity

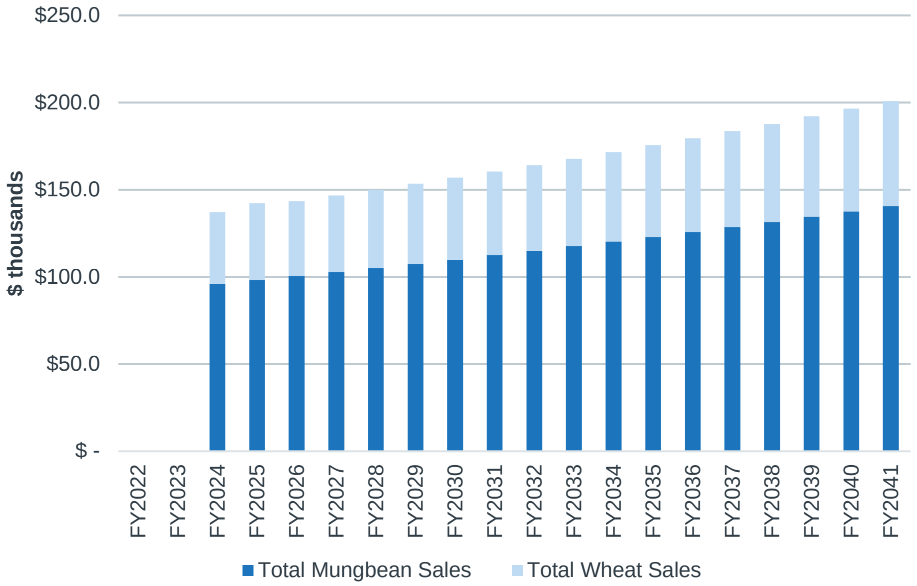
Commodity	Yield	Price
Mungbean Grade One	1.3tonnes/ Ha	$1,316/ tonne
Mungbean Grade Two	0.5tonnes/ Ha	$26/ tonne
Wheat	1.8tonnes/ Ha	$421/ tonne

Source: ABS (2021), ABARES (2022), DAF (2020c&e), NAB (2022).

Prices for both mungbean grade one and wheat are the average of the five-year forecast produced by ABS and ABARES, respectively (refer to section 4.3.4 for more detail on mungbean prices). Mungbean grade two prices have assumed to reflect the price published by DAF (2020c). Consultation with the Australian Mungbean Association indicated the typical mungbean yield in Queensland is often 70% grade one, and 30% grade two, with a total average annual yield of 1.8 tonnes in Central Queensland.

The forecasted revenue for both mungbean and wheat are shown in Figure 4.24. This forecast shows total soybean revenue exceeds total wheat revenue. The soybean revenue over the 20-year evaluation accounts for 70.0% of all farm revenue.

Figure 4.24. 20-year Revenue Forecast (FY2022 – FY2041)



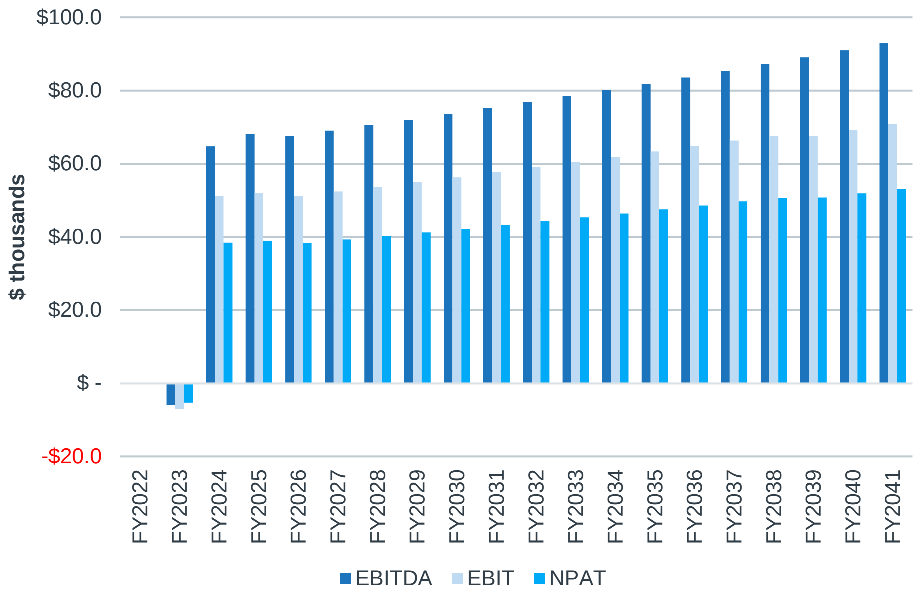
Source: AEC.

4.7.6 Financial Feasibility

The example farm in the Rookwood Weir Catchment Area is expected to return a positive EBITDA across all years in the evaluation. The operating breakeven month for the example farm modelled is December 2023. This shows the price point for both soybean and wheat are sufficient to recover the total COGS.

By FY2041 the NPAT of the farm is estimated to be $53,171 and the EBITDA is estimated to be $92,913. Figure 4.25 shows that the impact of depreciation and tax expenses have a significant impact to the profitability of the farm for the landholder with $39,742 of the total EBITDA required to cover these costs (in FY2041).

Figure 4.25. Farm Operating Profit (FY2022 – FY2041)



Source: AEC.

To understand the value of the farm investment, a DCF has been calculated. 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 Central Queensland between 2014 and 2021, which is 12.5% (HTW, 2021).

With an NPV of the farm at $0 the implied internal rate of return is 12.7%. The terminal value of the example farm growing mungbeans at the conclusion of the analysis (FY2041) is $34.9 million (undiscounted).

The example mungbean farm is estimated to start incurring positive discounted cash flows from FY2037. There are a couple of years of positive discounted cash flows before another anticipated year of negative discounted cash flow due to the required capital replacement.

The internal rate of return is above the growth rate estimated for the region, as such, the example mungbean farm represents a commercially viable investment.

4.7.6.1 Sensitivity Analysis

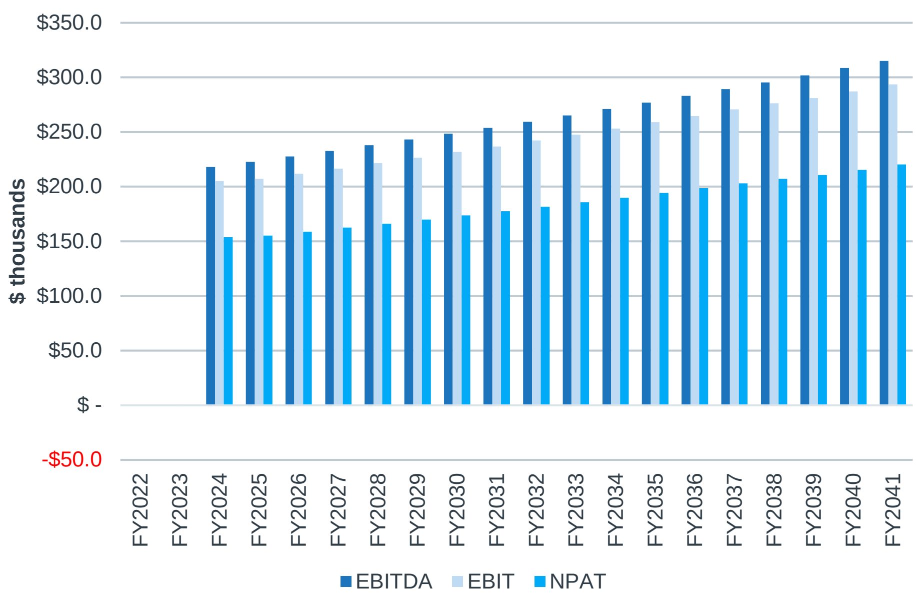
Crop Rotation Sensitivity

Figure 4.26 shows the farm operating profit when mungbean is the only crop farmed in the Rookwood Weir Catchment Area. Removing wheat has a multitude of impacts:

- Lower total water is required on an annual basis. This will enable farms to increase their farmed area as the average farm size is 197ha and under the rotational cropping system, the planted area is 54.5ha. A mungbean only farm will allow the landholder to farm 168ha.
- There is a marginal decrease in capital investment. This decrease relates only to on-farm storage for the mungbeans. Operationally, the impact of this is a slightly adjusted depreciation expense.
- Without a grain (or similar) crop, the farm is likely to experience an increased need for fertiliser to balance the soil nutrients. Similarly, the farm will likely have increased operating expenses associated with encouraging topsoil stability (to reduce the risk of erosion and increase water use efficiency). These costs have not been accounted for in the following profitability assessment.

A mungbean only farm of 168ha, is expected to return an NPAT of $220,275 by FY2041, where the EBITDA in the same year is $315,163.

Figure 4.26. Mungbean Operating Profit (FY2022 – FY2041)



Source: AEC.

Farmland Growth Rate Sensitivity

Historical growth rates are not always reflective of future growth rates. Recent land sales activity is a key driver on recent land value uplift, with the growth rate for rural property estimated to be 12.5% for the Central Queensland region. As land sales and value growth may not continue to grow with equal rates of the historical rates, sensitivity of the growth rate used to determine the terminal value of the example farm has been undertaken.

Rural Bank (2021) published the average Queensland rural land value long term growth rate of 8.8% (calculated over 20 years). Using this conservative growth rate and the IRR of 12.7%, the terminal value of a mungbean farm in the Rookwood Weir Catchment Area is $1.8 million with an investment NPV of negative $3.0 million.

With a growth rate of 8.8% and an NPV of the farm at $0 the implied internal rate of return is 9.2%. The terminal value of the example farm at the conclusion of the analysis (FY2041) is $19.3 million (undiscounted), ultimately showing a commercially feasible investment.

Table 4.9. NPV and Terminal Value, by IRR at 8.8% Growth Rates

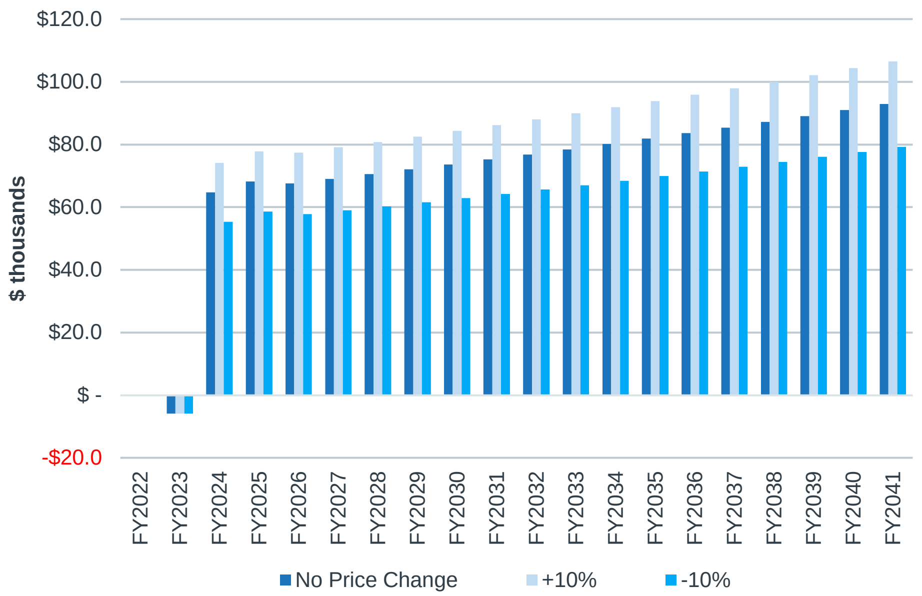
IRR	Net Present Value	Undiscounted Terminal Value
IRR at 12.7%	-$3.0 million	$1.8 million
IRR at 9.2%	$0.0 million	$19.3 million

Source: AEC

Price Sensitivity

To account for external price pressure on future mungbean 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.

Figure 4.27. Price Impact on Profitability (EBITDA) (FY2022 – FY2041)



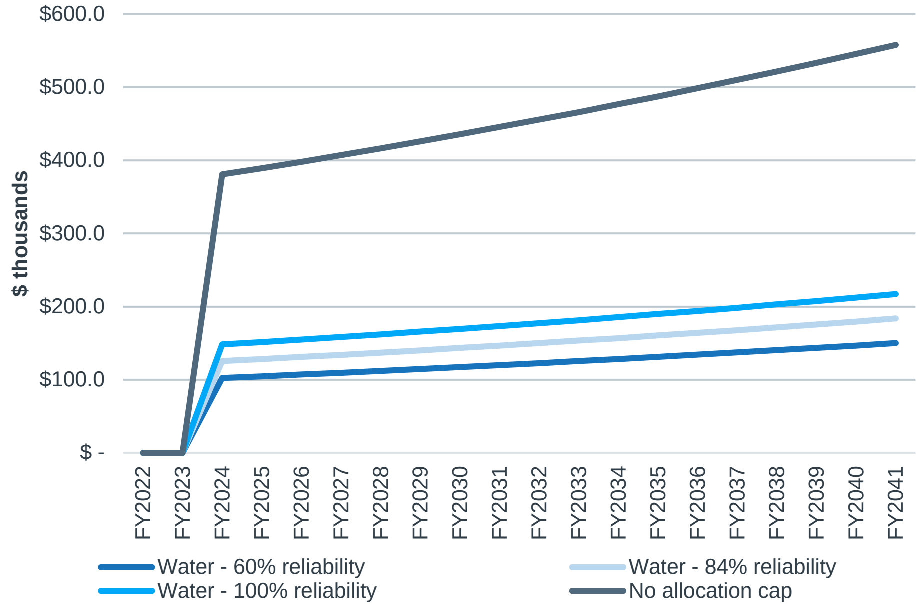
Source: AEC.

Water sensitivity

Water availability has a relatively linear relationship with the profitability of the example farm 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 farm.

The total water required in the no allocation cap is 1,517ML and under this scenario the example farm will have a positive operating surplus ratio. The variance in revenue is presented in the figure below.

Figure 4.28. Water Availability Impact on EBITDA (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 farm establishment timing. In practice, by increasing the available land there may be an increased time required to establish the farm. Under the No allocation cap scenario, the land farmed will increase from 51.9ha to 197ha, a significant increase, just less than four times larger.

4.7.7 Economic Impact

Investment in a farm enterprise will have an economic contribution to the Fitzroy region, and more broadly Central Queensland. The economic contribution of the example farm in the Rookwood Weir Catchment Area is presented in Table 4.10 and has been estimated using IO modelling (for further details, refer to Appendix F).

Initial capital investment of the farm is anticipated to cost approximately $3.6 million, not including the purchase of land and the purchase of water entitlements (both of which are not contributing factors of the economic impact), or the impact of price escalation over time. Capital investment and operation of the farm is anticipated to directly contribute to $2.6 million in industry output (i.e. revenues) to local businesses within the Rockhampton LGA.

A further $1.6 million in industry output is estimated to be supported in the catchment's economy through flow-on activity, including $0.9 million in production induced (i.e. supply chain) activity and $0.7 million through household consumption induced activity (i.e. expenditure of households within the local economy as a result of a lift in household incomes).

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

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

Table 4.10. Economic Activity Supported by a Mungbean Farm Enterprise, Rockhampton LGA

Impact	Output ($M)	Gross Regional Product ($M)	Incomes ($M)	Employment (FTEs)
Direct	$2.6	$1.1	$0.8	10
Production Induced	$0.9	$0.4	$0.3	3
Consumption Induced	$0.7	$0.4	$0.2	3
Total	**$4.2**	**$1.9**	**$1.3**	**16**

Note: Figures may not add due to rounding.
Source: ABS (2012), ABS (2017b), ABS (2021b, c and d), AEC.

5. LUCERNE

5.1 INTRODUCTION

Lucerne, also known as alfalfa throughout North America, is a legume which was introduced to Australia over 200 years ago (AgriFutures, 2017a). Historically, the lucerne industry in Australia has experienced volatility, with spotted alfalfa aphids destroying majority of the lucerne stands in Australia throughout the 1970s (AgriFutures, 2017a). The destruction of crops throughout the 1970s led to breeding new varieties, in which Australia has more than 50 (AgriFutures, 2017a).

Lucerne seed production in Australia is heavily concentrated in the south-east of South Australia (between 90% to 95%) (AgriFutures, 2020). The latest available information for lucerne seed production was from FY2018, highlighting that Australia produced approximately 6,162 tonnes, of which, 79.0% was proprietary varieties (AgriFutures, 2020). On the other hand, lucerne cut for hay was estimated to total 704,257 tonnes in FY2018 (ABS, 2019).

Australia exports the majority of lucerne seed production to international markets, and in 2020, Australia was the fourth largest exporter of lucerne seed on the global market (exporting 10,079 tonnes). Lucerne seed exports from Australia have experienced an average annual growth of 6.9% from 2012 to 2020. There was limited available information surrounding lucerne hay exports from Australia, however, information provided by AFIA (2022) highlighted that Australia exported 12,067 tonnes from September to December 2021. Majority of the lucerne hay exports were destined to ship and aircraft stores, which is used for the purposes of animal feed throughout the transportation of animals to international markets.

Key competitors for lucerne seed exports in 2020 were the USA, Canada and Italy, which together, all three countries represented 45.8% of total global exports. There is no available information for lucerne hay exports by country on the global scale, apart from the USA, which exported 2.9 tonnes of lucerne hay in 2021.

Information regarding lucerne on both the global and domestic scale is very limited and not necessarily complete. This report identifies available information from the United States Department of Agriculture, Com Trade, AgriFutures, the Australian Bureau of Statistics and industry (AFIA). Any information identifiable gaps have been highlighted throughout the report. Readers should be aware that the information contained in this report is most likely incomplete as a result of data limitations identified above.

5.2 OVERVIEW OF THE GLOBAL MARKET

5.2.1 Global Production

The global lucerne market (including hay, silage, grazing, processed and seed) is driven primarily by the dairy industry (AgriFutures, 2017b). The trends which will support the demand for lucerne include (based on the International Farm Comparison Network forecast 2014 to 2024, as highlighted in AgirFutures, 2017b):

- Increases in mill supply and demand
- Increases in dairy cow numbers
- Increase in the average dairy farm and subsequent herd size (combined with the decline in the overall number of dairy farms).

“Lucerne is currently estimated to be grown across about 30 million Ha worldwide, down from about 33 million Ha during the 1970s and 32 million Ha in the 1900s” (AgriFutures, p. 7, 2017b). In the Northern hemisphere, production is largely concentrated in the USA, Canada, Italy, France, China and southern Russia (AgriFutures, 2017b). In the Southern Hemisphere, production of lucerne is concentrated in Argentina, Chile, South Africa, Australia and New Zealand (AgriFutures, 2017b).

5.2.2 Major Producers

The AgriFutures (2017b) report highlights that in 2013, North America was the largest producer of hay and silage on the global scale. The area under production was estimated to total 11.9 million Ha, accounting for approximately 41% of total global production area (AgriFutures, 2017b). The section below analyses the production of lucerne seed and lucerne hay in the USA. Time series production figures for Canada were not publicly available.

Lucerne Seed (USA Production)

"On average, the USA produces approximately 36,300 tonnes of lucerne seed each year" (AgriFutures, p. 27, 2017b). Approximately 85% of total lucerne seed production is grown within five western states of the USA, including California, Oregon, Idaho, Washington and Nevada (AgriFutures, 2017b). The remainder of the lucerne seed is produced in Arizona, Utah, Montana and Wyoming (AgriFutures, 2017b).

The AgriFutures (2017 b) highlights that California is the single largest producer of lucerne seed in the USA, with the area planted for seed averaging 13,564 Ha per year between 2007 to 2015. Most of the production in California was estimated to be situated in the Imperial Valley (68%), which host a similar climate to Australia (AgriFutures, 2017b). The lucerne seed which is grown in the Imperial Valley has been labelled as a key competitor for Australia in export markets as it (AgriFutures, 2017b):

- Produces similar dormancy lucerne
- Has a GM-free status
- Competes directly in countries such as Saudi Arabia and Argentina.

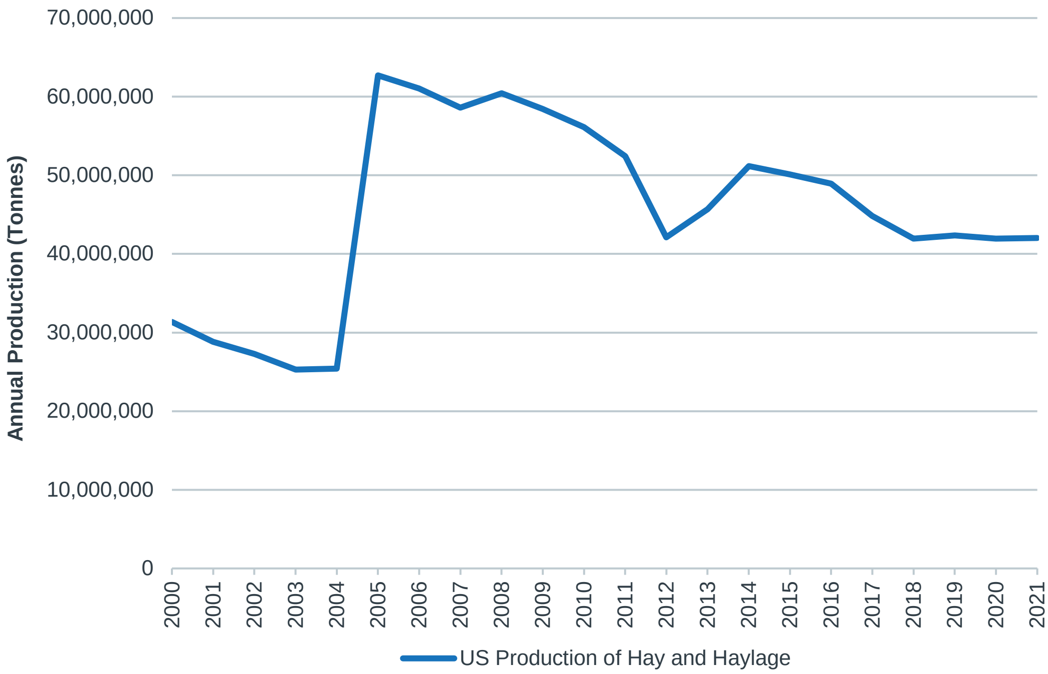
Lucerne Hay (USA Production)

In 2021, it was estimated that the USA produced 42.0 million tonnes of lucerne hay and haylage. The driver of demand for both lucerne hay and seed in the USA has historically been the dairy industry, with between 85% to 90% of all lucerne hay and seed produced in the USA grown for this market (AgriFutures, 2017b).

Lucerne production in the USA is largely concentrated in key dairy producing regions, with states including California, Idaho, Montana, North and South Dakota and Wisconsin (AgriFutures, 2017b). Around 40% of lucerne hay production in the USA is located in the 11 pacific west states of Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington and Wyoming (AgriFutures, 2017b).

The cost of production for lucerne hay has been increasing significantly, nearly doubling from 2001 to reach USD$4,164.4 per Ha in 2013 (AgriFutures, 2017b). The primary factors affecting the prices of production was the rise of casual labour costs and the water charges (AgriFutures, 2017b).

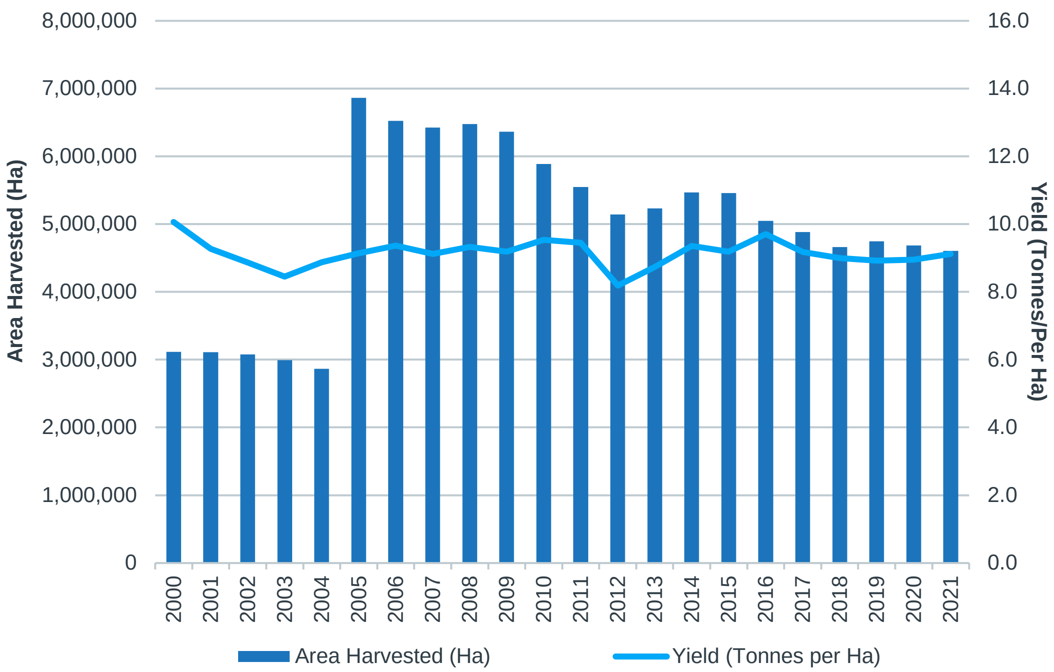
Figure 5.1. USA Production of Lucerne Hay and Haylage, 2000 to 2021



Source: USDA (2021).

Lucerne hay and haylage yield per Ha has remained relatively stable across the 30-year analysis period, reaching an estimated 9.1 tonnes per Ha in 2021.

Figure 5.2. Area Harvested & Yield (Lucerne Hay & Haylage), 2000 to 2021



Source: USDA (2021).

5.2.3 Major Exporters

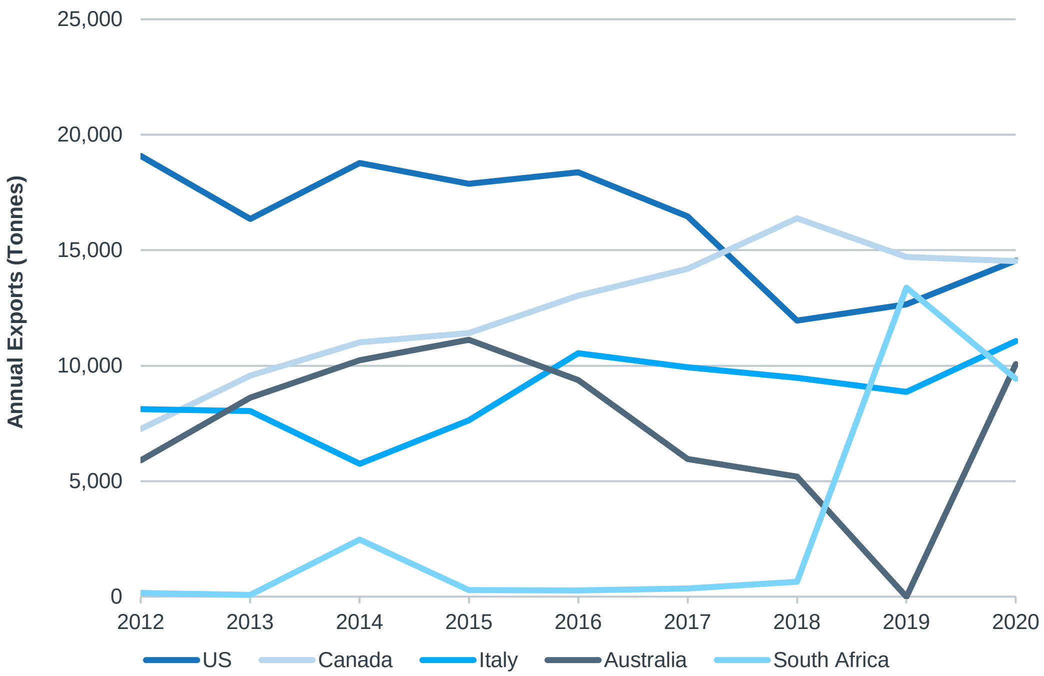
Lucerne Seed

From 2012 to 2020, global exports have experienced an average annual growth rate of 3.9% per annum to reach an estimated 87,738 tonnes in 2020.

The largest global exporter in 2020 was the USA, exporting an estimated 14,550 tonnes which represented 16.6% of total global exports for the year. Exports from the USA have experienced an average annual decline of 3.3% from 2012 to 2020. Exports have been experiencing a decline due to lower domestic production as the focus has shifted towards lower-risk crops such as corn (AgriFutures, undated). In 2020, the USA's largest export market was Mexico, accounting for 36.0% of total exports for the year. This was closely followed by Saudi Arabia, accounting for 24.7% of total USA exports in 2020.

The second largest global exporter in 2020 was Canada, exporting an estimated 14,532 tonnes, representing 16.6% of total global exports for the year. Unlike exports from the USA, exports from Canada have been experiencing an increase since 2012, growing by an average annual rate of 9.1% per annum. In 2020, Canada's largest export market was the USA, accounting for 55.4% of total exports for the year. This was followed by China (19.1%) and the Netherlands (15.2%).

Figure 5.3. Top Five Major Exporters of Lucerne Seed, 2012 to 2020



Notes:

- Excluding re-exports.
- No export data for Australia in 2019.

Source: Com Trade (2022).

USA Lucerne Hay Exports

The USA is the largest exporter of hay on the global scale, dominated by lucerne hay (AFIA, 2021), with exports totalling 2.9 million tonnes in 2021. Lucerne hay exports from the USA have been increasing by 5.6% per annum from 2012 to 2021. To satisfy export and domestic demand, the USA will be dependent on a number of factors including (AgiFutures, 2020):

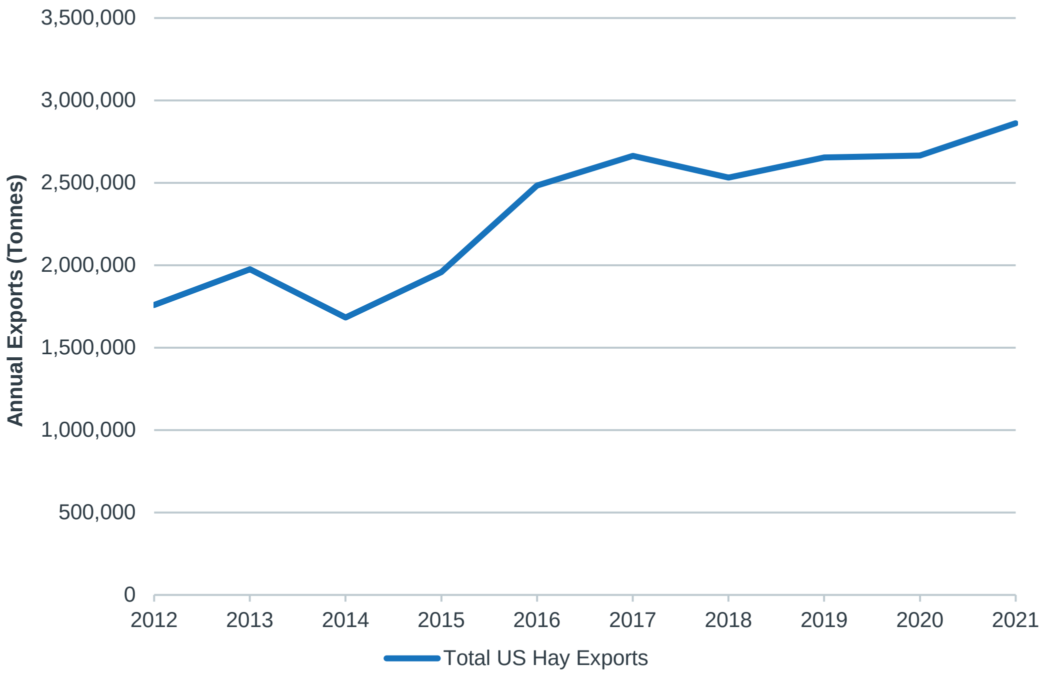
- Reducing the costs of inputs (including labour)
- Increased crop productivity per land unit
- Maintaining a 'GM-free' status

AgriFutures (2020) have highlighted that a key threat to the USA export market for lucerne hay and seed has been the introduction of GM lucerne. The GM lucerne was originally introduced for the use of the domestic hay market, with a number of countries not accepting product which contains GM lucerne. Historically, there have been traces of GM lucerne product found in non-GM lucerne hay exports particularly to China and the Middle East which resulted in trade disruptions (AgriFutures, 2020).

At the time of the AgriFutures report release in 2020, China did "not allow for the importation of GM lucerne, but approvals are in progress" (AgriFutures, p.26, 2020). "Approvals for the importation of GM feed and/or food purposes has been granted by Japan, Canada, Mexico, Korea, Philippines, Australia, and New Zealand" (AgriFutures, p.26, 2020).

In 2021, China was the largest export market for USA lucerne hay with exports totalling 1.6 million tonnes (accounting for 54.5% of total exports) (USDA FAS, 2022). The second largest export market for the USA in 2021 was Japan, accounting for 21.4% of total exports (USDA FAS, 2022).

Figure 5.4. USA Lucerne Hay Exports



Note: The above information only includes alfalfa hay and not alfalfa hay cube.
Source: USDA FAS (2022).

5.2.4 Major Importers

Lucerne Seed

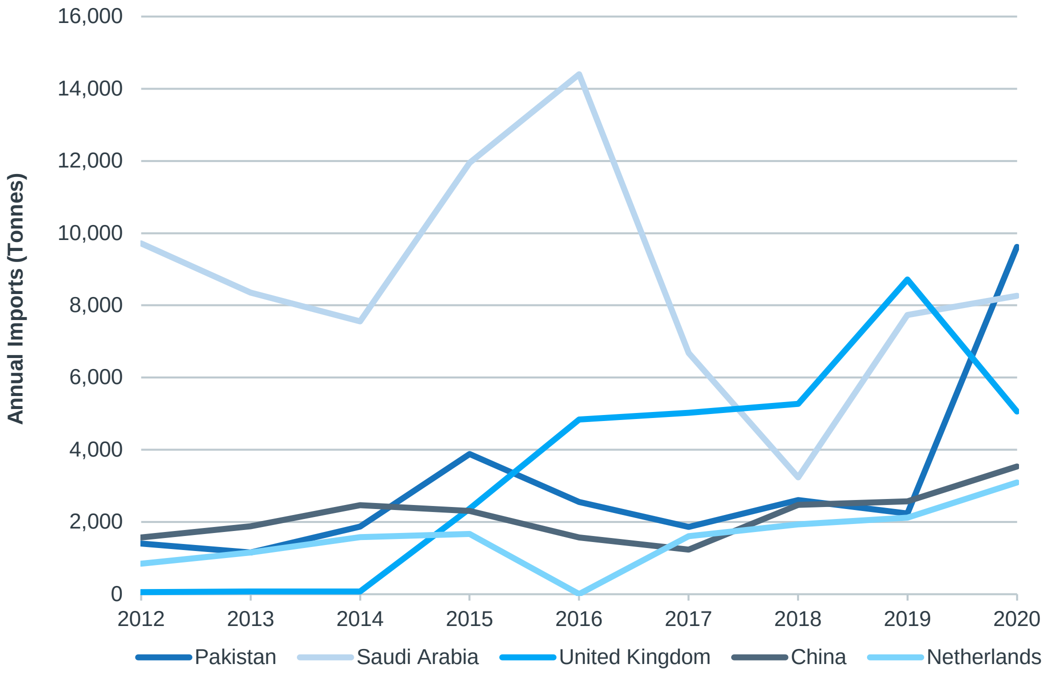
From 2012 to 2020, global imports have experienced an average annual growth rate of 3.3% per annum to reach an estimated 63,373 tonnes in 2020.

The largest global importer of lucerne seed in 2020 was Pakistan, importing 9,617 tonnes. From 2019 to 2020, imports to Pakistan increased significantly which was largely driven by an increase in imports from Afghanistan. In 2020, Pakistan only imported lucerne seeds from four global markets including Afghanistan, Australia, Iran and the USA.

Saudi Arabia was the second largest global importer of lucerne seed in 2020, importing an estimated 8,265 tonnes. From 2012 to 2020, imports of lucerne seed to Saudi Arabia experienced a peak in 2016 totalling 14,398 tonnes. In 2020, the supply of lucerne seed to Saudi Arabia were driven by two key global markets, Australia and the USA. These two countries accounted for 98.1% of total imports to Saudi Arabia in 2020.

The UK was the third largest importer of lucerne seeds in 2020, importing a total of 5,058 tonnes. The UK's largest lucerne seed supplier was France, accounting for 94.7% of total imports in 2020. The second largest supplier was Italy, suppling 2.7 %of total lucerne seed imports to the UK in 2020.

Figure 5.5. Top Five Major Importers of Lucerne Seed, 2012 to 2020



Note: Excluding re-imports.
Source: Com Trade (2022).

Lucerne Hay

No publicly available information was found for the top global producers of lucerne hay.

5.2.5 Global Consumption

No publicly available information was found for the global consumption of both lucerne seed or lucerne hay.

5.2.6 Growth Market for Lucerne

There is not enough publicly available information to draw sufficient conclusions on the key future growth markets for lucerne.

5.3 THE AUSTRALIAN LUCERNE INDUSTRY

5.3.1 Cultivars

There are over 50 commercial varieties of lucerne available on the market, as Table 5.1 shows. As a perennial plant, a major consideration in variety selection is the winter activity rating (WAR), reflecting the rate at which the cultivar will be able to grow in cold temperatures and days of shorter length. It is measured with a rating out of 10, with 1 very dormant and 10 very winter active. It should be noted that all lucerne varieties grow well outside of winter, so a high WAR does not necessarily imply a greater level of growth on an annual basis.

Table 5.1. Australian Lucerne Cultivars

Cultivar	Winter Activity Rating (WAR)
Jindera	1
Prime*	4
54Q53*	4

Cultivar	Winter Activity Rating (WAR)
Pioneer L34HQ	4
WL 342HQ	4
Cimarron	4
WL 342HQMF	4
WL Southern Special	4.6
L55	5
L56	5
Hunter River	5
Venus*	5
SARDI Five*	5
Grasslands Kaituna*	5
Stamina GT6	6
WL 414	6
Aurora	6
Siriver	6
Hunterfield	6
SuperAurora*	6
Trifecta	7
Genesis*	7
UQL-1*	7
Icon	7
Flairdale*	7
SARDI Seven*	7
Q75*	7
Quadrella*	7
Pioneer 57Q75	7
Pioneer L69	8
Eureka*	8
Hallmark*	8
Aquarius*	8
Multi Foli-8	8
WL 525HQ	8
Australis	8
SuperSiriver*	8.5
Pegasis	8.5
Saturn	9
Sequel	9
Sequel HR	9
SuperSequel	9
Sequence	9
SuperSonic*	9
Pioneer L90	9
SuperCuf	9
CUF 101	9
Salado*	9
Sceptre*	9
Blue Ace	9
Cropper 9	9
Sirosal	9
WL 612	9

Cultivar	Winter Activity Rating (WAR)
Silverado*	9
WL 925HQ	9.2
Cropper 9.5	9.5
SARDI Ten*	10
Rippa	10
ML99* Multileaf	10

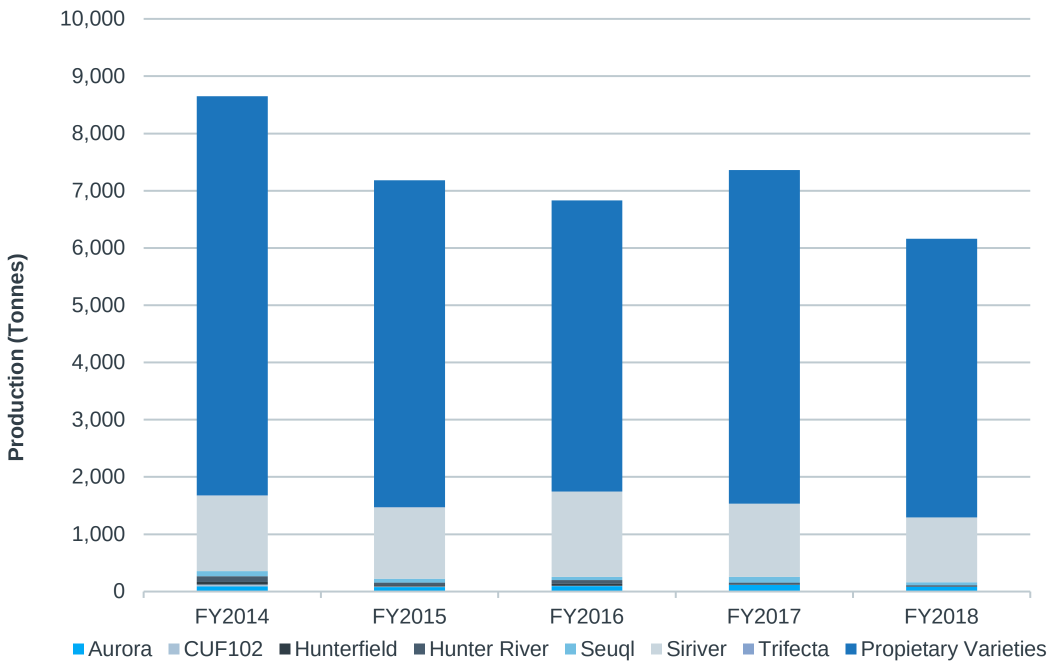
Note: *Protected by Plant Breeder's Rights (PBR).
Source: Pastures Australia (2008).

5.3.2 Australian Lucerne Production

Lucerne Seed

From FY2014 to FY2018, production of lucerne seeds in Australia experienced an average annual decline of 8.1% per annum to reach 6,162 tonnes in FY2018. Of all lucerne seeds produced in the FY2018, approximately 79.0% of the seeds were proprietary varieties. The next most prominent variety of lucerne seed in the FY2018 was Siriver, accounting for 18.4% of total production. Annual production in Australia has been variable due to a range of seasonal factors including dryland production being more opportunistic (AgriFutures, 2020).

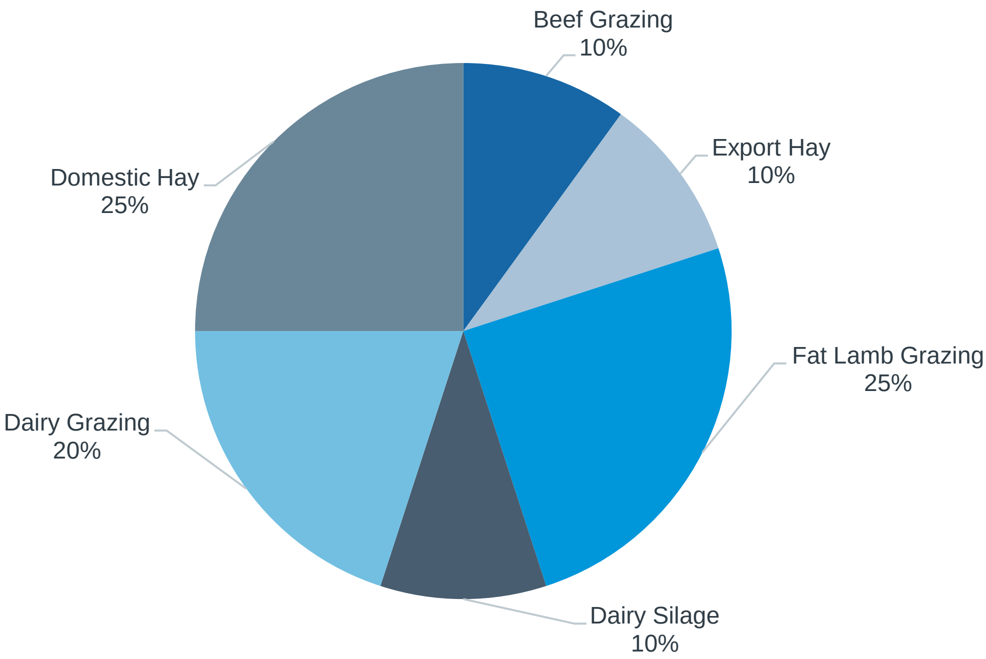
Figure 5.6. Australian Total Production of Lucerne Seed by Variety, FY2014 – FY2018



Source: AgriFutures (2020).

In 2016, it was estimated that 25% of Australia's lucerne seed production was used for domestic hay production and around 25% was used for lamb fattening pastures. Dairy grazing accounted for approximately 20% of total Australian lucerne seed use.

Figure 5.7. Australian Lucerne Seed Markets, 2016



Source: AgriFutures (2017b).

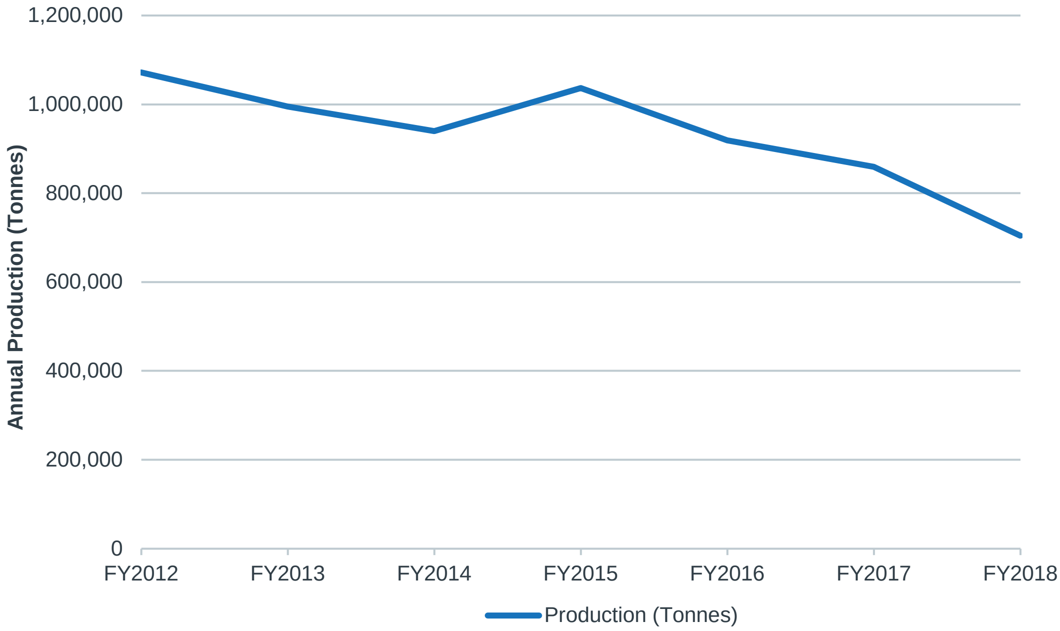
The AgriFutures (2017b) report highlights how Australian lucerne seed producers could improve management practices, including:

- Pollination management – number of hives per Ha
- Pre-harvest management – lock up paddocks earlier to maximise seed yield
- Harvest timing – need to lower seed moisture content (i.e., harden off)
- Harvest management – need to reduce screenings/abnormals by reducing drum seed (i.e., lower mechanical damage)
- Seed cleaning – be more attentive to quality assurance; particularly the need to reduce screenings in the final export product
- Length of crop rotation – needs to be shortened (from 6-7 years to 3-4 years) due to genetic drift.

Lucerne Hay

From FY2012 to FY2018, the production of lucerne cut for hay experienced an average annual decline of 6.8% per annum. Over the analysis period, production peaked at 1.1 million tonnes in FY2012, declining to an estimated 704,257 tonnes in FY2018. There are a number of factors which may have impacted lucerne hay production over the years, including the significant La Nina event which occurred throughout 2010 to 2012 and the decline in cattle herd (both meat and dairy) over FY2016 (2.4 million head decline) and FY2020 (2.9 million head decline).

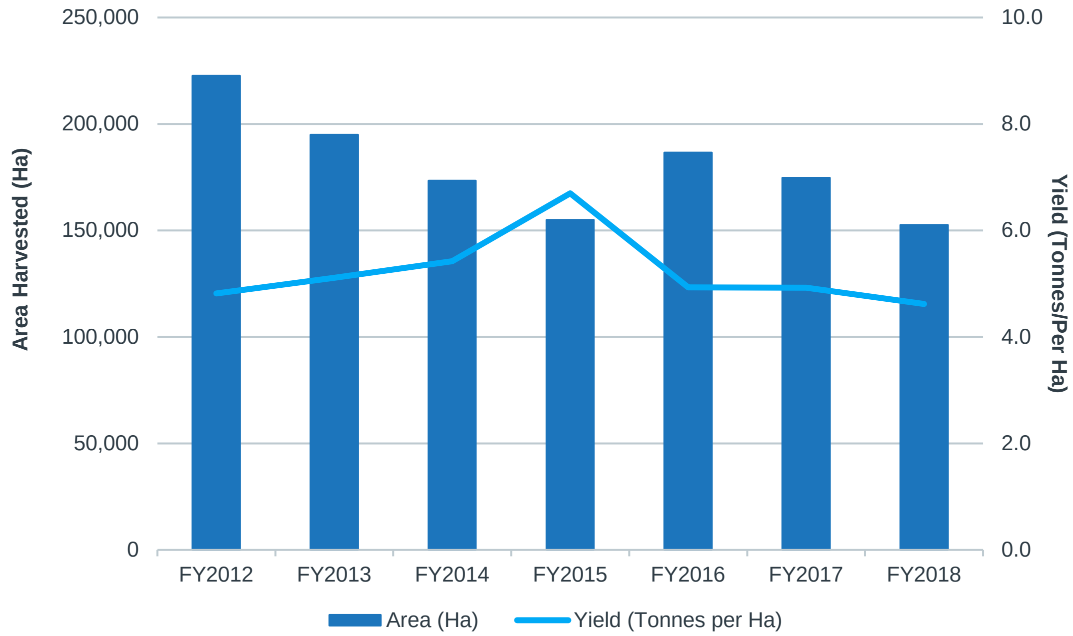
Figure 5.8. Australia Production of Lucerne Cut for Hay, FY2012 to FY2018



Note: ABS data in FY2019 and FY2020 is grouped and defined as "hay and silage – pasture (including lucerne), cereal and other crops cut for hay". The above figures only reflect the ABS data provided for lucerne cut for hay.
Source: ABS (2014, 2015, 2016, 2017, 2018, 2019).

The area under lucerne cut for hay has declined from 222,598ha in FY2012 to an estimated 152,466ha in FY2018. In FY2018, it was estimated that yields totalled 4.6 tonnes per Ha.

Figure 5.9. Area Harvested & Yield (Lucerne Cut for Hay), FY2012 to FY2018



Note: ABS data in FY2019 and FY2020 is grouped and defined as "hay and silage – pasture (including lucerne), cereal and other crops cut for hay". The above figures only reflect the ABS data provided for lucerne cut for hay.
Source: ABS (2014, 2015, 2016, 2017, 2018, 2019).

Key Growing Areas

Lucerne is suited to both dryland and irrigated farmland systems. Given its ability to grow in a range of climactic conditions from tropical to temperate, lucerne pasture is grown in all states and territories of Australia, with the majority used for grazing purposes. Lucerne production for the purposes of fodder is primarily grown in New South Wales (40%), followed by Victoria (25%) and Queensland (16%) (AgriFutures, 2017).

Lucerne seed production on the other hand is heavily concentrated in the south-east of South Australia (between 90% to 95%) (AgriFutures, 2020). Small areas of production also occur in irrigated regions of New South Wales and Victoria around the Lachlan Valley and Murray River, as well as in parts of southern Western Australia (RIRDC, 2008).

Table 5.2. Lucerne Seed Growing Regions

State	Town/Region	System
South Australia	• Keith • Naracoorte • Tintinara • Bordertown	Irrigated & Dryland
New South Wales	• Forbes • Wagga Wagga • Cootamundra	Irrigated
Victoria	• Dookie	Irrigated
Western Australia	• Merredin • Esperance	Dryland

Source: RIRDC (2008).

Production and Seasonality

Lucerne is generally sown in mild conditions as this favours its germination, establishment and growth. Sowing most commonly occurs in early autumn during March and April. All varieties can also be planted in early spring, and is often implemented in areas where winter temperatures are colder so as to avoid the harsh cold conditions. However, a spring sowing window usually requires sufficient rainfall/irrigation to be available in the early stages of growth. Winter sowing, while generally not recommended, is plausible with non-dormant varieties in regions with less harsh winter temperatures and minimal frost.

Table 5.3. Lucerne Sowing Windows and their Associated Optimal Conditions

Sowing Window	Months	Usual Rainfall Requirement (at sowing)	Winter Temperatures for the Sowing Window
Early autumn	March to April	Low	Sown where winters are mild
Early spring	Late August to mid-September	High	Sown where winters are mild or cold
Winter	Mid-June to early July	Low to Medium	Sown where winters are mild

Source: AgriFutures (2008).

Whilst some variation exists depending on growing region and sowing time, the haymaking and silage making season generally occurs between October and April. Lucerne seed is most commonly harvested from March to April, with flowering in January and seed set in February (AgriFutures, 2017b).

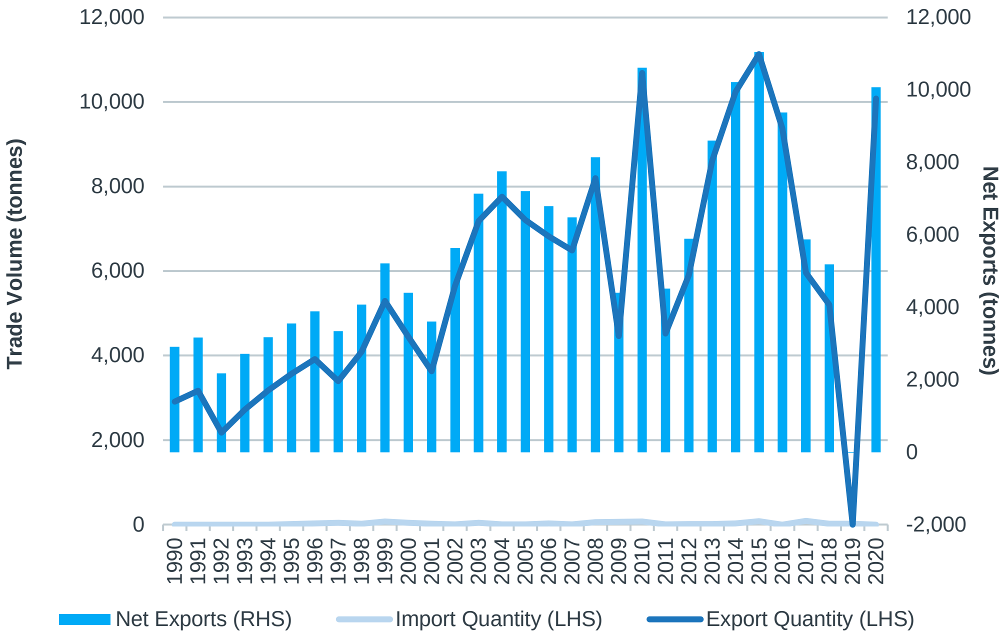
5.3.3 Australia's Trade Balance

Lucerne Seed

Historically, Australia has been a net exporter of lucerne seeds. Exports have grown by 6.2% on average per annum from 1990 to 2020, reaching an estimated 10,079 tonnes.

Over the entire 30-year analysis period, it is reported that the year with the highest import volume of lucerne seed was 2017 when imports totalled 87 tonnes.

Figure 5.10. Australia's Lucerne Seed Trade Balance, 1990 to 2020



Note: Of note, export information in 2019 has been recorded as zero, however, compared to historical exports it is unlikely that this is the case and that no information was available.
Source: Com Trade (2022).

Lucerne Hay

From September 2021 to December 2021, it was estimated that Australia exported 12,067 tonnes of lucerne hay and chaff. The vast majority (91.4%) of the lucerne was directed to ship and aircraft stores, serving the purpose of feeding livestock on transportation to international markets.

Table 5.4. Australian Lucerne Hay Exports (September 2021 to December 2021)

Country	Tonnes (2021)	Proportion (2021)
Ship & Aircraft Stores	11,028	91.4%
Indonesia	366	3.0%
Japan	248	2.1%
Philippines	173	1.4%
Hong Kong	76	0.6%
Thailand	64	0.5%
Malaysia	62	0.5%
United Arab Emirates	18	0.2%
Brunei Darussalam	12	0.1%
Singapore	11	0.1%
New Caledonia	9	0.1%
Qatar	0	0.0%
Total	**12,067**	**100%**

Note: The data is reflective of information provided from September 2021 to December 2021.
Source: AFIA (2022).

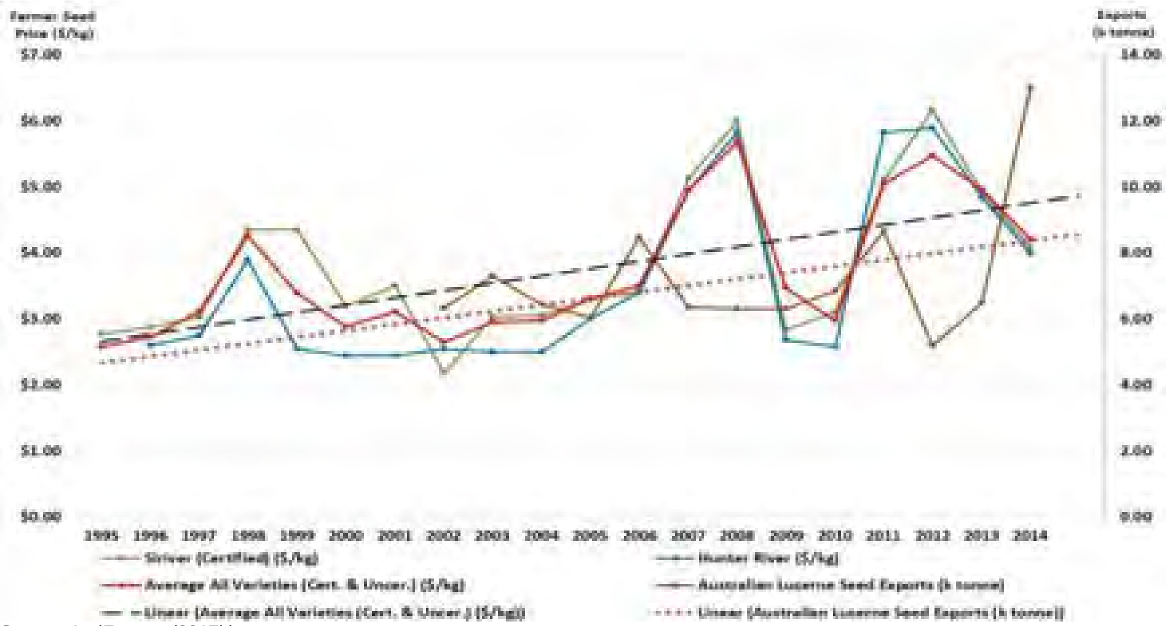
5.3.4 Lucerne Prices in Australia

Lucerne Seed

The value of contract lucerne seed (certified and uncertified) was estimated to grow from $2.58 per kg in 1995 to approximately $5.0 per kg in 2015. From 1995 to 2004, the average contract prices for USA producers have been higher than Siriver and Hunter River varieties. On average, CUF101 (USA producers) received $5.14 per kg contract production price, while Siriver received $3.23 per kg and Hunter River received $2.43 per kg (AgriFutures, 2017b).

More recent pricing information for lucerne seed was not publicly available.

Figure 5.11. Average Lucerne Contract Seed Prices and Exports of Australian Lucerne Seed



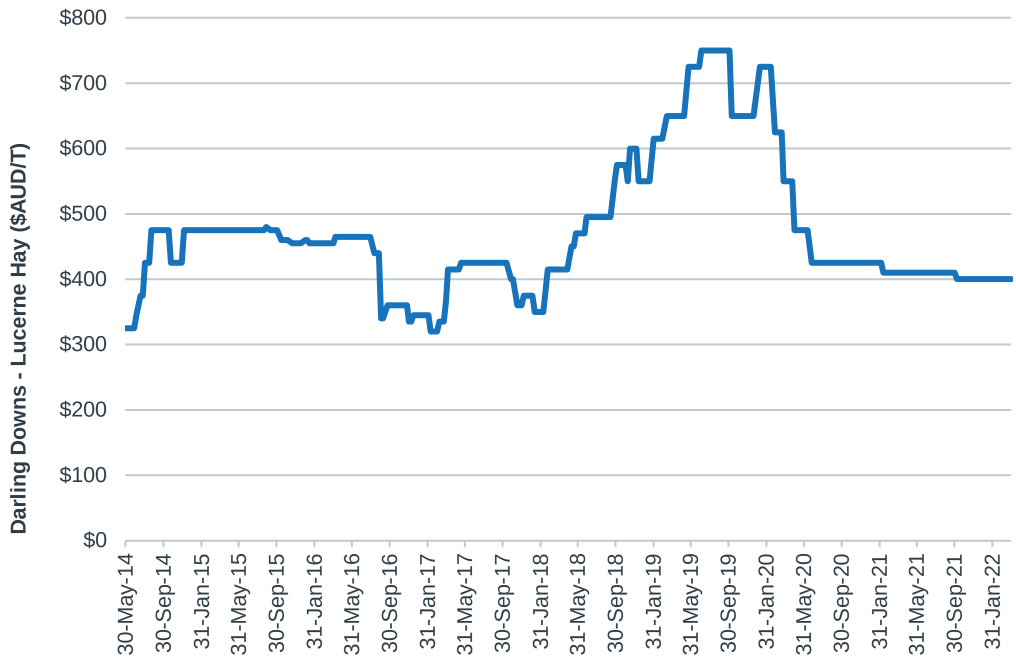
Source: AgriFutures (2017b).

Lucerne Hay

Dairy Australia report hay prices for 12 dairy regions across Australia, including the Atherton Tablelands which is the most comparable region for hay prices in Central Queensland. Atherton Tableland prices are only available for pasture hay and not lucerne hay. For the purposes of this report, the next best region for lucerne hay pricing is the Darling Downs, which is reported in the figure below.

From the beginning of October 2021 to the beginning of April 2022, lucerne hay prices in the Darling Downs was estimated to total $400 per tonne. Prices experienced a peak from the beginning of July 2019 to the beginning of October 2019, reaching an estimated $750 per tonne. Hay prices experienced a spike from 2018 due to the extended drought along the east coast of Australia (GRDC, 2019).

Figure 5.12. Darling Downs Lucerne Hay Prices ($AUD/ Tonne)



Notes:

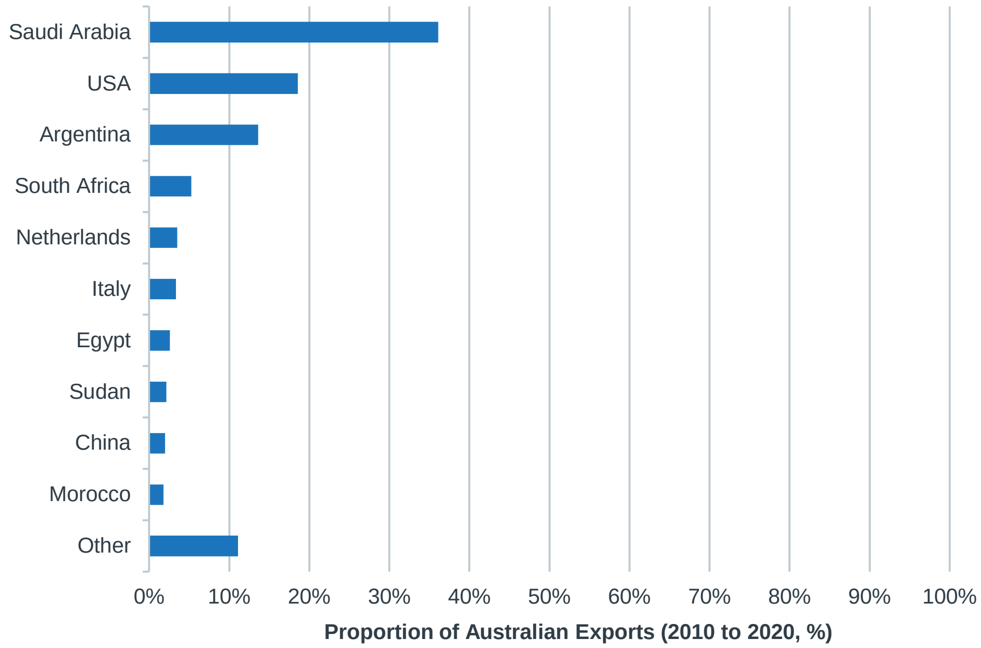
- Only 40 reports are released each year, therefore information is not reported consistently every week.
- Prices are inclusive of delivery.

Source: Dairy Australia (2022).

5.3.5 Australia's Key Markets for Lucerne Seed

From 2010 to 2020, Saudi Arabia accounted for 36.1% of Australia's total lucerne seed exports. The USA was Australia's second largest export market for lucerne seeds, accounting for an average of 18.6% of exports from 2010 to 2020.

Figure 5.13. Key Export Markets for Australian Lucerne Seed (Top 10)

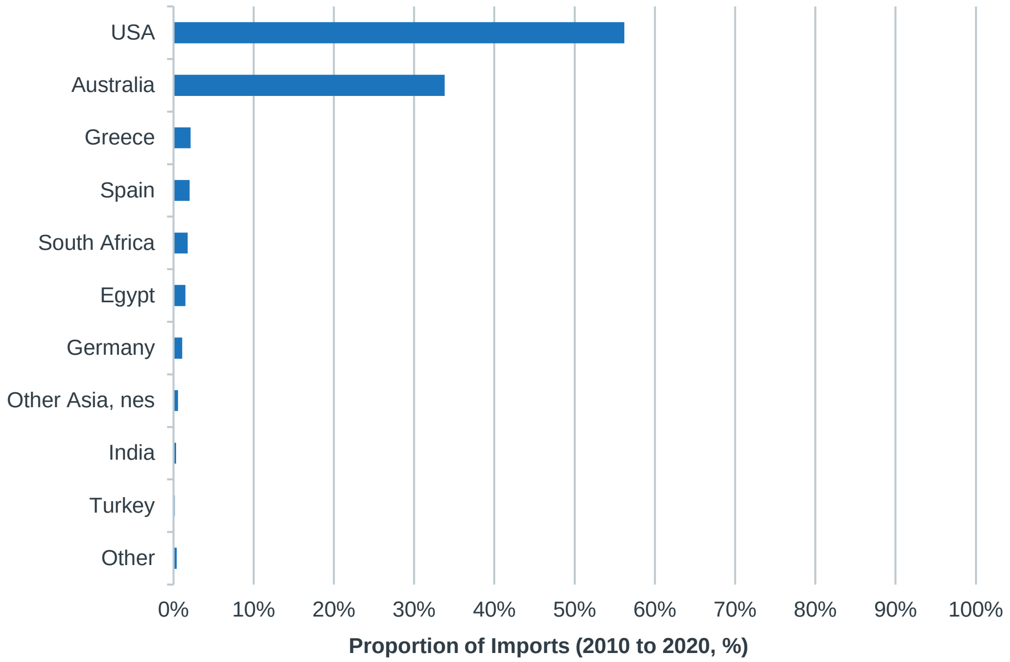


Source: Com Trade (2022).

Saudi Arabia

The largest source of lucerne seeds in Saudi Arabia was from the USA, accounting for 56.2% of total imports on average from 2010 to 2020. The second largest source of lucerne seeds in Saudi Arabia was from Australia, accounting for 33.8% of total imports on average from 2010 to 2020.

Figure 5.14. Lucerne Seed Imports to Saudi Arabia, 2010 to 2020

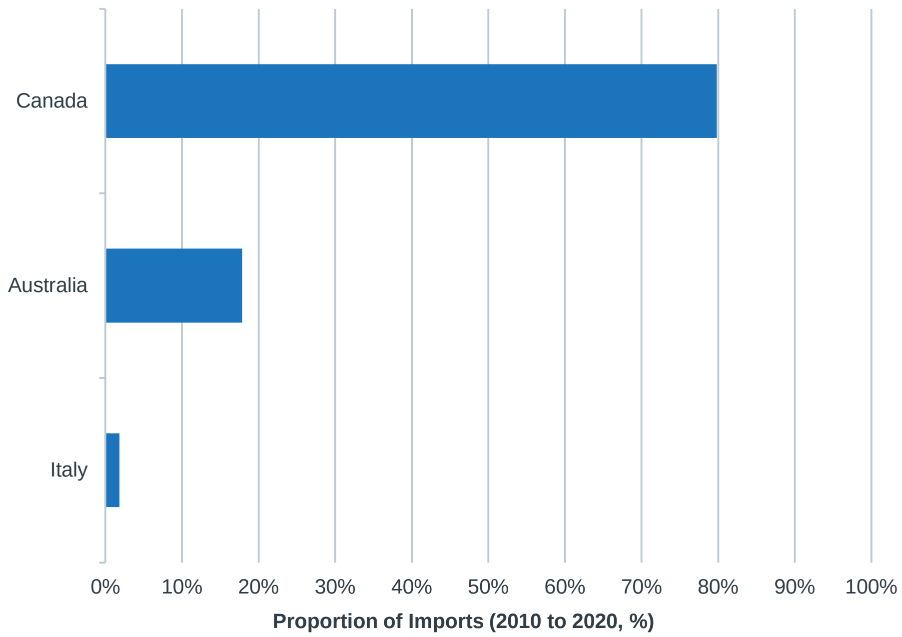


Source: Com Trade (2022).

USA

From 2010 to 2020, the USA sourced majority of its lucerne seeds from Canada, accounting for 79.8% of total imports on average from 2010 to 2020. The second largest source of lucerne seeds in the USA was from Australia, accounting for 17.8% of total imports on average from 2010 to 2020.

Figure 5.15. Lucerne Seed Imports to the USA, 2010 to 2020

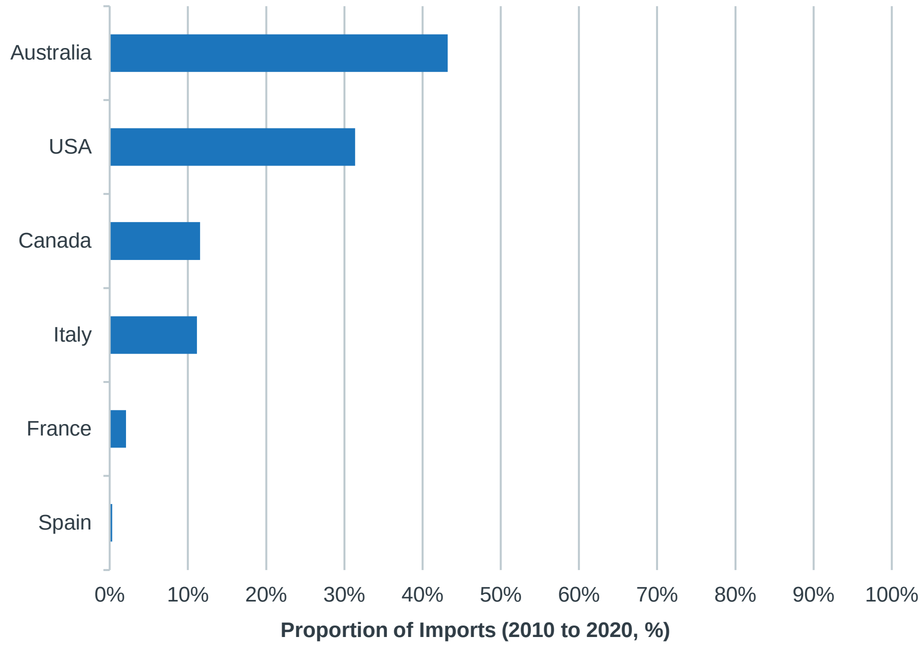


Source: Com Trade (2022).

Argentina

The largest source of lucerne seeds in Argentina was from Australia, accounting for 43.2% of total imports on average from 2010 to 2020. The second largest source of lucerne seeds in Argentina was from the USA, accounting for 31.4% of total imports on average from 2010 to 2020.

Figure 5.16. Lucerne Seed Imports to Argentina, 2010 to 2020

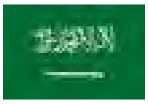


Source: Com Trade (2022).

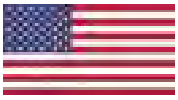
5.4 MARKET VIABILITY ANALYSIS FOR LUCERNE SEED

The commodity outlook identified three key priority markets that are Australia's largest lucerne export markets. The three key markets that were identified in the commodity outlook are listed below:

Saudi Arabia



United States



Argentina

The market viability analysis provides a snapshot of each key market that has been identified for lucerne. This snapshot includes:

- Market depth and maturity
- Market access considerations (access to Free Trade Agreements)
- Economic strength, market growth and consumer capacity to pay
- Political stability and financial risk.

Saudi Arabia

Lucerne production in Saudi Arabia has declined substantially within the last ten years, with the Saudi Arabian government enacting a three year program in 2016 to conserve water resources by greatly reducing its domestic production of lucerne and other commodities (PR Newswire, 2018). Continual depletion of aquifers in the Arabian Peninsula has posed many challenges for domestic production, and as such, the majority of the country's lucerne is sourced internationally. Lucerne is a key commodity for dairy and livestock production in Saudi Arabia. Saudi Almarai Dairy is one of the largest dairy factories in the world (PR Newswire, 2018), thus requiring considerable amounts of fodder.

Population 2021: 35.3 million 2050: 50.2 million	GDP 2020: $19,996 per capita (USD) 2026: $25,699 per capita (USD)
From 2010 to 2020, 90% of Saudi Arabian lucerne seed demand originated from Australia and the USA.	Second largest lucerne seed importer in 2020, importing 8,265 tonnes.

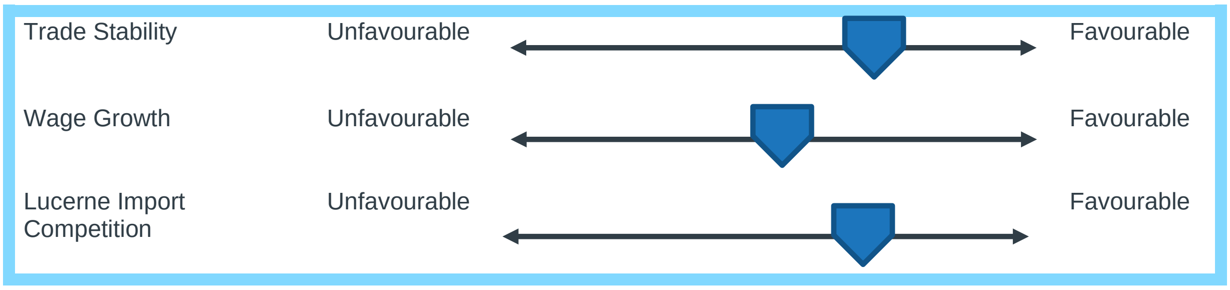
Note: Population forecasts have been estimated based on population projections by OECD.
Source: IMF (2022), OECD (2022), Com Trade (2022).

Market Access Consideration

- Australia currently has no Free Trade Agreements (FTAs) with Saudi Arabia.
  - The Gulf Cooperation Council (GCC), of which Saudi Arabia is a member, renewed its interest in pursuing an FTA with Australia at the GCC Leader's Summit in January 2021. Discussions are ongoing between the two parties at a ministerial level on a potential resumption of negotiations, with the last round of negotiations not having occurred since June 2009 (DFAT, 2022).
- The only other major market that supplies Saudi Arabia with the majority of their lucerne seeds is the USA. The USA also does not currently have an FTA in place with Saudi Arabia.
  - In 2003, the USA signed a Trade and Investment Framework Agreement (TIFA) with Saudi Arabia, effectively facilitating ongoing structured dialogue between the two nations on economic reform and trade liberalisation. The last TIFA meeting was held in May 2018 (ITA, 2022 a).
- The majority of food and agricultural products in Saudi Arabia are subject to a 10 to 15% import duty. Imports of lucerne are subsidised (ITA, 2022 b).

Australian Lucerne in Saudi Arabia

Saudi Arabia is Australia's largest export market for lucerne seed, accounting for 36.1% of all exports[8]. On a similar note, Saudi Arabia is fairly reliant on Australian lucerne, with 33.8% of its overall import demand derived from Australian production[1]. Hence, comparable trading dependencies between the two countries promotes a level of robustness in lucerne trade in the short to medium term. While competition exists with the USA, demand is likely to remain high with a heavy shortage of domestic production.

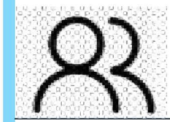


[8] On average from 2010 to 2020.

United States of America

The USA is a strong global producer of lucerne fodder crops, in particular hay and haylage. A large contributor to this is the dairy industry, with production generally occurring in key dairy-producing regions for feeding livestock (AgriFutures, 2017b). The USA have an abundance of land area for production, with land area harvested remaining relatively constant in recent years.

With yields declining slightly on average over the last 15 years, the country has also obtained imports to satisfy any further local demand. The vast majority of these imports are sourced from nearby Canada.

 Population 2021: 335.0 million 2050: 404.7 million	GDP 2020: $63,358 per capita (USD) 2026: $86,429 per capita (USD)
Largest global exporter of lucerne seed in 2020, despite declining figures on average over the last ten years.	All imports of lucerne seed are sourced from only three countries.

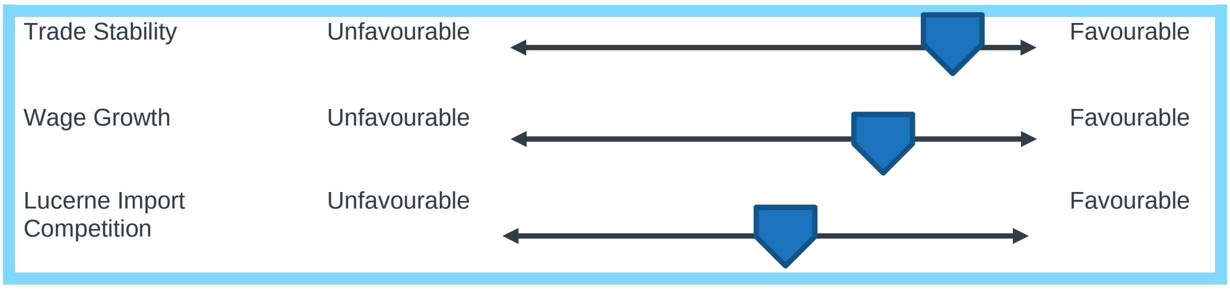
Note: Population forecasts have been estimated based on population projections by OECD.
Source: IMF (2022), OECD (2022), Com Trade (2022).

Market Access Consideration

- A free trade agreement between Australia and the USA (AUSFTA) has been in force since 1 January 2005. All Australian exports of lucerne to the United States are tariff-free. Under the FTA, approximately 96% of all Australian exports to the United States do not currently contain tariffs (DFAT, 2021), underlining the stability in trade between the two countries.
- The only other major market that supplies the USA with the majority of their lucerne seeds is Canada. Both nations are parties to the USA-Mexico-Canada Agreement (USMCA), which entered into force on July 1, 2020, and was a replacement of the North American Free Trade Agreement (NAFTA). Canadian exports of lucerne to the USA are also tariff-free (ITA, 2022).

Australian Lucerne in the USA

Australia is a moderate contributor to lucerne demand in the USA, accounting for around 17.8% of total imports[1]. It is one of only three markets to supply lucerne to the country, indicating low competition within the market and a USA preference for high-quality product. While trade relations between the USA and Australia are very stable with the presence of FTAs and a history of good relations, Canada also possesses this competitive advantage and thus remains a key threat to competition, currently holding an 80% share of the USA market[1].



Argentina

Argentina grows the second largest harvest area of lucerne in the world (Jauregui et al., 2022). A significant gap exists between potential and actual yields, meaning, in terms of final production levels, it does not rank amongst the top producers globally. While factors contributing to low yields are unclear, primary deductions are most likely linked to nutrient deficits and low grazing efficiency (Jauregui et al., 2022).

Lucerne is vital to Argentina's agricultural output, with pastures acting as the basis for over 50% of the country's meat production (Hiba, 2021). Demand is quite robust for animal feed and fodder product as the country is a prominent producer of livestock, particularly cattle and sheep.

Population 2021: 45.6 million 2050: 57.8 million	GDP 2020: $8,572 per capita (USD) 2026: $11,130 per capita (USD)
From 2010 to 2020, 75% of Argentinian lucerne seed demand originated from Australia and the USA.	Argentina's four key sources of lucerne seed imports came from the top four global exporters of lucerne[1].

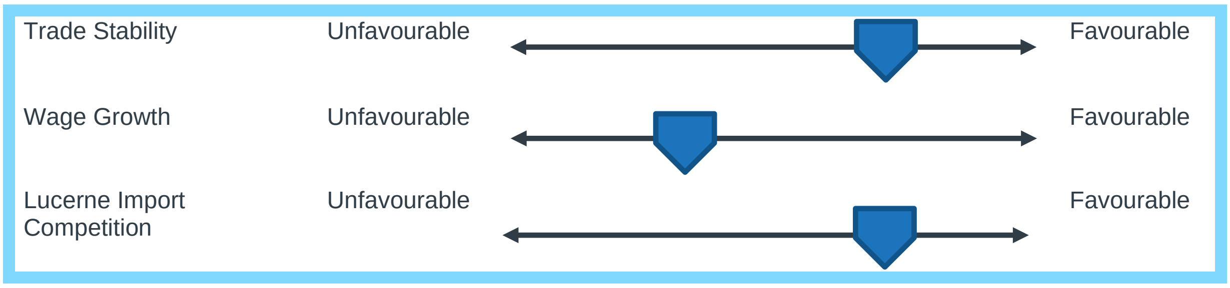
Note: Population forecasts have been estimated based on population projections by OECD.
Source: IMF (2022), OECD (2022), Com Trade (2022).

Market Access Consideration

- Australia currently has no FTAs with Argentina. As a member of Mercosur, Argentina applies the common external tariff (CET), which is between 0 and 20% for most products (ATIC, undated).
- The other major market that supplies Argentina with the majority of their lucerne seeds is the USA. Despite a TIFA signed by the two nations in 2016, the USA is subject to the same tariffs as Australia (ITA, 2020).
- Other markets that supply smaller amounts of lucerne seeds to Argentina are Canada, Italy, and France and Spain to a lesser extent. Canada also faces the same tariff requirements as Australia and the USA, however, a comprehensive trade agreement between Mercosur and the European Union which entered into force in June 2019 provides Italy, France and Spain with a competitive advantage (ITA, 2020).

Australian Lucerne in Argentina

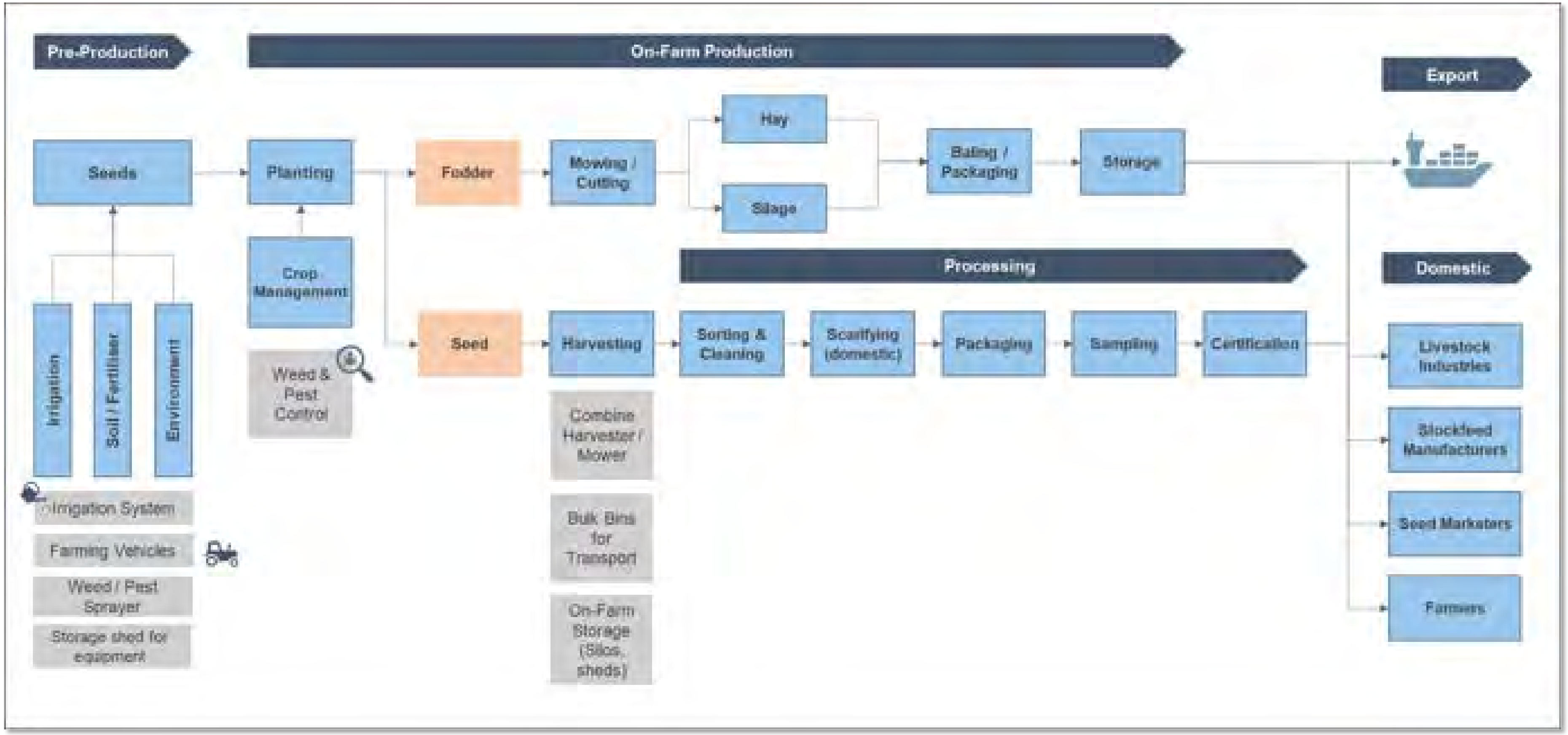
Australian lucerne seed is the largest source of Argentinian imports, accounting for 43.2% of total demand[1]. A reliance on lucerne seed from Australia, the USA and Canada means an erosion of market share is unlikely for Australia in the short-term given the North American markets face the same tariff limitations. Recent establishment of free trade between South American and European trading blocs presents new opportunities for Argentina to capture supply elsewhere.



5.5 LUCERNE SUPPLY CHAIN ANALYSIS

The figure below introduces a high-level supply chain analysis to investigate the activities and processes involved in producing lucerne within the Central Queensland region. To understand this process to identify potential industry constraints or opportunities for the region at each point of the supply chain.

Figure 5.17. Lucerne 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

In general, lucerne can be grown for three uses, including:

- Pasture in a cropping rotation to improve soil condition, and provide valuable forage for livestock.
- Fodder in the form of hay, silage, chaff or pellets, mostly sold for use in livestock industries.
- Seed for domestic and international markets, mostly under contract and/or public sale.

Equipment and infrastructure required for crop establishment for a lucerne stand include (AgriFutures, 2017a):

- Cultivation equipment for seedbed preparation,
- Seeding equipment (combine or direct seeder) with the capacity to sow small seeds.

Ongoing management of lucerne requires:

- Fertiliser spreader
- Spray equipment for application of herbicides and pesticides.
- Irrigation infrastructure.
- Standard farm equipment sch as a tractor, ute and/or truck.

Additional machinery may be required depending on the end product of lucerne, as outlined in Table 5.5.

Table 5.5. Machinery and Equipment for Lucerne Production

Production	Machinery and Equipment
Hay Production	• Mower to cut lucerne • Conditioner to bend the stems to speed the rate of drying • Hay rake to aid final drying and form windrows • Baler to process the lucerne into bales of the required size • Elevator and truck to lift bales • Lifting capacity (tractor with forks or specialised lifter) • Shed/s for the storage of hay.
Silage Production	• Mower to cut the lucerne • Conditioner to aid the wilting process • For bulk (pit or bunker) silage: o Earthmoving equipment (potentially hired) to dig the pit o Forage harvester or wagon (self-propelled or trailed) to collect the forage from the field and chop the plant material into small pieces o Pick-up wagon, if using a harvester, to transfer fresh silage back to the pit • For baled silage o Baler with a chopper o Wrapping machine lifters to transfer bales from field to truck to storage.
Seed Production	• Mower and rake, or windrower if the lucerne is to be swathed before harvest • Harvester – the conventional type used for other grains • Chaser bins and field bins to aggregate seed • Auger to transfer seed • Truck to transport seed to storage and cleaning facilities (generally off-farm).

Source: AgriFutures (2017 a).

Some growers may use contractors for some or all of the steps of the hay or silage making, however the ability to carry out each step at the correct time is critical for the production of quality hay and silage. Substantial production enterprises will own their equipment to maintain full flexibility with timing of operations.

On-Farm Production

Pasture

The "harvest" for lucerne pasture is grazing by livestock. A lucerne stand should not be grazed until full flowering in its first year of establishment as this will allow for energy reserves of the roots to be replenished, thus allowing the plant to withstand more intensive grazing in future seasons. It is ideally suited to rotational grazing, where the paddock is divided into grazing units and livestock are rotated through the different units and/or other pasture types that may be available (AgriFutures, 2017a). If carefully managed, lucerne crops can last several seasons for grazing purposes.

Fodder

Lucerne Hay

Lucerne is cut for hay when around 10% of the stems have open flowers. The earlier the cut, the higher the quality of fodder but the lower the yield. Harvest of lucerne hay involves mowing, curing, conditioning, raking (and sometimes windrowing) and baling. Hay bales can be packed in several shapes and sizes, depending on the end use, including small square, large square, round etc. Small rectangular bales have been the most popular package for hay, and remain so for the horse trade in particular, but large round and square bales have increased rapidly in popularity (AgriFutures, 2003).

Hay moisture should always be monitored throughout the process to ensure a high-quality product that stores well and is not susceptible to mould or heating. Lucerne hay can be stored in facilities which are either purpose-built, fully enclosed sheds with waterproof flooring, or also can be stored in less permanent structures such as polypropylene igloos or temporary in-field storage under tarpaulins. (AgriFutures, 2017a).

Lucerne silage

Lucerne silage is produced when an anaerobic bacterial fermentation uses plant sugars to produce lactic acid, which preserves the forage (AgriFutures, 2003). The harvest or silage includes mowing, wilting (possibly conditioning), windrowing, and harvesting.

Lucerne is cut for silage between the stages of full bud and the commencement of flowering. Likewise with hay, a trade-off exists between fodder quality and yield depending on the timing of the cut. After harvest, lucerne silage is baled and packed or wrapped in plastic for fermentation, as individual bales or transferred to earthen pits for fermentation. Chopped pasture must be stored in airtight conditions to maintain quality. Individual bales can be stored for around a year, while pit silage often lasts around three to five years (AgriFutures, 2017a).

Seed

Cross pollination is essential to ensure yields of lucerne seed are maximized, with honeybees being the most common pollinator of lucerne. Seed growers may engage the services of beekeepers to install beehives near lucerne crops.

Lucerne seed is mature five to six weeks after pollination and can be harvested approximately six weeks after the crop has finished flowering. To facilitate the ripening of seed, the crop will usually be either swathed or desiccated in preparation. The crop is harvested with a combine harvester before sent to processing facilities for cleaning and storage.

Post-Harvesting Processing

Seed

Seed harvests are generally transported from the farm to cleaning and storage facilities, with growers owning the facilities in rare instances. Seeds undergo a process of cleaning and grading before they are sent to market to remove any impurities and ensure quality. Certified seed can only be cleaned by a seed processor who is accredited to handle certified seed.

The seed cleaning process involves the following steps (AgriFutures, 2011):

- The seed passes over a series of screens where material that is larger or smaller is taken out of the seed, including weather damaged seeds, immature seeds, damaged or broken seeds and general trash.
- The seed is then run over a gravity table which separates the seeds by weigh. Light seeds are removed from the batch as it may include insect damaged seeds immature seeds, or weed seeds.
- The seed may then be scarified. Scarification involves weakening, opening or altering the coat of the seed to encourage germination. It is often done mechanically, thermally and chemically. This is less of a concern if destined for export markets as the product may not be shipped for several months, thus allowing sufficient time for hardness levels to drop.
- The seeds are then bagged/packaged.
- The seeds are then required sampled by an accredited seed sampler. Samples will be taken ad tested by the Certification Service to determine physical purity and germination. Once passing these tests the seed is officially certified and a certificate is supplied. This is particularly relevant if bound for export, as it instils confidence in international markets as to the genetic integrity and varietal purity of the seed (AgriFutures, 2017a).

Wholesale (Domestic & Export)

Fodder

On average, only around 10% of lucerne hay is exported. Domestic demand is strong for lucerne hay, and can be sold directly to farmers, including dairy, feedlotters and equine enterprises, or to wholesale and retail agents to small farm owners and stockfeed manufacturers. Lucerne hay is frequently transported long distances to meet demand for market requirements (AgriFutures, 2017a).

Table 5.6 outlines the export requirements for lucerne for stockfeed as the end use.

Table 5.6. Export Requirements, Lucerne for Stockfeed End Use

End Use	Country	Import Permit	Phytosanitary Certificate	Additional Declaration/ Endorsement
Hay	Malaysia	Yes	Yes	Yes (testing to attest freedom from Ragweed parthenium)
	Philippines	Yes	Yes	No
Silage	Philippines	No	Yes	No
Chaff	Bahrain	Yes	Yes	No
	Indonesia	No	Yes	No
	Malaysia	Yes	Yes	Yes (testing to attest freedom from Parthenium weed)
	New Caledonia	Yes	Yes	Yes (methyl bromide fumigation)
	Philippines	Yes	Yes	No
Pellets	Bahrain	Yes	Yes	No
	New Zealand	No	Yes	Yes (fumigation with phosphine or methyl bromide)
	Vietnam	No	Yes	No

Source: Micor (2022).

Seed

Lucerne seed is predominantly sold with certification under the OECD (Organisation for Economic Co-Operation and Development) or AOSCA (Association of Official Seed Certifying Agencies) protocols.

There are two main marketing options for lucerne seed:

- Producing seed under contract to a company that markets lucerne seed, or
- Produce public variety and either sell to neighbours or to companies that market public varieties either to domestic or international markets.

Prices for lucerne seed are heavily influenced by international markets and foreign exchange rates given the majority of Australia's lucerne seed crop is exported.

Table 5.7 outlines the export requirements for lucerne seed.

Table 5.7. Export Requirements, Lucerne Seed

Country	Import Permit	Phytosanitary Certificate	Additional Declaration/ Endorsement
Italy	No	Yes	No
New Caledonia	Yes	Yes	No
Taiwan	No	Yes	Yes (treatment for Stem nematode may be required)
Philippines	No	Yes	No

Source: Micor (2022).

5.5.1 Infrastructure Requirements and Gaps in Central Queensland

Fodder

Lucerne hay and silage can be largely produced on-farm and do not require off-site processing facilities. Additional infrastructure and equipment will be required depending on the end product.

Hay is predominantly sold to the domestic market and is usually transported by road within Australia at high cost, especially if long distances are involved. High moisture content, soft bales or inappropriate bale size will increase the cost of transport. Compressed hay in shipping containers is a cost effective way to transport export hay, however, because of the large distances from Australia to its markets compared to other countries and those markets, shipping costs may be high.

Seed

As mentioned, lucerne seed production is heavily concentrated in the south-east of South Australia (between 90% to 95%) (AgriFutures, 2020). If lucerne seed were to be produced in the Rookwood Weir Catchment, it is likely that seeds will need to be transported to processing facilities in the key growing regions in South Australia (such as the area of Keith, Naracoorte, Tintinara and Bordertown) in order to be cleaned, sample and certified. There are existing seed processing facilities within Queensland, however these are facilities do not appear to process lucerne seed (based on desktop research). Depending on the scale of future operations, additional seed processing facilities may need to be constructed within the region to service the increase in production.

5.6 COMPETITIVE ANALYSIS AND MARKET OUTLOOK

5.6.1 Key Exporters and Importers of Lucerne Seed

The figure below provides a snapshot of the top five exporters and importers of lucerne seed in the global market. The top five exporters accounted for 57.2% of total lucerne seed exports in 2020, while the top five importers accounted for 46.6% of total lucerne seed imports in 2020.

Figure 5.18. Major Exporters and Importers of Lucerne Seed

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

5.6.2 Future Growth Markets for Australia

The AgriFutures (2017b) report highlights that there are a range of opportunities to expand lucerne seed exports, however, there are challenges which limit the potential for the industry. "The challenge is that most, if not all, of the potential existed within Australia's recently-developed proprietary lucerne varieties rather than the traditional public sector commons such as Siriver. Therefore, if the industry is to act and take advantage of these export opportunities, the industry in the mid to long term would need to move from being dominated by 'publics / commons' to new 'proprietary' varieties with enhanced performance, such as yield (kg/ha), increased persistence, cold/frost, increased water use efficiency and improved nutrient quality" (AgriFutures, p. 86, 2017b).

The report also identified key future markets for Australian proprietary lucerne including (AgriFutures, 2017b):

- Eastern Europe: Belarus, Kazakhstan, Ukraine, Turkey
- Africa: Norther Africa (Sudan, Somalia), Centra Africa and South Africa
- China
- Mexico
- Latin America: Peru, Paraguay, Uruguay.

These opportunities for new markets exist in the mid to long term, while in the short term, it is important for Australia to maintain market access to the USA and Argentina (AgriFutures, 2017b). "In Argentina (and Mexico) deregulation of GM lucerne is being sought, with an expectation that once granted a significant proportion of these markets will transition into GM lucerne and reduce the opportunity for non-GM Australian lucerne" (AgriFutures, p. 69, 2017b). To maintain market access, Australia will need to focus on two things, increasing the reliability of supply and the volume of supply (AgriFutures, 2017b).

5.6.3 SWOT Analysis of Australian Lucerne Production

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

Table 5.8. SWOT Analysis – Australian Lucerne Production

Strengths	Weaknesses
• Australia harvests and supplies seed earlier than the USA, providing a ‘first mover’ market entry advantage	• Depending on market prices and seasonal conditions for lucerne hay and seed, the crop is often targeted for hay production, with lucerne seed being an option • Declining trend of investment into lucerne in Australia • Limited information available about the global market • Depending on pricing and seasonal conditions, the lucerne crop is often targeted towards hay production, with lucerne seed being an option
Opportunities	**Threats**
• Potential to improve management of seed and hay crops may improve yields particularly for irrigated operations. • Irrigated lucerne provides a more consistent production program that can assist in improving long term customer relationships. • Strong correlation with weather and herd size means that as the effect of La Nina dissipates and the Australian cattle herd is rebuilt, demand for lucerne hay will increase providing a stable outlook for prices.	• Reduced opportunities for non-GM Australian lucerne in the USA and Argentina • Globally, introduction of low-cost corn silage to replace lucerne for demand in the dairy industry • Contamination of Australia non-GM domestic and export seed

Source: AgriFutures (2017b), AEC.

5.7 LUCERNE 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 lucerne production is 197ha. With water entitlement restrictions and a conservative water use assumption, the total sustainable land available for farm development (i.e. planted area) is estimated to be 48.0ha.
- The anticipated initial capital investment for a rotational cropping farm is $5.9 million – including, land clearing, infrastructure and equipment, and water entitlements. This includes water allocation at an assumed cost of $1,500 per ML (RFM, 2021).
- Assuming the crop rotation with lucerne is wheat, the break-even point for the example lucerne farm, at the current assumed weighted average price of $6.80 per bale is November 2023. Under this scenario, the assumed price for wheat is $421 per tonne.
- The lucerne farm will return positive discounted cash flows from FY2024.
- The long-term growth rate for agricultural farm values is 12.5%, with an NPV of the farm at $0 the implied internal rate of return is 13.4%. The terminal value of the example farm with rotational cropping at the conclusion of the analysis (FY2041) is $46.1 million (undiscounted).

5.7.1 Approach

The commercial and financial feasibility of an average lucerne farm 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 capital investment required, operating costs, and the anticipated revenue over the 20-year time frame. The following sections detail the following:

- Farm establishment
- Farm operations
- Financial feasibility (including sensitivity analysis).

5.7.2 Crop Rotation

The financial analysis is undertaken for the purposes of growing lucerne as a primary commodity. In modelling the financial feasibility of lucerne in the Rookwood Weir Catchment Area, the farm has been assumed to be a monoculture farm, farming lucerne, with a single crop rotation of wheat. As lucerne is a perennial plant lasting five effective years (AgriFutures, 2003), the structure of the example farm is a six-year cycle of five years lucerne and one year wheat.

5.7.3 Rookwood Weir Water Availability

The Rookwood Weir Scheme allows for a maximum 500ML water allocation for agricultural landholders. Lucerne irrigation in the Central Queensland region reportedly requires, on average, 8.8ML of water per annum per Ha (DAF, 2020b). Wheat irrigation in the Central Queensland region 5.2ML of water per annum per Ha (Harris, et al, 2012). Appendix D discusses lucerne water requirements and growing environment in more detail.

Under the assumption this water is provided with a conservative 84% reliability and 14.0ML per ha per year is required for both wheat and lucerne production, the maximum growing area in the Rookwood Weir Catchment Area is 48.0ha.

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 5.9.

Table 5.9. Land Availability, by Reliability Rate

60% Reliability	84% Reliability	100% Reliability	No Water Allocation Cap
34.3 ha	48.0 ha	57.1 ha	197 ha

Note: Total land available considers the soil suitability of soybean only and does not factor the rotation crop.
Source: HTW, AEC.

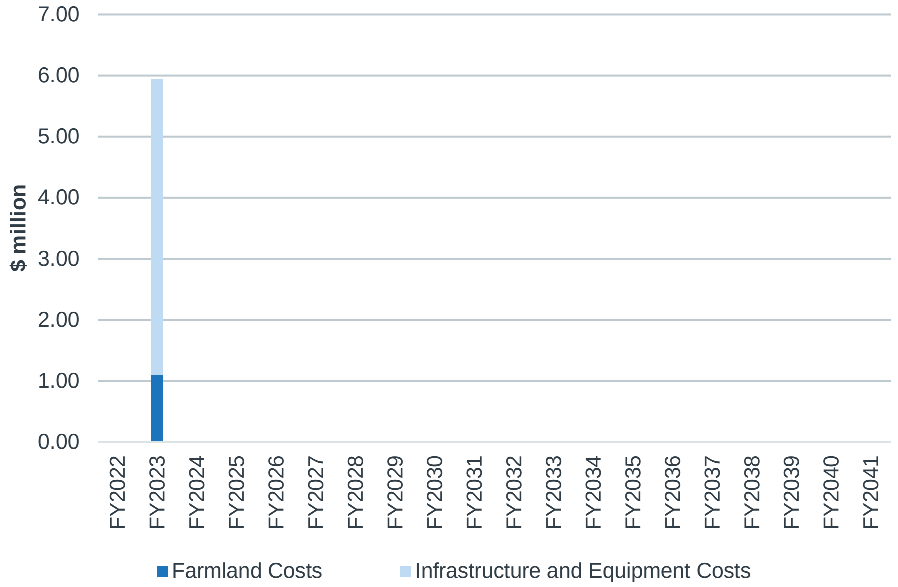
The outcome of the scenario analysis is presented below in Section 0.

5.7.4 Rotational Cropping Capital Investment

5.7.4.1 Farm Establishment

Rotational cropping farm establishment requires three key capital investments, the land, the on-farm infrastructure and associated equipment (including storage), and the horticultural crop. For the purpose of analysis, it is assumed the landholder already owns the land and the majority of the initial investment occurs across four months, starting 1 January 2023. For the 48.0ha farm, the initial capital investment is $5.9 million ($123,622/ha), not including the cost of planting.

Figure 5.19. Farm Establishment Costs, Not Including Planting Costs (FY2022 – FY2041)



Source: AEC, HTW.

<u>**Farmland Costs**</u>

Farmland costs include the cost of land clearing, and water entitlements. Total farmland costs per farm are estimated to be $1.1 million.

- **Water entitlement** – 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
- **Land clearing** – it is assumed the land, upon purchase, will need to be cleared and prepared for farm establishment. Total land clearing is estimated to be $332,147 in nominal terms.

<u>**Infrastructure and Equipment Costs**</u>

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.

For the example farm, the infrastructure and equipment will cost an estimated $4.8 million. This investment includes the following:

- **Irrigation infrastructure and equipment** – this assumes the irrigation method will be centre pivots and includes the necessary pumps, pipes, centre pivots and soil monitoring equipment. Overall irrigation equipment will cost an estimated $4.6 million.
- **Production equipment** – equipment and machinery included in the production of crops include the cultivation and harvesting equipment. Total production equipment expense is anticipated to cost $148,470.
- **Storage and other infrastructure** – this asset group includes storage facilities for the harvested crop and any relevant grain elevators, as all as general storage sheds. This asset group is estimated to cost $118,488.

All infrastructure and equipment costs are assumed to be a combination of new and second-hand equipment with costs quoted from sites such as Farm Machinery Sales (https://www.farmmachinerysales.com.au/items/), Farm Tender (https://www.farmtender.com.au/), and John Deer (https://www.deere.com.au/en/).

Further details are outlined in Appendix E.

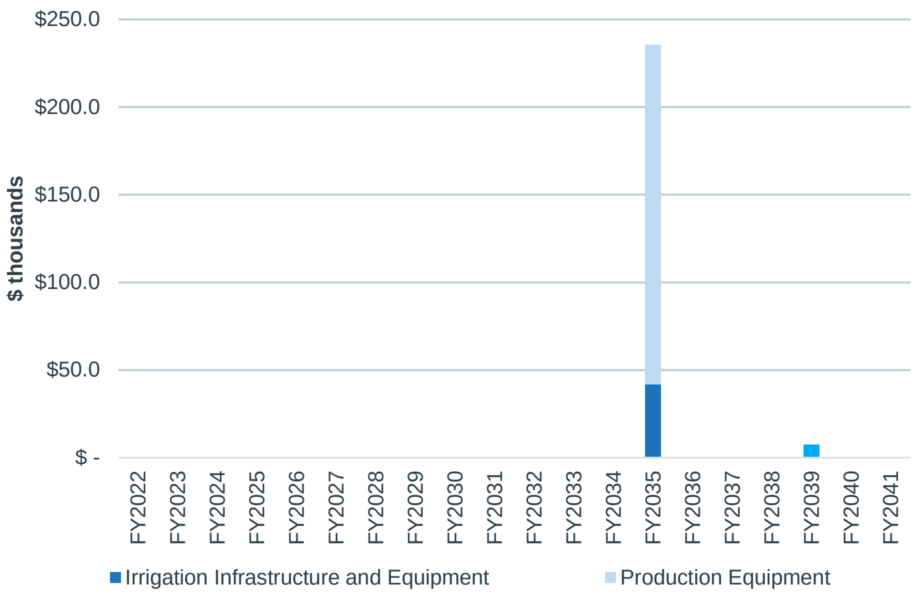
5.7.4.2 Planting Costs

Planting costs are on ongoing capital investment incurred twice a year – once for lucerne, and once for wheat. It is assumed the first sowing will occur in 2024 (FY2025) as the soil will need at least 12 months to rest after clearing. Based on planting costs published by DAF (2020b & e), lucerne is anticipated to costs $36.48/ha and wheat is anticipated to cost $59.78/ha in FY2021 real terms.

5.7.4.3 Asset Renewal

As general farming equipment, harvesting and spraying equipment, farm vehicles and irrigation 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 $243,012 is required to maintain operational farm assets over the evaluation period. This expense is show in Figure 5.20.

Figure 5.20. Total Asset Renewal (FY2022 – FY2041)

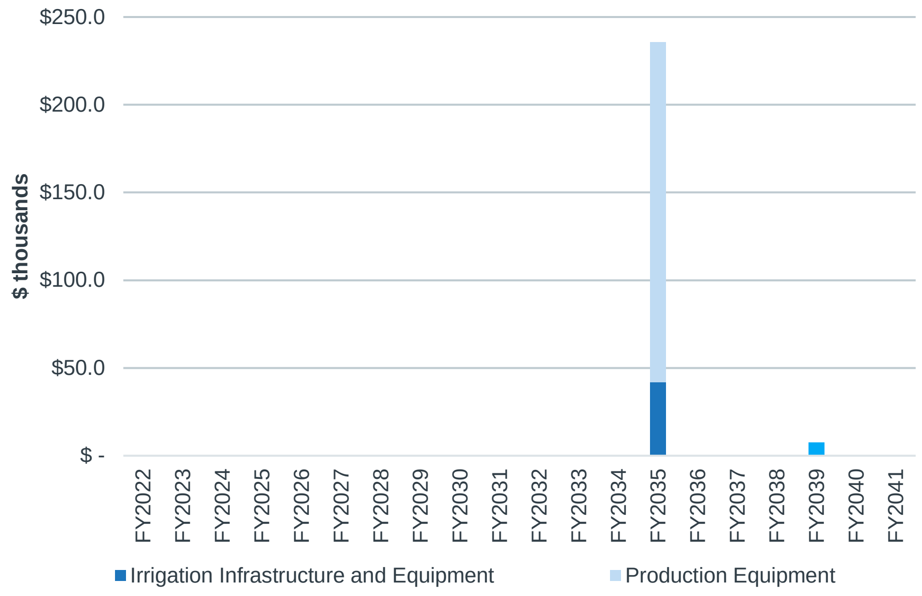


Source: AEC.

5.7.4.4 Depreciation and amortisation of assets

The capital investment required to establish the farm form the depreciable asset base of the farm. The total depreciation and asset write-off expense over the evaluation period is shown in Figure 5.21.

Figure 5.21. Total Depreciation Expense (FY2022 – FY2041)



Source: AEC (2022).

Treatment of each asset type is outlined in Appendix E.

5.7.5 Lucerne Operations

5.7.5.1 Operating Structure

The operating structure of the farm enterprise gives consideration to the ownership and management of the farm as well as the sources of funding for the enterprise. Establishment of the example farm requires significant investment to cover the capital requirements and the operating shortfall.

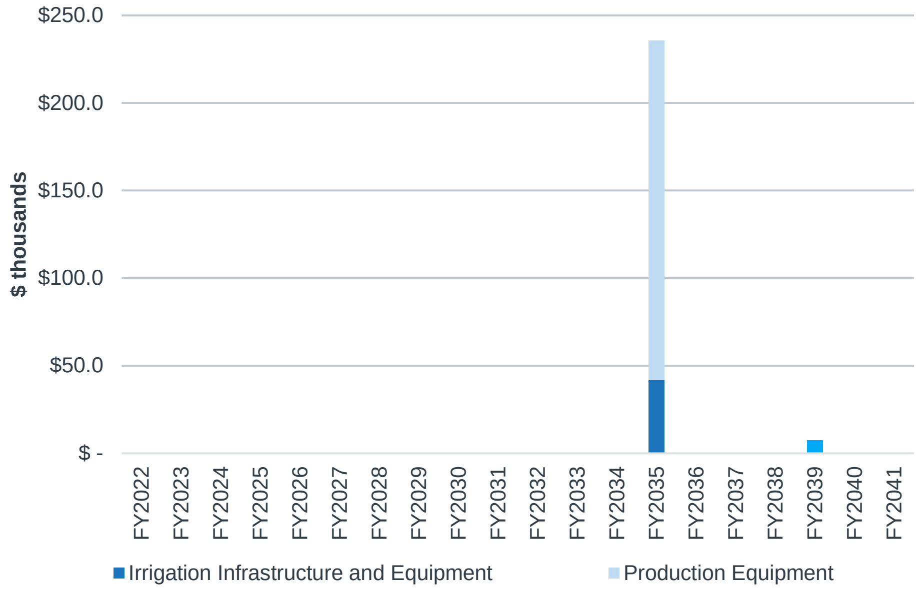
There are a number of high-level assumptions which guide the investment sources as a part of this analysis which are detailed in more detail in Appendix E.

5.7.5.2 Lucerne Operating Costs

Farm 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 5.22 below.

The COGS account for approximately 45.0% of total operating costs, over the 20-year evaluation period. The COGS include costs such as packing, harvesting and materials. Years FY2029, FY3035 and FY2041 show the lower anticipated operating costs associated with growing and harvesting wheat.

Figure 5.22. Total Operating Costs (FY2022 – FY2041)



Source: AEC.

Operating costs pertaining to wheat production are presented in Appendix E.

5.7.5.3 Farm Revenue

The farm revenue consists of the operating income associated with the sale of both lucerne and wheat, pursuant to the crop's grade. For the purposes of analysis, it is assumed all wheat and lucerne harvested have the following yield and price expectations.

Table 5.10. Price and Yield, by Commodity

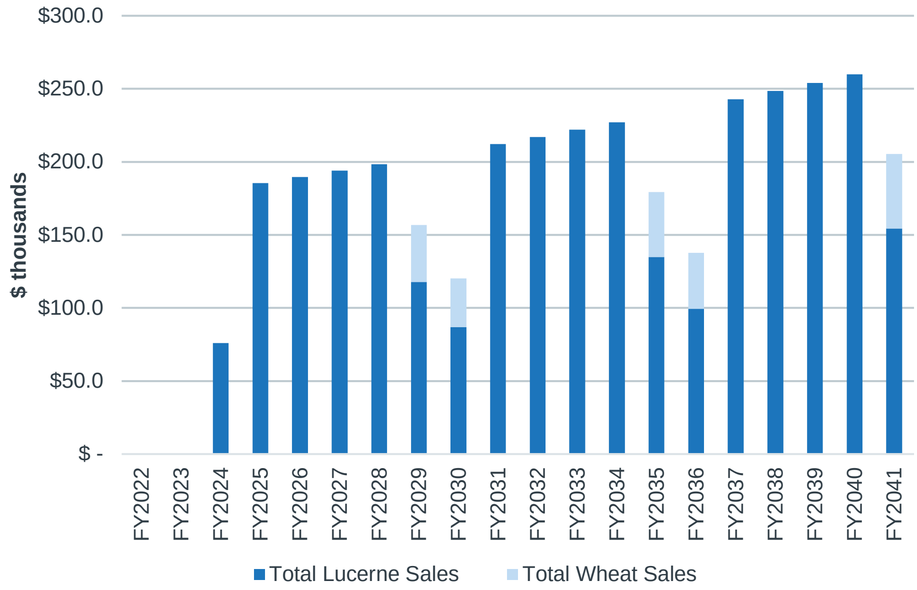
Commodity	Yield	Price
Lucerne	532bales/ Ha	$6.80/ bale
Wheat	1.8tonnes/ Ha	$421/ tonne

Source: ABS (2021), ABARES (2022), DAF (2020b& e), NAB (2022).

Prices for both lucerne and wheat are the average of the five-year forecast produced by ABARES (refer to section 5.3.4 for more detail on lucerne prices).

The forecasted revenue for both lucerne and wheat are shown in Figure 5.23. This forecast shows total lucerne revenue exceeds total wheat revenue. The lucerne revenue over the 20-year evaluation accounts for 94.2% of all farm revenue. The forecast presented below shows the impact of the six-year planting cycle, with FY2029 and FY2030 being the first periods to show the impact of the enterprises lower revenue associated with the sale of wheat.

Figure 5.23. 20-year Revenue Forecast (FY2022 – FY2041)



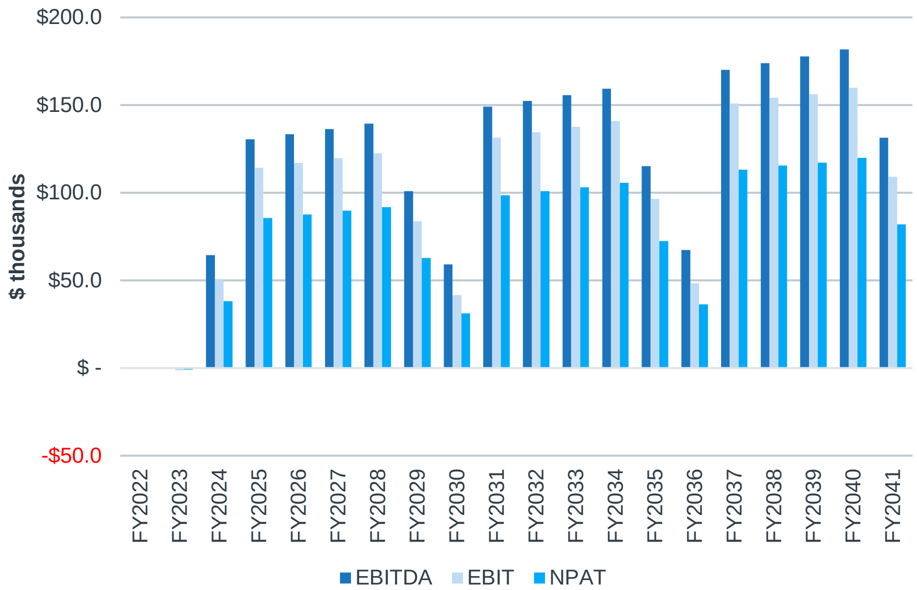
Source: AEC.

5.7.6 Financial Feasibility

The example farm in the Rookwood Weir Catchment Area is expected to return a positive EBITDA across all years in the evaluation. The operating breakeven month for the example farm modelled is November 2023. This shows the price point for both lucerne and wheat are sufficient to recover the total COGS.

By FY2041 the NPAT of the farm is estimated to be $81,873 and the EBITDA is estimated to be $131,307. Figure 5.24 shows that the impact of depreciation and tax expenses have a significant impact to the profitability of the farm for the landholder with $49,434 of the total EBITDA required to cover these costs (in FY2041).

Figure 5.24. Farm Operating Profit (FY2022 – FY2041)



Source: AEC.

To understand the value of the farm investment, a DCF has been calculated. 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 Central Queensland between 2014 and 2021, which is 12.5% (HTW, 2021).

With an NPV of the farm at $0 the implied internal rate of return is 13.4%. The terminal value of the example farm with rotational cropping at the conclusion of the analysis (FY2041) is $46.1 million (undiscounted).

The discounted cashflows are expected to be positive from the first year after planting (FY2024). The internal rate of return is above the growth rate estimated for the region, as such, the example lucerne farm represents a commercially viable investment.

5.7.6.1 Sensitivity Analysis

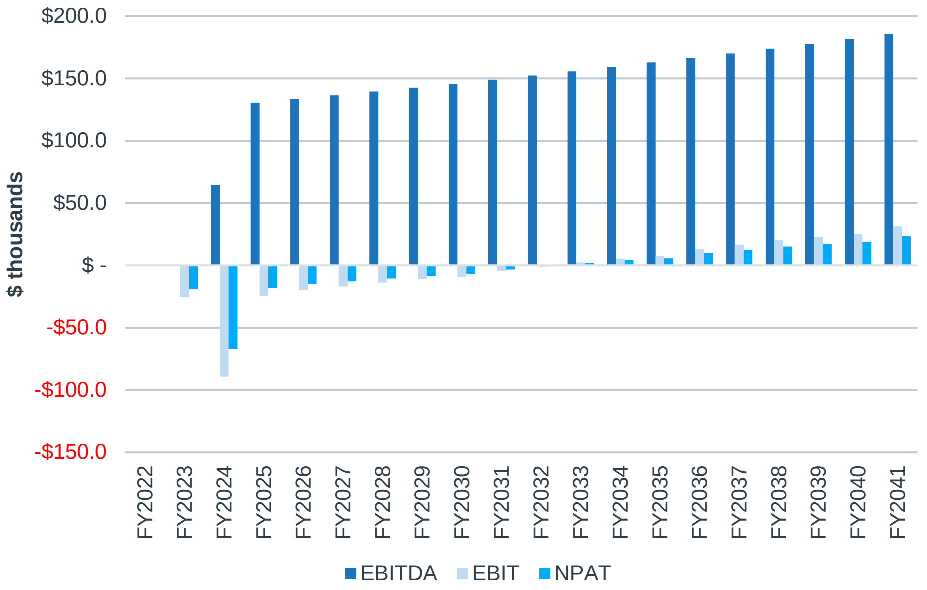
Crop Rotation Sensitivity

Figure 5.25 shows the farm operating profit when lucerne is the only crop farmed in the Rookwood Weir Catchment Area. Removing wheat has a multitude of impacts:

- There is a marginal decrease in capital investment. This decrease relates only to on-farm storage for the lucerne. Operationally, the impact of this is a slightly adjusted depreciation expense.
- Without a crop rotation, the farm is likely to experience an increased need for fertiliser to balance the soil nutrients. Similarly, the farm will likely have increased operating expenses associated with encouraging topsoil stability (to reduce the risk of erosion and increase water use efficiency). These costs have not been accounted for in the following profitability assessment.

A lucerne only farm of 48.0ha, is expected to return an NPAT of $23,442 by FY2041, where the EBITDA in the same year is $185,740.

Figure 5.25. Lucerne Operating Profit (FY2022 – FY2041)



Source: AEC.

Farmland Growth Rate Sensitivity

Historical growth rates are not always reflective of future growth rates. Recent land sales activity is a key driver on recent land value uplift, with the growth rate for rural property estimated to be 12.5% for the Central Queensland region. As land sales and value growth may not continue to grow with equal rates of the historical rates, sensitivity of the growth rate used to determine the terminal value of the example farm has been undertaken.

Rural Bank (2021) published the average Queensland rural land value long term growth rate of 8.8% (calculated over 20 years). Using this conservative growth rate (lower than the HTW estimate), the terminal value of a lucerne farm in the Rookwood Weir Catchment Area is $9.1 million with an investment NPV of negative $3.0 million.

With a growth rate of 8.8% and an NPV of the farm at $0 the implied internal rate of return is 10.4%. The terminal value of the example farm at the conclusion of the analysis (FY2041) is $26.4 million (undiscounted), ultimately showing a commercially feasible investment.

Table 5.11. NPV and Terminal Value, by IRR at 8.8% Growth Rates

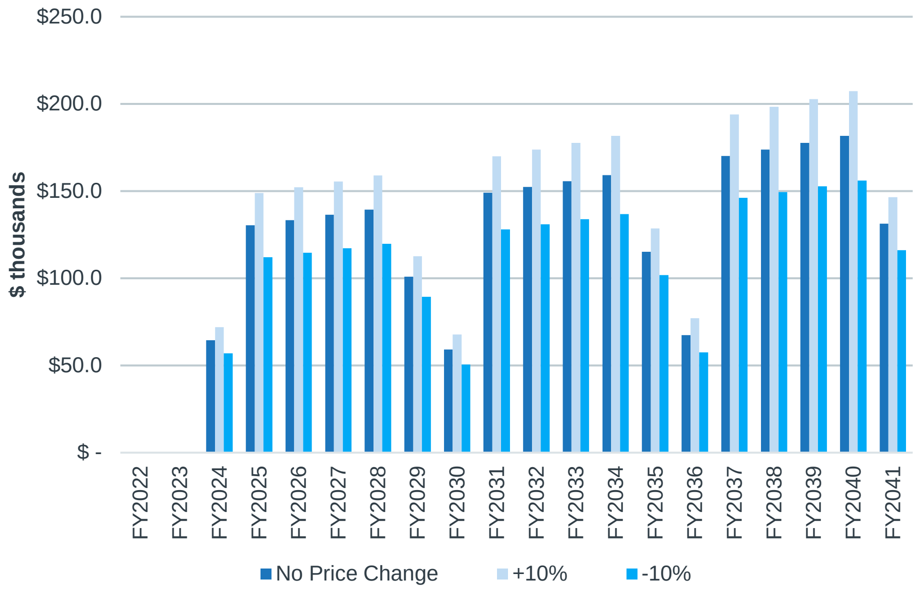
IRR	Net Present Value	Undiscounted Terminal Value
IRR at 13.4%	-$3.0 million	$9.1 million
IRR at 10.4%	$0.0 million	$26.4 million

Source: AEC

Price Sensitivity

To account for external price pressure on future lucerne 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.

Figure 5.26. Price Impact on Profitability (EBITDA) (FY2022 – FY2041)



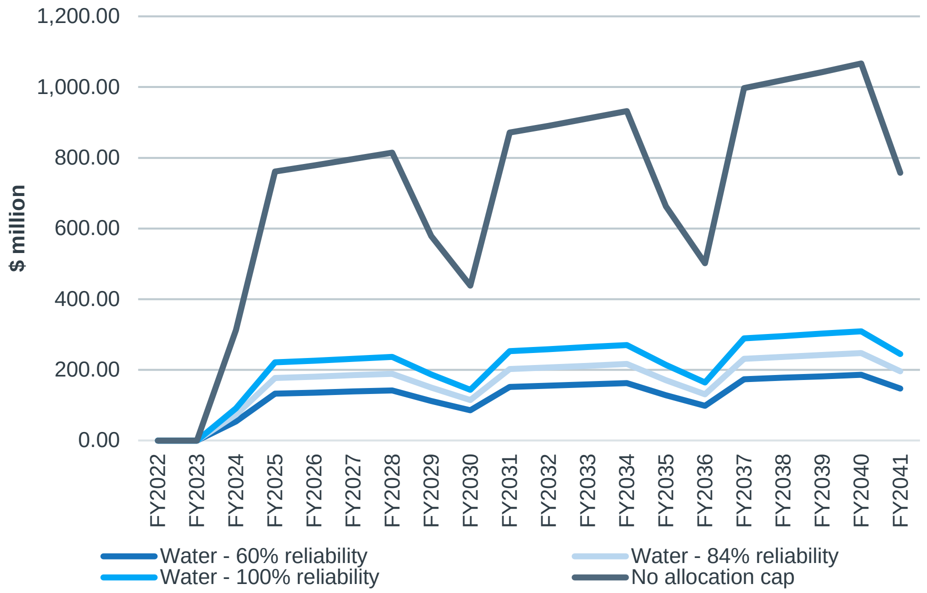
Source: AEC.

Water sensitivity

Water availability has a relatively linear relationship with the profitability of the example farm 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 farm.

The total water required in the no allocation cap is 2,748ML and under no scenario will the example farm have a positive operating surplus ratio. The variance in revenue is presented in the figure below.

Figure 5.27. 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 farm establishment timing. In practice, by increasing the available land there may be an increased time required to establish the farm. Under the No allocation cap scenario, the land farmed will increase from 45.7ha to 197ha, a significant increase, just less than four times larger.

5.7.7 Economic Impact

Investment in a farm enterprise will have an economic contribution to the Fitzroy region, and more broadly Central Queensland. The economic contribution of the example farm in the Rookwood Weir Catchment Area is presented in Table 5.12 and has been estimated using IO modelling (for further details, refer to Appendix F).

Initial capital investment of the farm is anticipated to cost approximately $5.0 million, not including the purchase of land and the purchase of water entitlements (both of which are not contributing factors of the economic impact), or the impact of price escalation over time. Capital investment and operation of the farm is anticipated to directly contribute to $3.6 million in industry output (i.e. revenues) to local businesses within the Rockhampton LGA.

A further $2.2 million in industry output is estimated to be supported in the catchment's economy through flow-on activity, including $1.2 million in production induced (i.e. supply chain) activity and $1.0 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 $2.6 million contribution to GRP including $1.5 million directly
- 22 FTE jobs (including 14 FTE jobs directly), paying a total of $1.8 million in wages and salaries ($1.2 million directly).

Table 5.12. Economic Activity Supported by a Lucerne Farm Enterprise, Rockhampton LGA

Impact	Output ($M)	Gross Regional Product ($M)	Incomes ($M)	Employment (FTEs)
Direct	$3.6	$1.5	$1.2	14
Production Induced	$1.2	$0.5	$0.4	4
Consumption Induced	$1.0	$0.5	$0.3	4
Total	**$5.8**	**$2.6**	**$1.8**	**22**

Note: Figures may not add due to rounding.
Source: ABS (2012), ABS (2017b), ABS (2021b, c and d), AEC.

6. CONCLUSION

The Rookwood Weir Catchment Area provides the region with a unique opportunity to structurally shift farm incomes and employment.

Based on an analysis of 2021 sales data (HTW, unpublished), the estimated average land value is approximately $3,800 per hectare (ha). 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.

Rotational cropping farms are a medium-term investment, which can return an operational profit within one year of establishment. Rotational crop farming is highly responsive to the farm operational practices employed and the natural environment. The success of rotational cropping relies heavily on soil health and water availability to ensure the planted land can return high quality crops with a reliable yield.

Rotational crops can be an attractive investment opportunity, with operational profit being accounted for in all forecast years. The return of a rotational cropping farm, like most horticulture operations, will improve with scale, as extensive upfront capital is required for farm establishment.

Although all four commodities; soybean, chickpea, mungbean, and lucerne, are presented as separate crops it is understood the majority of farming practices will incorporate a rotational structure involving a combination of these crops to reflect not only market trends and anticipated commodity prices, but also the environmental conditions (weather, soil health, and season) at the time of planting.

Soybean

Global soybean production has been growing by an average annual rate of 4.0% per annum from 1990 to 2020, to reach a total of 353.5 million tonnes in 2020. Soybean production is expected to increase at a modest rate of 1.5% from 2020 to 2030. Soybean production is estimated to reach a total of 411.1 million tonnes in 2030, driven largely by improved efficiency in land use.

Consumption of crushed soybean (including soybean meal and soybean oil) has increased by 4.9% on average per annum from 1990 to 2020. Soybean meal is a major source of protein and is largely used for animal feed across the globe. However, a key growth market for soybean is in the culinary space as soybean derivatives such as soy milk and soy oil are increasingly adopted by the health-conscious consumer.

Production has been increasing over the 30 years of 1990 to 2020 to meet the increasing demand for both soybean as an animal feed and soybean for culinary use. Quarter one of 2021 saw the highest soybean prices ($752 per tonne) in the last 20 years. However, forecasts indicate that by 2027 global soybean prices will return to the average price from 2014 to 2020 (around $500 per tonne).

Chickpeas

Global chickpea production has been growing, on average, 2.7% annually from 1990 to 2020. Australia's growth has largely mirrored the global growth, at an average annual rate of 2.6% over the same time-period. In 2020 Australia was the seventh largest producer of chickpeas and the largest exporter, with domestic consumption accounting for only 1% of total domestic production.

Subcontinental countries such as India. Pakistan, and Bangladesh are key consumers of Australian chickpeas, importing a collective 85.2% of Australia's chickpea exports. Australia, and more specifically Central Queensland, is well positioned to continue to service these major importers. Central Queensland produced nearly 60% of Australia's production in 2020. However, water security and sufficient rainfall has historically been a key determinant of the success of chickpea crops in Australia.

Mungbeans

Mungbean, as with soybean and chickpea, are a key staple of the Indian diet, and as such, are a key driver of the global mungbean market. Global production figures, although sparse, report that on average mungbean production averages 5.3 million tonnes. Over the 11-year period, 2012-2021, India's production increased 6.6% annually, reaching over 3 million tonnes, or roughly 20% of global production. From 2012-2020 India's total imports have decreased 27.5% from over half a million tonnes to 0.38 million tonnes.

Concurrently, China has become a key import market in the global space, increasing imports 22.3% annually from 2012-2020. In 2020 Australia exported 62.2% of total mungbean production, with India being the largest export market at 28.4%. China accounts for approximately 13.5% of Australia's exports.

With Australia's position as the third largest producer, and China's clear appetite for mungbeans, there is likely an opportunity to expand Australia's production and exports to the Chinese market.

Lucerne

Lucerne production for hay is recognised as a complementary market for the Rookwood Weir Catchment area, and more broadly, Central Queensland. With a strong existing beef industry lucerne is a commercially and economically appropriate commodity. Domestic lucerne production is predominantly used for grazing purposes, adding economic value to complementary industries, rather than being distinguished as its own market.

The capital investment required and their rate of return across the four key farm scenarios presented below.

Table 6.1. Capital Investment and Return

Commodity	Capital Investment	Implied Internal Rate of Return
Soybean	$3.4 million	12.8%
Chickpea	$4.8 million	12.9%
Mungbean	$4.4 million	12.7%
Lucerne	$5.9 million	13.4%

Source: AEC.

Whilst it is improbable that the Rookwood Weir Catchment Area will be planted with these four crops, the following underscores the potential value creation derived from the Rookwood Weir Water Scheme.

- **Soybean** – The Rookwood Weir Catchment Area has the potential to grow up over 23,253ha of soybean based on constraints imposed by various production factors including slope, soil suitability. This area would produce in excess of 69,759 tonnes of soybean, which would notionally increase Australia's total production four-fold (based on 2020 production results), resulting in a potential farm-gate value of over $41.4 million.
- **Chickpea** – The Rookwood Weir Catchment Area has the potential to grow up over 28,417ha of chickpea based on constraints imposed by various production factors including slope, soil suitability. This area would produce in excess of 90,934 tonnes of chickpea, which would notionally increase Australia's total production by 38.7%, resulting in a potential farm-gate value of over $75.3 million.
- **Mungbean** – The Rookwood Weir Catchment Area has the potential to grow up over 23,253ha of mungbeans based on constraints imposed by various production factors including slope, soil suitability. This area would produce in excess of 41,855 tonnes of mungbean, which would notionally increase Australia's total production by 41.9%, resulting in a potential farm-gate value of over $38.8 million.
- **Lucerne** – The Rookwood Weir Catchment Area has the potential to grow up over 23,253ha of Lucerne based on constraints imposed by various production factors including slope, soil suitability. This area would produce in excess of 106,964 tonnes of lucerne (hay), which would notionally increase Australia's total production by 15.2% (based on FY2018 production), resulting in a potential farm-gate value of over $84.1 million.

Water rights are dependent on market forces, the most recent water sales of 21,600ML by Rural Funds Management are estimated to be $1,500 per ML to acquire the permanent entitlement. Details on expected access and usage costs are not accessible at the time of publication, but have been indicated to cost approximately $25 per ML. Efficient water infrastructure and minimising the lift distance will be critical in managing this input cost.

Overall, the analysis demonstrates that these crops are appropriate for the Rookwood Weir Catchment Area and given the extraordinary capital investment required, landholders should look to market trends in determining the best crops to farm each season in order to maximise profit. Further, landholders who require greenfield investment need to carefully consider their oppositions given the capital investment required. Landholders who have existing infrastructure and assets within the lower Fitzroy are likely to be in a more favourable position to maximise value creation from a Rookwood Weir water allocation.

REFERENCES

AARI (undated). *Chickpea Kabuli.* Ayub Agricultural Research Institute. Retrieved from https://aari.punjab.gov.pk/chickepea_kabuli_pulses#:~:text=It%20is%20cultivated%20on%20an,Layyah%20and%20Jhang%20(partly).

ABARES (2021). *African Swine Fever.* Retrieved from https://www.awe.gov.au/abares/research-topics/agricultural-outlook/african-swine-fever

ABARES (2022a). *Agricultural commodities and trade data.* Retrieved from https://www.awe.gov.au/abares/research-topics/agricultural-outlook/data#australian-crop-report-data

ABARES (2022b). *Oilseeds: March quarter 2022.* Retrieved from https://www.awe.gov.au/abares/research-topics/agricultural-outlook/oilseeds#opportunities-and-challenges

ABS (2012). *Census of Population and Housing 2011 – Employment by Place of Work*. Cat. No. 2068.0. Australian Bureau of Statistics, Canberra.

ABS (2014). *Agricultural Commodities, Australia 2011-12.* Cat. No 71210. Australian Bureau of Statistics, Canberra.

ABS (2014). *Agricultural Commodities, Australia 2012-13.* Cat. No 71210. Australian Bureau of Statistics, Canberra.

ABS (2015). *Agricultural Commodities, Australia 2013-14.* Cat. No 71210. Australian Bureau of Statistics, Canberra.

ABS (2016). *Agricultural Commodities, Australia 2014-15.* Cat. No 71210. Australian Bureau of Statistics, Canberra.

ABS (2017a). *Agricultural Commodities, Australia 2015-16.* Cat. No 71210. Australian Bureau of Statistics, Canberra.

ABS (2017b). *Census of Population and Housing 2016*. TableBuilder. Australian Bureau of Statistics, Canberra.

ABS (2018). *Agricultural Commodities, Australia 2016-17.* Cat. No 71210. Australian Bureau of Statistics, Canberra.

ABS (2019). *Agricultural Commodities, Australia 2017-18.* Cat. No 71210. Australian Bureau of Statistics, Canberra.

ABS (2021). *Agricultural Commodities, Australia 2019-20.* Cat. No 71210. Australian Bureau of Statistics.

ABS (2021b). *Australian National Accounts: Input-Output Tables – Electronic Publication, 2018-19 tables*. Cat. No. 5209.0.55.001, Australian Bureau of Statistics, Canberra.

ABS (2021c). *Labour Force, Australia, Detailed, Quarterly*. Cat. No. 6291.0.55.003, Australian Bureau of Statistics, Canberra.

ABS (2021d). *Wage Price Index, Australia*. Cat. No. 6345.0, Australian Bureau of Statistics, Canberra.

ACIAR (2020a). *Myanmar.* Retrieved from https://www.aciar.gov.au/sites/default/files/2020-11/aciar-aop2020-myanmar.pdf

ACIAR (2020b). *Sprouting a new market through mungbean research.* Retrieved from https://www.aciar.gov.au/media-search/blogs/sprouting-new-market-through-mungbean-research

ACIAR (2020c). *Partners in research for development.* Retrieved from https://www.aciar.gov.au/sites/default/files/aciar_partners_issue_1_2020_lr_final.pdf

ACIAR (2020d). *Mungbean central.* Retrieved from https://www.aciar.gov.au/sites/default/files/mung-central-v6-final.pdf

ACIAR (2022). *Establishing the international mungbean improvement network.* Retrieved from https://www.aciar.gov.au/sites/default/files/2022-03/CIM-2014-079-final-report.pdf

AEGIC (2021). *Australian pulses: quality, versatility, nutrition.* Retrieved from https://aegic.org.au/wp-content/uploads/2021/03/AEGIC-Grain-Note-pulses_LR-1.pdf

AFIA (2021). *About fodder.* Australian Fodder Industry Association. Retrieved from https://afia.org.au/about-fodder/

AFIA (2022). *Hay exports by state of destination, Jul 2019 to December 2021_8Mach2022.* Australian Fodder Industry Association. Email received 29th March 2022.

Agriculture Victoria (2022). *Growing chickpea in Victoria.* Retrieved from https://agriculture.vic.gov.au/crops-and-horticulture/grains-pulses-and-cereals/growing-grains-pulses-and-cereals/growing-chickpea-in-victoria#:~:text=Chickpeas%20prefer%20warmer%20gimbibe%20waterowing%20conditions,important%20for%20high%20yield%20harvests.

AgriFutures (2003). *Lucerne for pasture and fodder*. Retrieved from https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0010/164737/p2225pt1.pdf

AgriFutures (2008). *Lucerne for pasture and fodder*. Retrieved from https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0010/164737/p2225pt1.pdf

AgriFutures (2011). *Agronomic Support Manual for Lucerne Seed Production*. Retrieved from https://www.agrifutures.com.au/wp-content/uploads/publications/10-106.pdf

AgriFutures (2017a). *Lucerne*. Retrieved from https://agrifutures.com.au/farm-diversity/lucerne/

AgriFutures (2017b). *Towards a sustainable Australian temperate pasture legume planting seed market.* Retrieved from https://www.agrifutures.com.au/product/towards-a-sustainable-australian-temperate-pasture-legume-planting-seed-market/

AgriFutures (2017c). *Mungbeans.* Retrieved from https://www.agrifutures.com.au/farm-diversity/mungbeans/

AgiFutures (2020). *Assessment of size and scope of the certified temperature pasture seeds industry.* Retrieved from https://agrifutures.com.au/wp-content/uploads/2020/11/20-104.pdf

AgriFutures (undated). *Lucerne.* Retrieved from https://www.agrifutures.com.au/wp-content/uploads/publications/10-123.pdf

ATIC (undated). *Tariffs and regulations*. Retrieved from https://www.austrade.gov.au/australian/export/export-markets/countries/argentina/doing-business/tariffs-and-regulations

ATO (2016). *Calculating the decline in value of horticultural plants*. Retrieved from https://www.ato.gov.au/business/primary-producers/in-detail/valuing-plants-and-animals/calculating-the-decline-in-value-of-horticultural-plants/

ATO (2021a). *Instant asset write-off for eligible businesses*. Retrieved from https://www.ato.gov.au/Business/Depreciation-and-capital-expenses-and-allowances/Simpler-depreciation-for-small-business/Instant-asset-write-off/

ATO (2021b). *Primary production depreciating assets.* Retrieved from https://www.ato.gov.au/Forms/Guide-to-depreciating-assets-2021/?page=15

ATO (2021c). *What is a depreciating asset?*. Retrieved from https://www.ato.gov.au/Forms/Guide-to-depreciating-assets-2021/?page=6

ATO (2022). *TR 2021/3 - Income tax: effective life of depreciating assets (applicable from 1 July 2021)* Retrieved from https://www.ato.gov.au/law/view/view.htm?docid=%22TXR%2FTR20213%2FNAT%2FATO%2F00001%22

Austrade (2021). *Insight – Pakistan agrees to improve market access for grains, pulses and oilseeds*. Retrieved from https://www.austrade.gov.au/news/insights/dawe-insight-pakistan-agrees-to-improve-market-access-for-grains-pulses-and-oilseeds

Austrade (2022a). *Insight – Taiwan temporarily improves import conditions or multiple commodities.* Retrieved from https://www.austrade.gov.au/news/insights/insight-taiwan-temporarily-improves-import-conditions-for-multiple-commodities

Austrade (2022b). *Insight – export opportunities increase as India reduces tariff on lentils.* Retrieved from https://www.austrade.gov.au/news/insights/dawe-insight-export-opportunities-increase-as-india-reduces-tariff-on-lentils

Australian Mungbean Association (2015). *Australian mungbean industry strategic plan 2015-2019.* Retrieved from http://www.mungbean.org.au/assets/ama_strategicplan2015-19.pdf

Australian Mungbean Association (2020). *Mungbean quality, reputation counter market uncertainty.* Retrieved from http://www.mungbean.org.au/2020-market-outlook.html

Australian Mungbean Association (2022). *2022 market outlook.* Retrieved from http://www.mungbean.org.au/2022-market-outlook.html

Australian Mungbean Association (undated a). *Desiccation and harvest.* Retrieved from http://www.mungbean.org.au/harvest.html

Australian Mungbean Association (undated b). *Varieties.* Retrieved from http://www.mungbean.org.au/varieties.html

Australian Mungbean Association (undated c). *Marketing mungbeans.* Retrieved from http://www.mungbean.org.au/marketing.html

Australian Mungbean Association (undated d). *Mungbean management guide.* Retrieved from http://www.mungbean.org.au/best-management-guide.html

AVRDC (undated). *International mungbean improvement network.* The World Vegetable Centre. Retrieved from https://avrdc.org/intl-mungbean-network/

Baylis, K., Coppess, J., & Xie, Q. (2017). *Reviewing the US-Korea free trade agreement.* Retrieved from https://farmdocdaily.illinois.edu/2017/11/reviewing-the-us-korea-free-trade-agreement.html

Bean Growers Australia (2021). *Welcome to Bean Growers Australia*. Retrieved from https://www.beangrowers.com.au/

Bert, F, de Estrada, M., Naumann, G., Negri, R., Podesta, G., de los Milagros Skansi, M., Spennemann, P., & Quesada, M. (2021). *The 2017-18 drought in the Argentine pampas: impacts on agriculture.* Retrieved from https://www.undrr.org/publication/2017-18-drought-argentine-pampas-impacts-agriculture-0

BOM (2005). *Average annual & monthly evapotranspiration.* Retrieved from http://www.bom.gov.au/jsp/ncc/climate_averages/evapotranspiration/index.jsp

BOM (2020). *Previous droughts*. Retrieved from http://www.bom.gov.au/climate/drought/knowledge-centre/previous-droughts.shtml

BOM (2022 a). *Recent and historical rainfall maps.* Australian Government – Bureau of Meteorology. Retrieved from http://www.bom.gov.au/climate/maps/rainfall/?variable=rainfall&map=totals&period=12month&region=qd&year=2021&month=12&day=31

BOM (2022 b). *Climate outlooks – weeks, months and seasons.* Australian Government – Bureau of Meteorology. Retrieved from http://www.bom.gov.au/climate/outlooks/#/rainfall/total/75/seasonal/0

Business Insider (2018). *India has raised the stakes in its trade wat for chickpeas with a new 60% tariff.* Retrieved from https://www.businessinsider.com.au/tariff-on-chickpeas-indian-government-2018-3

Cattelan, A, & Dall'Agnol, A. (2018). *The rapid soybean growth in Brazil.* Volume 25, Issue No 1. Retrieved from https://www.ocl-journal.org/articles/ocl/full_html/2018/01/ocl170039/ocl170039.html

CBS (2020). *Soybean imports from Brazil up by 40 percent.* Retrieved from https://www.cbs.nl/en-gb/news/2020/40/soybean-imports-from-brazil-up-by-40-percent

CGTN (2019). *Why does China import so many soybeans?* Retrieved from https://news.cgtn.com/news/3d3d514e3441444d34457a6333566d54/index.html

COE-Resources (2015). *Soy supply security for the Netherlands. Anticipating future global challenges through strategic responses.* Retrieved from http://trinomics.eu/wp-content/uploads/2018/07/Soy-supply-security-for-the-Netherlands.pdf

Colussi, J., & Schnitkey, G. (2021). *Brazil likely to remain world leader in soybean production.* Department of Agricultural and Consumer Economics University of Illinois. Retrieved from https://farmdocdaily.illinois.edu/wp-content/uploads/2021/07/fdd120721.pdf

Com Trade (2022). *UN Comtrade Database.* Retrieved from https://comtrade.un.org/

Commonwealth Consolidated Acts (undated). *Excise Act 1901 -sect 160A.* Retrieved from http://classic.austlii.edu.au/au/legis/cth/consol_act/ea190180/s160a.html

Coriolis (2018). *Mungbean the $70m diversification opportunity in northwest Queensland.* Retrieved from https://coriolisresearch.com/pdfs/coriolis_daf_01_NWMP_Stage_III_MUNG_103r.pdf

Cotenca (2021). *Brazilian soybeans exports – markets and quality insights.* Retrieved from https://www.cotecna.com/en/media/news/brazilian-soybeans-exports-market-and-quality-insights#:~:text=GMO%20soybeans%20represent%20the%20majority,and%20Indian%20non%2DGMO%20products.

CRCNA (2020). *Northern Australian broadacre cropping situational analysis.* Retrieved from https://www.crcna.com.au/resources/publications/northern-australian-broadacre-cropping-situational-analysis#:~:text=This%20situational%20analysis%20is%20an,but%20not%20rice%20or%20sugar.

DAF (2020a). *Chickpea (Irrigated) Central Highlands 2020*. Retrieved from https://agmargins.net.au/Reports/Details?id=68854fab-0be5-45e7-a366-788b8c07bc91

DAF (2020b). *Lucerne – Steady State (Irrigated) Darling Downs 2020*. Retrieved from https://agmargins.net.au/Reports/Details?id=3a41c8b1-9183-4198-98e4-3f4208059fc0

DAF (2020c). *Mungbean (Irrigated) Central Highlands 2020*. Retrieved from https://agmargins.net.au/Reports/Details?id=463c20c3-f17d-4023-b340-9c2902c2aec2

DAF (2020d). *Soybean (Edible) (Irrigated) Central Highlands 2020*. Retrieved from https://agmargins.net.au/Reports/Details?id=11215e56-f318-43de-8ccd-eda45ec47ef0

DAF (2020e). *Wheat (Irrigated) Central Highlands 2020*. Retrieved from https://agmargins.net.au/Reports/Details?id=a4c5512f-adf1-47dd-902a-6047a1e52345

DAF (2022). *Rookwood Weir Soil Suitability Tool*. Retrieved from https://www.daf.qld.gov.au/business-priorities/agriculture/sustainable/rookwood-weir/mapping-tool-report

Dairy Australia (2022). *DD lucerne hay historical prices.* Email received 1st of April 2022.

DAWE (2021). *Chickpeas.* Manual of importing country requirements. Retrieved from https://micor.agriculture.gov.au/Plants/Pages/Bangladesh_BD/Chickpeas.aspx

DAWE (2022). *Chickpeas.* Manual of importing country requirements. Retrieved from https://micor.agriculture.gov.au/Plants/Pages/Pakistan_PK/Chickpeas.aspx

Dawn (2021). *The Bhakkar district's wrath of climate change.* Retrieved from https://www.dawn.com/news/1623034

Deloitte (2017). Market opportunities for Queensland agribusiness from FTA with South Korea. Retrieved from https://www2.deloitte.com/content/dam/Deloitte/au/Documents/Economics/deloitte-au-economics-product-profiles-qld-agribusiness-ftas-south-korea-060317.pdf

DES, Ministry of Agri. & FW (2020). *Latest APY State Data.* Retrieved from https://eands.dacnet.nic.in/APY_96_To_06.htm

DES, Ministry of Agri. & FW (2022). *Advance estimates of food grains, oilseeds & other commercial crops.* Retrieved from https://eands.dacnet.nic.in/Advance_Estimates.htm

DFAT (2021). *Australia-United States FTA*. Retrieved from https://www.dfat.gov.au/trade/agreements/in-force/ausfta/australia-united-states-fta

DFAT (2022). *Australia-Gulf Cooperation Council (GCC) FTA*. Retrieved from https://www.dfat.gov.au/trade/agreements/negotiations/agccfta/australia-gulf-cooperation-council-gcc-fta

Dialogo Chino (2021). *Is Argentina's soy boom over?* Retrieved from https://dialogochino.net/en/agriculture/44411-is-argentinas-soy-boom-over/

DoESE (2021). *Small Area Labour Market Data*. Department of Education, Skills and Employment, Canberra.

Doni & Company (2019). *Webinar – update on the south Asia pulse market.* Retrieved from https://www.austrade.gov.au/ArticleDocuments/1418/2019_event_presentation_Update_South_Asia_Pulse_Market.pdf.aspx

EMR (2021). *Global soybean market outlook.* Retrieved from https://www.expertmarketresearch.com/reports/soybean-market

EMR (2022a). *Global chickpeas market outlook.* Retrieved from https://www.expertmarketresearch.com/reports/chick-peas-market#:~:text=The%20major%20regional%20markets%20for,Wimmera%20Grain%20Store%2C%20and%20others.

EMR (2022b). *Global mung beans market outlook.* Retrieved from https://www.expertmarketresearch.com/reports/mung-beans-market

Ertuk, A., & Gul, M (2018). *Analysis of production and trade of chickpea in Turkey and the world.* Vol. 18, Issue 2. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development. Retrieved from https://www.researchgate.net/publication/326156009_ANALYSIS_OF_PRODUCTION_AND_TRADE_OF_CHICKPEA_IN_TURKEY_AND_THE_WORLD

FAO (2020). *Oilcrops.* Food and Agriculture Organisation of the United Nations. Retrieved from https://www.fao.org/fileadmin/templates/est/COMM_MARKETS_MONITORING/Oilcrops/Documents/Food_outlook_oilseeds/Oilcrops_Oils_and_Meals_Food_Outlook_2020.pdf

FAOSTAT (2022). Food and Agriculture Organisation of the United Nations. Retrieved from https://www.fao.org/faostat/en/#data

Feedipedia (2015). *Mungbean (Vigna Radiata).* Retrieved from https://www.feedipedia.org/node/235

Financial Review (2022). *Inflation to force RBA interest rate pivot.* Retrieved from https://www.afr.com/policy/economy/inflation-to-force-rba-interest-rate-pivot-20220125-p59r1x

Flegg, A.T., Lamonica, G.R., Chelli, F.M., Recchioni, M.C. and Tohmo, T. (2021). *A new approach to modelling the input-output structure of regional economies using non-survey methods*. Journal of Economic Structures, 2021, 10:12.

Government of India (2018). *pulses revolution from food to nutritional security.* Retrieved from https://farmer.gov.in/SucessReport2018-19.pdf

Grain Central (2016). *Mung beans stage comeback in north.* Retrieved from https://www.graincentral.com/cropping/mung-beans-stage-comeback-in-north/

Grain Central (2019). *India announces 150,000t pea import quota for 2019/20.* Retrieved from https://www.graincentral.com/markets/india-announces-150000t-pea-import-quota-for-2019-20/

Grain Central (2020a). *Big competition for little crop lifts chickpea prices.* Retrieved from https://www.graincentral.com/markets/export/big-competition-for-little-crop-lifts-chickpea-prices/

Grain Central (2020b). *Queensland researchers launch new mungbean 'gem'.* Retrieved from https://www.graincentral.com/cropping/queensland-researchers-launch-new-mungbean-gem/

Grain Central (2022). *Australia ships 82,362t chickpeas, 137,976t lentils in Jan.* Retrieved from https://www.graincentral.com/markets/australia-ships-82362t-chickpeas-137976t-lentils-in-jan/

GRDC (2014). *Grow notes: mungbeans.* Retrieved from http://www.mungbean.org.au/assets/grdc-grownotes-mungbeans.pdf

GRDC (2016a). *Grow notes: soybeans – northern region*. Retrieved from https://grdc.com.au/resources-and-publications/grownotes/crop-agronomy/soybeansgrownotesnorthern/grdc-grownotes-soybeans-northern.pdf?utm_source=website&utm_medium=download_button&utm_campaign=pdf_download&utm_term=North&utm_content=Soybeans%20Northern%20Region%20-%20GrowNotes%E2%84%A2

GRDC (2016b). *Grow notes: chickpeas – northern region.* Retrieved from https://grdc.com.au/resources-and-publications/grownotes/crop-agronomy/chickpeagrownotes/GRDC-Chickpeas-GrowNotes-Northern.pdf?utm_source=website&utm_medium=download_button&utm_campaign=pdf_download&utm_term=North&utm_content=Chickpeas%20Northern%20Region%20-%20GrowNotes%E2%84%A2

GRDC (2017a). *Grow notes: chickpeas – southern region.* Retrieved from https://grdc.com.au/resources-and-publications/grownotes/crop-agronomy/chickpea-southern-region-grownotes/GRDC-GrowNotes-chickpea-Southern-region.pdf?utm_source=website&utm_medium=download_button&utm_campaign=pdf_download&utm_term=South&utm_content=Chickpea%20Southern%20Region%20-%20GrowNotes%E2%84%A2

GRDC (2017b). *Grow notes: chickpeas – western region.* Retrieved from https://grdc.com.au/resources-and-publications/grownotes/crop-agronomy/chickpeas-western-region-grownotes/GRDC-GrowNotes-Chickpeas-WESTERN.pdf?utm_source=website&utm_medium=download_button&utm_campaign=pdf_download&utm_term=West&utm_content=Chickpeas%20Western%20Region%20-%20GrowNotes%E2%84%A2

GRDC (2018). *Industry at a glance.* Retrieved from https://rdeplan.grdc.com.au/industry-at-a-glance

GRDC (2019). *Hay – how is it stacking up?* Grains Research and Development Corporation. Retrieved from https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2019/03/hay-how-is-it-stacking-up

GRDC (2021). *New chickpea offers regional balance.* Retrieved from https://groundcover.grdc.com.au/crops/pulses/new-chickpea-offers-regional-balance

GRDC (2022). *Ground cover – challenges to chickpea expansion tackled.* Retrieved from https://groundcover.grdc.com.au/crops/pulses/challenges-to-chickpea-expansion-tackled

Harden Up (2003). *Cyclone Beni*. Retrieved from http://hardenup.org/be-aware/weather-events/events/2000-2009/cyclone-beni.aspx

Hiba (2021). *Livestock farming in Argentina seeks a more sustainable horizon*. Retrieved from https://dialogochino.net/en/agriculture/48446-livestock-farming-in-argentina-seeks-a-more-sustainable-horizon/

HTW (2021). *Rookwood Weir – Rural Property Overview.*

HTW (unpublished a). *Overview map of all properties.*

ICRISAT (2017). *New variety of chickpea helps Bangladeshi farmers fight climate change.* Retrieved from https://www.icrisat.org/new-variety-of-chickpea-helps-bangladeshi-farmers-fight-climate-change/

IMF (2022). *World Economic Outlook Database: October 2021.* Retrieved from https://www.imf.org/en/Publications/WEO/weo-database/2021/October

Insider (2019). Global mung beans market outlook to 2024 – driven by numerous health benefits, population growth, changing dietary habits, new market opportunities. Retrieved from https://markets.businessinsider.com/news/stocks/global-mung-beans-market-outlook-to-2024-driven-by-numerous-health-benefits-population-growth-changing-dietary-habits-new-market-opportunities-1028321960

IPM (2017). *Chickpea – northern region.* IPM Guidelines. Retrieved from https://ipmguidelinesforgrains.com.au/crops/winter-pulses/chickpea-northern-region/

ITA (2020). *Trade Agreements*. Retrieved from https://www.trade.gov/knowledge-product/argentina-trade-agreements

ITA (2022 a). *Trade Agreements*. Retrieved from https://www.trade.gov/country-commercial-guides/saudi-arabia-trade-agreements

ITA (2022 b). *Import Tariffs*. Retrieved from https://www.trade.gov/country-commercial-guides/saudi-arabia-import-tariffs

Jauregui et al. (2022). *Yield gaps of lucerne (Medicago sativa L.) in livestock systems of Argentina*. Retrieved from https://onlinelibrary.wiley.com/doi/10.1111/aab.12745?af=R

Khan, O.Z., Naseer, A., Shahbaz, M., Akhtar, S., Faisal, M., Mushtaq, K., (2017). *Assessing the factors affecting the yield of chickpea in Thal Punjab, Pakistan.* Retrieved from https://www.researchgate.net/publication/323540328_Assessing_the_factors_affecting_the_yield_of_Chickpea_in_Thal_Punjab_Pakistan

Kousonsavath, C., & Vagneron, I. (2018). Analysing mungbeans value-chains in the Loa PDR. Retrieved from https://ali-sea.org/aliseaonlinelibrary-dashboard/get/file/Understanding-the-potential-of-Mung-bean-value-chains-in-the-LAO-PDR.pdf

KPR Vittal, Masood Ali, G Ravindra Chary, GR Maruthi Sankar, T Srijaya, M. Udaya Bhanu, YS Ramakrishna and JS Samra (2005). District based Promising Technologies for Rainfed Chickpea Based Production System in India. All India Co-ordinated Research Project for Dryland Agriculture, Central Research Institute for Dryland Agriculture, Indian Council of Agricultural Research, Hyderabad 500 059. 119 Pages. Retrieved from https://krishi.icar.gov.in/jspui/bitstream/123456789/32621/1/Districtwise%20Promising%20Technologies%20for%20Rainfed%20Chickpea%20based%20Production%20System%20in%20India.pdf

Krishi Jargan (2021). *Global chickpeas market likely to show moderate growth in next 4-5 years.* Retrieved from https://krishijagran.com/agriculture-world/global-chickpeas-market-likely-to-show-moderate-growth-in-next-4-5-years/

Li, L., Yang, T., Liu, R., Redden, B., Maalouf, F., & Zong, X. (2017). *Food legume production in China.* The Crop Journal, Volume 5, Issue 2, pp. 115-126. Retrieved from https://www.sciencedirect.com/science/article/pii/S2214514116300502#:~:text=The%20production%20of%20mung%20bean,in%20the%20world%20%5B27%5D

Linden, J (2012). *Brazil: competitive factors in Brazil affecting US and Brazilian agricultural sales in selected third country markets.* Retrieved from https://www.thepigsite.com/articles/brazil-competitive-factors-in-brazil-affecting-us-and-brazilian-agricultural-sales-in-selected-third-country-markets

MICRO (2021). *Mung beans.* Manual of importing country requirements. Retrieved from https://micor.agriculture.gov.au/Plants/Pages/India_IN/Mung-bean.aspx

MMSIS (2020). *Sown acreage harvested acreage and production of selected crops by states and regions.* Retrieved from http://mmsis.gov.mm/statHtml/statHtml.do

NAB (2022). *Spot exchange rate forecasts.* Retrieved from https://www.nab.com.au/business/international-and-foreign-exchange/financial-markets/exchange-rate-forecast

NC Soybean Producers Association (2019a). *Growing soybeans.* Retrieved from https://ncsoy.org/media-resources/growing-soybeans/

NC Soybean Producers Association (2019b). *Uses of Soybeans*. Retrieved from https://ncsoy.org/media-resources/uses-of-soybeans/

Nimje (undated). *Soybean Production technology*. Retrieved from https://www.nsdcindia.org/scmp/assets/image/1913597640-20_SoybeanProductionTechnology_preview.pdf

OECD (2022). *Population projections*. Retrieved from https://stats.oecd.org/Index.aspx?DataSetCode=POPPROJ

OECD-FAO (2021a). *OECD agricultural statistics.* Retrieved from https://www.oecd-ilibrary.org/agriculture-and-food/data/oecd-agriculture-statistics_agr-data-en

OECD-FAO (2021b). *OECD-FAO Agricultural Outlook 2021-2030.* Retrieved from https://www.oecd-ilibrary.org/docserver/19428846-en.pdf?expires=1646039857&id=id&accname=guest&checksum=C26E6F05BE99BCEE0A4A6BF71116EBD6

Pastures Australia (2008). *Lucerne*. Retrieved from https://keys.lucidcentral.org/keys/v3/pastures/Html/Lucerne.htm

pbAgrifood (2021). *Soybeans.* Retrieved from https://www.pbagrifood.com.au/soybeans

PNGUT (2000). *Food Security for Papua New Guinea*. Retrieved from https://ageconsearch.umn.edu/bitstream/135368/2/PR099.pdf

PR Newswire (2018). *Global Alfalfa Hay Market 2018-2023: Saudi Arabia imports is Projected to Grow at a Maximum Rate, Due to the Country's Banning of Forage Crops Production in 2019*. Retrieved from https://www.prnewswire.com/news-releases/global-alfalfa-hay-market-2018-2023-saudi-arabia-imports-is-projected-to-grow-at-a-maximum-rate-due-to-the-countrys-banning-of-forage-crops-production-in-2019-300746502.html

Proterra Foundation (2021). *The non-gm production: how volatility is killing the supply chain in Brazil.* Retrieved from https://www.proterrafoundation.org/news/the-non-gm-production-how-volatility-is-killing-the-supply-chain-in-brazil/

Pulse Australia (2015 a). *Best management guide – chickpea production: southern and western region.* Retrieved from https://www.pulseaus.com.au/growing-pulses/bmp/chickpea/southern-guide

Pulse Australia (2015 b). *Australian pulse bulletin – pulses: understanding global markets.* Retrieved from https://www.pulseaus.com.au/growing-pulses/publications/marketing-pulses

Pulse Australia (2016a). *Australian pulse crop forecast.* Retrieved from https://www.pulseaus.com.au/storage/app/media/markets/20160721_Australian-Pulse-Crop-Forecast.pdf

Pulse Australia (2016b). *Best management guide – chickpea production: northern region.* Retrieved from https://www.pulseaus.com.au/growing-pulses/bmp/chickpea/northern-guide

Pulse Australia (2020). Australian pulse varieties 2020. Retrieved from https://www.pulseaus.com.au/storage/app/media/uploaded-files/Pulse%20Variety%20Charts%202020-v4-20210324.pdf

Pulse Australia (unpublished). *Commodity and industry information – chickpeas. mung beans and soybeans.* Email received 28th March 2022.

Queensland Government (2008). *Queensland Soybean Grower Guidelines.* Retrieved from http://www.australianoilseeds.com/__data/assets/pdf_file/0010/7669/Queensland_Soybean_Grower_Guidelines.pdf

Queensland Government (2021). *Soya bean production: suitable land for spray irrigation.* Retrieved from https://www.publications.qld.gov.au/dataset/land-soil-suitability-maps-for-irrigated-crops-proposed-rookwood-weir/resource/f11d84b5-469b-4ad7-8c6b-218ad49048bc

Queensland Treasury (2021). *Budget Paper 2 – Budget Strategy and Outlook.* Retrieved from https://budget.qld.gov.au/budget-papers/

Rashid, A., Hossain, S., Deb, U., Charyulu, K., Shyam, M., Bantilan, C, (2014). *Targeting and introduction of chickpea improved cultivars in Barind region of Bangladesh.* Retrieved from https://www.researchgate.net/publication/277035796_Targeting_and_introduction_of_Chickpea_improved_cultivars_in_Barind_region_of_Bangladesh

Reliefweb (2016). *Drought in India 2015-16: when coping rumbles – a rapid assessment of the impact of drought on children and women in India.* Retrieved from https://reliefweb.int/report/india/drought-india-2015-16-when-coping-crumbles-rapid-assessment-impact-drought-children-and#:~:text=In%202014%2D15%2C%20India%20had,officially%20declared%20drought%20in%202016

Research and markets (2022). *Soybean derivatives market – growth, trends, COVID-19 impacts, and forecasts (2022-2027).* Retrieved from https://www.researchandmarkets.com/reports/4544644/soybean-derivatives-market-growth-trends#:~:text=Key%20Highlights&text=Geographically%2C%20Asia%2DPacific%20dominates%20the,fastest%20growth%20in%20the%20market.

Reuters (2018). *Soy source: Brazil's share of soybean exports to China hits record.* Retrieved from https://www.reuters.com/article/us-china-economy-trade-soybeans-idUSKBN1FE111

RFM (2020). ASX release: Central Queensland water allocation acquisition. Retrieved from https://company-announcements.afr.com/asx/rff/c45adec6-3ff0-11eb-86da-76b5339583c3.pdf

RIRDC (2008). *Economic Analysis of the Australian Lucerne Seed Industry*. Retrieved from https://www.agrifutures.com.au/wp-content/uploads/publications/08-103.pdf

Rural Bank (2021). *Australian Farmland Values*. Retrieved from https://www.ruralbank.com.au/knowledge-and-insights/publications/farmland-values/?gclid=EAIaIQobChMI9eDb3uqz9gIVMQPnCh0PBgfTEAAYASAAEgKl-PD_BwE

SCMP (2022). *China's soybean production to increase 40 per cent by 2025 amid food-security alarms.* South China Morning Post. Retrieved from https://www.scmp.com/economy/china-economy/article/3163281/chinas-soybean-production-increase-40-cent-2025-amid-food

Seednet (2021). *Plant breeder's rights.* Retrieved from https://www.seednet.com.au/plant-breeders-rights

Soy Australia (2011). *Soybeans in the Australian and global market 2011*. Retrieved from http://www.australianoilseeds.com/__data/assets/pdf_file/0005/8177/Industry__and__Market_Review_2011.pdf

Soy Australia (2015). *Marketing soybeans.* Retrieved from http://www.australianoilseeds.com/soy_australia/marketing_soybeans

Soy Australia (2019). *Australian soybean industry commits to ride out the drought.* Retrieved from http://www.australianoilseeds.com/about_aof/news/australian_soybean_industry_commits_to_ride_out_the_drought

Soy Australia (2020). *Licensed varieties.* Retrieved from http://www.australianoilseeds.com/soy_australia/licensed_varieties

Soy Australia (undated). *Australian soy industry*. Retrieved from http://www.australianoilseeds.com/__data/assets/pdf_file/0004/8176/Regional_Schedule_and_Strategy_FINAL_28_June.pdf

SRA (2019). *Complementary crops in the sugarcane industry.* Retrieved from https://sugarresearch.com.au/sugar_files/2019/04/Complementary-crops-in-the-sugarcane-industry-B14007.pdf

Sugar Research Australia (2019). *Harvesting and drying of soybeans.* Retrieved from: https://sugarresearch.com.au/sugar_files/2019/04/Harvesting-and-drying-of-soybeans-B14008.pdf

Sunwater (2022). *Rookwood Weir Project Progress Report, January 2022.* Retrieved from https://www.sunwater.com.au/wp-content/uploads/Home/Projects/Rookwood/Rookwood_Weir_Progress_Report_January_2022.pdf

Sunwater (2022). *Rookwood Weir Project Progress Report, January 2022.* Retrieved from https://www.sunwater.com.au/wp-content/uploads/Home/Projects/Rookwood/Rookwood_Weir_Progress_Report_January_2022.pdf

The Western Producer (2021). *Turkey significantly expands lentil production.* Retrieved from https://www.producer.com/news/turkey-significantly-expands-lentil-production/

Turkish Statistical Institute (2021). *Data portal for statistics.* Retrieved from https://data.tuik.gov.tr/Kategori/GetKategori?p=tarim-111&dil=2

US Soy (2019). *Recapping the 2019 U.S. soybean crop results.* Retrieved from https://ussoy.org/recapping-the-2019-u-s-soybean-crop-results/

USDA (2016a). *Argentina oilseeds and products annual.* Retrieved from https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Oilseeds%20and%20Products%20Annual_Buenos%20Aires_Argentina_4-4-2016.pdf

USDA (2016b). *Turkish pulses market overview.* Retrieved from https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Turkish%20Pulses%20Market%20Overview_Ankara_Turkey_2-3-2016.pdf

USDA (2019a). *Crop Production Maps.* Retrieved from https://ipad.fas.usda.gov/ogamaps/cropproductionmaps.aspx

USDA (2019b). *Interdependence of China, United States, and Brazil in Soybean Trade.* Retrieved from https://www.ers.usda.gov/webdocs/outlooks/93390/ocs-19f-01.pdf

USDA (2019c). *Korea remains mature, steady market for oilseeds and products.* Retrieved from https://kr.usembassy.gov/wp-content/uploads/sites/75/KS-1905-Oilseeds-and-Products-Annual_3-5-2019.pdf

USDA (2019d). *Opportunities for US agricultural exports in Taiwan.* Retrieved from https://www.fas.usda.gov/data/opportunities-us-agricultural-exports-taiwan

USDA (2019e). *China – Peoples Republic of: Pulse Annual.* Retrieved from https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Pulse%20Annual_Beijing_China%20-%20Peoples%20Republic%20of_9-11-2019.pdf

USDA (2020). *Burma beans and pulses updates 2020.* Retrieved from https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Burma%20Beans%20and%20Pulses%20Updates%202020_Rangoon_Burma%20-%20Union%20of_06-04-2020

USDA (2021). *Statistics by subject.* United States Department of Agriculture. National Agricultural Statistics Services. Retrieved from https://www.nass.usda.gov/Statistics_by_Subject/index.php?sector=CROPS

USDA (2021a). *Oilseeds and Products Annual.* Retrieved from https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Oilseeds%20and%20Products%20Annual_Taipei_Taiwan_04-01-2021#:~:text=Taiwan%20relies%20on%20imports%20to%20meet%2096%20percent%20of%20its%20soybean%20demand.

USDA (2021b). *Oilseeds and products annual.* Retrieved from https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Oilseeds%20and%20Products%20Annual_Seoul_Korea%20-%20Republic%20of_03-01-2021

USDA (2021c). *2021 U.S. soybean outlook remains strong after record first quarter export volume.* Retrieved from https://www.fas.usda.gov/data/2021-us-soybean-outlook-remains-strong-after-record-first-quarter-export-volume

USDA (2021d). *India – food inflation concerns lead to the removal of import restrictions on select pulses.* Retrieved from https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=India%20-%20Food%20Inflation%20Concerns%20Lead%20to%20the%20Removal%20of%20Import%20Restrictions%20on%20Select%20Pulses_New%20Delhi_India_05-18-2021.pdf

USDA FAS (2022). United States Department of Agriculture – Foreign Agricultural Service. Retrieved from https://apps.fas.usda.gov/gats/ExpressQuery1.aspx?Source=homepage

USSEC (2021). *Non-GMO food-grade soybeans quantification study September 2021.* Retrieved from https://ussec.org/wp-content/uploads/2021/11/2021-Foodgrade-Soybean-Quantification-study-shareable.pdf

USTR (2020). *Taiwan.* Office of the United States Trade Representative. Retrieved from https://ustr.gov/countries-regions/china/taiwan#:~:text=Taiwan%20is%20currently%20our%209th,was%20%2430.2%20billion%20in%202020.

World Bank (2022). *The World Bank.* Retrieved from https://www.worldbank.org/en/home

World Grain (2019). *Brazilin soybean exports decline.* Retrieved from https://www.world-grain.com/articles/12551-brazilian-soybean-exports-decline

World Grain (2020). *Mexico soybean imports on the rise*. Retrieved from https://www.world-grain.com/articles/13600-mexico-soybean-imports-on-the-rise

World Grain (2022). *Severe drought lowers Turkey's wheat production.* Retrieved from https://www.world-grain.com/articles/16442-severe-drought-lowers-turkeys-wheat-harvest

APPENDIX A: SOYBEAN GROWING CONDITIONS

Growing Conditions

Crop Establishment

As with any agricultural venture, establishing a soybean crop takes careful planning and design to ensure that the final development maximises yield at an efficient cost. Crop establishment has been broken down into five core components:

- Land management – tillage method, residue, weed control and proximity to water sources. Zero tillage is the best method for developing sustainable soybeans farming (GRDC, 2016a). Soybeans are adapted to a range of soil types including sands to heavy clays (GRDC, 2016a).
- Environment – temperature variation, rainfall and adverse weather events
- Seedbed requirements – soil acidity, salinity and moisture
- Crop utilisation – use as either a single crop, double/multiple crop or rotation crop
- Infrastructure and service support – access to support services such as agronomic advisors, inputs and supply chain infrastructure (i.e. processors, transport, etc.)

Environment

Environmental considerations are as equally important as land suitability. Soybeans grow best in a warm and moist climate, naturally pertaining to being a summer crop. They can also be grown in winter where conditions are mild. Since this climate is applicable to many different environments, soybeans are commonly adapted to range of geographical regions.

When choosing a site for a soybean crop, the maximum and minimum temperatures should always be considered. A temperature between 26°C and 30°C is optimal for most varieties (Nimje, undated). Environments in which temperatures regularly exceed 35°C should be avoided, as this can reduce growth rates by killing rhizobia and emerging seedlings (GRDC, 2016a). Cooler conditions are unsuitable for soybean production, with temperatures below 18°C inhibiting growth (Nimje, undated).

Humidity levels are also a key factor due to their direct association with moisture content of the soybean. This is particularly important at harvest, where a lack of moisture can cause pod breakage.

Water Requirements

Production of soybeans requires adequate irrigation and/or areas in which there are substantial levels of rainfall (Soy Australia, 2011). In tropical production regions, particularly North and Central Queensland and comparable to that of the Rookwood catchment, soybeans produced in summer are usually grown on rainfall alone. It is common for irrigation to be undertaken to supplement growth if necessary. This is particularly the case in subtropical production regions in Southern Queensland and parts of Northern New South Wales.

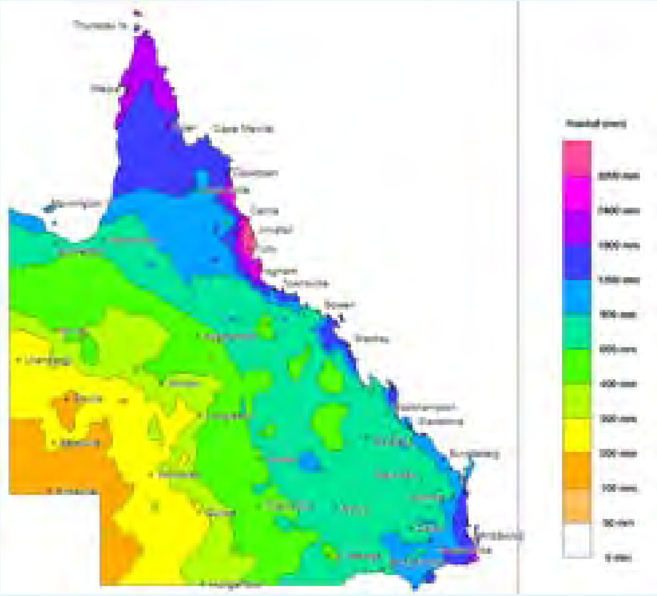
The ideal amount of rainfall in a growing season falls within the range of 500mm to 1000mm, with rainfall occurring roughly every three to four days (Nimje, undated). Growth can occur with as little as 180mm of rainfall throughout the entire growing season, however, yields would substantially decline. According to Figure A. 2 the Rookwood catchment area is expected to receive approximately 100mm of rainfall between March and May 2022 (BOM, 2022b). Thus, up to eight megalitres of irrigation water could be required in the summer FY2022 growing season in the region (GRDC, 2016a).

Irrigation is a necessity outside of the tropical and coastal regions, especially in Central to Southern New South Wales and Northern Victoria. High yielding soybeans that receive very minimal rain in their growing cycle typically use 6-8ML of irrigation water per Ha (GRDC, 2016a). Number of irrigations applied vary depending on season and soil type. Pre-irrigation of the field one to three weeks prior to planting is recommended (GRDC, 2016a).

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.

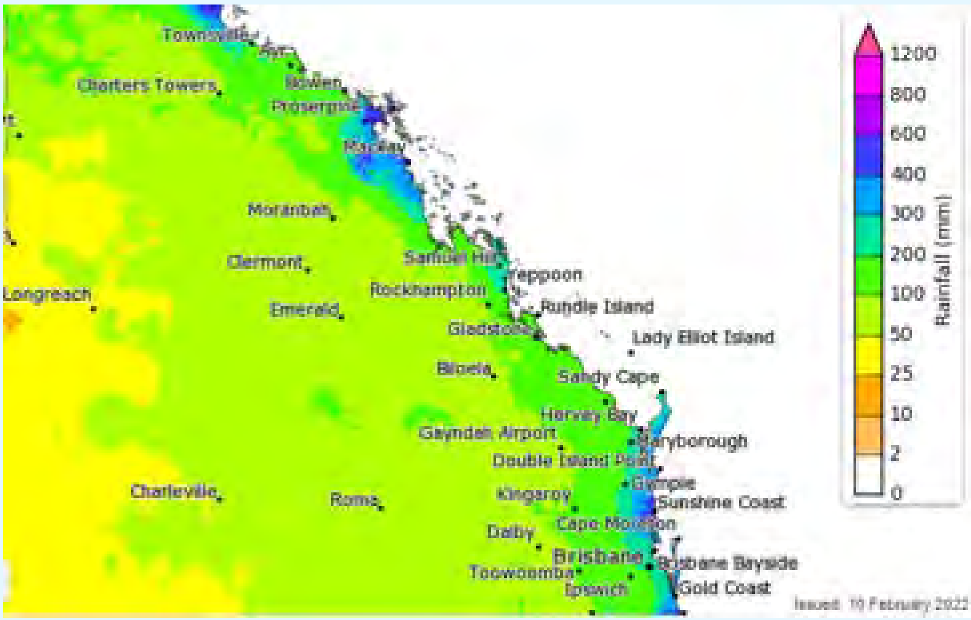
Figure A. 1. Rainfall Map Queensland, 2021



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

Soybeans are a short-term venture, with plants generally maturing roughly four to five months after planting (GRDC, 2016a). This makes the planting phase critical to the overall health and success of the crop.

The first major step in the planting process is inoculation, which essentially refers to the act of introducing microorganisms (i.e. bacteria) into the soil. Legumes form an interaction with a nitrogen-fixing soil bacteria called *rhizobia*. Correct inoculation of soybean seeds with rhizobia allows nodules to form on the roots of the plant, which are essential for fixing nitrogen from the atmosphere and ensuring successful plant growth. Since soybean plants have a high nitrogen requirement, inoculation of every soybean crop is highly recommended, as rhizobia is largely absent in Australian soils (GRDC, 2016a).

Key planting considerations for a typical summer soybean crop in conditions comparable to that of the Rookwood Weir Catchment Area are identified in Table A. 1 below. Recommendations may vary slightly depending on particular seasonal conditions and the type of variety used.

Table A. 1. Planting Recommendations for a Summer Soybean Crop in Rookwood Catchment

Consideration	Recommendation
Time of Planting	Mid to late December (for a May harvest)
Plant Population	250,000 to 300,000 plants per ha
Seed Requirements	50kg per ha
Row Spacing	50-75cm
Planting Depth	No more than 5cm – ideally as shallow as possible whilst allowing maximum contact between the seed and moist soil.

Note: Seed requirements assume a germination rate of 92%, establishment rate of 85% and average seed size of 6,400 seeds per kg.
Source: GRDC (2016).

Crop Management

A detailed overview of the various factors associated with soybean crop management is described in the table below.

Table A. 2. Managing Soybean Crops

Consideration	Description
Plant Growth	Plants should be around 35-45cm tall when flowering begins, which commences in response to lengthening hours of darkness. This has a strong influence on maturity time, plant height and yield. Irrigation is critical when the first full pod emerges.
Nutrition and Fertiliser	Soybean crops have a particularly high demand for nitrogen, phosphorous, sulphur and potassium. All nitrogen requirements can be established via inoculation; however, fertilisers are often required to achieve sufficient nutrient requirements for other key elements. Soil testing is essential to understand nutrient levels and achieve maximum economic yield.
Weed Control	Weeds compete with soybeans for moisture, nutrients and light. They are most effectively managed via a combination of chemical (herbicides) and non-chemical methods. Soybean plants are most sensitive to weed competition 4 to 7 weeks after emergence. As such, weeds should aim to be controlled as much as possible before planting.
Insect Control	While pest attacks can occur at any stage of growth, insect pests are most attractive from flowering onwards. Thus, non-selective pesticides should be avoided for as long as possible to foster a build-up of predators and parasites and as such, buffer the crop against pest attack at later growth stages. Major insect pests in soybeans are helicoverpa, pod-sucking bugs and the silverleaf whitefly. Soybeans also attract foliage-feeding pests such as loopers, leaf miners and the grass blue butterfly.
Nematode Control	Major nematode pests in soybeans are the *reniform* and *root-knot*. The *soybean cyst nematode* is the greatest pest of soybean worldwide, however, has not yet been found in Australia.
Diseases	Careful varietal selection, as well as thorough decomposition and incorporation of crop residues are key to minimising disease occurrences. Planting soybeans

Consideration	Description
	directly after other legumes or sunflowers should be avoided. Best practice strategies include maintaining farm hygiene and use of high-quality seed.
Crop Desiccation	If applying desiccant to accelerate the harvest, timing usually occurs when the grain is between 75 to 90% mature. Other reasons for application include to manage late-season weeds and to prevent seed set. Growers should proceed with caution when considering desiccation.
Environmental Issues	Planting in low lying areas should be avoided to prevent waterlogging of soil and potential flooding of the field. Seedling stems often die in temperatures above 35°C. Yields can also be affected in instances where either salinity or acidity are high.

Source: GRDC (2016a).

Rotational Cropping

Rotation cropping is important in the farming system as it reduces the risks associated with seasons and markets (GRDC, 2016a). When considering rotational cropping, it is important to look at the growing window for winter and summer crops. Soybeans are a summer crop and are considered to be ideal with rotations in broadleaf (legumes, canola, sunflower) and grass crops (maize, wheat, sugarcane) (GRDC, 2016a). Soybeans as a rotational crop can be beneficial as a number of uses including soybeans grown for grain, used for forage, hay or silage, or incorporated as a green manure (GRDC, 2016a).

Soybean rotational cropping with sugarcane has shown to provide a number of benefits, including (GRDC, 2016a):

- Reduced use of fertilisers with soybean residues releasing nitrogen slower
- Reduced tillage after the soybean crop
- Reduced weed seed populations with herbicides in soybean cropping that are not suitable for use in sugarcane crops
- Improved soil health and improved gross margins.

Harvesting

Harvest usually occurs 18 to 20 weeks after planting, at which around 95% of the pods are mature and grain moisture generally ranges from 13 to 18%. Once full maturity of the crop is reached, five to ten days of good drying weather are generally required for the grain to reach an ideal harvest moisture level of 12 to 14%, unless desiccation is undertaken. In order to maximise grain quality, harvesting should occur as soon as possible, as this will reduce risk of damage from wet weather or harvest losses from overdried grains (GRDC, 2016a).

The harvesting seasons of each growing region in Australia is highlighted in Table 2.5.

Post-Harvest Processing Activities

Soybeans are generally delivered to processors whole, making them susceptible to splitting and breakage when mechanically handled. They are then weighed, screened, gravity-graded, de-stoned, colour sorted and passed over by magnets and metal detectors, depending on the processor (Bean Growers Australia, 2021).

An advantage of legumes are that they can be stored for a fair period of time before being sold to retail food processors or in export markets. Storage may occur on the farm before processing and/or at the processing facility before moving along the supply chain. The storability of soybeans depends upon the degree of damage to the seedcoat, if any, which can promote insect pests and mould within the storage (GRDC, 2016a).

The figure below highlights the average composition of a typical soybean, demonstrating its use in various end markets.

Figure A. 3. Average Soybean Composition

Source: NC Soybean Producers Association (2019b)

APPENDIX B: CHICKPEA GROWING CONDITIONS

Growing Conditions

Crop Establishment

As with any agricultural venture, establishing a chickpea crop takes careful planning and design to ensure that the final development maximises yield at an efficient cost. Crop establishment has been broken down into five core components:

- Land management – tillage method, residue, weed control and proximity to water sources. Chickpeas prefer well-drained loams to self-mulching clays (GRDC, 2016b).
- Environment – temperature variation, rainfall and adverse weather events
- Seedbed requirements – soil acidity, salinity and moisture
- Crop utilisation – use as either a single crop, double/multiple crop or rotation crop
- Infrastructure and service support – access to support services such as agronomic advisors, inputs and supply chain infrastructure (i.e. processors, transport, etc.)

Environment

When selecting a site for a chickpea crop, the maximum and minimum temperatures should be considered. The three main factors which affect chickpea production is temperature, day length and drought (GRDC, 2016b). Unlike other winter legumes, chickpeas are rather susceptible to cold temperatures and frost damage, particularly at time of flowering (GRDC, 2016b).

Research from GRDC highlights that the average daily temperatures (day and night) are a more important measure than any specific effects of minimum and maximum temperatures (GRDC, 2017a). If the average daily temperatures are lower than 15 degrees Celsius then pollen viability is reduced (GRDC, 2016b). Pods which are in the later stages of development are more resistant to frost than flowers and smaller pods, however, they still may be impacted by mottled darkening of the seed coat (GRDC, 2017a).

Chickpea crops are also sensitive to heat stress, however, are more heat tolerant than other winter legumes (GRDC, 2017a). During spring (September to November), temperatures above 35 degrees Celsius will have an impact on flowering and yield potential by causing flower abortion (GRDC, 2016b). Drought stress is often associated with high temperatures in spring, resulting in immature pod sets and developing seeds and abortion of flowers (GRDC, 2017a). Additionally low light and high levels of humidity will prevent pod set (GRDC, 2017a).

There has been and continues to be investment in researching an improved chickpea to heat tolerance.

Water Requirements

Under dryland conditions chickpeas require more than 350mm of rainfall per annum, however, if there is adequate soil moisture present at sowing, lower rainfall is adequate (GRDC, 2017a).

For irrigated crops, GRDC (2017a) note key points including:

- Select fields with good layout and tail water drainage
- Avoid high bulk density or high clay content soils that do not internally drain quickly
- Avoid acid, saline, or sodic soils
- Pre-irrigate or water-up to fill the soil profile wherever possible
- Irrigate early at 60-70% of field capacity to avoid crop stress and soil cracking.

Irrigated is common in northern Australia where chickpea is grown in rotation with other irrigated crops (GRDC, 2017a). Irrigated sites are sensitive to waterlogging; therefore, it is important to ensure chickpeas have well drained soil. Generally irrigated chickpeas require one tonne per ML water supply per Ha (GRDC, 2016b), for the purpose of analysis, an average rate of 1.5ML per Ha as indicated by the chickpea Agmargins produced by DAF (2020).

Combined with well managed crops, irrigated chickpeas have the potential to yield over 3.5 tonne per Ha (GRDC, 2017a).

Planting

Similar to soybeans, the first major step in the planting process is inoculation. Chickpeas did not originate from Australia and therefore require to be inoculated with a specific strain of *rhizobia* (symbiotic N-fixing bacteria) before planting (GRDC, 2016b). A key summary of planting from GRDC (p.101, 2017a) is provided as follows:

- The strain of *rhizobia* used for inoculating chickpeas is highly specific (Group N, CC1192). Inoculation is essential for effective nodulation and will result in a crop that is self-sufficient for N and provide soil health benefits in subsequent seasons
- All seed, regardless of source, should be treated with a registered thiram-based fungicide seed dressing prior to sowing
- The sowing window in many favourable areas tends to be after cereals and other pulses. Early sowing (even dry sowing) is common in the lower rainfall areas
- While yields are relatively stable within the range of 35-50 plants/m^2, higher seeding rates (50 plants/m^2) produce the highest yields in western and southern area
- Sowing at 30-50 cm spacing is becoming common. Some innovators are sowing in 50-100 cm row spacing into standing cereal stubble and using inter-row spraying for weed control.
- Sow chickpeas 5-7 cm deep into good moisture. The seedlings are robust, provided high quality seed is used. There are also benefits to deep-planting chickpea.

The table below provides summarised planting recommendations.

Table B. 1. Planting Recommendations

Consideration	Recommendation
Time of Planting	Mid-May to mid-June (see Table 3.4, Table 3.5 and Table 3.6 above for optimal sowing times in different areas).
Plant Population	35-50 plants/m^2. Reports from Agriculture Victoria suggest that the Desi varieties will be planted around 40-50 plants/m^2 while Kabuli varieties will be planted around 25-35 plants/m^2 (2022).
Seed Requirements	Seeding rates vary by variety. For further information refer to GRDC's grow notes for chickpeas.
Row Spacing	Chickpeas grow with a variety of row spacing ranging from 20-100 cm. Wider row spacing of 50-100 cm is becoming more common.
Planting Depth	The general planting depth is 5-7 cm. Although, chickpeas can be planted from 5-20 cm according to seasonal conditions.

Source: GRDC (2016b), GRDC (2017a).

Crop Management

A detailed overview of the various factors associated with soybean crop management is described in the table below.

Table B. 2. Managing Chickpea Crops

Consideration	Description
Plant Growth	With optimum moisture and temperature conditions, chickpea seeds will soak up water quickly and germinate within a few days. This is if the temperatures are not below 0 degrees Celsius. Desi chickpeas generally incur less damage from low temperatures at germination over Kabuli varieties. Emergence usually occurs 7-30 days after sowing (depending on moisture, temperature and depth of sowing). Chickpeas will germinate, mature, deteriorate and die within 100 to 225 days of sowing. The plant is usually 15-60 cm in height, but can reach up to 80 cm.
Nutrition and Fertiliser	It is important to understand the visual signs of nutritional problems which will be present if the condition is extreme. Primary nutrients include nitrogren and phosphorous. Nitrogen is the main nutrient of consideration in chickpea crops. Phosphorous is also required, however, chickpea is not as responsive to this fertilizer as other pulse crops. Phosphorus influences the nodule growth rate and around 2 tonnes of chickpea per Ha require approximately 6.5 kilograms of the fertiliser per Ha. Soil testing is essential to understand nutrient levels and achieve maximum economic yield.
Weed Control	Before planting takes place, it is important to consider weed management practices, both chemical and non-chemical. Chickpeas battle with weeds, with the critical period of interferences suggested between 35 and 49 days after emergence. To sustainably reduce weeds in chickpea crops, management must be completed before the chickpea emerges. Post-emergence weed control have limited options. By large, chickpeas should remain weed free from 17-60 days after emergence, any weeds outside this time is unlikely to significant impact yield.
Insect Control	Chickpeas produce malic acid and are therefore more tolerant to most insects (including redlegged earth mite, lucerne flea and aphids) than other pulses. Key pests for chickpea and crop susceptibility to damage is highlighted below: • RLEM, lucerne flea, cutworms and aphids are damaging during the emergence/seedling stage in the southern and western regions. In the northern region, the false wireworm, cutworm and the blue oat mite are damaging during the emergence/seedling stage. • In the northern region, aphids are damaging during the vegetative and flowering stages. • Native budworm (Helicoverpa punctigera) is damaging during the podding and grainfill stages for the southern and western regions. Generally Helicoverpa is damaging in the northern region during the podding and grainfill stages. Regular monitoring is required to determine the need for insecticides.
Nematode Control	The nematodes are common pests which are located in the soil and feed on roots. Root-lesion nematodes are microscopic animals that extract nutrients from the crop and result in yield loss. The most common specie found in the northern region is *Pratylenchus thornei* and *P. neglectus* and are found in soils ranging from heavy clays to sandy soils. These animals are largely found in wheat.
Diseases	Key diseases for chickpeas include as highlighted in the GRDC northern grow notes: • Asocohyta blight: water-splashed spores • Botrytis grey mould: airborne spores • Phytophthora root rot: waterborne spores • Sclerotinia rot: airborne spores or directly into crowns. Disease management involving paddock selection, variety choice, strategic fungicide uses and crop hygiene. Management options include: • Crop rotation and paddock selection • Reducing proximity to previous seasons chickpea stubble • Growing resistant varieties • Using clean seed and fungicide seed dressings • Regular crop monitoring

Consideration	Description
	• Strict hygiene on and off farm • Strategic use of foliar fungicides.
Crop Desiccation	Key notes of crop desiccation are provided by GRDC (p. 401, 2017a): • Chickpeas often mature unevenly and require herbicides to ripen more evenly • Desiccation assists production by removing the late weeds such as thistles which can stain the seed. This allows for earlier harvesting which lessens the weather risk at harvest and browning out green stems • Desiccation should occur when 80-85% of the seeds in the pod have turned yellow and are firm and the remaining 15-20% have yellow 'beaks' on the seed or are starting to turn colour • After desiccation, plants become more brittle, so it is advised not to delay harvest.

Source: GRDC (2016b), GRDC (2017a, b), IPM (2017).

Rotational Cropping

Generally, pulse crops are complementary in a cropping rotation, however, there are no set rules in determining the most suitable cereal-pulse-oilseed rotation (GRDC, 2016b). There is careful planning required when determining rotation crops and the same pulse should not be grown after the next (GRDC, 2016b). There should be extreme care taken when the same crop is grown in the same paddock for at least three years (GRDC, 2016b).

There are benefits of chickpea production with wheat including improved soil friability, expanded weed-control options, a break for diseases such as crown rot in wheat, improved nitrogen supply for cereal crops and improved soil health (GRDC, 2016b). The risks for chickpea rotation with wheat includes poor weed competition and nematodes (GRDC, 2016b).

Harvesting

Traditionally, the chickpea harvest was delayed until the harvest of wheat has taken place, however, this can result in significant yield and quality loses. A harvest that is slightly early or on time has the potential to increase returns by up to 50% (GRDC, 2017a).

The harvest timing depends on moisture content of the chickpea that is acceptable for storage. Storage requirements are "influenced by who is purchasing the grain and whether aeration is available in the storage" (GRDC, p. 319, 2017a). The ideal harvesting moisture content for chickpeas is between 13-15% (to reduce cracking), with the maximum moisture content for grower receivals at 14% (GRDC, 2017a).

Post-Harvest Processing Activities/Storage

When storing chickpeas, good hygiene and aeration cooling (to manage the storage temperature and moisture) is key to prevent damage from mould and inspections. It must be noted that the quality of chickpeas continue to deteriorate over time as they continue to age. Notably, Desi chickpeas that are in storage will darken significantly which is accelerated by high temperatures, humidity, seed moisture content (GRDC, 2017a).

To control pests in silos, fumigation is the only option that is available (GRDC, 2017a). This requires gas-tight, sealable storage silos. For more information on post-harvest processing activities, refer to section 5.5.

APPENDIX C: MUNGBEAN GROWING CONDITIONS

Growing Conditions

Crop Establishment

As with any agricultural venture, establishing a mungbean crop takes careful planning and design to ensure that the final development maximises yield at an efficient cost. Crop establishment has been broken down into five core components:

- Land management – tillage method, residue, weed control and proximity to water sources. Mungbeans are well suited to no-till lands as it increases the efficiency of storing moisture and reduces the risk of crop failure (GRDC, 2014). Mungbeans are suited well-drained with a loam soil (GRDC, 2014).
- Environment – temperature variation, rainfall and adverse weather events
- Seedbed requirements – soil acidity, salinity and moisture
- Crop utilisation – use as either a single crop, double/multiple crop or rotation crop
- Infrastructure and service support – access to support services such as agronomic advisors, inputs and supply chain infrastructure (i.e. processors, transport, etc.)

Environment

When choosing a location for mungbean production, it is important to consider cropping in warmer and drier climates. Mungbeans are generally regarded as being chill sensitive, with temperatures below 15 degrees Celsius known to impair the cell structure and the function (GRDC, 2014).

Emergence of the mungbean crop occurs when the base soil temperatures reach 10.5 degrees Celsius. The optimum temperature for seed germination and plant growth occurs at around 28 to 33 degrees Celsius (GRDC, 2014).

Factors that impact on the key growth stages of mungbean include (GRDC, 2014):

- Daylength, impacting on flowering times. The further south the crop is planted, the more likely flowering will be delayed.
- Temperatures impact on flowering times. The warmer temperatures generally speed the crops development; however, yields drop significantly when temperatures exceed 33 degrees Celsius.

Water Requirements

Mungbeans require soils that are well drained with a medium to heavy texture and the crops do not tolerate waterlogging or soil compaction (GRDC, 2014). When considering dryland cropping, it is important to identify the amount of plant available water (PAW) in the soil. Paddocks with less than 100mm of PAW will generally produce unprofitable crops and paddocks with this amount of stored soil water is best left unplanted and fallowed through to another crop (GRDC, 2014).

Irrigation management is crucial for mungbean crops and spray irrigation allows a smaller and more frequent amount of water to be applied to the crop. It is estimated that mungbeans require 3.5 to 4.5 ML of water per Ha. If furrow irrigation is being exercised, water should be applied in four to eight hours and therefore shorter runs are preferred (GRDC, 2014). The faster irrigation is important to minimise waterlogging and subsequently crop death.

For more information regarding dryland and irrigated cropping, refer to mungbean grow notes as highlighted by GRDC (2014).

Planting

The table below provides a summary of the key planting recommendations for mungbean crops. For a more detailed description of time of planting refer to Figure 4.9.

Table C. 1. Planting Recommendations for a Mungbean Crop

Consideration	Recommendation
Time of Planting	Two main planting seasons of spring and summer. Summer is more conventional.
Plant Population	20-30 plants/m^2 in dryland crops and 30-40 plants/m^2 for irrigated crops
Seed Requirements	Seed requirements are very dependent on variety. For more information refer to mungbean grow notes from GRDC.
Row Spacing	Suitable for anywhere in between 18 to 100cm. Trends have been moving towards 50 to 100 cm due to ease of configuration for machinery used on other crops.
Planting Depth	30-50mm

Source: GRDC (2014).

Crop Management

A detailed overview of the various factors associated with the mungbean crop management is described in the table below. The Australian mungbean industry and the associated breeding program has a focus on higher value mungbean with a shiny bright green colour and a smooth outer layer of the seed coat (GRDC, 2014).

Table C. 2. Managing Mungbean Crops

Consideration	Description
Plant Growth	Mungbean is a legume crop, grown for high protein edible seeds for human consumption. The plant grows from anywhere between 40 to 125cm tall. Mungbeans are a short duration crop which usually flower within 30 to 60 days of planting. In Central Queensland, the mean flowering time for a crop planted in December is approximately 41 days. Mungbeans are self-fertile and highly self-pollinated with pods maturing around 20 days after flowering. The key growth stages include emergence, Cotyledon, first node, second node, third node, fourth node, N-node, start flowering, beginning pod, beginning seed, full seed, beginning maturity, 50% black pod (50% maturity), 90% black pod (90% maturity).
Nutrition and Fertiliser	Fertiliser applications are dependent on a number of factors including soil test results, yield potential, fallow length and paddock history. Mungbean growth is generally dependent on beneficial fungi for phosphorous and zinc from the soil. The fungis is depleted by long fallows, or by canola and lupin crops (which do not grow the fungis). Nutrient removal and crop requirements for one tonne of grain are highlighted in the table below: • Nitrogen: 35-40kg/Ha removed in grain, 60-70kg/ha total crop requirement • Phosphorous: 3-5kg/Ha removed in grain, 6-9kg/ha total crop requirement • Potassium: 12-14kg/Ha removed in grain, 45-50kg/ha total crop requirement • Sulfur: 2-2.5kg/Ha removed in grain, 3-7kg/ha total crop requirement • Calcium: 18-30kg/ha total crop requirement • Magnesium: 8-13kg/ha total crop requirement
Weed Control	Weeds compete with mungbeans for moisture and interfere with harvesting. The limited broadleaf herbicide options are available; therefore, growers should select paddocks clean of these weeds. Prior to planting, it is important to consider the previous herbicide usage on the paddock. For late season control of weeds, desiccation can provide a degree of control.
Insect Control	To support the quality of mungbeans, the crops should be inspected weekly from vegetative stage through to budding and twice a week thereafter from flowering to podfill completion. "The preferred method for insect checking is to use a beat sheet between rows to identify, monitor and count insect numbers" (GRDC, p. 121, 2014). Major pests include mirids, *Heicoverpa,* podsucking bugs, bean pod borer and lucerne seed web moth. It is important for the grower to understand when the mungbean crop is most susceptible to insect pests. This is usually from budding onwards which in Central Queensland can occur as early as 28 to 35 days after planting.
Nematode Control	Major nematode pests which impact the mungbean crop is root-knot nematodes and RLN. The worm like animals cause yield losses by extracting nutrients from plants. "Intensive cropping of susceptible species, particularly wheat, will lead to an increase in RLN levels" (GRDC, p. 190, 2014). To reduce the damage caused by RLN, the key is to rotate crops with resistance species. The above ground

Consideration	Description
	symptoms of RLN include poor establishment stunting, yellowing of lower leaves and poor tillering.
Diseases	Key diseases which are impacting mungbean production in New South Wales and Queensland include: • Tan spot • Halo blight • Powdery mildew • Charcoal rot • Fusarium root rot, puffy pod and gummy pod • Root-lesion nematodes • *Tobacco streak virus* (Central Queensland only, 2010) Table C. 3 below provides management options for halo blights, tan spot, powdery mildew and charcoal rot. It is important to focus on integrated disease management.
Crop Desiccation	Mungbeans do not have a defined flowering period and can have flowers, green pods and black pods on the plant at the same time. When around 90% of the pods have turned black then the crop has reached maturity and the crop is ready for a desiccant application of direct harvest. Desiccation is an important process to minimise seed staining and dry the crop before commencing harvest.
Environmental Issues	Key environmental issues for the mungbean crop include sensitivity to low temperatures and excessive waterlogging. Crops which are waterlogged for more than five days are subject to the root nodules dying and nitrogen-deficiency problems.

Source: GRDC (2016).

Table C. 3. Impact of Different Management Options

Management Option	Halo blight and tan sport	Powdery mildew	Charcoal rot
Rotation	✓	x	✓✓✓
Residues	✓	x	✓
Volunteers, Alternative hosts	✓✓	✓✓	✓✓
Clean seed	✓✓✓	x	x
Quarantine	✓✓	x	x
Hygiene	✓✓	x	x
Resistance, tolerance	✓✓✓✓	✓✓✓✓	x
Fungicides	x	✓✓	x

Note: The number of ticks assigned to each management option by disease combination in an assessment of the relative impact of that management option on the specific disease.
Source: GRDC (2014).

Rotational Cropping

Mungbeans are grown best in rotation after a cereal crop and can be double cropped "immediately following a winter cereal harvest, as a short fallow (6 months) following sorghum, or after a long fallow (18 months) from a winter cereal crop" (GRDC, p. 17, 2014).

Although mungbeans are a short-term crop (approximately three-month growing period), the crop is not considered an ideal choice for rotational cropping with sugarcane particularly in the north coast or the south (GRDC, 2014; SRA 2019).

Harvesting

For maximum yield potential, the ideal time for harvest is when around 90% of the pods have changed colour from yellow through to black (Australian Mungbean Association, undated a). At this point the crop is ready for desiccation and harvest.

Desiccation is key to minimise the level of seed staining, which is known as the most important issue impacting mungbean quality and returns to growers (GRDC, 2014). If the crop is impacted by seed staining, then the potential loss to growers can range between $100 and $300 per tonne (GRDC, 2014). Staining occurs when the sap from the crop forms a film over the seed during harvest, which attracts dust (GRDC, 2014). Not only does this build-up of sap and dust impact on end market quality, but is can also cause blockages inside the header during harvest (GRDC, 2014).

The GRDC (2014) grow notes highlights that "the decision not to use a desiccant is warranted only in situations where the crop has dried down naturally because of terminal drought stress" (p. 230). The Satin variety is less prone to staining damage as it has a naturally dull seed coat and dried down evenly (GRDC, 2014).

In commercial mungbean crops, harvesting is a key management issue that affects the overall profitability. Crop losses can exceed 30% due to a number of factors including (GRDC, 2014):

- Pods detaching or shattering due to the shaking motion as plants are being cut
- Lodged or uncut pods which remain attached to the stubble.

The harvesting losses can be reduced by double-cut knife guards, extension fingers, reduced ground speeds of 6 to 7 km/h, air fronts and vibra-mat (GRDC, 2014).

Post-Harvest Processing Activities/Storage

Mungbeans can be stored on farm, providing growers with flexibility regarding timing of sale to best suit market conditions. There are a number of factors which impact on the quality of the grain through storage, including:

- Moisture: Pulses which are harvested with a moisture content more than 14% must be dried before storage. Generally, "every 1% rise in moisture content above 11% will reduce the storage life of pulse seed by one-third" (G Cumming et al. as cited in GRDC, p.239, 2014).
- Temperature: High temperatures will cause deterioration in grain viability. The optimal temperature for storing mungbeans should be less than 20 degrees Celsius and should not exceed temperatures over 25 degrees Celsius. For every 4 degree rise in storage temperature will halve the storage life of the grain.
- If the mungbean is exposed to field withering before harvest, then the crop will deteriorate a lot quick in storage, even under optimal conditions. The storage of weathered crops should be avoided.

Mungbeans are sold in three main grades, including sprouting, cooking and processing (GRDC, 2014). Most of Australia's mungbean production (approximately 80%) is utilised in the processing market, with only a very small proportion achieving price premiums in the sprouting grade (less than 10% of all mungbean produced) (GRDC, 2014). For cooking, sprouting and No 1 Processing classifications the mungbeans must be bright in colour with no discolouration, staining, dust or wrinkles (GRDC, 2014).

The table below highlights the mungbean varieties which meet the requirements for each grade.

Table C. 4. Mungbean Grades and Varieties

Mungbean Grades	Varieties that meet criteria	Test required
Sprouting	• Berken • Emerald • Regur • Satin II • White Gold	• Appearance • Size range • Purity, moisture • Germination • Oversoaks • Charcoal rot • Microbiological • Physical sprout test
Cooking	• Berken • Crystal • Emerald • Regur • Satin II • White Gold	• Appearance • Purity • Moisture • Size range

Mungbean Grades	Varieties that meet criteria	Test required
Premium and No 1 Grade	• Celera • Green Diamond	• Appearance • Purity • Moisture • Size range
No 1 Processing	• Berken • Crystal • Emerald • White Gold	• Appearance • Purity • Moisture • Size range
Processing (all varieties)	• Berken • Celera • Crysal • Emerald • Green Diamond • Regur • Satin II • White Gold	• Appearance • Purity • Moisture
Manufacturing	All varieties	• Purity • Moisture

Note: Premium grade normally make it into the sprouting market.
Source: GRDC (2014).

APPENDIX D: LUCERNE GROWING CONDITIONS

Growing Conditions

Crop Establishment

As with any agricultural venture, establishing a lucerne crop takes careful planning and design to ensure that the final development maximises yield at an efficient cost. Crop establishment has been broken down into five core components:

- Land management – tillage method, residue, weed control and proximity to water sources
- Environment – temperature variation, rainfall and adverse weather events
- Seedbed requirements – soil acidity, salinity and moisture
- Crop utilisation – use as either a single crop, double/multiple crop or rotation crop
- Infrastructure and service support – access to support services such as agronomic advisors, inputs and supply chain infrastructure (i.e. processors, transport, etc.)

Environment

Lucerne grows best in relatively mild conditions and is suited to subtropical and temperate climates. On average, optimum temperatures for production in a dryland system range from 15°C to 25°C during the day and 10°C to 20°C at night, although this can vary somewhat based on the winter activity rating of the cultivar (Pastures Australia, 2008).

Extreme air temperatures and weather patterns will inhibit growth, especially in the presence of frost or hot conditions for extended periods.

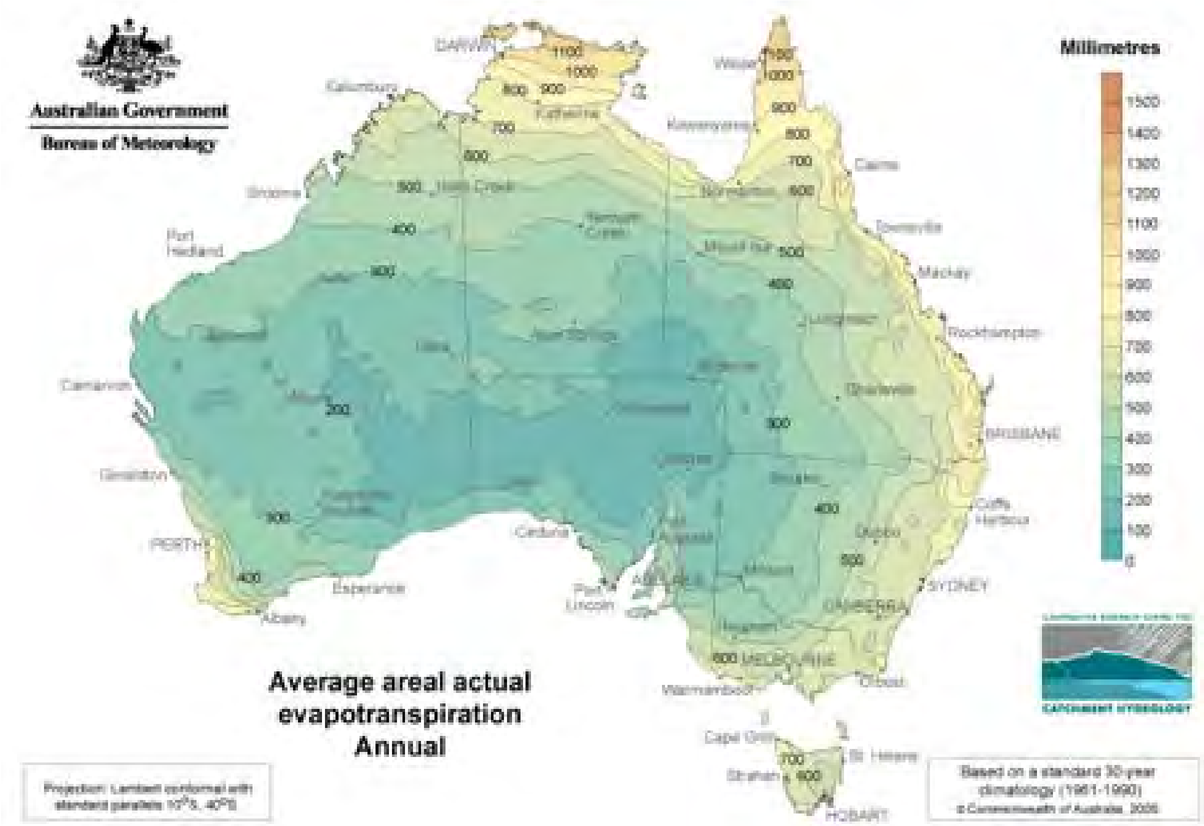
Water Requirements

In rain grown stands in the subtropics, lucerne grows in areas that receive 500 to 1200mm of annual rainfall. In areas of southern Australia and Western Australia where the climate is more temperate, the range is around 250 to 800mm (Pastures Australia, 2008). Despite this, the plant can survive with a minimum of 300 to 400mm of annual rainfall. In general, lucerne has good drought tolerance and is well suited to irregular rainfall patterns but will begin to go dormant in extended dry periods (Government of Western Australia, 2018).

Farms with irrigation systems are most commonly involved in fodder production. If growing primarily for the purposes of hay and silage, the irrigation requirement is approximately seven to thirteen megalitres per hectare. While seed production enterprises operate successfully in south-east South Australia with roughly 400 to 600mm of rainfall per year, most setups will plan for the application of about four to eight megalitres of irrigation water per Ha (AgriFutures, 2017a).

The average annual evapotranspiration in the Rockhampton region is approximately 900 millimetres per year. Comparing Figure A. 1 and Figure D. 1, Rockhampton (on average) may experience a net rainfall deficit. This indicates that the available water from irrigation maybe lower than expected and reserves or production sizing may need to be structured to enable continuous production.

Figure D. 1. Average Annual Evapotranspiration



Source: BOM (2005).

Planting

Similar to most legumes, the first major step in the planting process is inoculation. Lucerne requires seed to be freshly inoculated with Group AL rhizobia (symbiotic nitrogen-fixing bacteria) and lime coated before planting (Pastures Australia, 2008).

Lucerne is often sown as a pure sward (community of pasture plants) and is very competitive. If sown at a low rate, it can grow with a variety of species such as annual medics, Phalaris and certain types of tall fescue to boost winter production (Pastures Australia, 2008).

Key planting considerations for a typical lucerne crop in conditions comparable to that of the Rookwood Weir Catchment Area are identified in the table below. Recommendations may vary slightly depending on particular seasonal conditions and the type of variety used.

Table D. 1. Planting Recommendations

Consideration	Recommendation
Time of Planting	March or April
Sowing Rate	As a single species: • 2-12 kg/ha for dryland hay or grazing (depending on annual rainfall) • 8-20 kg/ha for irrigated hay production In a mixture: • 0.25-1 kg/ha in a grass pasture (depending on makeup of legume component of the stand)
Soil Requirements	Requires deep, well-drained soils (sands to moderately heavy clays) with a slightly acid to alkaline pH. Intolerant of high levels of exchangeable aluminum and short periods of waterlogging.
Planting Depth	1-2 cm

Source: Pastures Australia (2008).

Crop Management

A detailed overview of the various factors associated with lucerne crop management is described in the table below.

Table D. 2. Managing Lucerne Crops

Consideration	Description
Nutrition and Fertiliser	Key nutrients need to be maintained at the following levels: • Potassium: 3 mg/kg • Phosphorus: 25 mg/kg • Sulphur: 10 mg/kg Maintenance fertiliser should be applied regularly in irrigated lucerne where large quantities of nutrient are removed in hay. Aluminum toxicity can occur on soils with a pH below 5.5 (in water) or 4.7 (in calcium chloride). In more marginal fertility soils, nutrients such as magnesium, manganese, zinc, molybdenum, boron and copper may be required.
Weed Control	Low weed potential (in keeping with its inability to spread). Herbicides can be used to take out weeds selectively or applied pre or post planting to tackle at different stages of crop development.
Insect Control	Any variety sown in Australia should be resistant to spotted alfalfa aphid, with resistance to blue green aphid also recommended. Other key pests to monitor and control if detected include red-legged earthmite, lucerne flea, aphids and weevils. There are also pests that may be endemic to different growing regions.
Diseases	Major diseases to control include phytophthora, anthracnose, bacterial wilt and stem nematode. Disease is more commonly prevalent under irrigated conditions.
Grazing/cutting	Timing should be matched to the build-up of carbohydrate reserves in the plant's roots, which reach their maximum around 4-8 weeks after the previous defoliation, depending on time of year and winter activity rating. Cutting for hay is best done at 10% flower or when the basal shoots are 3-5 cm in length. Lucerne is recommended to be rotationally grazed for long-term persistence, whether grown as a pure stand or in mixed swards.

Source: Pastures Australia (2008), AgriFutures (2017a).

Harvesting

Pasture

The "harvest" for lucerne pasture is grazing by livestock. A lucerne stand should not be grazed until full flowering in its first year of establishment as this will allow for energy reserves of the roots to be replenished, thus allowing the plant to withstand more intensive grazing in future seasons. It is ideally suited to rotational grazing, where the paddock is divided into grazing units and livestock are rotated through the different units and/or other pasture types that may be available (AgriFutures, 2017a). If carefully managed, lucerne crops can last several seasons for grazing purposes.

Fodder

A lucerne fodder "harvest" pertains to the production of either lucerne hay or silage.

Lucerne is cut for hay when around 10% of the stems have open flowers. The earlier the cut, the higher the quality of fodder but the lower the yield. While yields can range for each individual cut, it generally declines with successive harvests. Harvest of lucerne hay involves mowing, curing, conditioning, raking and finally bailing. Hay moisture should always be monitored throughout the process to ensure a high-quality product that stores well and is not susceptible to mould or overheating (AgriFutures, 2017a).

Lucerne is cut for silage between the stages of full bud and the commencement of flowering. Likewise with hay, a trade-off exists between fodder quality and yield depending on the timing of the cut. Lucerne is suited to the production of bulk (pit) and bailed silage. Harvest involves mowing, wilting, windrowing and packaging. Stands used for silage production should be allowed to flower at some stage of the growing season to allow replenishment of plant root reserves and maintain productivity (AgriFutures, 2017a).

Seed

Lucerne seed is harvested five to six weeks after pollination and will usually be either swathed or desiccated in preparation. The crop is harvested with a combine before sent to processing facilities.

Post-Harvest Processing Activities

Fodder

Lucerne hay should be stored undercover to protect it from outdoor weather and ensure its quality and colour (which is especially important for retail markets). Farm storage facilities can range from purpose-built, fully enclosed sheds with waterproof flooring to less-permanent structures such as polypropylene igloos. Temporary in-field storage under a tarp should only be implemented if absolutely necessary and if weather conditions are favourable (AgriFutures, 2017a).

After harvest, lucerne silage undergoes a process of ensiling, where it is wrapped in plastic and transferred to earthen pits for fermentation. To ensure the highest quality, the correct dry matter content must be established and subsequently stored in airtight conditions. Individual bales can be stored for around a year, while pit silage often lasts around three to five years (AgriFutures, 2017a).

Seed

Seed harvests are generally transported from the farm to cleaning and storage facilities, with growers owning the facilities in rare instances. Seeds undergo a process of cleaning and grading before they are sent to market to remove any impurities and ensure quality. After this, seeds are then bagged and sent to their respective end-market. If destined for domestic markets, cleaned outputs may also require scarifying before being sent to reduce hardness levels. This is less of a concern if destined for export markets as the product may not be shipped for several months, thus allowing sufficient time for hardness levels to drop (AgriFutures, 2017a).

If lucerne seed is to be sold as certified seed, it must be cleaned by an accredited seed cleaner. While mobile cleaning units are available, the process is almost always undertaken at a centrally located facility. Before being bagged, an accredited seed sampler will sample the contents to test for purity and germination. If certified, the bag will contain its own certification tag. This is particularly relevant if bound for export, as it instils confidence in international markets as to the genetic integrity and varietal purity of the seed (AgriFutures, 2017a).

APPENDIX E: FINANCIAL MODELLING CONVENTIONS

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 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). All costs presented in the following sections are in nominal terms (i.e., accounts for inflation), unless otherwise stated.

Table E. 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)

Crop Rotation

Crop farming takes many structures and shapes, such as either a monoculture or polyculture method. As the names suggest, monoculture and polyculture differ due to the number of crops farmed in a single season. Polyculture farming can include practices whereby multiple crops are planted in a single field whereas monoculture is a practice where one crop is planted at time. Often, monoculture farmers will continually farm the same crop, season after season.

Monoculture farming can present a plethora of challenges for farmers which must be managed through adopting appropriate farming practices. These include an increase reliance (and expenditure) on fertilisers to ensure soil health enables effective growth. Similarly, there is often an associated pesticide expense due to potential decreased biodiversity. In contrast, monoculture does allow for increase efficiencies of machinery and infrastructure use, potentially lower asset requirements given less variety of crops produced.

Capital Investment

Rotational cropping farm establishment requires three key capital investments, the land, the on-farm infrastructure and associated equipment (including storage), and the horticultural crop.

Farm Establishment Costs

Farmland and Acquisition Costs

Land suitability analysis shows each property within the Rookwood Weir Catchment Area has on average 197 available hectares suitable for growing rotational crops. At a 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 rotational cropping production is approximately $771,642 in nominal terms. In the analysis presented, the cost of land has not been included as it is assumed the landholders of the example farms are already owned by the landholder.

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 will need to be cleared and prepared for farm 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.

For the example farm, the infrastructure and equipment will cost an estimated $2.8 million. This investment includes the following:

- **Irrigation infrastructure and equipment** – this assumes the irrigation method will be centre pivots and includes the necessary pumps, pipes, centre pivots and soil monitoring equipment. Most costs (such as the pump) are a fixed cost and will be required irrespective of the planted land, whereas other irrigation costs (including the centre pivots, and the quantity of pipe required) are determined by the planted hectares.
- **Production equipment** – equipment and machinery included in the production of crops include the cultivation and harvesting equipment. Cultivation and harvesting equipment are those associated with the planting, growing, and harvesting include a sprayer, air seeder, leveller, plougher, and combine harvester.
- **Storage and other infrastructure** – this asset group includes storage facilities for the harvested crop (silos) and any relevant grain elevators, as all as general storage sheds.

All infrastructure and equipment costs are assumed to be a combination of new and second-hand equipment with costs quoted from sites such as Farm Machinery Sales (https://www.farmmachinerysales.com.au/items/), Farm Tender (https://www.farmtender.com.au/), and John Deer (https://www.deere.com.au/en/).

Soybean and wheat are likely to mostly find synergies in the equipment required on farm. Both commodities are expected to utilise the same on-farm infrastructure, including the irrigation system, farm vehicles, and combine harvester and other harvesting and planting equipment. The wheat rotation will likely have an impact on the quantity of bulk bins and silos depending on the farm management process, namely the amount of time the produce is stored on farm prior to distribution. This will be influence by whether the produce is to be sold for export or domestic use.

For the purpose of analysis, two guiding assumptions have been made. The first is that all centre pivots are fixed and are not able to be relocated across the farm. Individual farms may be able to reduce the capital required for irrigation through investing in travelling centre pivots. Secondly, all harvested pulse and grain is assumed to be stored on-farm until transport to milling facilities. The effect of this assumption is two-fold: first the farm will incur a higher capital expense to establish appropriate on-site farm infrastructure, and secondly, will have a lower operating expense associated with storage.

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, 2021c). 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 weather 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 a 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).
- **Plants** – As a horticultural asset, the planted crop will 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, except for plants which have an effective life less than three years. Where this is the case, the entire capitalised value can be written off in full, from the first year in which the commercial season starts.

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.

Operating Structure

Ownership 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 much higher average labour cost, on average 30-50% higher. It is assumed that the farm manager (the owner) will pay themselves through paying all positive net profit after tax (NPAT) positions paid out as a dividend to the farm owner. These dividends are paid out on an annual basis at the end of the financial year.

Operating Expenses

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 harvested (either when at maximum production or within that period), a share of revenue, or an annual fixed cost. Each operating cost for soybean and their cost driver are listed in the following tables.

Table E. 2. Soybean Operating Costs

Operating Cost	Cost Driver	Cost per Driver (Real $FY2021)
Non-Labour Operating Costs		
Operation: Self-propelled sprayer FORM	Planted Ha	$6.00
Herbicide: Glyphosate 450 CT	Planted Ha	$47
Nutrition	Planted Ha	$45
Crop Protection	Planted Ha	$90
Water	ML Applied	$25
Labour Operating Costs		
Harvesting	Planted Ha	$43
Overhead Operating Costs		
Levies	Revenue	1.0%
Consultants	Planted Ha	$9.00
Insurance	Revenue	1.0%

Source: DAF (2020d).

Table E. 3. Mungbean Operating Costs

Operating Cost	Cost Driver	Cost per Driver (Real $FY2021)
Non-Labour Operating Costs		
Irrigation Equipment	Planted Ha	$141
Water	ML Applied	$25
Sprayer Use	Planted Ha	$8.51
Herbicide	Planted Ha	$31
Crop Nutrition	Planted Ha	$48
Crop Protection	Planted Ha	$4
Harvesting equipment	Tonne	$12
Harvesting ops	Tonne	$3.55
Post-Harvest	Tonne	$0.39
Labour Operating Costs		
Mungbean Harvesting	Planted Ha	$41
Post-Harvest Operations	Tonne	$121
Overhead Operating Costs		
Levies	Revenue	1.0%
Consultants	Planted Ha	$10
Insurance	Revenue	1.0%

Source: DAF (2020c).

Table E. 4. Chickpea Operating Costs

Operating Cost	Cost Driver	Cost per Driver (Real $FY2021)
Non-Labour Operating Costs		
Sprayer Operations	Planted Ha	$6.08
Herbicide	Planted Ha	$212
Crop Protection	Planted Ha	$119
Irrigation Equipment	Planted Ha	$81
Water	ML Applied	$25
Harvesting	Tonne	$7.60
Labour Operating Costs		
Chickpea Harvesting	Planted Ha	$24
Post-Harvest Ops	Tonne	$0.32

Operating Cost	Cost Driver	Cost per Driver (Real $FY2021)
Overhead Operating Costs		
Levies	Revenue	1.0%
Consultants	Planted Ha	$9.12
Insurance	Revenue	1.0%

Source: DAF (2020a).

Table E. 5. Lucerne Operating Costs

Operating Cost	Cost Driver	Cost per Driver (Real $FY2021)
Non-Labour Operating Costs		
Fallow Management	Planted Ha	$29
Nutrition	Planted Ha	$45
Irrigation Equipment	Planted Ha	$467
Water Use	ML Applied	$25
Crop Protection	ML Applied	$112
Labour Operating Costs		
Lucerne Harvesting (incl. baling)	Planted Ha	$274
Overhead Operating Costs		
Consultants	Planted Ha	$7.00
Insurance	Revenue	1.0%

Source: DAF (2020b).

Rotational Crop (Wheat)

Wheat is used as the rotational crop for all pulses modelled. The wheat operating expense are shown in the table below. Wheat operations cost an estimated $/ ha (taken for the full year of operations in FY2024).

Table E. 6. Wheat Operating Costs

Operating Cost	Cost Driver	Cost per Driver (Real $FY2021)
Non-Labour Operating Costs		
Herbicide	Planted Ha	$34
Sprayer Operations	Planted Ha	$6.00
Nutrition	Planted Ha	$341
Crop Protection	Planted Ha	$77
Irrigation	Planted Ha	$250
Cartage	Tonne	$0.37
Water	ML Applied	$25
Labour Operating Costs		
Plough and Tractor Operations	Planted Ha	$12
Harvesting	Planted Ha	$54
Overhead Operating Costs		
Levies	Revenue	1.0%
Consultants	Planted Ha	$9.00
Insurance	Revenue	1.0%

Source: DAF (2020e).

Revenue Assumptions

For the purpose of analysis, all revenue has been accounted for in across the 12-month period until the next harvest of each commodity. It is assumed landholders will hold their commodity in storage and sell on a monthly basis. This may not be reflective of each landholder's farm management practices. Further, decisions around the type of commodity end market will influence whether the harvested commodity will be held on farm or by transported off-farm immediately after harvest.

APPENDIX F: 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 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, 2017b; 2021b; DoESE, 2021), and applied to Australian gross output identified in the FY2019 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.

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

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