SAHARA FOREST PROJECT

The Sahara Forest Project

SFP in Karratha, Western Australia

Date: May 2018

Table of Contents

1. EXECUTIVE SUMMARY AND CONCLUSIONS

The Sahara Forest Project is a Norwegian limited liability company that develops and operates large scale facilities for vegetable production in arid areas, integrated with revegetation of surrounding lands driven by renewables. In 2017 the Sahara Forest Project signed an agreement with the City of Karrratha, The Pilbara Development Commission and Yara to explore project opportunities in Karratha, Australia. Following the initiation of this project, a broad analysis has been conducted to evaluate local, regional and international market- and value chain opportunities, as well as obtaining pricing for all CAPEX and OPEX elements for various facility alternatives. A thorough site assessment has been carried out that has informed the design of the technological concept, adapted to the local conditions of Karratha. Extensive stakeholder dialogue and business development efforts have also been an important part of assessing the feasibility of establishing The Sahara Forest Project in Karratha. Through local community dialogues, concrete opportunities for collaboration with aboriginal communities have been identified.

The report first presents a comprehensive business case for a first stage Sahara Forest Project facility at a specific site in Karratha, including investment and operations strategies for addressing the local/regional market. The following section looks at the business opportunities for a large scale facility. The choice of technological concept is described in detail in section 5. Chapter 6 provides a strategic Environmental Assessment while chapter 7 provides insight into the social implications of the project. The last section gives an overview of some of the stakeholder dialogues that have resulted in further business opportunities.

The business case is designed and calculated around two scenarios:

- A small facility of 6 hectares which includes 2 hectares of greenhouses, a 1.5 hectares PV park, 2 hectares outdoor growing areas, in addition to pack house/storage, desalination unit and other infrastructure. This facility focuses on local market with a range of integrated industrial synergies and a strong collaboration with local aboriginal groups as well as local authorities
- A large facility of 60 hectares which includes 20 hectares of greenhouses, a 15 hectares PV park, 20 hectares outdoor growing areas in addition to pack house/storage, desalination unit and other infrastructure. This facility is depicted with Karratha as a base for regional Western Australia sales and international exports.

Preliminary calculations indicate a modest return from building and operating a small facility catered to local and regional demand. With the local market not being large enough to support a 2 hectare greenhouse mono crop, some regional sales would be required and/or multicrop production initiated. This positive return assumes government support for the common user infrastructure interfaces. Even though a larger facility could yield a stronger return (contingent on favourable logistics costs and a comprehensive off-take agreement), the preferred option is to start the roll-out of The Sahara Forest Project in the Pilbara with the smaller scale facility. The strategy would then be to roll it out to larger scale in Karratha and elsewhere in Pilbara when the concept has been established and proven its success on the ground in Karratha.

The report further shows that several attractive industrial synergies are available in Karratha. In particular, the initiative of a comprehensive Ecohub co-operation has created interest. The Ecohub would deliver synergistic benefits of water and energy to several of the industrial stakeholders in Karratha, and shows that combined efforts could increase the competitiveness of each of the players.

Pilbara is a region that currently is experiencing industrial and social changes, and public and private initiatives alike are set out to adapt to the changes. This report concludes with a positive answer to the feasibility of establishing Sahara Forest Project in Karratha - it is an opportunity for value creation that can benefit both the investors of the business venture, the society and the environment.

2. INTRODUCTION

The Pilbara region offers a wide spectre of natural resources and opportunities. Since the first visit to Australia in 2016, The Sahara Forest Project team has had the opportunity to assess the feasibility for establishing a Sahara Forest Project facility in Karratha for producing vegetables and clean energy in the most sustainable manner, while at the same time vegetate surrounding areas and engaging with the local community.

For the last 15 months we have worked closely together with the City of Karratha, the Pilbara Development Commission and Yara, to conduct a comprehensive Feasibility Study. The work has been co-financed by all the parties and carried out by The Sahara Forest Project team, with assistance from a wide range of experts, and from representatives from the partners. Several site visits to Karratha as well as meetings in Perth and Singapore have been carried out as part of the assessment.

The study provides a business case for two facilities of different sizes and looks into the opportunity for creating a renewable energy hub that several of the industries in Karratha can benefit from. The study also assesses the social and environmental benefits that such facilities can contribute with, while also providing concrete opportunities for local community programs.

The work has been a truly joint effort from all parties to the project, and we are pleased to hereby present the results in this report. The findings are encouraging from a triple bottom line perspective - that establishing a Sahara Forest Project in Karratha can bring added value to both the local community, to the investors and to the environment. We now look forward to exploring these opportunities further with the project partners as well as new partners in the private and public sector.

3. BUSINESS CASE FOR THE FIRST STAGE SFP FACILITY IN KARRATHA

3.1 National Market Potential

To understand the local, regional and international market potential we have assembled a broad market fact base, with the key findings included in this report. The work has covered the analysis of supply and demand conditions as well as the resulting competitive factors including market pricing, market channel power distribution and logistics costs to facilitate the necessary background for considering continued project development.

The markets we have analysed appear to be growing healthily on a local, regional and national level. Markets are nevertheless highly competitive, making it necessary to target the most attractive pockets of demand and take advantage of new environmentally friendly production methods, such as the Sahara Forest Project proposal, and consumer preferences to break through barriers to entry and secure necessary off-take agreements.

3.1.1 National Market Analysis

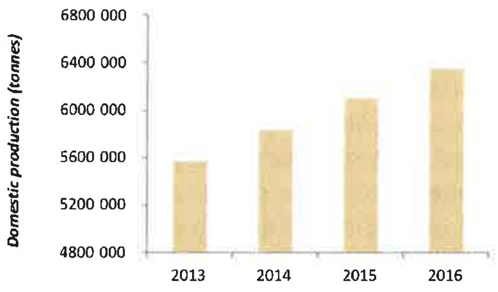
In 2016, Agriculture, Forestry & Fishing accounted for around 2.2% of Australian GDP and employed around 2.6% of the workforce.[1] Over the past five years, employment in the industry has increased by 7.2%.[2] Output from the sector in 2015–16 fell significantly by 5 per cent to $36.7 billion, mainly related to declines in livestock production. Being an export-focused industry, this fall in agricultural output overall was reflected in the country's agricultural exports as well; in seasonally adjusted terms, the value of meat and cereal grains exports fell 7.5%, and wool exports fell 12.0%. In contrast, the value of Other Rural exports grew by 8.7%. The biggest growth in value for 2015–16 was in exports of Miscellaneous Edible Products & Preparations (71.8%) and Crude Animal & Vegetable Materials (57.4%).[3] Research by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) predict that gross value of agricultural production will grow steadily going forward reaching $63 billion by 2022–23 (in 2017–18 dollars), and strong demand for livestock and some horticultural products, and improved productivity in cropping, are expected to support growth.[4]

3.1.2 Horticulture Industry

In 2016, 6.36 million tonnes of horticultural products were produced in Australia. The value of the production for all categories was $11.36 billion while the wholesale value of fresh supply was $11.29 billion, with Australia being a net exporter of horticultural products.[5]

[1] Australian Industry Report, 2016
[2] Australian Government Labour Market Portal
[3] Australian Industry Report, 2016
[4] ABARES, Agricultural commodities, March quarter 2018
[5] Horticulture Innovation Australia 2017

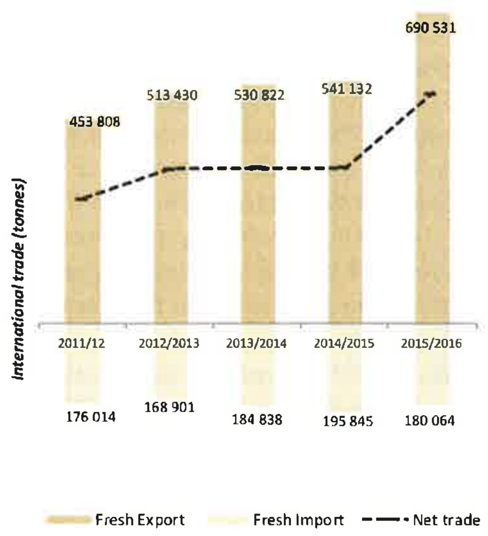
Australian horticultural production



For the year ending June 2016:

- 6.36 million tonnes of horticultural products was produced in Australia
- The value of the production for all categories was $11.36 billion while the wholesale value of fresh supply was $11.29 billion

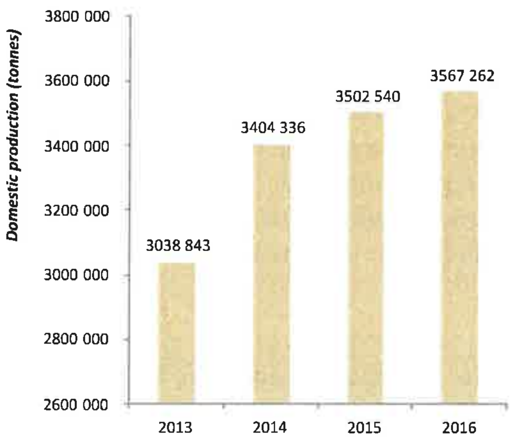
All fresh horticulture international trade



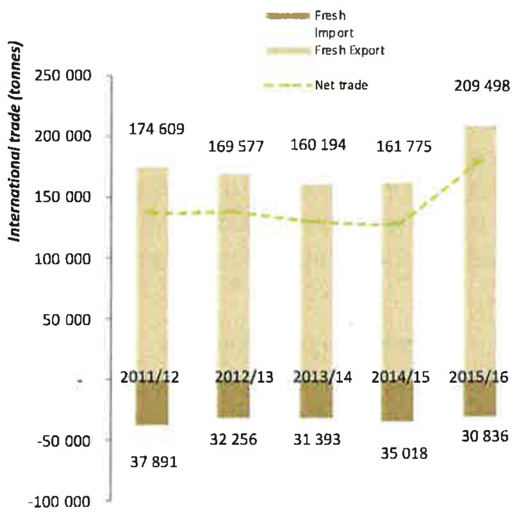
Source: Australian Horticulture Statistics Handbook Vegetables 2015/16

Seen in an agricultural context, the horticulture industry's gross value of production ranks fourth-highest of Australian agricultural industries, this after cattle, wheat and milk. In total it made up 7.9% of Australia's gross value of agricultural production in 2015/16.[6] Vegetable production that same year reached 3.57 million tonnes, with a value of vegetable production of $3.80 billion and with a wholesale value of fresh supply of $4 billion. Australia exported 6% of its vegetable production in 2015/16 and with only 1% of vegetables imported, Australia is a net exporter of vegetables. The vegetable consumption per capita was 87 kg based on volume supplied, with household penetration reaching 99%. [7]

Key production and consumption facts



Fresh vegetable international trade



Source graphs: Australian Horticulture Statistics Handbook Vegetables 2015/16

[6] Australian Vegetable Industry Strategic Investment Plan 2017-2022
[7] Australian Horticulture Statistics Handbook Vegetables 2015/16

The state with the highest number of outdoor vegetable-growing businesses is New South Wales (24 % of total), then Queensland (23 %) and Victoria (19 %), South Australia (14 %), Western Australia (12 %), Tasmania (7 %) and the Northern Territory (1.5%). These numbers reflect undercover vegetable growing as well. Whereas farms tend to be smaller in New South Wales, Queensland and Victoria stand out as the two largest producers, together accounting for 47% of area sown to vegetables in 2013/14.[8] Most vegetable-growing farms grow vegetables exclusively outdoors. In 2014/15 an estimated 87% of Australian vegetable-growing farms had solely outdoor vegetable operations. Some farms used hydroponics (3%) or under-cover systems such as glass or shade cloth (10%). Vegetable-growing farms with more than 20 hectares of vegetables had exclusively outdoor operations. Under-cover systems often generate higher yields for a range of vegetable crops, giving farmers more control over output quality and ensuring a more reliable supply. However, farms using these systems require higher receipts to cover the increased input costs. Marketwise, the conditions also favour greenhouse production: retailers have reportedly indicated to greenhouse producers that they would like to increase the proportion of greenhouse tomatoes in stores from the current level of 17% up to 50% of tomato stocks.[9]

3.1.3 Future industry growth

In 2016/17 the real value of Australian vegetable production decreased with 2% compared to the previous year. This was mainly due to the impact of Cyclone Debbie, and even related price increases from scarce supply could not outweigh falls in production, causing a lower gross value of production. According to ABARES, the value of vegetable production is forecast to increase to $3.8 billion in 2017/18. They expect that increases in production going forward will come from under-cover farming operations, expansion into new varieties of leafy and easy-to-process vegetables and expanding export markets, while processing improvements that enhance quality are expected to increase average prices. Average prices are also expected to be affected by quality improvements and increasing popularity of snacking varieties of tomatoes.

Horticultural export has been a strong driver of industry growth over the last years. This is reflected in the fact that over the past six years up until 2016/17 the value of Australia's fruit and nut exports to its top five export markets more than doubled, while the value of vegetable exports was up 50%. ABARES' March Quarter 2018 report suggests that the strong growth in global import demand is expected to continue. Their findings suggest that in developing countries demand for fresh produce is driven by quality and choice, while also by concerns for food safety, health, traceability and the environment. In emerging markets growing incomes and urbanisation are heavily driving demand for choice and high-quality fresh produce. The opportunities that lie in Australia's geographical position close to some of the fastest growing regions in the world has led to a strategic focus where Australia's institutional and policy environment has supported the development of export-oriented horticultural industries, with ongoing reform to industry-specific regulation. Industry organisations have supported export growth through initiatives to improve market access and by promoting Australian produce abroad to increase Australia's competitiveness in global markets.[10]

3.1.4 Vegetable categories in focus

Australia produces a broad range of vegetables suitable for hydroponic production. The next section will focus on a selection of vegetables for further analysis.

[8] Australian Vegetable Industry Strategic Investment Plan 2017-2022
[9] ABARES Economic Survey 2017
[10] ABARES, Agricultural commodities, March quarter 2018

Source: Australian Horticulture Statistics Handbook Vegetables 2015/16; SFP analysis and estimates

With tomatoes and cucumbers being two of the larger- and most likely production categories, we have made a broader review of these vegetables as potential vegetables for our business case, with some key facts presented below.

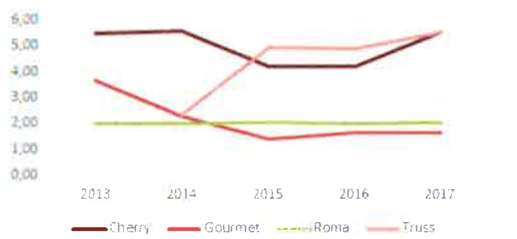
Key Facts | Tomatoes

Tomatoes are grown in most states of Australia, with the majority of production being based in Victoria and Queensland. Most tomatoes have traditionally been grown outdoors, but in recent years, more tomatoes are being grown in high-tech glasshouses.

According to *Horticultural Innovation Australia*, year ending 2016:

- 521,449 t was produced with 53% sent to processing.
- The value of production was $541.6 m while the wholesale value of the fresh supply was $605.3 m
- 86% of Australian households purchased fresh tomatoes
- The consumption per capita was 10.25 kg

Wholesale price: AU$/Kg*

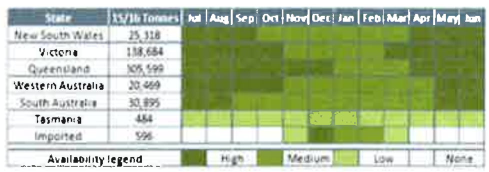


*Based on wholesale market in Perth

Main tomato types

Type	% of fresh production	Main production
Field tomatoes	42%	Outdoors
Large truss tomatoes	33%	Glasshouse
Cherry tomatoes	33%	Glasshouse
Roma tomatoes	5%	

Seasonality by State



Sources: Australian Horticulture Statistics Handbook Vegetables 2015/16; Market West; SFP analysis and estimates

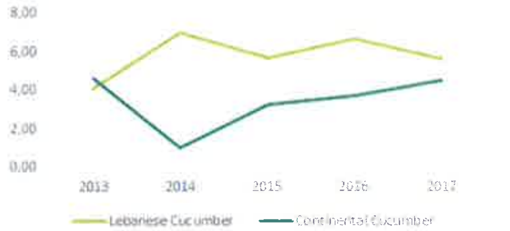
Key Facts | Cucumbers

The majority of cucumbers are grown in protected cropping - covered, more and more in high-tech glasshouses. The largest producers are found in in Queensland, and South Australia.

According to *Horticultural Innovation Australia*, year ending 2016:

- 86,434 t was produced with 5% sent to processing
- The value of production was $164.2 m while the wholesale value of the fresh supply was $192.1 m
- 66% of Australian households purchased cucumbers
- The consumption per capita was 3.4 kg

Wholesale price: AU$/Kg*

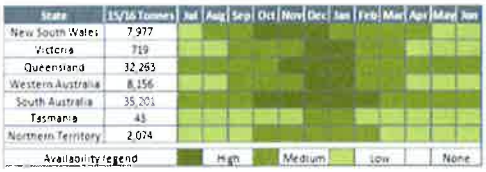


*Based on wholesale market in Perth

Main Cucumber types

Type	% of fresh production	Main production
Continental	59%	Protected cropping
Lebanese	31%	Protected Cropping
Baby	9%	Protected Cropping

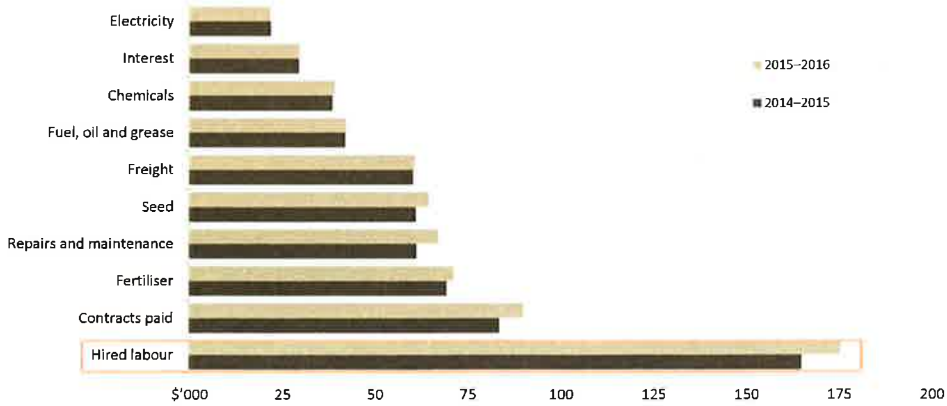
Seasonality by State



Sources: Australian Horticulture Statistics Handbook Vegetables 2015/16; Market West; SFP analysis and estimates

3.1.5 Costs of production

One of the challenges that confronts Australian vegetable farmers are related to rising input costs with prices for vegetables broadly remaining stagnant. The rising input costs include electricity, fuel, chemicals and fertilisers, while some farmers are faced with reductions in water allocation allowances. The cost that reportedly concerned growers the most was according to Horticulture Innovation Australia the cost of labour. [11] Hired labour remains the most significant variable cost and for vegetable growers the overall variable cost component has remained around 77-80% of total income. Vegetable growing in Australia is more labour-intensive than other agricultural industries and produce commonly requires the use of labour to hand pick the vegetables, which limits vegetable growers' ability to introduce mechanised technologies as a substitute for labour. Growers dependency on labour to grow vegetables reduces capacity to minimise labour costs. Australian labour costs are amongst the highest in the world. This challenges the Australian vegetable farmers in an already highly competitive environment, both at home and abroad. Over the past years, vegetable growers are finding it increasingly difficult to access skilled and unskilled workers, adding to the existing pressures related to labour costs. [12]

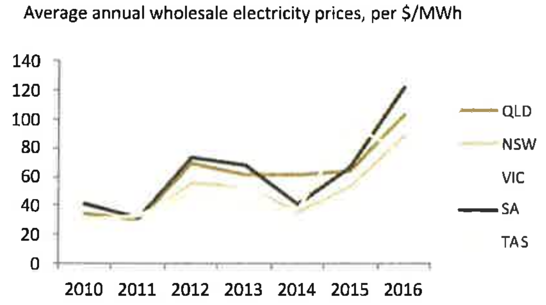


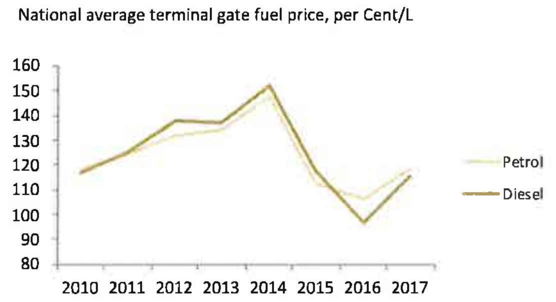
Source: ABARES Economic Survey 2017

[11] Australian Vegetable Industry Strategic Investment Plan 2017-2022

[12] ABARES Economic Survey 2017; ABARES Economic Survey 2014; Ausveg 2014

Rising energy costs (electricity, fuel, oil and grease) place additional cost pressures on the vegetable growing industry. On average, energy costs accounted for approximately 8% of total cash costs per farm in 2011/12. Agriculture accounts for nearly 4% of industry energy usage in Australia. Energy in agriculture is consumed in three major forms: general electricity, fuel, and heating/cooling and refrigeration. Farmers have limited influence on the energy prices. However, installing solar energy solutions would relive such pressures. Electricity prices vary considerably amongst states, due to different electricity generation methods and grid investment strategies. Regardless, most Australian states' wholesale electricity prices have experienced significant price increases since 2011/12. The price increase is largely driven by improvements in infrastructure networks and transition to electricity generation from renewable energy sources. Fuel is also an important production input for vegetable growers, as it enables a more efficient production, and the recent increase in fuel prices adds further cost pressure on growers.[13]

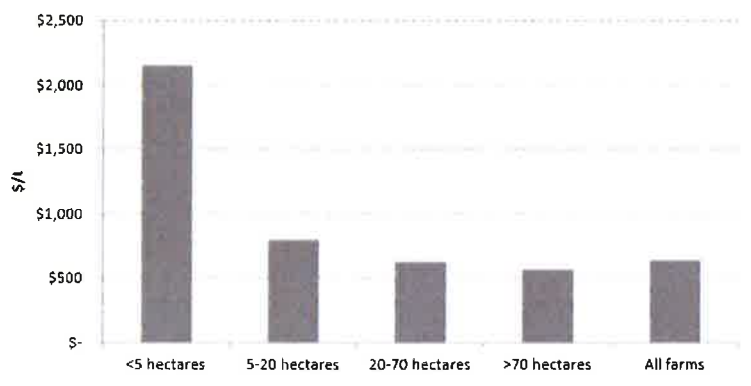




Source Graph 1: Australian Institute of Petroleum, Source Graph 2: Australian Energy Regulator

Research by Ausveg and Horticulture Innovation Australia suggests that the impact of cash costs on vegetable growers varies depending on the size and scale of the business in question. Their graph below shows that growers producing vegetables on less than five hectares has significantly higher average cash costs than those that grew vegetables on five or more hectares. It is also evident that average cash costs decline as the size of area sown increases. There seems to be clear cost advantages achievable with increased vegetable production.[14]

Total cash costs per tonne of production area sown (2010 – 2011) Source: Ausveg 2014



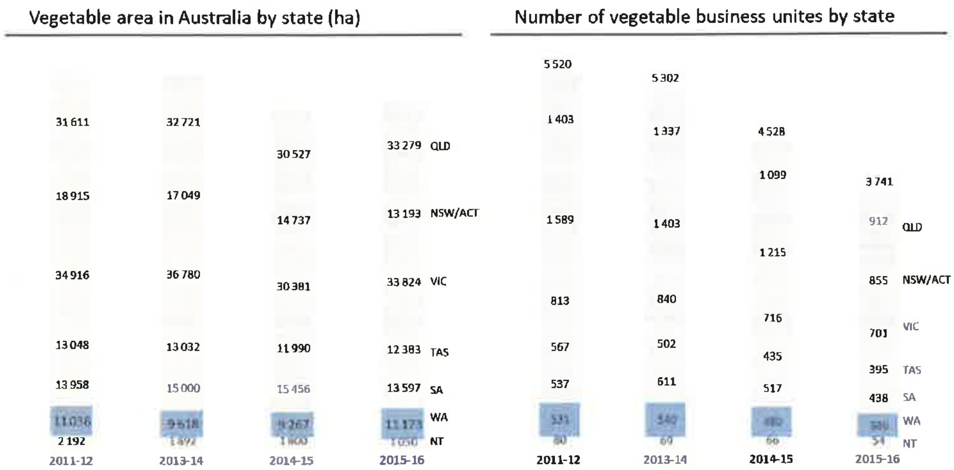
Graph Excerpt from: Ausveg and Horticulture Australia: Cost of Production for Australian Vegetable Growers, 2014

In summary, reducing production costs and improving productivity is critical to improving returns for Australian vegetable growers. Although increasing scale of production may help to alleviate

[13] ABARES Economic Survey 2014; Ausveg 2014
[14] Ausveg 2014

production costs, this may not be an option for many vegetable growers. Therefore, it becomes increasingly important to understand the costs involved in vegetable production and what techniques are being implemented by growers to reduce these cost pressures.[15]

Vegetable industry consolidation



Source Graph: ABS (2017)

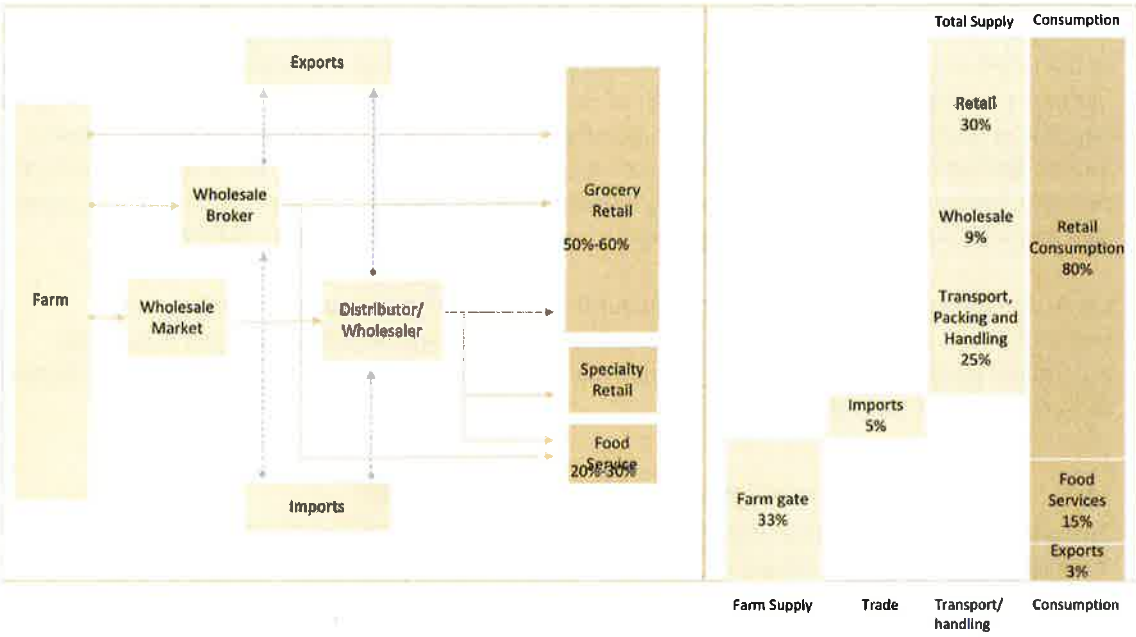
Continued increase in vegetable growing area combined with a decreasing number of growers implies a trend of industry consolidation in the Australian vegetable industry. This means that larger actors emerge, benefitting from economies of scale.[16]

[15] Ausveg 2014
[16] ABS (2017)

3.1.6 **Valus chain analysis**

Below is an overview of the value chain and key national channels and flows in the Australian vegetable industry. The next section will give and overview of the value chain in the Australian national vegetable market and quantfy the flow of produce between growers and key off-take categories.

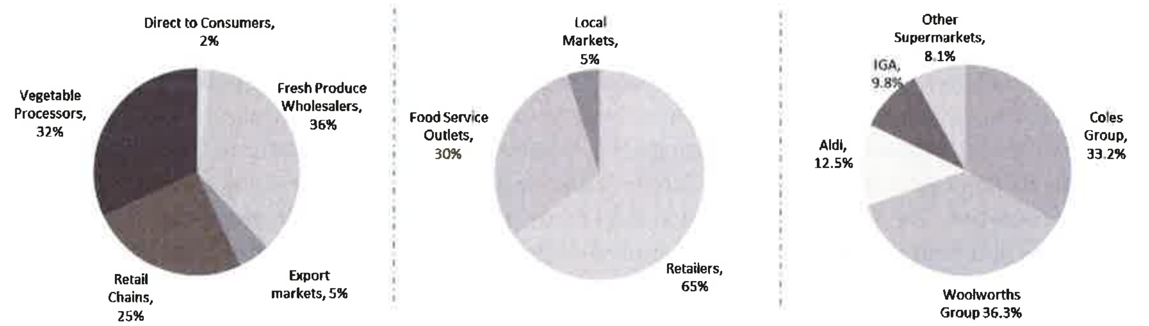
Value chain configuration



Source: Ausveg and Horticulture Australia: Australian Vegetable Industry Strategic Investment Plan 2012-2017

The largest suppliers to 'direct sales to retail chains' are currently wholesalers. For wholesalers, retailers constitute 65% of sales, food service outlets contribute 30% and local markets account for 5%. Major supermarket retailers purchase 50-70% of their fresh produce directly from growers rather than through wholesalers. Australian consumption of leviable vegetables is defined by nearly 80% being household demand while the remaining 20-30% being from the food services sector. [17]

Distribution channel breakdown | Wholesale channel breakdown | Retail channel breakdown



Source Graph 1 and 2: Australian Vegetable Industry Strategic Investment Plan 2012-2017: Ausveg and Horticulture Australia, March 2012
Source Graph 3: Roy Morgan Research 2016

[17] Australian Vegetable Industry Strategic Investment Plan 2012-2017

But there are strong price pressures for growers in the value chain. The wholesale market is driven by short-term pressure to sell produce that comes in and prices are often not set according to quality or consumer demand. The wholesale market dynamics are also affected by relationships between grower and wholesaler, and loyal growers usually receives higher prices than occasional suppliers for similar quality produce (according to the Australian Vegetable Industry Strategic Investment Plan 2012-17 up to 70% difference). The wholesale commission of 15%-20% puts additional price pressure on the grower, where the risk of produce not being sold still lies with the grower. Currently, the largest suppliers to 'direct sales to retail chains' are wholesalers. This is changing however, as there is an increasing amount of direct sales from farmer to retail. There is also a high level of consolidation in the retail sector, and the growing bargaining power and ongoing consolidation of food retail chains increases buying power of a small number of retailers. As retailers are bypassing intermediaries and negotiates directly with farmers, their bargaining power causes fragmented growers to compete heavily against each other and become price takers from the retailer. Still, when selling directly to retailers, growers can benefit by avoiding wholesale fees. There will also be contract negotiations that allow for a higher level of predictability in volume sold to the relevant off-taker.

Lastly, the general high wage level in the country is reflected in the costs of packing and transportation, the levels makes it hard to compete with countries with lower cost structures. Australia is geographically large with a relatively low population density – this increases the burden of transportation costs on the grower.[18]

3.1.7 Increased domestic consumption will come from population growth

Australian domestic growth in vegetable production is expected to largely come from population increase going forward. [19] However, 93% of Australians do not consume the recommended daily allowance of vegetables of about 5 serves a day, the national average consumption is estimated at 2.3 serves per day, with the lowest consumption of vegetables recorded in the 18-24 age group. Australia has been ranked 63rd in the world by vegetable consumption per capita, placing it behind other OECD countries. China was ranked first in the same study, consuming over three times more vegetables than Australia.[20] There is also an observed growing move away from meat consumption related to concerns related to health, animal welfare and the environment. [21] As such, there is potential for household demand to increase some above population growth.

Australian households are recorded to have slightly reduced the amount of fresh produce (includes fruit, vegetables, dried fruit and nuts) they bought last year, but are spending more than they did in the previous year. The strongest contributor to both of these trends is the vegetable category; volume declines of -1.5% and value increases of 9.1%. Fruit on the other hand has slightly lower rates of volume decline at -1.2% and value growth of 5.3%.

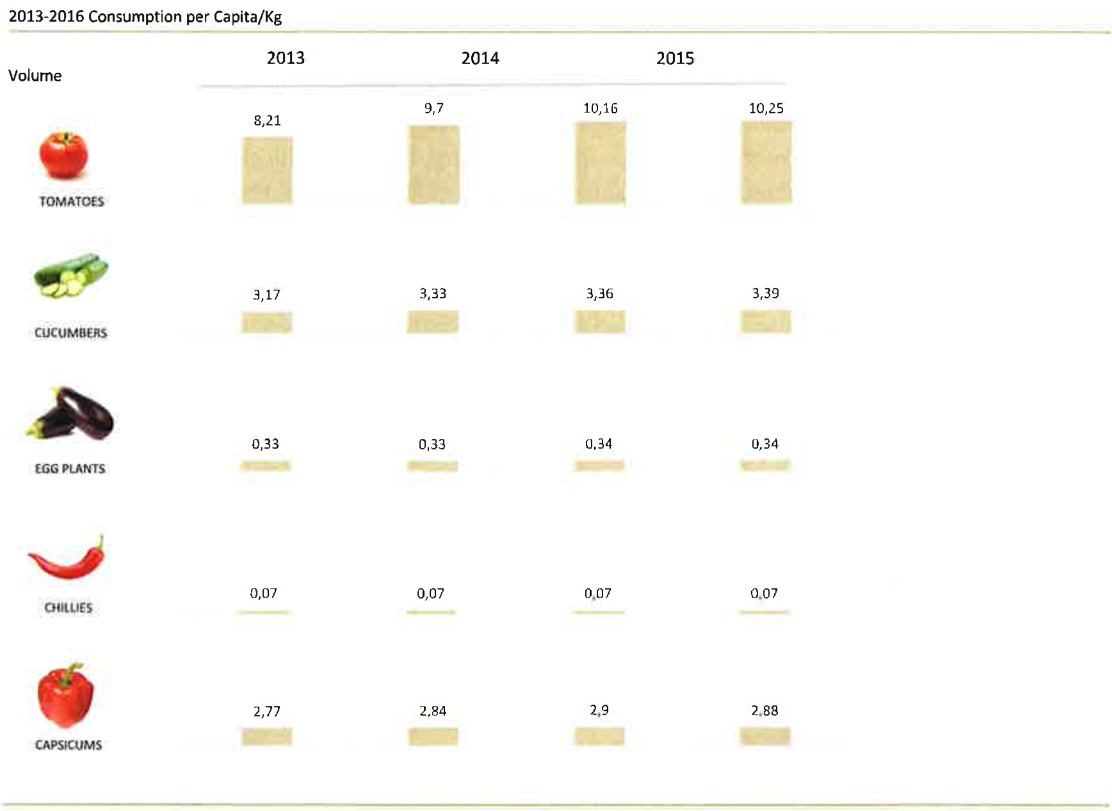
In general, for food, a survey in the Project Harvest Monthly Tracker Report by Horticulture Innovation Australia suggests that for Australian shoppers Price is the most important factor of choice (37%), followed by Taste (17%), Australian Made (15%) and other incidental factors such as Environmental Impact (2%) and Packaging (2%). However, the results are altered looking at findings specific to vegetables where local produce is found to be more than twice as important than any price promotion. This indicates that 'Australian made' plays a special role in guaranteeing quality, freshness and food safety above and beyond packaged goods in the domestic market. [22] The importance of provenance for all vegetables represents a huge opportunity for the Australian agriculture industry, as well as retailers.

---

[18] Australian Vegetable Industry Strategic Investment Plan 2012-2017
[19] ABARES, Agricultural commodities, March quarter 2018
[20] Deloitte for Horticulture Innovation Australia, 2016
[21] Australian Vegetable Industry Strategic Investment Plan 2012-2017
[22] HIA Project Harvest 2016

The Deloitte Millennial Innovation Survey in 2013 revealed that the 300 Millennials interviewed thought climate change would be the biggest problem facing society in the next 20 years. 61% of Millennials also showed greater willingness to pay more for products guaranteed to have ethical and responsible manufacturing practices.[23] This is an important observation in identifying the characteristics of the future vegetable customer.

Australian consumers are found to be satisfied with their level of vegetable consumption, which could be seen as a barrier to increasing purchases. In their Vegetable Strategic Investment Plan 2017-2022, AusVeg and Horticultural Innovation Australia state that rising incomes are not expected to increase total vegetable consumption, but rather expected to encourage households to substitute away from cheaper vegetables towards more exotic, organic and local produce. Revenue growth in this market is then seen to come from the expansion of niche markets, such as organic vegetables, based on consumers' growing concerns about environmental impact, the increase in favoring fresh produce, and the indication of a preference for vegetable products grown without pesticides.[24]



Source graphs: Australian Horticulture Statistics Handbook Vegetables 2015/16

3.1.8 Exports remains as a significant opportunity for the industry

Horticultural exports represent a significant opportunity for the industry with Australia being located in the Asian region that is home to more than 60 % of the world's population. The region also has the fastest population growth and income growth. Such fast paced advances put a strain on available resources and leads to a decline in arable land. These conditions will continue to drive demand for high-quality vegetables from Australia going forward.[25] Targeting such high growth markets has become an important part of Australia's horticultural growth strategy for the future. The envisioned growth of the industry should be supported by increases in both domestic demand, and demand in

[23] Deloitte Millennial Innovation Survey, 2013
[24] Australian Vegetable Industry Strategic Investment Plan 2017-2022
[25] Australian Vegetable Industry Strategic Investment Plan 2017-2022

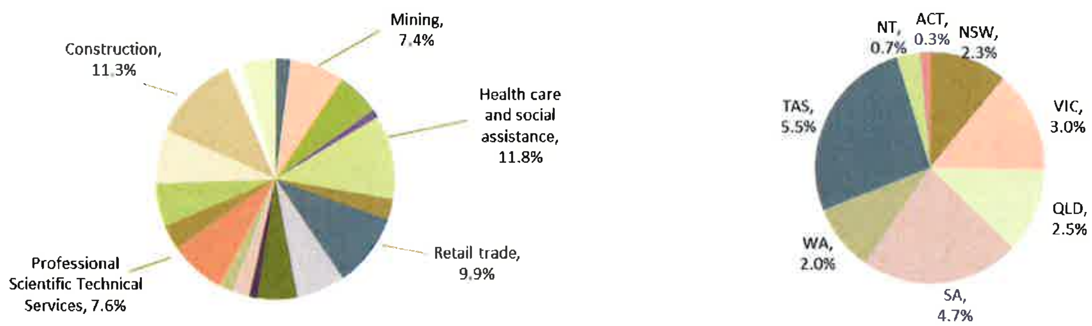
Australia's surrounding high growth markets. Increasing exports would also relieve pressure on the Australian domestic vegetable market and related domestic vegetable prices, and growers would experience the benefits of having an alternative volume channel to market.[26] It is nevertheless important to recognize that increasing national production without sufficiently securing export volumes could entail significant risk for oversupply and thus farm gate price pressure. [27]

Horticultural Innovation Australia reports that consultation with exporters reveals the competitive advantage of Australian produce in export markets is based on quality and reputation for food safety. Looking at the current market situation where China is the largest competitor in term of terms of supply to most of Australia's top export destinations, Australia's position is solid as exporters believe Chinese produce has a less favorable reputation in those markets for quality. [28]

3.2 National Market Potential | Zooming in on Western Australia

Western Australia (WA) has a relatively small population with its 2,6 million out of Australia's 24 million, while being the geographically largest state in the country. WA is the main minerals and petroleum exporting state of Australia and its economy benefits from its proximity to the growing markets of Asia. WA's extraordinary natural resources expansion is unwinding, and the economy is returning to historically more typical conditions. This leaves the economy in transition to a period of lower growth. As this transition unfolds, economic activity will broaden into other sectors of the economy. The competitiveness of agriculture, manufacturing, tourism, education and other services exports are no longer constrained by a high Australian $ as at the height of the resources expansion. Businesses will also benefit from increased availability of labour and lower input costs. [29] Regional development is high up on the agenda. Growth in irrigated food production brings major benefits to regional communities, which is why agriculture becomes an important part of initiatives for regional development. This focus is being strengthened by the state's location near the growing Asian markets where the demand for Australian "green and clean" vegetables is increasing. Initiatives to actively negotiate better terms of trade with many of the most promising export opportunities has increased prospects for growth in the sector.[30]

Employment by industry in WA vs. Employment in Agriculture by state



Source graphs: Aus. Dept. of Employment, 2016

The value of agriculture production in WA was $7.9 billion in 2015, with broadacre crops being by far the largest component, comprising 63% or $4.9 billion. The horticultural industry's contribution to WA economy was $702m that same year.[31] In 2014–15 an estimated 260 vegetable-growing farms were operating in Western Australia, accounting for around 11% of Australian vegetable-growing farms.[32] WA is a leading exporter of fresh vegetables, standing for over a third of Australian vegetable exports, with vegetables standing for about half of horticultural exports from the state.

[26] Horticulture Innovation Australia: Vegetable Industry Export Strategy Volume 1, 2016
[27] Australian Vegetable Industry Strategic Investment Plan 2012-2017
[28] Australian Vegetable Industry Strategic Investment Plan 2017-2022
[29] *WA State of the Economy, Sept.2017*
[30] *jtsi.wa.gov.au1*
[31] *The Bankwest Curtin Economics Centre, 2016*
[32] *ABARES Economic Survey 2017*

Agricultural export is also driving the industry and the value of WA vegetable exports grew by 49% between 2013 and 2016. Carrots is the major vegetable export from WA, with a share of 81% of the total vegetable exports by value.[33]

WA's horticultural industries are well positioned to capture the growing demand and opportunities in the overseas market: Geographic location is beneficial for targeting the growing Asian and Middle Eastern markets. WA can deliver high quality produce in face of the growing demand for safe and clean food in these markets. This has led to coordinated efforts to incentivise the industry, such as 'Seizing the Opportunity Agriculture' which is a $350 million initiative funded through the state's Royalties for Regions program, DAFWA's 'Agrifood 2025+' initiative aiming to double the real-term value of sales from WA's agriculture sector between 2013 and 2025, and WA's 'Water for Food' initiative targets $40 million state funding towards the development and diversification of agriculture in Western Australia.[34]

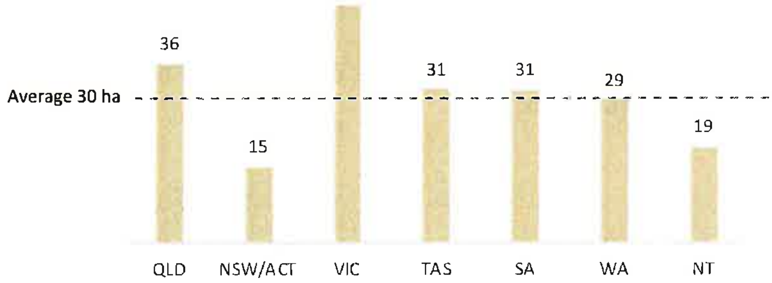
3.2.1 Water issues

Prime Minister's Science Engineering and Innovation Council reports on future challenges for Australian agricultural sector, including land degradation, long-term climate change, competition for arable land, scarcity of water, and nutrient and energy availability. In terms of water availability, initiatives for more sustainable water use is encouraged.[35] Australia's Climate Council estimates that water flow from rainfall into Perth's dams has slumped by 80% since 1970 with precipitation in the south-west corner of Australia forecast to drop by up to 40% by the end of the century. [36]

With a rapidly growing population in the state's capital, combined with a vast amount of agricultural businesses located in the state's south, water security and sustainability will be an important issue to tackle in the time to come.

3.2.2 Industry consolidation

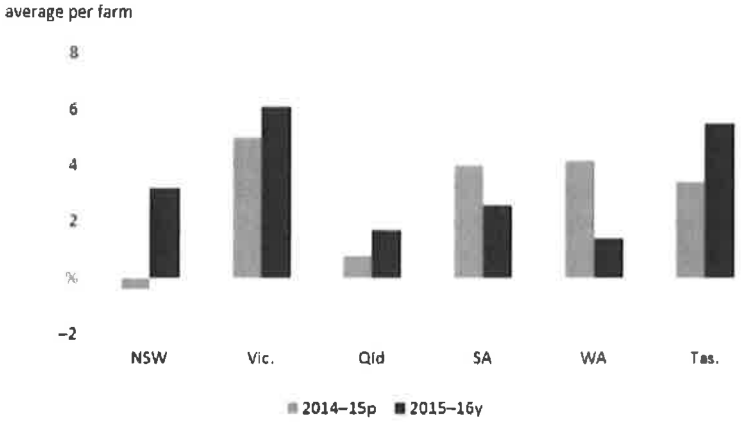
The aforementioned trend of increase in vegetable growing area combined with a decreasing number of growers, hence industry consolidation, is just as relevant for WA, allowing growers to benefit from economies of scale.[37] In 2015/16 the financial performance of vegetable farmers improved in all states except South Australia and Western Australia, related to a fall in average receipts for all major vegetable types because of lower crop yields. Compared to the previous year's high levels, only surpassed by Victoria, the estimated average farm cash income for WA declined by 46% in 2015–16 to around $207 000, 21% lower than the estimated average farm cash income (in real terms) for vegetable-growing farms in Western Australia over the nine years to 2014/15.



Source: ABS (2017)

[33] *agric.wa.gov.au1; agric.wa.gov.au2*
[34] *The Bankwest Curtin Economics Centre, 2016*
[35] *PMSEIC*
[36] *The Climate Council, 2015*
[37] *Ausveg and Horticultural Innovation Australia Nov. 2015*

Figure 15 Rate of return, Australian vegetable-growing farms, by state, 2014–15 and 2015–16



Source Graph: ABARES Economic Survey 2017

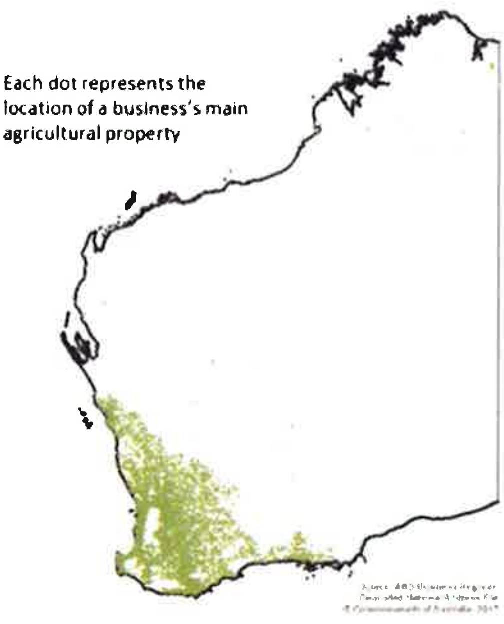
3.2.3 **Distribution**

Vegetables are produced throughout Western Australia from the tropical north near latitude 16°S to the temperate south of the state at 35°S. The main production region is the South West including the Swan Coastal Plain from Gingin (100km north of Perth) to Myalup (100km south of Perth). The South West also includes production in the Pemberton, Manjimup and Albany areas. Heading north, vegetable production areas are located near Geraldton, Carnarvon, Broome and Kununurra.[38]

There were 260 vegetable growing farms in Western Australia in 2014/15 (322 in 2013/14), accounting for around 11% of Australian vegetable growing farms. Most farms were located along the coast extending north and south from Perth, around Carnarvon along the Gascoigne River and in the far north of the state in the Ord River irrigation area. The average area of vegetable farms in Western Australia in 2014/15 was around 191 hectares, of which 33 hectares was planted to vegetables (28 ha in 2013/14). The same year vegetable production accounted for 4% of the gross value of agricultural production in Western Australia, compared with 7% nationally.[39]

The largest wholesale market in WA is located in Perth, Market City Canning Vale, and it is central in the distribution of fresh produce in the State. The proximity to the wholesale market in Perth, or to the distribution centres of the larger retailer chains, most of which are situated in the larger Perth area, will affect transportation costs. This is also true relative to the other larger growing areas, if distribution can be made directly from these. With some of the regions in the state sparsely populated, transportation costs tend to be high. Such costs can be mitigated by backloading options. This means that production areas far from key markets in the state or population centres can make use of empty trucks heading back to Perth after delivery to local regional markets. This has the potential to reduce transportations costs significantly.

[38] agric.wa.gov.au3
[39] ABARES Economic Survey 2017



Source Pic1: Government of Western Australia, Department of Primary Industries and Regional Development
Source Pic2, excerpt from: 2015-2016 Agricultural Census, Australian Bureau of Statistics

3.2.4 Key market segment

Mapping the potential off-takers and sales channels in the WA market, one market segments stands out as attractive based on size and level of consolidation. As nearly 80% of demand is related to household consumption in Australia, the retail and specialty stores are of interest. The large supermarket segment stands out as attractive based on size and level of consolidation. It will also allow for bypassing the wholesale market and through contract negotiations allow for predictability of volume and in off-take capability.[40]

3.3 National Market Potential | Zooming in on the Pilbara

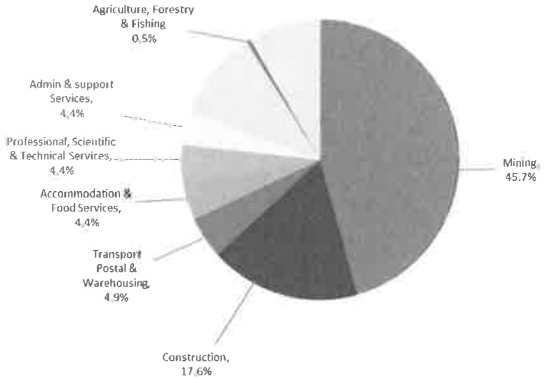
The Pilbara is one of the largest regions in WA, and represents 20% of the state's total land mass, covering a total area of 507,896 square kilometres, with a population of 65'859. Located approximately 1200km north of Perth, the region's history dates back 40,000 years with evidence of the Aboriginal population living off the land. The mineral rich region is often described as the engine room of the nation due to its immense reserves of natural resources, with the mining industry being the main employer in the region.

The Pilbara is recognised as a region of global significance related to its proximity to Asia and its extensive resource assets.[41] With petroleum production of $23.7 billion and mineral production of 53.6 billion (Production value based on 2014/15 data), industry growth has been fuelled by strong demand for raw resources, especially iron ore, in emerging fast growing economies such as China.[42] To put this in perspective, Western Australia is the largest iron ore producer and exporter in the world, accounting for 37% of global production and 52% of global seaborne exports in 2015 - the Pilbara region accounted for 94 % of Australia's iron ore production in 2015.[43]

---

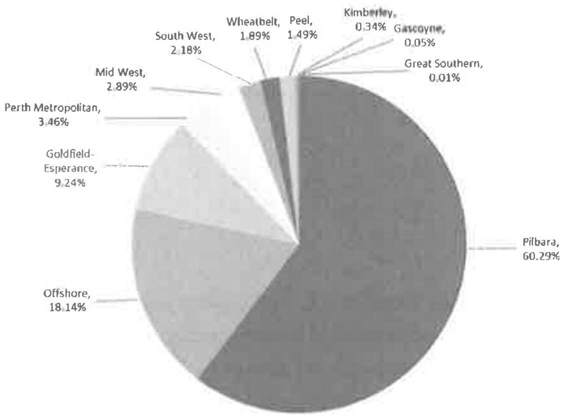
[40] Australian Vegetable Industry Strategic Investment Plan 2012-2017
[41] Pilbara Development Commission(pdc.wa.gov.au1)
[42] PDC Strategic Plan 2016/2018
[43] Western Australia Iron Ore Industry Profile 2017

Employment by industry Pilbara



Source: Pilbara Development Commission

Value of mineral and petroleum by region 2016–17 $104.95bn



Source: Mineral and Petroleum Statistics Digest 2016-17

However, the strong presence of the mining industry has put a strain on Pilbara's local communities. The rapid growth and heavy reliance on resource exports has resulted in the region's high cost structure and exposure to commodity price fluctuations. High demand for skilled labour along with the remote nature of the Pilbara region has led to high living and business costs in addition to inflating prices and crowding out other industries. This has affected regional towns' ability to possess the critical mass to support certain services and industries.[44]

The Government of Western Australia recognises the importance of a prosperous and secure future for the Pilbara and its $1.7 billion Royalties for Regions Pilbara Cities initiative has contributed significantly to addressing the challenges. Pilbara townships has received considerable public and private sector investment in amenity and liveability enhancements over the past years and as a result Pilbara has moved towards the levels of services to better cater to the size of the population, building a stronger sense of permanency for settlements that have been a challenge for the mining towns. But the conditions still challenge growth going forward. This is furthered by the mining industry's transition from construction to production reflected in a related decline in investments.[45] The Pilbara Development Commission has stated the need for a coordinated, whole-of-business, government and community approach to achieve a sustainable future for the Pilbara and tackle challenges to growth, develop the communities and diversify the economy.[46]

[44] The Pilbara Resources and Beyond, 2014
[45] Aus. Dept. of Employment, 2016
[46] Pilbara Regional Investment Blueprint Summary Report, 2015

The Pilbara region comprises four local government authorities; Shire of Ashburton, Shire of East Pilbara, the City of Karratha and the Town of Port Hedland.[47] The region has established a strong strategic direction for the future: the Pilbara Regional Investment Blueprint with a Vision for the region up until 2050. One of the main goals of this strategy will be to increase the population of Pilbara significantly based on diversification of the economy and capitalizing on the region's competitive advantages.[48] The table below is from the Investment Blueprint. It maps out the identified 'Transformational Opportunities' – the potential catalysts for projects that will drive the desired development:

APPROACH	REGIONAL PILLAR	TRANSFORMATIONAL OPPORTUNITY
Enabling	Land Access and Economic Infrastructure	Normalised Property Market and Land Access
		Secure and Sustainable Infrastructure Services
	Education, Training and a Skilled Workforce	Lifelong Education
		Workforce Development and Skilled Migration
	People and Communities	Diverse and Vibrant Intergenerational Communities
		Innovative Local and Remote Healthcare Delivery
Value-Adding	Logistics, Engineering and Supply Chains	Maritime Maintenance, Safety & Emergency Management
		Industrial Fabrication, Assembly and Technology
	Innovation and Advanced Technology	Business Digital Connectivity
		Automation Technology and Services
	Diverse and Robust Small to Medium Sized Businesses	SME Support
		Streamlining Governance
Diversifying	Agriculture & Aquaculture	High Value Agriculture and Cropping
		Aquaculture, Algae Biofuels and Co-products
	Energy	Energy Production
		Energy Export
	Tourism	Nature Based Tourism
		Heritage and Aboriginal Tourism Development

Source Table: Pilbara Development Commission, Pilbara Regional Investment Blueprint

3.3.1 The Pilbara is looking to agriculture as an avenue for regional growth

Agriculture is recognised as one of the Regional Pillars in diversifying the economy in The Pilbara regional Investment Blueprint. High value agriculture and cropping, along with aquaculture, algae biofuels and co-products are identified as avenues for such development.[49] These opportunities are seen in relation to changing climates, increased water security challenges and market opportunities in Asia for safe, high-quality food. Vast amounts of sunlight and fertile soils, in combination with the existing bulk export infrastructure and investments links with Asia to service global food markets creates the basis for such business opportunities, with the potential of providing local supply of fresh produce while attracting international investment capitalising on the related potential for export. The PDC is working in partnership with government, industry and business to achieve the strategic objectives that aim to build on the Pilbara's potential in agriculture. [50]

3.3.2 Assessing local agricultural opportunities

Projects to assess the agricultural opportunities for development in the region has been initiated - one of the most extensive ones has been the Pilbara Hinterland Agricultural Development Initiative(PHADI) which has investigated the future of irrigated agriculture development in the Pilbara. Funded by Royalties for Regions over four years, PHADI has assessed the potential of

[47] Pilbara Development Commission(pdc.wa.gov.au1)
[48] Pilbara Regional Investment Blueprint Summary Report, 2015
[49] Pilbara Regional Investment Blueprint Summary Report, 2015
[50] Pilbara Development Commission(pdc.wa.gov.au2)

irrigated agriculture in the Pilbara utilising surplus mine dewater and other in-situ water resources and deliver high-impact research outcomes to assist future development decisions by government and industry. PHADI is delivered by DAFWA in partnership with the Pilbara Development Commission and the Department of Regional Development. [51] 'The Transforming Agriculture in the Pilbara' (TAP) will continue the work from PHADI in terms of identification of suitable soils, water resources (mine dewater and groundwater) and land tenure issues, however this is focused on more traditional farming as opposed to intensive horticulture in greenhouse. The City of Karratha Green Paper 2014 also recognized horticultural development and the growing of fresh fruit and vegetables as an avenue for regional growth. With an excess of available land, sun and seawater, arid agriculture is seen as a prime agricultural industry sector for development.[52]

3.3.3 Pilbara fresh produce production and logistics

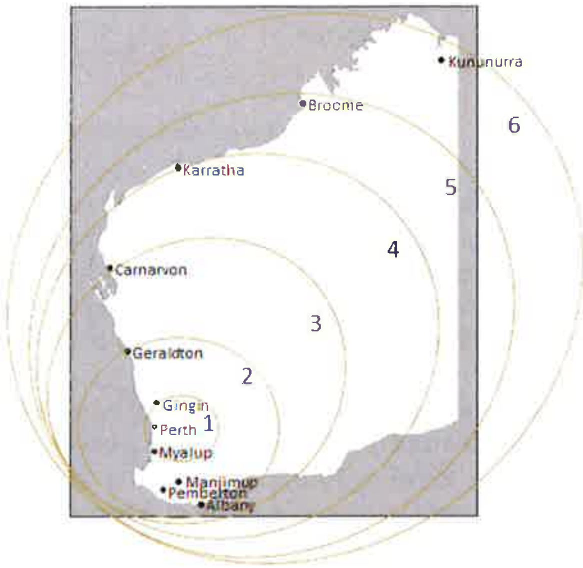
Rangeland beef production is the dominant agricultural activity in the region with an output of more than $46 million per annum and current agricultural production consists primarily of beef cattle production for live export. [53] There seems to be no current commercial vegetable production of scale in the Pilbara and there is no history of commercial agricultural production outside of extensive pastoral activities. As such, the region relies heavily on horticultural produce being trucked in from Perth at great expense. This leaves no immediate competitors in the local market in the Pilbara region. However, there are large prominent growing areas between Pilbara and Perth - one of the larger ones being Carnarvon. The proximity to the wholesale market in Perth, or to the distribution centres of the larger retailer chains, most of which are situated in the larger Perth area, will affect transportation costs, however, backloading options existing from the Pilbara will lower cost of such transportation significantly.

Further north, Broome has emerged as a growing area, especially for export purposes, due to its location being in near proximity to the Asian markets. Ports in Broome currently has container infrastructure which allows for transport to the Asian markets. However, related transportation options from the Pilbara and Karratha area would then entail frontload rates. At the moment it is indicated that such rates are not competitive compared to backload rates to Perth. Despite Pilbara having several ports, these are currently used mainly for transportation in relation to the mining industry. The Pilbara Ports Authority's long-term Port Development Strategy have nevertheless indicated a goal to develop The Port of Dampier into a modern multi-commodity port. In relation to transportation to international markets, such infrastructure would affect the competitiveness of horticultural production in the Pilbara significantly, as the current option for international distribution of fresh produce would be container freight down to Perth for further sea freight to international markets. Air freight options at Karratha Airport does not seem to be feasible for commercial production at the moment in relation to the available aircrafts' capacity for large volume, fresh produce cargo space. The new flight route from Karratha to Singapore will employ aircrafts with a 2 tonnes freight capacity and flights will be twice weekly - this could represent a produce export opportunity. The new international route could also be extended with cargo planes for high volume transport, which would increase the competitiveness of produce export from the region. To our understanding, there is ongoing progress to look into establishing cargo planes for high volume production in the future.

[51] agric.wa.gov.au4
[52] City of Karratha Green Paper 2014
[53] Pilbara Development Commission(pdc.wa.gov.au2)

5 geographical levels based on Perth as hub

Level (from map)	Distance from Perth	Time (truck)
1	93 km	1 hour
2	432 km	4,5 hours
3	892 km	9,5 hours
4	1525 km	16 hours
5	2240 km	24 hours
6	3213 km	35 hours



3.3.4 Market Potential Pilbara

Local production would relieve pressure on regional food supply based on the current reliance of fresh produce items, most of which is being trucked in from Perth at great expense. Although the local market is small in size, based on its number of inhabitants, two market segments stand out as attractive based on size and level of consolidation: retail and larger businesses related to the mining industry. As nearly 80% of demand is related to household consumption in Australia, the retail and specialty stores are of interest. The large supermarket segment stands out as attractive based on size and level of consolidation. It will also allow for bypassing the wholesale market and through contract negotiations give predictability of volume and off-take capability.[54] In this particular market, there is also another key target group of interest and that is the large companies located in the region related to the mining industry. As such, their catering services are of interest and this would also allow for predictability related to contractual negotiations.

3.4 National Market Conclusions

Ultimately, the market- and competitive analytics conducted in this study is set to conclude if it is feasible to obtain sufficiently large sales and distribution agreements amidst competition at price levels that can defend the total CAPEX investments and operational running- and logistics costs. From our research we do believe there is such a case and have modelled the business case in following sections on this base. From our research, we perceive that both national and regional markets are growing at a healthy rate with a demand upside on healthier consumption and with a competitive playing field allowing the introduction of capacity with more environmentally friendly practices. In particular, we find the Pilbara region encouraging based on the strong political will to diversify and support new industrial initiatives and a greener economy.

Throughout the study we have also analysed potential export markets and the export opportunities with horticulture products from Australia are broad and varied. To substantiate our fact-base we have conducted high level desk based research on key markets including Malaysia, Singapore, UAE

[54] Australian Vegetable Industry Strategic Investment Plan 2012-2017

and Saudi Arabia. We have also conducted several meetings with export trade promoting agencies as well as distributors and stakeholders in the value chain including visits to Singapore markets. Additional business development work is needed to further develop the necessary trade relations to succeed as an exporter.

3.5 Market analyses for relevant international markets in SE Asia and Australia

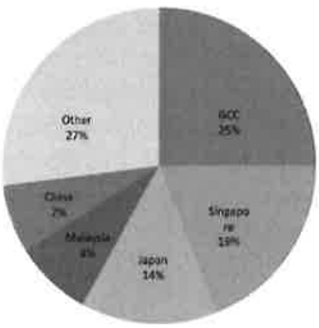
Australia's geographical location close to some of Asia's fastest growing markets both in terms of population growth and income growth represents a significant opportunity for horticultural exports going forward.[55] The opportunities for growth in international markets has led to increased efforts in the Australian horticultural industry, by industry organisations and government, supporting export growth through initiatives to improve market access and by promoting Australian produce abroad.

Australian fresh produce exports have increased significantly in recent years, reflecting the strong global demand for high-quality fresh produce and Australia's increasing competitiveness in global markets. Between 2010/11 and 2016/17 the value of Australian fresh produce exports (in 2016/17 dollars) increased by an average of 18% per year, according to ABARES. This was mainly driven by increased export volumes of fruit up by 15% per year and nuts by 20% - export volumes of vegetables increased more slowly, 1.5% over the same period. [56]

Global demand for the horticultural products that Australia produces is set to grow into the future as income growth and urbanisation shift consumer preferences towards more diverse, higher-quality and safer fresh produce continues.[57] According to ABARES, Australian vegetable production is projected to reach more than $4 billion by 2021–22 because of growing domestic market requirements resulting from population growth and export demand.[58]

Australia's largest vegetable export markets are South East Asia (SEA) and the Middle East. The SEA markets are particularly strong because of the geographic proximity and related airfreight advantages, in these markets Australia also has a strong reputation for the quality of its produce. As the region is highly price sensitive, the volumes fluctuate with exchange rate movements. The importance of the middle Eastern markets is growing, and buyers in the region are prepared to pay a premium for Australia's superior quality.[59] For the year 2016/17 Australia's top five horticultural export destinations were countries in Asia the Middle East, where China was the top market for fruit and the Gulf Cooperation Council (GCC) for vegetables. In 2016/17 GCC accounted for 25% of vegetable imports, Singapore 19%, Japan 14%, Malaysia 8%, China 7% and other countries the remaining 27%. In the six years leading to 2016/17 the value of vegetable exports to the top five vegetable-export markets increased by more than 28 per cent. [60]

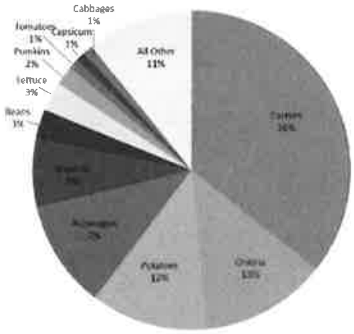
Share of Australian fresh exports by country, 2016-17



[55] Australian Vegetable Strategic Investment Plan 2017-2022
[56] ABARES Agricultural commodities, March quarter 2018
[57] ABARES Agricultural commodities, March quarter 2018
[58] ABARES Agricultural Commodities, March quarter 2017
[59] Horticulture Innovation Australia: Vegetable Industry Export Strategy Volume 1, 2016
[60] ABARES Agricultural commodities, March quarter 2018

Source: ABARES Agricultural Commodities – March quarter 2018

Category percentage of vegetable exports(value)



Source: Horticulture Innovation Australia: Vegetable Industry Export Strategy – Volume 1

Produce that is exported at highest volume are dominated by hard vegetables, mainly carrots, onions, potatoes. High value vegetable export is found among more perishable lines as well.[61]

As competition in international markets intensifies, Australia's horticultural industries will need to keep track of innovation by international competitors in order to understand and build Australia's comparative advantage in global fresh produce markets.[62] Australia's challenge related to capturing real global market share in vegetable exports is related to cost structure. As vegetables are extremely labour intensive, growers with low cost labour models are equipped to be globally competitive. These conditions suggest that Australia should compete in high value products; exporting to higher value niche markets, segments and channels where the customers are prepared to pay a premium based on Australia's superior quality and reputation for safety and product integrity. This niche must be targeted and cultivated if Australian products are to claim a position in the near lying, fast growing markets such as SEA and the GCC.[63]

Analysis by the SFP reveals potential for export of the set of vegetables studied, in the high potential regions of SEA and the GCC. The focus in this report has been on four key markets; Singapore, Malaysia, UAE and Saudi Arabia. These were selected based on level of imports, market growth potential, potential for premium pricing positioning and demand for high quality produce, available distribution options, regulation and market access. The markets in focus revealed the potential for exports of vegetables seen in the table below.

[61] Horticulture Innovation Australia: Vegetable Industry Export Strategy Volume 1, 2016
[62] ABARES Agricultural commodities, March quarter 2018
[63] Horticulture Innovation Australia: Vegetable Industry Export Strategy Volume 1, 2016

Country	Population	GDP (USD)	Per capita income (USD)	Current trade with Australia (FOB AUD)	Regulatory access	Airfreight Connectivity	Key potential vegetables
Malaysia	30.3 million	$313.2 billion	$26,300	$17,403,623	Open	Daily services from to Kuala Lumpur	Lettuce, Tomatoes, Capsicum
Singapore	5.6 million	$297.9 billion	$85,300	$36,127,523	Open	Multiple daily direct flights	Lettuce, Tomatoes, Capsicum
UAE	9.2 million	$402.3 billion	$67,600	$33,043,446	Conditional	Daily service via Dubai	Capsicum, Lettuce, Tomatoes
Saudi Arabia	31.5 million	$748.4 billion	$53,600	$8,710,188	Conditional	Daily service via Dubai	Capsicum

SAHARA FOREST PROJECT

Source: Horticulture Innovation Australia: Vegetable Industry Export Strategy Volume 2 2016; UN Comtrade; Coriolis,2016; SFP Analysis

An SFP facility would produce high quality horticultural produce in an environmentally sustainable way, at the level of Australian food security standards. As such, the product niche that SFP represents is in line with market findings related to the competitive advantage that Australian produce can capitalise on in these international markets. We believe that there is a strong case for exporting vegetable produce from an SFP facility to these markets.

3.6 Karratha Site identification

Moving on from the Market analysis this section looks into specific sites for establishing SFP in Karratha. In the following sections we have detailed key factors with selected supporting data for selecting a site located around the City of Karratha.

The primary resources that an SFP facility needs are abundant sunlight, seawater and suitable land. These are all available in the region. Access to markets is another important factor, as is the provision of labour. There are also particular weather characteristics that highly affect the conclusions, such as the fact that the region is prone to Category 5 cyclones. These factors apply to all sites.

In this study we have worked to identify resources and technical requirements including:

- Optimal light levels
- Flat and easy to construct on
- Relatively clear ownership and tenancy procedures to be able to develop the land
- Area to expand operations. The initial site area would be less than 10 ha but could expand up to 60 ha with a larger facility
- Access to seawater
- Access to a brine disposal
- Access to roads and infrastructure
- Possibilities for synergies with other stakeholders
- Maximise the beneficial public exposure for the stakeholders

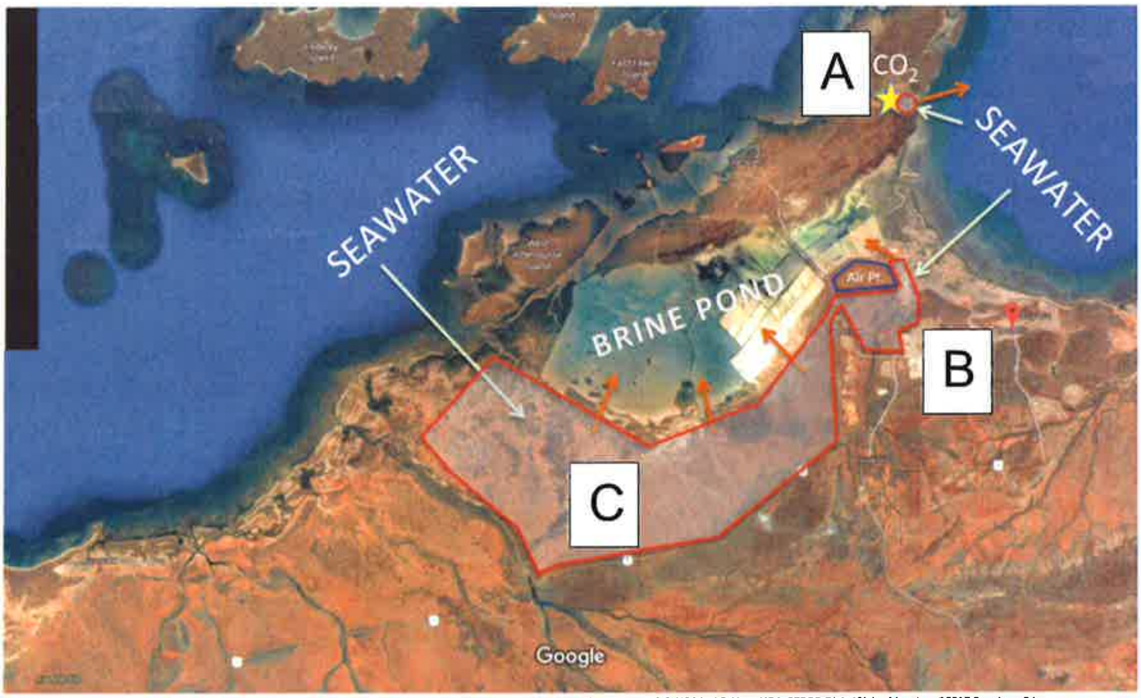
The following will be part of a more extensive study once a site has been identified, but an initial assessment was made of the following factors:

- Flood risk
- Archaeological sensitivities
- Potential issues with the existing ecology. Ideally there should be a potential to improve external growing areas
- Negative interference with neighbours
- Any other environmental impact

The size of the first facility was taken as being based on a 2ha greenhouse on a 10ha plot to allow for external planting and adequate area for solar power production.

3.6.1 Initial Site Review

On the first visit in June 2016, the City of Karratha officials showed the SFP team a number of sites that fulfilled the initial criteria SFP set out. The areas bounded in red show the rough outline of the areas of interest.



Imagery ©2017 CNES / Astrium, Data SIO, NOAA, U.S. Navy, NGA, GEBCO, DigitalGlobe, Map data ©2017 Google 2 km

Three basic areas where offered that on first pass fulfilled SFP's criteria:

A. The area to the North near the plant of project partner Yara as indicated by the yellow star
B. The area around the Karratha Airport
C. The large area to the south of the brine ponds where 1000's of ha are available

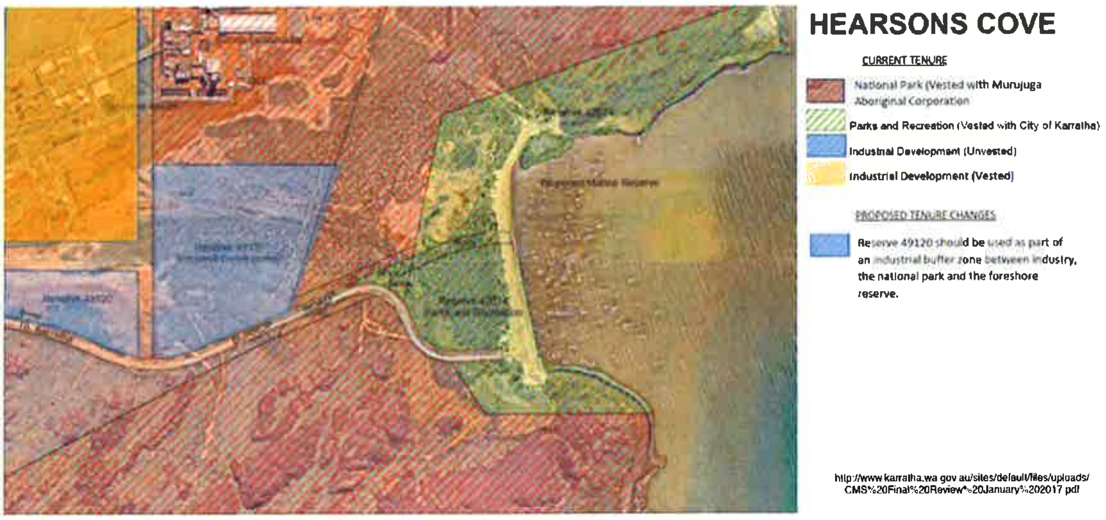
Of these, C was discounted at this stage as being too big and far from infrastructure. However, the area does offer good potential for an expansion into a very large facility or sets of facilities as and when the project moves into a large scale.

Area A

This area has the advantage of being near the Yara site and would benefit from the waste CO2 stream coming from the plant that could be used in the greenhouse.

The Yara facility also has the benefit of a seawater cooling intake and discharge pipeline discharge to King Bay in the Dampier Harbour on the other side of the peninsular, to save the need to have new supplies into Hearsons cove.

Planning advice indicating the area for Parks and Recreation, National Park and Reserve for a buffer zone between industry and the parks.



The land near the Yara plant.

However, there were a number of challenging issues that ruled this area out:

- The land was low lying and subject to flooding
- The land to the east of the site indicated is very close to the civic amenity of Hearsons Cove
- Scope for expansion is limited
- The Proximity to the important rock art installation in the hills. The location of large development would be insensitive to this heritage

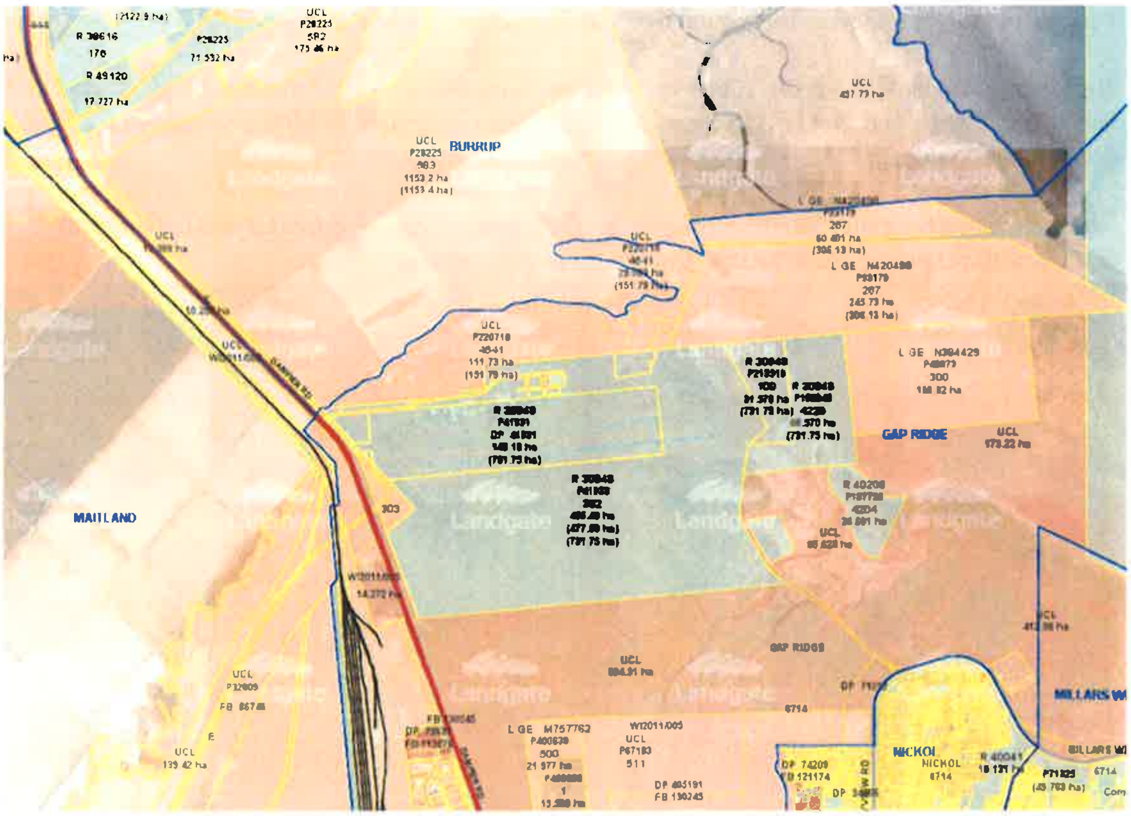
As such this area was discounted.

Area B

The land round the airport has many advantages and rates highly on all the initial criteria set out for the site selection. The site is generally level, well serviced for infrastructure, reasonable proximity to seawater, and has a number of other stakeholders who would be interested in joining SFP in shared infrastructure projects. It is one of the best-connected areas for getting visitors and attracting attention.

The study examined the areas around the airport site in more detail to understand what the relative benefits of them are.

Land tenure



SFP were provided this map from the City of Karratha to indicate land tenures around the airport. SFP understand that the area in green is under the control of the City of Karratha and could be handed over for development relatively quickly provided the City was not using it themselves for, say, airport related activities.

3.6.2 **Sites in Area B / Airport sites**

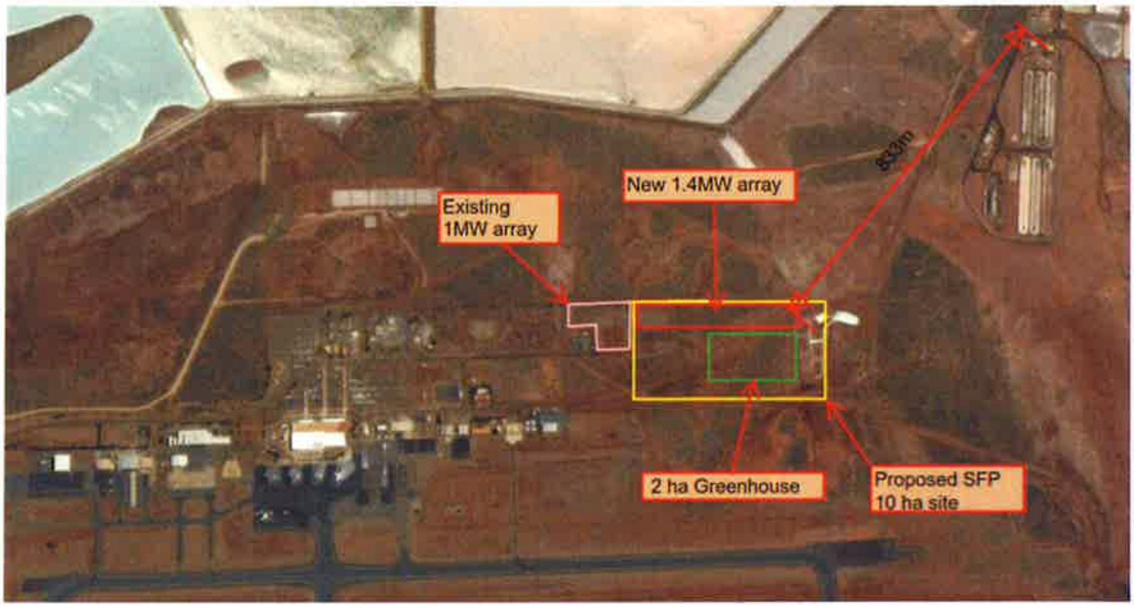
Three sites around the airport were examined in greater detail as indicated below.

Site B1

This site is closest to the airport and next to the existing PV facility. It is also reasonably close to the Rainstorm seawater intake. This would be a viable position, but the area is constrained.

The illustration below is for the 10ha site. To fit this onto the site would mean substantial infill and levelling of the ground that falls to the east and has been excavated to form a speedway for boats, flooded by the tide.

However, a much smaller facility with say a 2000m2 greenhouse [as opposed to a commercial 20,000m2 greenhouse] could be constructed there as a proof of concept.



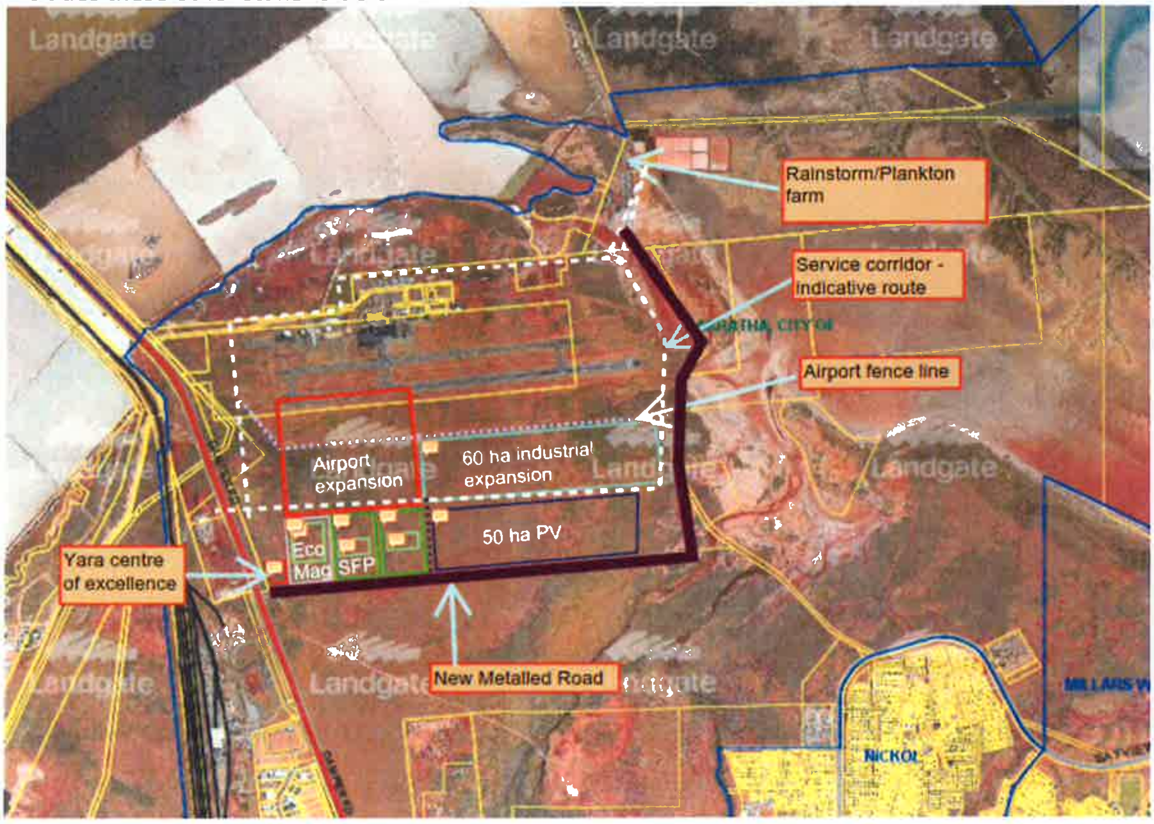
Site B2

The site next to the Rainstorm/Algae farm is close to the seawater supply but is constrained, low lying and exposed to flooding. As such it was discounted.

Site B3

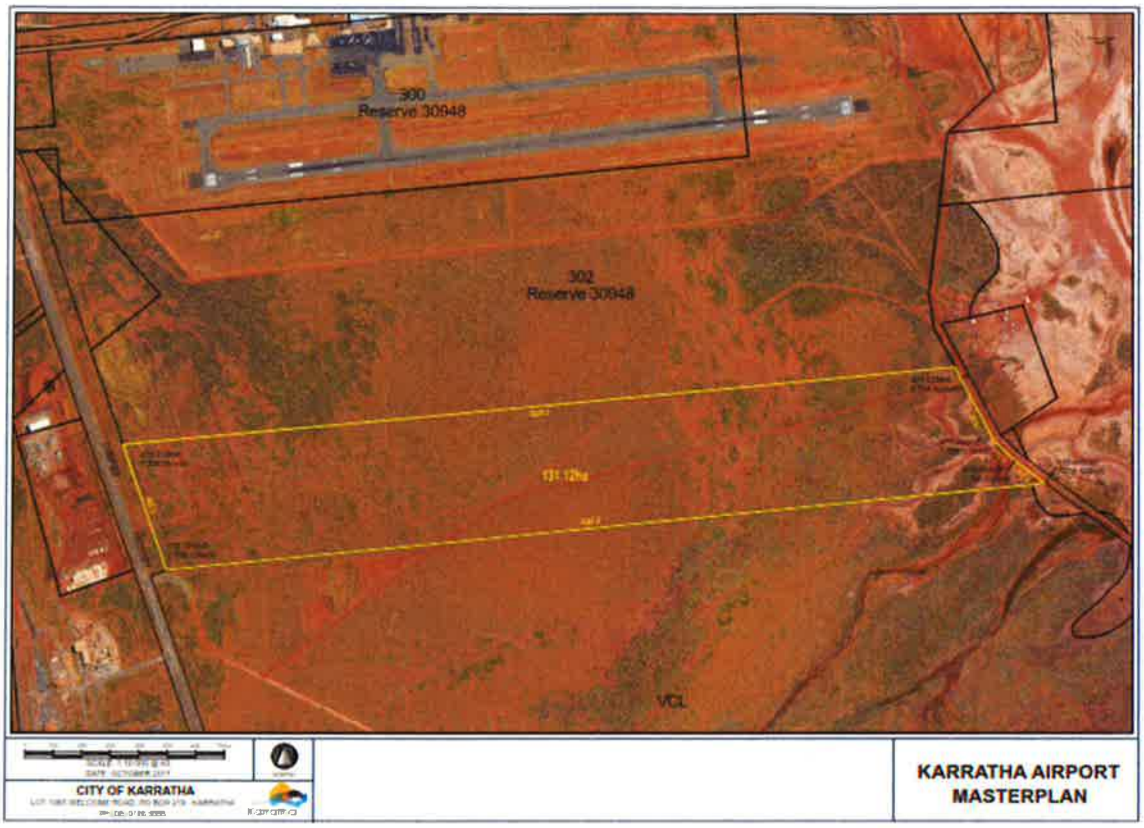
Site 3 has potential for expansion. It is a flat and level area of land that is at an elevation of 5 to 7 m and less prone to flooding. The land area is designated for the airport. Initial consultation with the planners and the airport management indicate that they would be happy if a smaller area of land was left for airport expansion, allowing the rest of the site to have commercial development.

SFP have considered the development of this site in conjunction with other stakeholders who have expressed an interest sharing the infrastructure. The drawing below illustrates an arrangement that includes these other stakeholders:



In this arrangement, an area of expansion for the airport equivalent to the current facilities on the other side of the runway has been left. The proposed development has been sited to the south of the current airport fence line. A 10ha SFP site has been indicated. There is capacity to expand if required into the 60ha expansion area. There is currently a road connection to the Dampier Highway that could be extended to serve the site. While the site would suit a stand-alone SFP facility the site also has the space to accommodate other stakeholders and a shared infrastructure. The shared facilities would include the provision of renewable power from a photo-voltaic installation, an HV ring to distribute the power, a centralised desalination, fresh water, seawater and brine installation, and roads. The detail of this is outside the scope of this site selection report.

Site 3 has been discussed with the City of Karratha who has provided in-principle support for the establishment of the facility at this site. The land allocated is as set out below and represents a very positive response to the SFP and shared infrastructure project.



3.6.3 Interested Stakeholders

The following stakeholders have expressed an interest in working together to make a larger synergistic scale facility work. They each have overlapping and complementary requirements that can be served by the shared infrastructure. See section 4.6 for more details about the industrial energy hub proposal called the *EcoHub*.

Yara

Yara have expressed an interest in making use of solar power generated at a common site to wheel energy back to the Yara facility.

The Airport

The airport is run by the City of Karratha. They have already installed a 1 MW PV array on site that meets approximately 30% of the airport electrical load. They are interested in increasing the amount of renewable power. They already run a 33kV HV electrical distribution system and meter tenants. They have expressed an interest in managing an extended distribution system that would include the other stakeholders.

Rainstorm/Plankton Farm

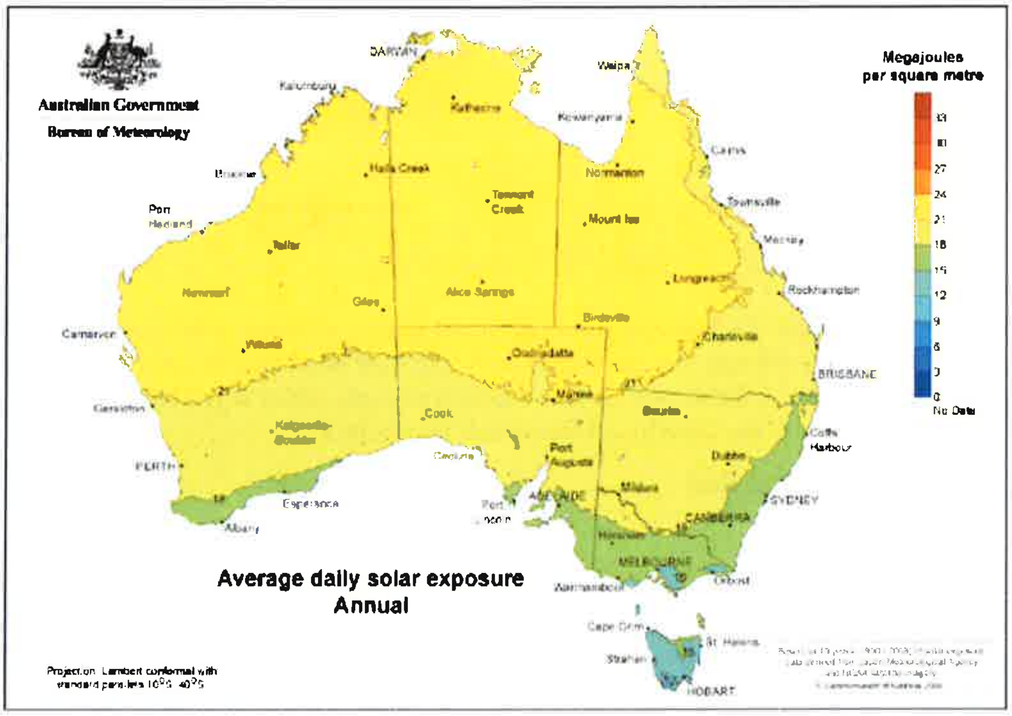
These two businesses are already on the site and have expressed an interest in replacing the off grid diesel electrical generation with PV. They also have an underutilised seawater connection that they are happy to get more benefit from.

Eco-mag

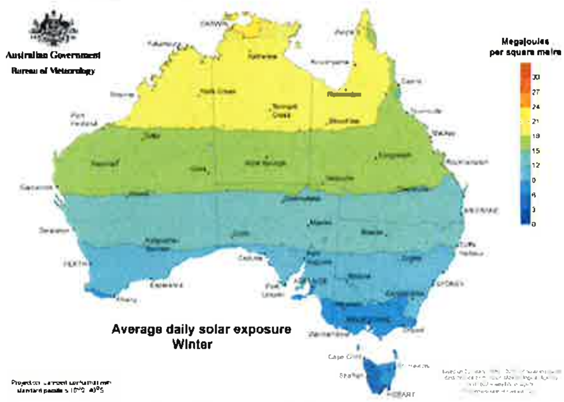
This is a new company with a technology to make use of the magnesium in the Salt Works waste brine stream to make high value magnesium products. Their facility requires large amounts of power, access to the brine, and fresh water and a good access to the road network for their product.

3.6.4 **Light levels in Karratha**

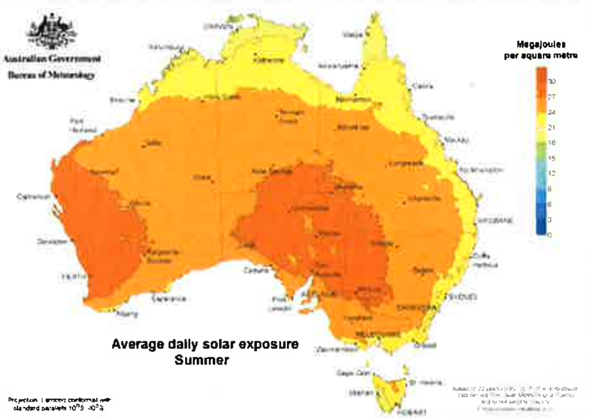
A greenhouse provides a controlled environment that allows plants to be grown at near perfect conditions and protects them from harmful external weather events. However, they represent a high capital expenditure, particularly in Karratha where structures need to be sufficiently strong to cater for cyclone speed winds. To make the expenditure worthwhile the productivity of the greenhouse needs to be high in terms of the volume and value of produce grown. High light levels contribute positively to both these factors.

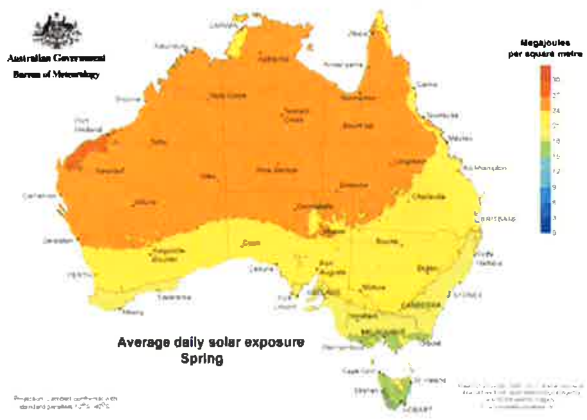


The light levels in the Pilbara are of the highest in Australia and indeed the world. Data from the Bureau of Meterology shows that the average winter time daily light levels are as high as the summer peaks in Northern Europe. Winter light levels of 15 to 18 MJ/m2.day in the Pilbara compare to light levels of 9 to 12 MJ/m2.day in the southern belt of Australia spanning Perth to Sydney. This is around 60% more light. Through the rest of the year there are similar benefits for light levels over the southern part of Australia, but it is less pronounced in the summer. Overall the annual light levels in Pilbara fall into the 21- 24 MJ/m2.day category while the south is 18-21 around Perth and across to Queensland, and 15 to 18 to 18 around Sydney/Melbourne.

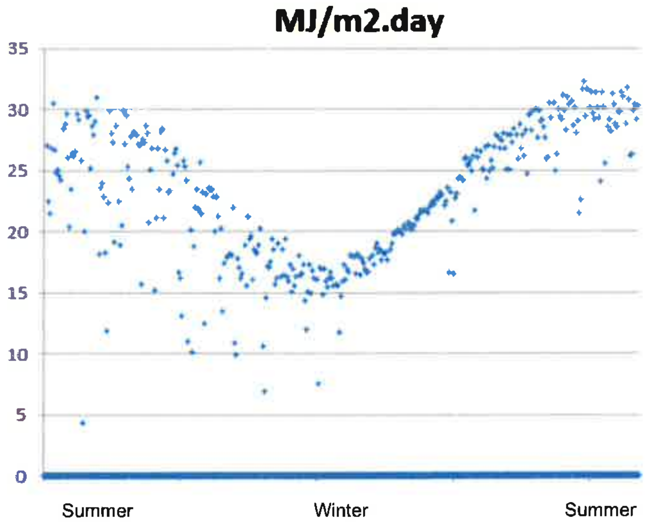


Light is one of the most important features in photosynthesis. All things being equal, the rule of thumb is a 1% increase in light gives 1% increase in growth. As such there is a significant benefit in the higher light levels in higher productivity, especially in the winter when the productivity is at its lowest in the south and the prices are therefore higher.





To take advantage of the levels of sunlight within an enclosed space the heat needs to be taken with a cooling system. The SFP greenhouse was developed with cooling in mind and has been proven at The Sahara Forest Project Pilot in Qatar. See section 4 for more details. Chart of typical annual distribution of daily light level in Karratha from Meteonorm hourly data:



It should be pointed out that 18 MJ/m2.day in UK is seen as a very good summer day light output.

3.6.5 Seawater intake and brine discharge opportunities in Karratha

There are some complications with the seawater intake and brine discharge that need to be taken into account in the next stage of site analysis, design and partnering. The ocean around Karratha has a tidal range of up to 5 meters. The Nickol Bay that is to the East of the airport is the obvious place to extract seawater for the site. The Salt production facility precipitates out the NaCl from the seawater which is the product it sells. The remaining liquid [Bitterns] from this process is a dense and concentrated salt solution of Mg Cl2 and other compounds in lesser quantities.

The brine discharge has been flowing into the Nickol Bay for 40 years or so. It is likely that the sea floor is covered with a layer of this very dense brine. As such it would not be sensible to take a seawater intake from the sea floor as it is likely to be concentrated brine rather than fresh seawater.

In addition, the tidal zone is gently sloping and has established mangrove plantations. Getting a new pipeline to the open water at low tide would require a long pipe through mangrove plantations.

The Rainstorm/Plankton farm leases a portion of land to the north east of the airport. The facility has a seawater intake that operates when the tide is approximately over the halfway mark. This currently serves a desalination plant. The waste brine flow channel from the Salt works also passes adjacent to the site. The seawater intake is currently underutilised, and the owners of Rainstorm are happy to share the intake at a suitable commercial rate. It is also considered that the Salt outflow could act as a potential outlet for brine from a desalination facility given that it is making use of an existing pathway.

As such it is considered that the most cost-effective source of seawater is a tidal supply from the Rainstorm site. Other routes are possible but at a higher cost and would involve threading through the mangrove plantations.

3.6.6 Summary

There are several sites around Karratha that are interesting for establishing a Sahara Forest Project Facility. However, bearing in mind the various elements of the site analysis above, the airport site B3 offers the greatest prospects for a shared infrastructure and space to expand. However, if a smaller facility of 2000 m2 was considered appropriate, then site B1 would be less expensive to construct in isolation. As the council has given in-principle support for site B3, building in the alternative site would require their further consideration.

3.7 Costings of construction elements

The Sahara forest project facilities constitutes a range of CAPEX elements as outlined below. The specific costings are detailed in section 3.8 and depends on scale, site specific requirements and infrastructure cost.

The components of an SFP facility of a greenhouse and solar installations are mass produced commodity items that are tightly designed to be very low cost structures for an agricultural setting. However the site in Karratha has a number of engineering and logistics challenges that add complexity to the standard solutions that are challenging to price.

The costing was broken into three elements being the greenhouse, the PV and battery installation, and the site infrastructure.

Enquiries were sent out to several PV and battery suppliers and 7 reasonable replies were obtained indicating a high interest in the project. The responses provided an interesting range of battery technology choices. We received four prices clustered between $79m and $95m for the largest 23 MWp and 90 MWh scheme.

There were more challenges getting costings from the Greenhouse industry. We understand that the market is over-heating now due to high global demand for greenhouses following a depression in the market two years ago. It is usual for the greenhouse contactors to provide the structural design as part of their package. However to assist the costing process and for SFP to understand the issues of a greenhouse structure to cater for the cyclone conditions, SFP commissioned a structural engineer to produce a design that could be used as a touch stone for other designs. The specification of the greenhouse is of the highest standard of greenhouse using SFP salt water cooling and computer controlled hydroponic irrigation and climate control. To date we have received "ball park" figures from 4 contractors.

A Perth based quantity surveyor and building services consultants were employed to price the infrastructure and ancillary building elements working to the brief for the various scales of projects positioned in the strip of land to the south of the airport. The QS provided costings on the roads, site clearance, builder's work, fencing, ancillary buildings etc. then gave a view on the overall pricing and added an uplift for being in Karratha. These costs where used in the business case for the project.

3.8 Operational cost

We have modelled the operational cost components of the combined technologies. This section looks at the operating parameters for the greenhouse in particular.

The highest cost for the greenhouse operation is the labour which we have based on an hourly rate of $23/hour and executive rates for the management. We are expecting much of the labour to come from the local community to build a local commitment to the project. We believe that labour availability will be supported by the fact that the mining industry, the largest employer in the region, is in transition from construction to production.

The fertiliser, seed, packaging are global commodity rates for horticulture. We have allowed for transport to Perth at $1000 a container, which is taking advantage of the lower back haul price of trucking going south. This adds $0.05 to $0.15/kg on the produce depending on the crop. Allowance has been made for maintenance, replacement and insurance of the facilities, based on the capital costs.

We are imagining that the CO2 will be taken from the pure CO2 waste stream from Yara's facility and the costs are linked to the capital and energy costs of processing the gas. The water and energy costs for the greenhouse operation have been taken as the costs to make water from seawater RO and power from solar power as separate business entities. The running costs for the RO have been built up taking into account the energy, maintenance costs of parts and labour together with the chemical dosing requirements. Equally the cost of the power has been built up taking into account the maintenance of the array and battery installation. As discussed elsewhere the back- up provision for power when the sun is not out for a day will be standby generation rather than the grid. The standing availability charges for the grid supply are much higher than a generator.

3.9 Expected return on investment (ROI)

Based on the site identification process and the market analysis, we have developed two primary scenarios for the development of a facility in Karratha. The business case is based on the modelling of a small- and large facility. We have also reviewed scenarios with tighter integration with local industrial partners. These have been described, but not modelled specifically in this report as the implication of these arrangements are of a sensitive nature due to third party confidential information and contingent on a range of commercial arrangements being fully agreed. We are however very positive to the evolution of a group of companies enabling the use of shared infrastructure as well as utilising each other's waste streams and production processes.

3.9.1 Scenario A

In the Small-scale scenario, the facility would be of limited size to comparable greenhouse operations. However, in terms of local consumption the facility would yield a significant output in the local market, act as a first step for a more diversified local economy and work well with local synergy opportunities.

	Market	Size / capacity	Synergies	Environmental & Social Impact
A **Small scale «Karratha» facility ~8 ha** (2 ha Greenhouse)	Local & regional market	**Area Breakdown** • 2 ha of greenhouse (0.2 ha potentially reserved Wanggalili project) • 1.5 ha of PV • 160 m3/day RO unit on site • Ancillary areas for packhouse roads etc • Total site area of 6 ha excluding the external planting • Irrigation run off to be used to water external areas. This will provide 2 ha of external planting with 1.6 mm of water per day that amounts to about 500 mm/year	• Sharing of infrastructure with industrial partners including seawater connection and brine discharge from local company Rainstorm	• Desert species cultivation • Carbon sequestration through revegetation • Local production capacity for local demand • Creation of local jobs and community driven projects

As such, an 8 ha (2ha greenhouse) facility would imply a sub-optimal scale for having several simultaneous crops, albeit we believe it could be feasible to adjust the greenhouses to allow for 2-3 separate crops without increasing cost to an unfeasible range.

To establish a clear base-case, we have modelled the financials based on a mono-crop facility growing Australian Red Truss tomatoes. We have based the further modelling on an average annual yield of between 50-70 kg per square meters, where we have applied an intermediary measure.

As outlined in the market section we have estimated the local market value and volume in Karratha, Pilbara and Western Australia. Considerable effort has been made to establish a relevant market estimate through triangulation of several data sources, albeit this must still be considered a rough estimate as we have not had access to precise metrics with regional specificity nor negotiated sales- and distribution agreements. We do however believe that we have sufficient information to populate the base case scenarios contingent on the negotiations of off-take agreements and the associated sensitivities as outlined in the following section.

NPV mAUD	Price -5%	Price Base case	Price + 5%
Yield -5%	1,9	0,2	2,4
Yield Base Case	0,2	2,4	4,7
Yield + 5%	2,2	4,6	7,0

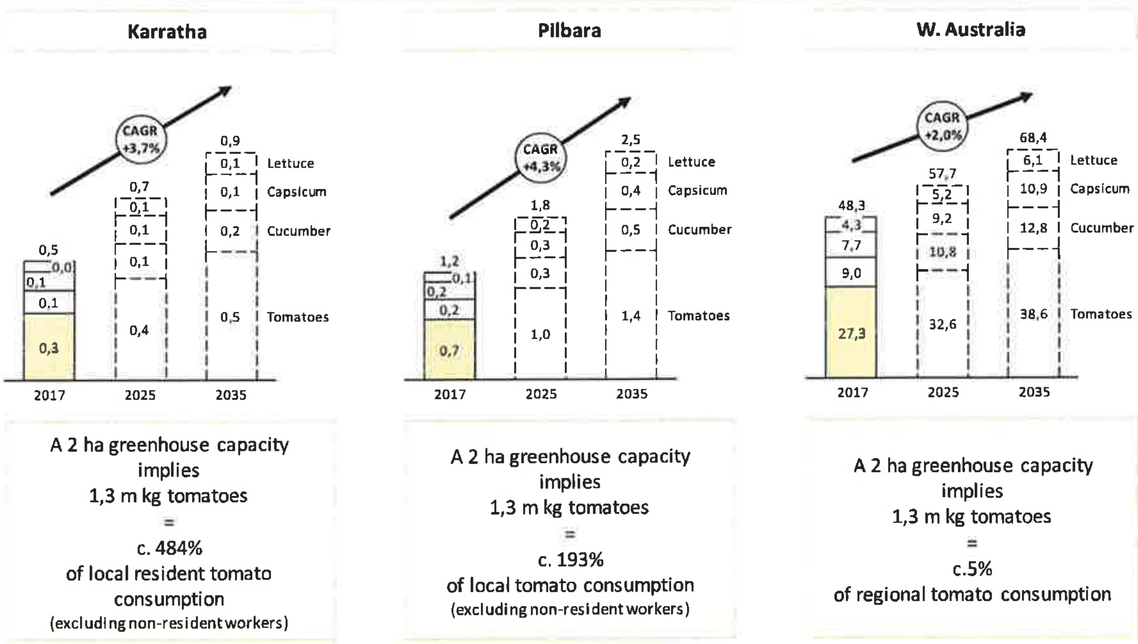
NPV mAUD	Price & Yield Base Case
Discount Rate -1pp	4,7
Base Case	2,4
Discount Rate + 1pp	0,9

1) Sales Volume

Given these estimations, it appears clear that a 2ha greenhouse would be more than sufficient for covering local potential demand in a mono-crop scenario and would thus have to be modified for several crops to enable Karratha-only sales. The modelling has nevertheless not included the consumption of mining guest workers. Combining 1-2 additional crops, distribution to the local mining industry would yield a plausible for case for operating a greenhouse in the local community. It would however appear more efficient to base the facility on distribution to the greater Pilbara Region.

Indicative estimates

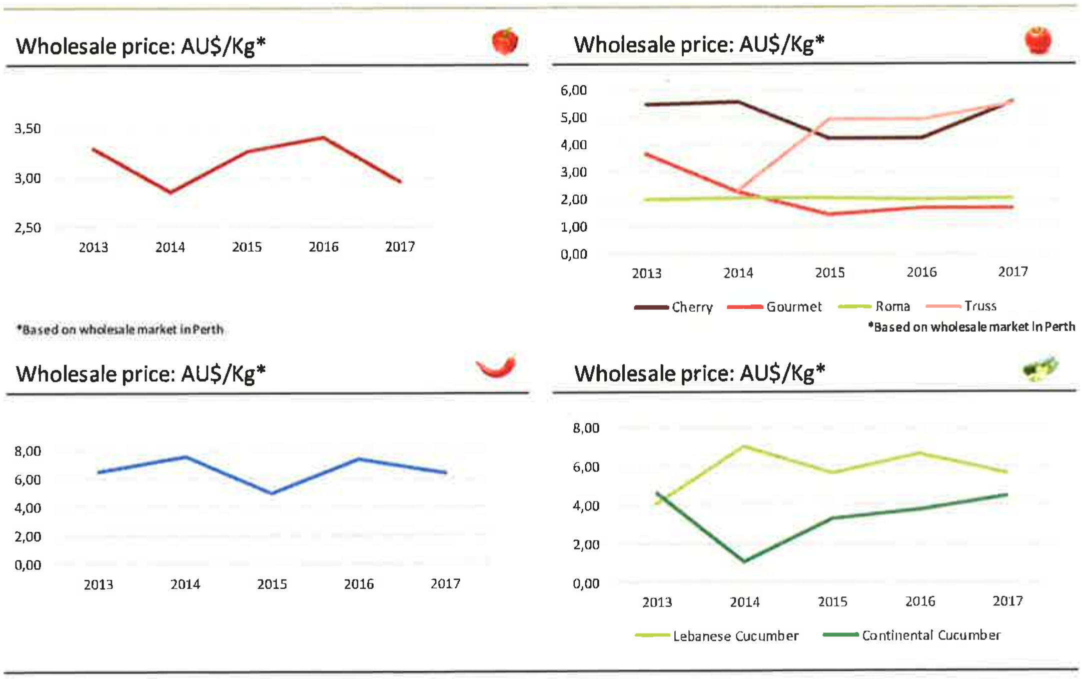
Size of local market, million kg



Source: SFP Analysis

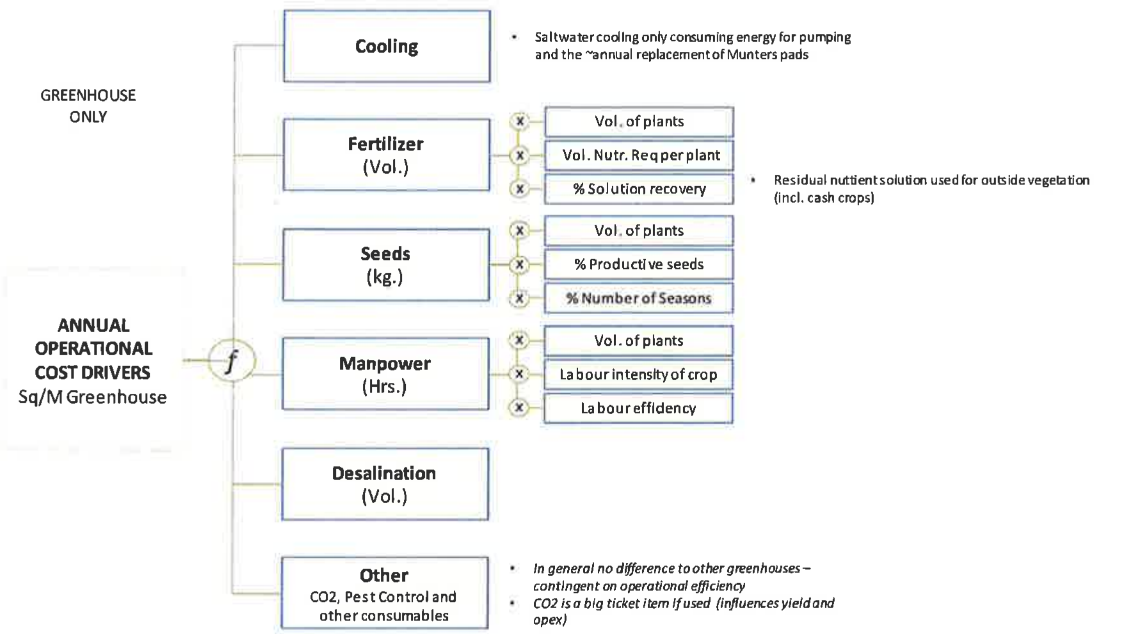
2) Market Prices

Market prices been evaluated based on Perth central market wholesale prices as well as local and regional retail market price observations for major vegetables throughout first half year of 2017. Of these we have conservatively estimated the cost of transportation, marketing and retail markup to achieve the farmgate price expected to return c. 30% of retail market prices.



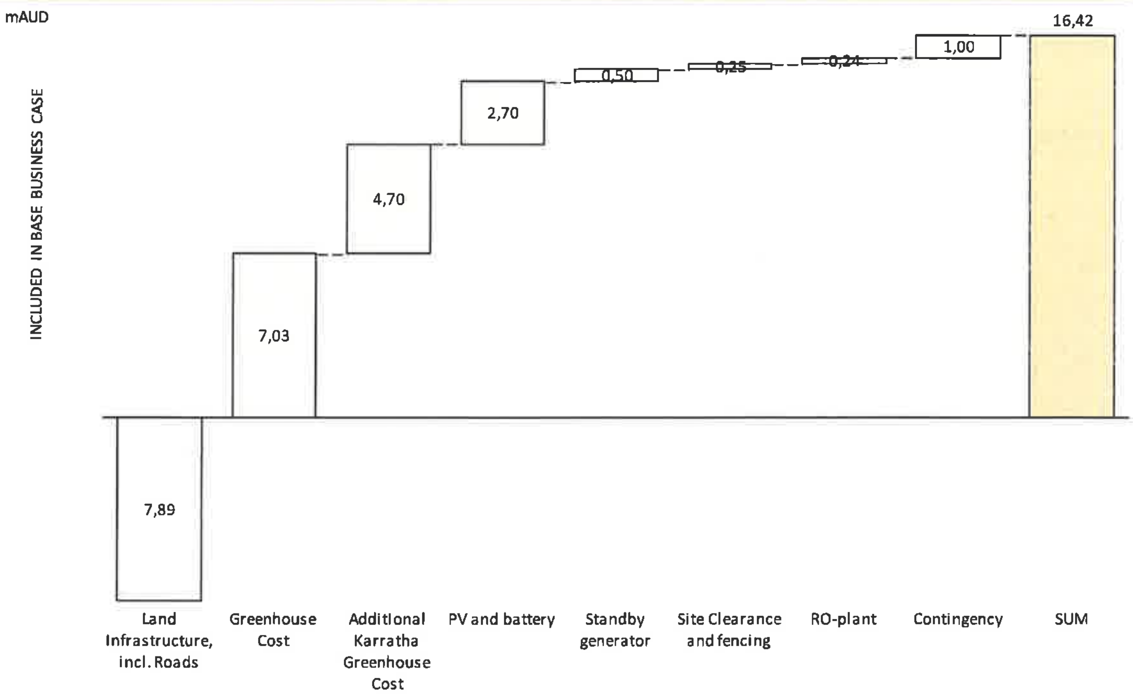
Source: Horticulture Innovation Australia 2017, Market West

3) OPEX



Energy not induded / treated as CAPEX only

4) CAPEX



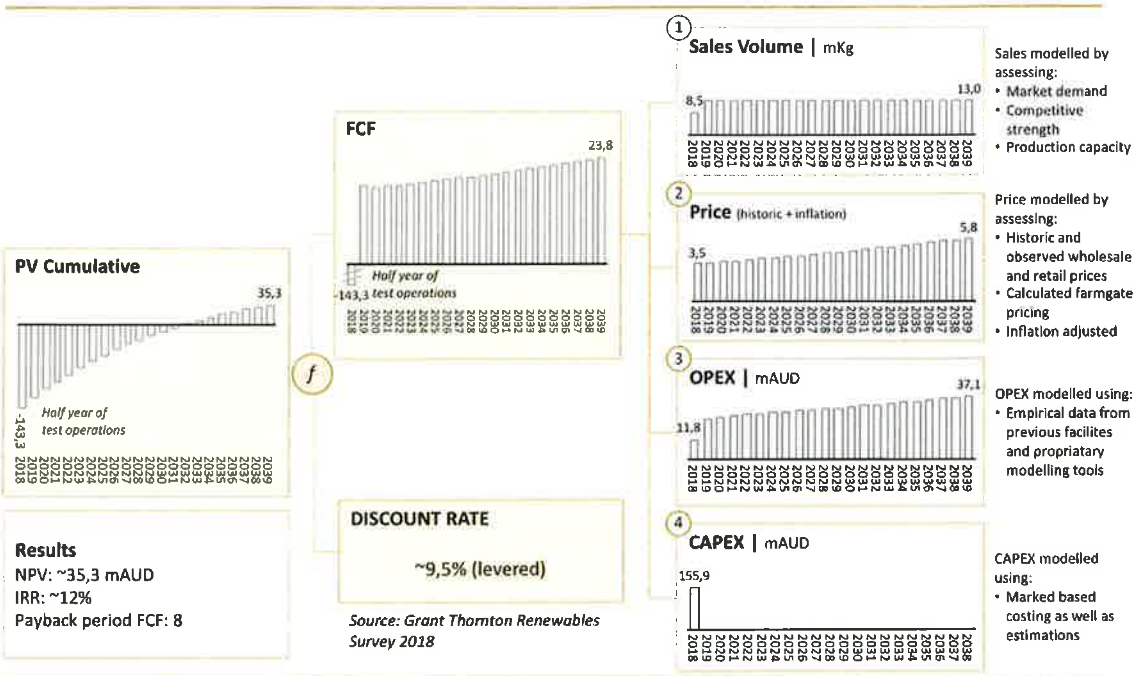
Source: SFP Analysis

The modelled scenarios are based on sharing the saltwater infrastructure (pipeline) with existing companies and covering some of the shared user infrastructure outside the calculated business case as detailed here	**Item**	**mAUD**
	Electrical site work	1,77
	Site pipework	1,26
	Roads and drain crossings	5,15
	SUM	**7,89**

3.9.2 Scenario B

A 20ha facility would imply a significant production capacity for Western Australia considering a mono-crop set-up. A full scale facility would nevertheless allow for a greater degree of mixed crop-production to cater for regional demand, as well as niche-production for export markets. Produce evaluated have included traditional Truss tomatoes, variations of cherry tomatoes, variations of cucumbers, capsicum as well as Strawberries. For comparability we have included a modelling of Red Truss Tomatoes, albeit this would imply a considerable big volume off-take agreement.

	Market	Size / capacity	Synergies	Environmental Impact
B **Large scale «Karratha» facility ~60 ha** (20 ha Greenhouse)	Local, national & export market	**Area Breakdown** • 20 ha of greenhouse area made up of several smaller greenhouses to allow for differing crop and climate regime and pest/disease control. 10% of the area could be reserved for Wanggalili project as it develops • 15 ha of PV • 1600 m3/day RO unit on site • Seawater connection and brine discharge from Rainstorm. • Ancillary areas for packhouse roads etc • Irrigation run off can be used to water the external areas. This will provide 20 ha of external planting with 1.6 mm of water per day that amounts to about 500 mm/year	• Sharing of infrastructure with industrial partners including seawater connection and brine discharge from local company Rainstorm	• Desert species cultivation • Carbon sequestration through revegetation • Local production capacity for local demand • Creation of local jobs and community driven projects

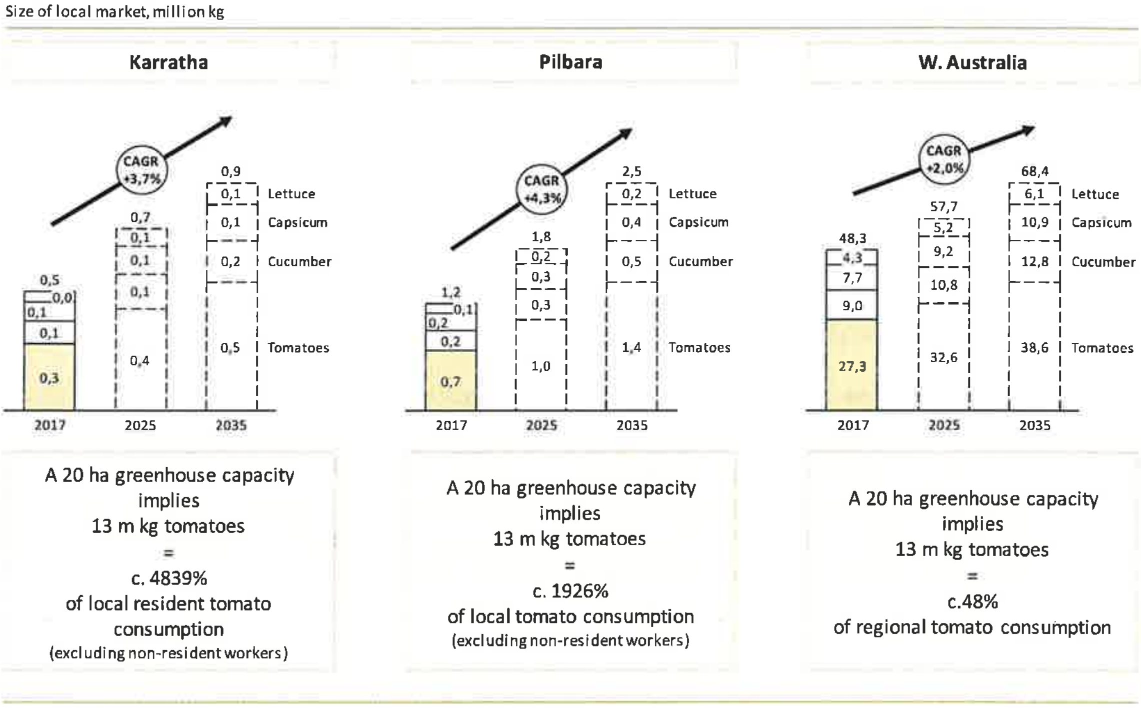


NPV mAUD	Price -5%	Price Base case	Price + 5%
Yield -5%	-1,2	16,6	61,8
Yield Base Case	16,6	35,3	54,0
Yield + 5%	34,4	54,0	73,7

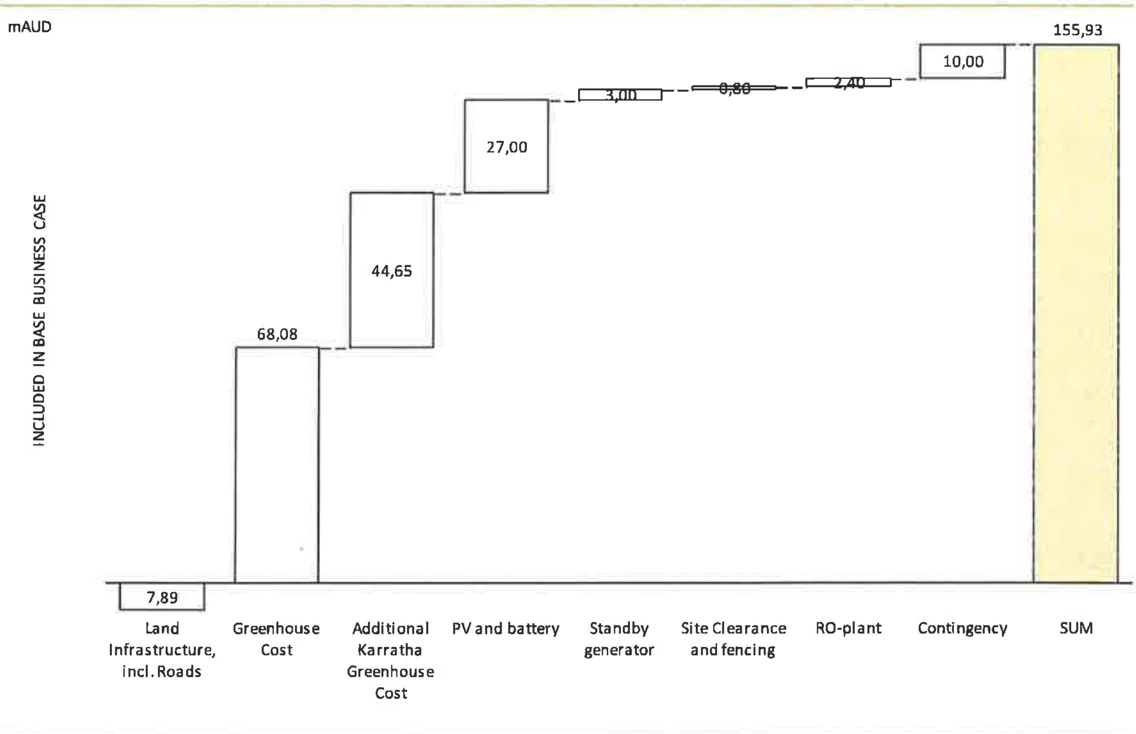
NPV mAUD	Price & Yield Base Case
Discount Rate -1pp	49,0
Base Case	35,3
Discount Rate + 1pp	23,2

1) Sales Volume

Indicative estimates



4) CAPEX



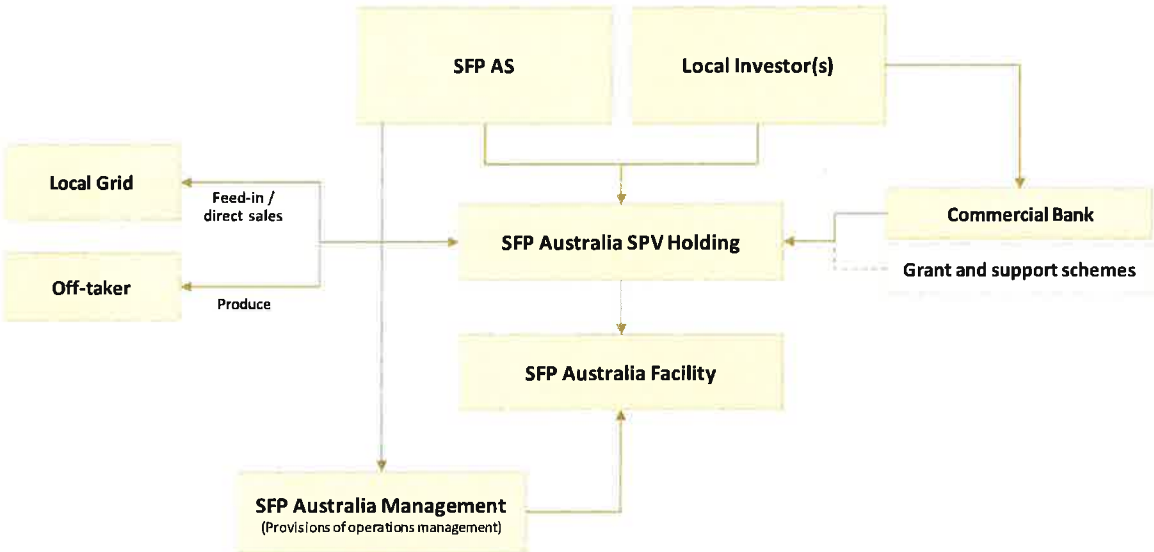
Source: SFP Analysis

3.9.3 **Summary**

Preliminary calculations indicate a modest return from building and operating a small facility catered to local (Karratha) and regional (the Pilbara) demand. With the local market not being large enough to support a 2 hectare greenhouse mono crop, some regional sales would be required and/or multicrop production initiated. This positive return assumes government support for the common user infrastructure interfaces. Even though a larger facility could yield a stronger return (contingent on favourable logistics costs and a comprehensive off-take agreement), the preferred option is to start the roll-out of The Sahara Forest Project in the Pilbara with the smaller scale facility. This is based on the current market demand in Karratha in combination with the business opportunities that exists with the right local partners (government and private). The smaller facility would also be of a suitable scope to attract the necessary Capex for the concept at this stage. The strategy would then be to roll it out to larger scale in Karratha and elsewhere in Pilbara when the concept has been established and proven its success on the ground in Karratha.

3.10 Commercial structure set up for facility including investment and operational strategy

The commercial structure of an SFP facility would be based on standardised project finance schemes catered to local conditions and investor requirements with SFP acting as a co-owner and the operator of the facility. As such a principal scheme has been included below, albeit a final set-up would be contingent on the various requirements of investor



3.11 Large scale schemes for export markets

This study illustrates the possibilities for an SFP facility at a small and reasonable scale. The projects would provide hundreds of new jobs and economic development into entirely new sectors to the region. However, the potential does not end there as we see the concept as entirely scalable with attractive markets for food and energy exports from the Pilbara.

At our first discussion in Karratha with the PDC and the City of Karratha we showed a comparison of the area of Karratha to that of Almeira in Spain. The white area is land used for enclosed horticulture.

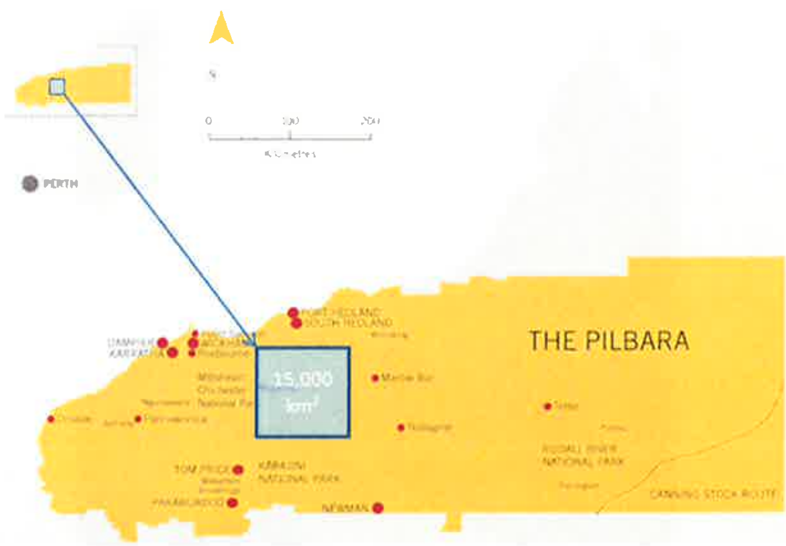
- Google map of Karratha at the same scale as the Almeria, Spain.

- 20,000 ha of greenhouse in Almeria produces
- €2 billion horticultural export.

We have not researched this scale further but none of our studies to date have suggested that this is not possible and the generation of a $3bn industry could be possible over time with this initiative being the first step.

Going further, the combination of available land and the highest solar radiation in the world apart from the Atacama desert, makes the Pilbara an excellent place for generating large amounts of solar electricity. To illustrate the potential, we have calculated the area of solar farm required to match the Pilbara's mineral export income of $41bn a year. This income would be generated from a 1000 GWp 15,000km2 of solar array at an electricity sale value of $0.02/kWh, a low figure that will be a target in the medium term. That energy could be exported by electricity cable, hydrogen or ammonia.

This high level sum shows the potential of the use of the land. The land is however a precious commodity and the traditional owners need to be engaged and included in this use. We suggest that part of this process is making good use of the land between the solar panels for native plants that could not only provide a potential additional income, but a link back to the history of the land. This links back to the work being done on the SFP facility on planting between the panels and the Wanggalili project.



4. OUTLINE FACILITY DESIGN

4.1 Technology choices

SFP is about using solar power to desalinate water for irrigation in greenhouses that are cooled with the waste brine from the desalination process. It is also about the re-vegetation surrounding land. There needs to be an infrastructure to make use of or disposal of the concentrated brine. There are various ways of meeting this brief and we set out the options and choices that have been made for Karratha. The study was commissioned on the basis of two scales of greenhouse 2ha and 20ha.

Through our work, opportunities for synergies with other stakeholders became apparent and the designs were expanded to include them. This section of the report has not dealt with the financial aspects of the wider opportunities, but the technical aspects are discussed here.

There are constraints for working in Karratha that affect the technology choices. The high cyclone winds and occasional high rainfall are factors that increase the size and cost of the structure and rainwater disposal. The area is reasonably remote and the logistics to get there and labour is expensive.

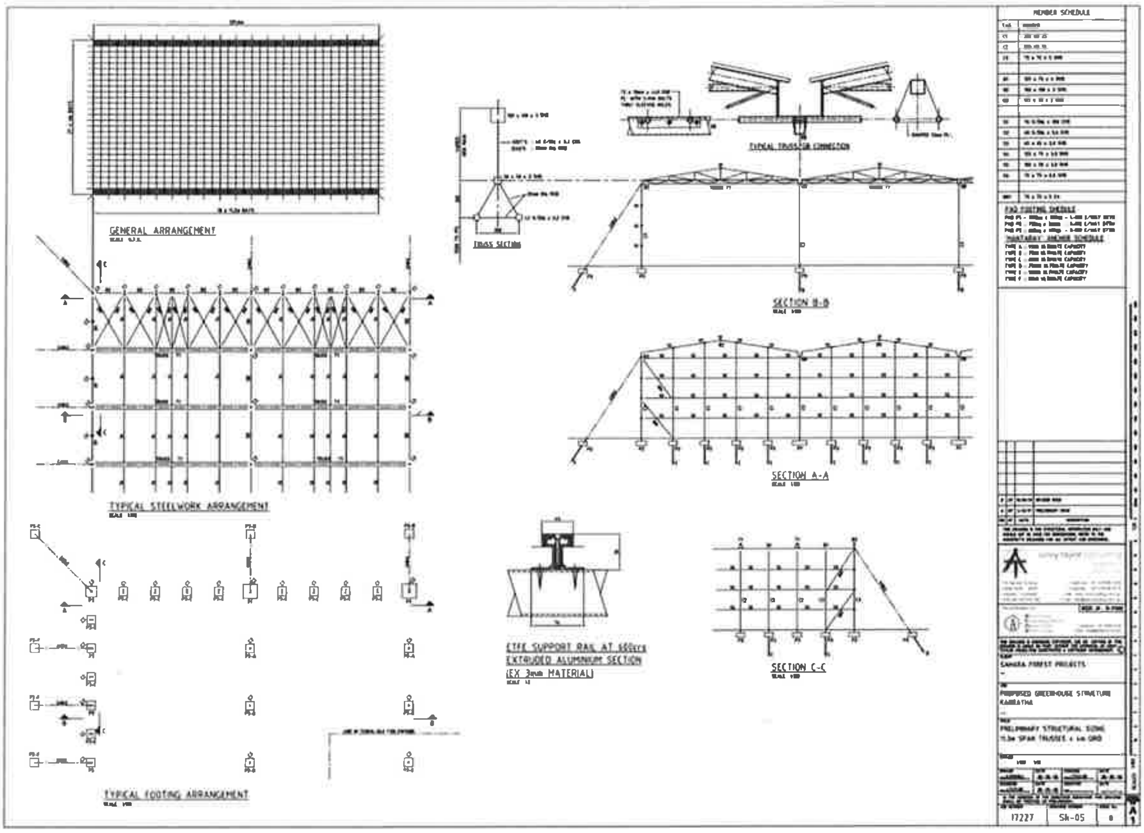
4.2 Greenhouse

The SFP model is based on a multispan modern greenhouse with raised gutters, and hydroponic irrigation to get the maximum yield from commercial protected crops such as tomatoes, peppers and cucumbers.

Greenhouse in Qatar. The air is introduced at the far end and distributed down the greenhouse in polythene ducts. The air is extracted at the other end behind the photograph. Here the shade screen is pulled closed to protect the young plants. The irrigation lines are inserted next to the plants in the coir slabs.

Greenhouse with mature cucumber plants. The plants are grown in coir slabs that are mounted on metal gutters that collect the excess irrigation water.

The basic greenhouse offering is a highly optimised, cost effective structure designed to be as light weight as possible. SFP commissioned a structural engineer to design a structure in keeping with the standard shape of the greenhouse, able to withstand the category 5 cyclone loads.



The design indicates that that it is possible to meet the wind loadings without an excessive degree of overdesign. In reality the greenhouse manufacturer selected would design the structure using his standard truss shapes.

There are a variety of covers for greenhouses to let in light. The most common are listed below:

- Polythene – lowest cost at a c 1 $/m2. Lifetime is 2 to 4 years before it needs replacing. There are schemes to re-cycle the sheet in big horticultural areas.
- Polycarbonate: Sheet material. Multilayer can give some insulation. Discolours over time and needs replacing over 5 to 10 year cycle.
- Glass: The material of choice of most high end greenhouses. Very good light transmission and indefinite life. Cost 10 to 20 $/m2.
- ETFE manufactured as F-Clean: Very robust film with life of 25 years+; Used in conventional buildings. Easy to clean and very high light transmission. Cost at the upper end of glass.

SFP have used F-Clean, film on our greenhouses in Qatar and Jordan. This has proved to be a robust alternative to glass and may be more suitable in high wind areas where there may be some flexing and avoids the hazards of broken glass.

4.2.1 Evaporative Cooling system:

For most of the year the greenhouse will need to be cooled. This is a trade off against very high light levels that should lead to high yield production.

With the SFP greenhouse this is done by drawing the hot dry incoming air across a cardboard "Munters" pad that is wetted with a recirculating flow of brine. The air is humidified and cooled as it runs along the corrugations of the cardboard and blown into the greenhouse. This was trialled in Qatar were the summer wet-bulb temperatures were higher than in Karratha. The thickness of the pads has been optimised from 300 mm thick to 150 mm which reduces the airflow pressure drop and pumping power significantly providing savings of a factor of 6.

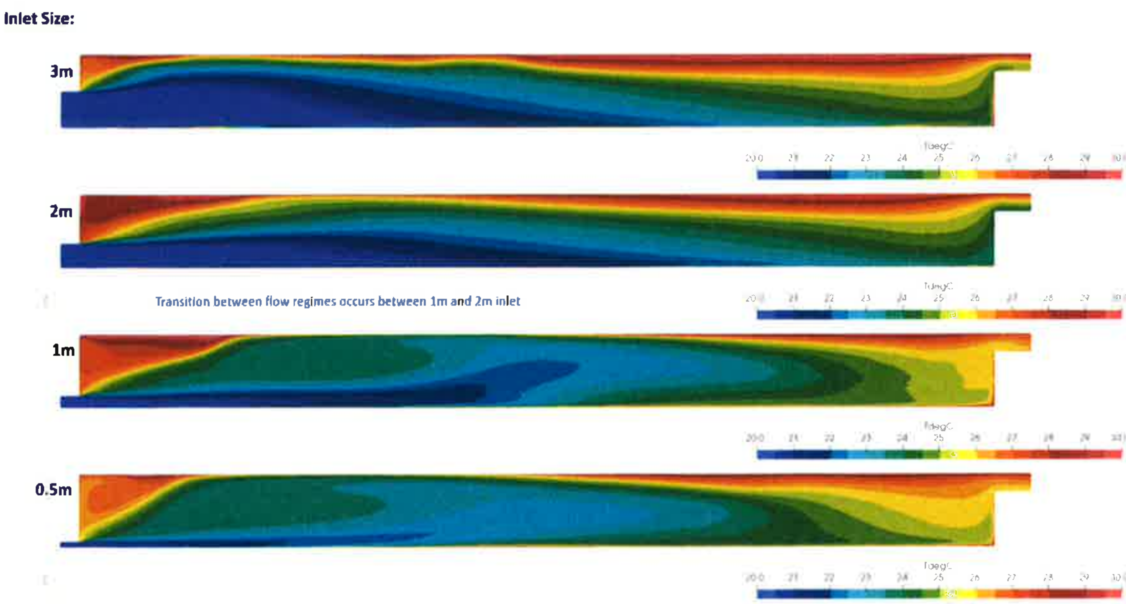
The salts in the waste brine get more concentrated as the water vapour is evaporated. The brine is replaced when the salinity gets to a trigger point before causing precipitation on the pads.

The airflow comes in at the far end of the row and extracted over the "road", the concrete path at the start of the row. In Qatar the air was distributed in polythene tubes. Research is being carried out to see if the air can be introduced without the tubes

The airflow in the greenhouse has been modelled with CFD to investigate a number of different options of introducing the air, the length of the greenhouse and the evenness of the temperature. Some of the results are shown here for a 75 m long bay with different inlet velocities.

Inlet Size – Temperature

Parameter	Value	Units
Volume flow rate	50	l/s/m²
Inlet Size	-	m
Inlet Height	0.0	m
Length of greenhouse	75	m
Number of Outlet	1	no



It can be seen that a reasonable distribution is achieved with a 2m high inlet over 75m. Notwithstanding the analysis the initial Karratha greenhouse will be a 50m long run.
The arrangement of the air inlet is to provide the coolest air at the bottom of the growing area and the air moves up through the plant picking up heat as it goes. It is common for varieties such as tomatoes to have the fruit hanging at low level. This will ensure that these are kept the coolest part of the plant.

4.2.2 Provision of heating and cooling

The crop needs to be kept within a temperature range and temperature regime that is suitable for the plant. The likely crops of tomatoes, cucumbers and peppers are tropical plants and prefer warm humid conditions that the SFP greenhouse can provide. The evaporative cooling will keep the maximum temperatures below the 30 to 34°C peak in the day. At night the greenhouse needs to be cooled to provide a day/night swing that the plants require and to reduce the respiration rate. The evaporative system can provide most of this, but we suggest that a short period of additional cooling with chilled water is used in the evening to pull the temperature down to below 20°C. At night the temperature should not drop below 15 °C which is unlikely in Karratha making heating at night unnecessary. At sunrise the plants will become active and the air gets warm and humid very quickly. The plants need to be warmed up before dawn to prevent condensation on them that leads to fungus attack. As such there is a small amount of heat required before dawn and some cooling after dusk. This will be done with a heat pump that provides both cooling and heating that can be stored in water tanks. The electric heat pump would be run during the day when there is solar power available, to both charge up the cooling buffer tanks – that will be used in the evening, and the heating buffer tanks – that will be used in the morning. An allowance of 100Wh per m2 of greenhouse has been made to provide two hours of 50 W/m2 of heat to warm up the crop at dawn, and 75Wh per m2 of cooling. The energy and water flows have been modelled based on hourly weather data.

The heating will be provided using the 50 mm diameter pipes on the floor that also double as rails for trollies to run along the planting. Hot water is circulated through the pipework when heat is needed.

4.2.3 Pest control

The intensive climate controlled agriculture in the greenhouse is an excellent environment for crop pests and diseases. It will be the aim of the project to control these with the minimal use of pesticides and make use of native predator species to keep a natural control on the pest population. This approach is best for the product and the operatives and ultimately is the lowest cost solution.

Our Nepalese apprentice Laxman on a trolley in Qatar picking cucumbers and inspecting the plants for pests

4.2.4 Irrigation

The plants are grown in a 50 to 100mm thick slab of coconut coir matting that is elevated on raised "gutters". The roots develop in the coir growth medium. Each plant is irrigated with a mix of water and nutrients that is 20 to 30% more than the plants uses. The balance of what the plant does not use drops out of the growth medium and runs down the gutters where it can be collected. The oversupply of water maintains the correct nutrient balance in the growth medium and flushes away any nutrient imbalances.

The amount of irrigation and nutrient balance is essential to minimise the amount of water used and optimise the growth and taste of the crop. The system is computer controlled to provide the correct mix of nutrients and water that is linked to the light levels in the greenhouse. The irrigation water is injected into the growing medium next to each plant giving very precise control. The computer allows all the climatic and plant variables to be monitored and optimised to provide the best production in terms or output and taste. Excess irrigation water that is nutrient rich can be sterilised and recycled into the greenhouse or used elsewhere. The SFP model is to have external planting and generally the run-off water is used to irrigate the external crops.

4.2.5 CO_2

CO2 is an essential aspect of photosynthesis. In temperate climates and in cold weather the ventilation rates in greenhouses are limited and the plants will absorb CO2 to the extent that the levels are pulled down below the atmospheric levels which starve the plants. To deal with this CO2 is injected into the greenhouse and the CO2 levels are maintained at higher than atmospheric levels. [800 to 1000 ppm as opposed to the atmospheric 400ppm].
However, in hot climates the ventilation rates are significantly higher which means that the plants are unlikely to pull the CO2 levels down and it is difficult to inject enough CO2 to make a difference because of the high levels of dilution. It is a reasonably high cost and SFP will be experimenting with and without and looking for synergies with other industries to make use of clean waste CO2.

4.2.6 Shade and thermal screens

The greenhouse will have a motorised shade and thermal roof screen. Research has shown that in high light levels plant leaves shut down in the middle of the day to assimilate the products of the starch created in the morning. The shade can be used to protect the plant at these times. It will also be used to reduce the incoming solar radiation when the external air enthalpy is very high, and the cooling system will not be able to keep the temperatures in range. At night in the winter, the shade will be used to reduce the heat loss on cooler nights.

4.2.7 Space for the Wanggalili Project

SFP have signed an MOU with the Wanggalili Project, an initiative to look to commercialise the desert species in conjunction with Aboriginal communities who know the plants and understand their benefits. The plants can provide food and other products from natural sources. This is a very exciting project that brings together a number of SFP ideals of restoring land and cultivating the desert in conjunction with the local communities. SFP's commitment to the project is to provide space in the greenhouse for the growth of seedlings of native desert species. This will look to test the response of these plants in a high technology horticultural controlled environment and irrigation system. The planting area would share the same environment as the commercial crops but could have its own irrigation and shading regime controlled by the central computer. It is hoped that this will accelerate the growth of the plants that normally grow slowly in the challenging arid external environments. The mature seedlings can be transplanted to external growing areas on the site or to other sites in the region.

4.2.8 Greenhouse ancillary areas

The scale of the greenhouse will be defined by the market opportunities discussed elsewhere. As well as the greenhouse there will be a number of other ancillary buildings that are required for a horticultural operation such as workshops, staff welfare, offices and cold stores. These can be incorporated into the greenhouse structure itself. The picked produce is graded and packaged on site. The cold store is needed to keep the produce between collections.

The areas of the ancillary spaces are linked to the area of the greenhouse. We have taken the following scale based on experience in European commercial greenhouse operations as a first pass assessment. In reality the scale and sizing will depend on what is being grown. The picker population does vary according to the type of product grown.

			Size of greenhouse			
Activity	Area		2	ha	20	ha
Picker population	7	per ha	14	person	140	person
Managerial population			3	person	7	person
Pack house	4%	of greenhouse	800	m2	8000	m2
Staff facilities	0.75%	of greenhouse	150	m2	1500	m2
Workshop	0.75%	of greenhouse	150	m2	1500	m2
Plant room	0.75%	of greenhouse	150	m2	1500	m2
Offices	15	m2 per person	45	m2	105	m2
Total non- cold store			1295	m2	12605	m2
Cold Store	0.65%	of greenhouse	130	m2	1300	m2

At peak production the 20ha greenhouse could be producing 400 tons a week resulting in 40 truck movements. As such the roads need to be of reasonable quality to take a high number of heavy goods vehicles.

4.3 External planting

The existing planting around airport.

A significant part of the Sahara Forest Project concept is external planting. The run off water from the greenhouse irrigation system is a nutrient rich resource. This could be recycled into the greenhouse, but this poses risks of spreading infection through the greenhouse if not adequately treated. To eliminate this risk and make full use of the resource we use the run off to promote the growth of external plants. Karratha does get an average of just under 300 mm of rainfall a year that comes at certain times with very little from August to December. The ground water level is 2-3 m below the surface according to boreholes next to the runway, but we understand that it is saline. As such the ground does have some moisture that can support growth. Saline tolerant species with longer roots can tap into the ground water.

The site is in a cyclone area and next to the airport which creates some limitations on what is planted. The plants needs to withstand the high winds that occur intermittently, and not to attract birds to any great extent that might affect the aircrafts.
Mangoes have been mentioned as a successful fruit crop that could be used. We would also like to use the external space to grow out the native species from the Wanggalili project after they have been grown in the greenhouse.

The ground around the site in March.

4.3.1 Planting around solar panels

We are also looking at the possibility of growing plants/farming in the areas between the solar arrays. We anticipate that the Pilbara will be seeing a number of solar farms in the future to make use of the abundant land and one of the highest light levels in the world. The space between the panels provides an opportunity to grow plants particularly native species from the Wanggalili project. The panels themselves will provide shade and concentrate rainfall onto a strip of ground. The benefits of this will be the subject of research.

PV array around the airport in Karratha

PV in Dorset, UK. With sheep

4.4 Power and desalination options

Energy is required to run the greenhouse systems in powering the pumps, fans, ancillary processes and to desalinate the water. There is also a requirement for heating in the morning warm up. The two solar power options are concentrated solar power [CSP] and photovoltaic [PV] panels.

CSP is based on a thermal process to make steam that can be used for power generation. This heat can also be used to drive a thermal desalination [MED] system. This generates substantial amounts of waste heat that can be used in the greenhouse as required. The solar energy is first collected as heat that can be stored relatively cheaply over a period of hours.
PV's transfer solar energy directly into electricity. Unlike the thermal systems there is no buffering and variable light levels reflect in instantaneous changes in electrical output. This can be harmful if the PV output is large compared to the system they are connected to and some form of buffer such as a battery is required to deal with short term fluctuations. To provide output at night a bigger battery is required.

Reverse osmosis [RO] is the favoured desalination system for new systems as it requires no heat energy and uses similar or less electrical energy than the MED thermal systems.
As such the comparison is between CSP+MED against PV+Battery+RO.

The benefit of the PV option is that each component is simple and scalable from powering a mobile phone to powering a city and is being sold at high volume. The costs of PV have been dropping as the market volume has increased at an exponential rate.
Demand for battery technology is being driven hard both in the transport sector and the grid stabilisation market. As a result, the cost of static bulk battery electricity storage is also coming down. RO is a relatively mature technology, but incremental advances are still being made in membrane construction that will reduce cost and energy use.

Most CSP systems are now trough or tower based installations with tracking mirrors. By comparison to PV, CSP is a complex set of systems that is not very scalable using engineering based on relatively mature technologies [Steam generation, moveable mirrors]. Equally MED does not scale very well at the low end and is falling out of favour due to the high energy requirement. The advantage of the CSP option is the ability to store energy over a period of a day using heat that is much less costly than other sources of storage such as batteries.

The cost of PV electricity is already much cheaper than CSP. The discussion becomes more interesting and challenging to answer when one requires storing and using the energy overnight and using large amounts of heat.

However, PV, battery and RO are currently commodity items being driven by high demand, CSP is being developed in a more niche way. Another issue with CSP is the robustness of the system of moveable mirrors that can withstand a cyclone. As such we have focused on the PV, Battery, RO option that has a number of suppliers available in Australia, rather than the highly specialised CSP systems.

4.4.1 Energy storage and the grid

Solar power is by its nature a variable resource that does not necessarily match the loads it needs to meet. The fluctuations in generation cover a number of time periods:

	Speed of response	Relative scale of storage/ energy needed	Accuracy of prediction	Regularity
Short term fluctuations due to cloud cover	Fast	Small	Medium	Irregular but estimable
Day night	Medium	Medium	High	Predictable
Weekly weather cycles	Slow	Large	Medium	Irregular but estimable
Seasonal cycles	Slow	Very large	High	Predictable
System failure	Fast	Medium	Low	Irregular and unlikely

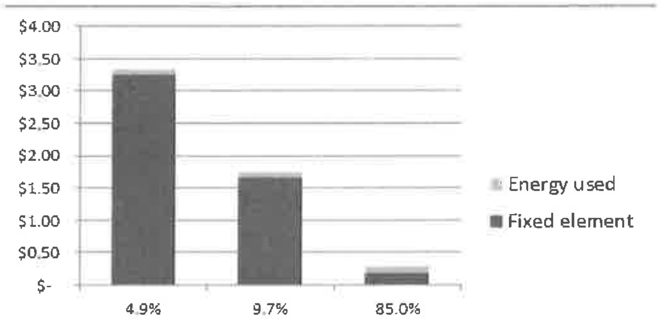
There are a few ways of ways of dealing with this:

1. By storing power in a battery for when you need it. The most obvious solution but expensive.
2. Interconnection with other renewable technologies such as wind or to other geographical locations that are also intermittent but over a different time period. Also, expensive but makes better use of the generating resource.
3. Over sizing the generation systems. As the costs of PV at least has come down this is increasingly viable. Routinely the Panel array is oversized by 20 to 30% to ensure that there is a more even output from the inverter at the high but variable light levels. This can help with short term fluctuations and seasonal cycles.
4. Only taking power when it is available and not when it isn't. This is not viable for many uses such as say irrigation pumps for crops, lighting or other amenities. Some loads have storage intrinsic to the process which could be shut down. Desalination plant could be switched off providing there was sufficient water stored to meet the immediate needs. This requires the

plant to be oversized to make enough product when it does run. A comparison can be made between the cost of oversizing and the cost of storing energy to enable continuous running. For desalination it would be more expensive to oversize the RO unit such that it only runs by day than the cost of batteries to allow a smaller unit to run continuously. However, oversizing by a small amount and having sufficient stored water to cover occasional weather events is economic.

5. Backing up with conventional fossil fuel/biofuel generation. This is the supply of last resort.
6. Connecting to a conventionally powered grid.

The economics of any system depends on the fixed cost of the installation divided by the number of times it is used. An expensive system that is used very often can be economic. However, a system that is used infrequently such as for back-up power needs to have a very low fixed cost as it isn't used very often. This is the problem with a grid connection as the fixed infrastructure costs are high. Horizon power require a fixed annual fee to cover the capital and maintenance of the generation and distribution system to guarantee the facility to draw a certain amount of power. These fixed costs dwarf the cost for the actual power taken.



kWh cost of Horizon Power with different capacity factors

The chart shows costs from Horizon that indicates the contribution of the fixed and variable cost on the total kWh cost for an 8.4 MW, 4.2 MW and 3.3 MW connections being used at 4.9%, 9.7% and 85% of the total available capacity respectively. The electricity using the grid connection at full capacity for 85% of the time would cost $0.29/kWh but only using it for 5% of the time would cost $3.35/kWh.

The other way of looking at this is the capital cost of a diesel generator against a grid connection.

	3.7 MW Horizon connection	4 MW diesel standby generation
One off capital Fixed annual costs Energy price per kWh	*UKNOWN* $5.3m $0.10/kWh	c. $ 4.0m In the running cost $0.25/kWh for fuel and maintenance

This business model of charging for the fixed costs is entirely understandable and has been built on the business model of central generation providing all the electricity that a user needs. As local displaces central generation this model fails, and it does push one into making use of standby diesel generation as a back-up as the lowest cost option and becoming an island site. As an observation this makes the #2 solution of interconnection more difficult. It also creates other societal issues that the grid is used by fewer users which will increase its cost to those who cannot generate their own power.

The other aspect to this is the ability to wheel power to Yara's remote site. It may be that a small connection that is used continuously without the need to reserve generation capacity could be and economic solution.

4.4.2 Battery selection

We suggest that the energy storage for this scheme is from batteries. There are many other systems to store energy, but battery technology is being driven hard with considerable investment from the automotive industry with a result that they are getting better and cheaper.

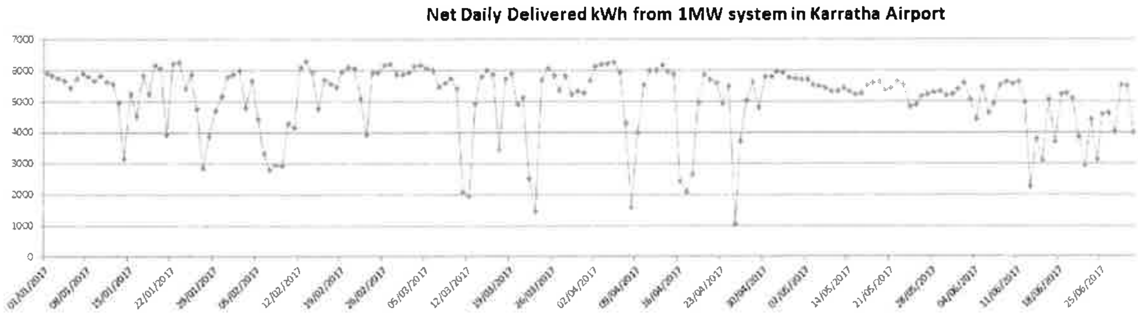
Most of the suppliers have solid state chemistries that have very high energy densities and capable of high discharge rates needed in a car. These systems do degrade over time and the rate of degradation is subject to much research. The degradation is linked to the number of cycles and the so called "depth of discharge" or DOD. The consequence of the degradation is a reduction in storage capacity. This is much less of a problem for a fixed installation rather than a vehicle and can be solved by simply adding more batteries to the system as they degrade, which by then will be at a lower cost. We understand that this strategy [Augmentation] is being used by Fluence [a JV of Siemens and AES] when providing a solar and battery solution for an Island on Hawaii of a similar scale to that being proposed for the energy hub.

The alternative to the solid state batteries is a flow cell in which the electrolyte is liquid and is pumped through the electrodes. These do not degrade and in many ways are better for static applications as the storage capacity can be increased with the volume of electrolyte. However, by not being an automotive component, they are not getting the high degree of investment for R&D.

4.4.3 Meeting the loads with solar power

These monthly loads where compared to the output of a PV array to estimate the sizing required.

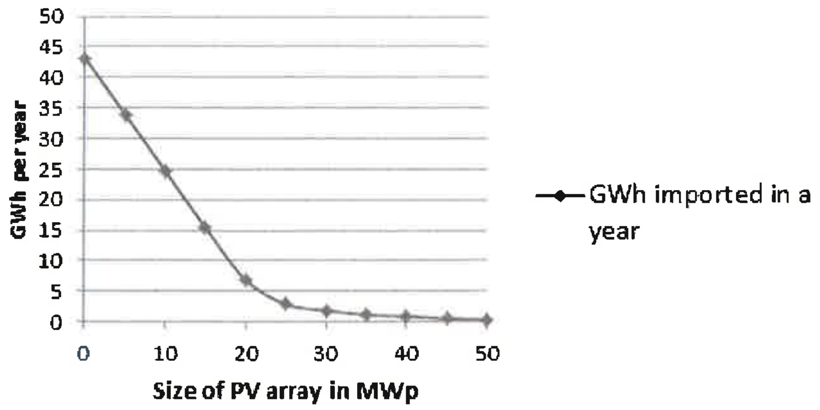
For the PV output we have the advantage of using data from the airport system to provide a realistic estimate of the real output of a system over the first 6 month period in 2017.



One can see the drop in the output due to weather events that last one to three days. It is also clear that the summer winter 2:1 variation in total in light level is not seen here and the output is reasonably consistent probably due to the angle of the array and the oversizing of the PV panels to the inverter capacity.

The monthly power requirement for the systems was set against the measured daily solar output as an indicative level of performance and daily variability. The more PV installed the less energy needs to be imported. Below is an analysis of the amount of PV installed against the amount of electricity that needs to be imported assuming all the electricity produced in the day can be used in the day [ie there is enough storage to make use of the surplus over night]. The illustration is for the whole *EcoHub* facility discussed later with a 20ha greenhouse. With no PV the total electricity used by the site is 43 GWh per year.

GWh Imported



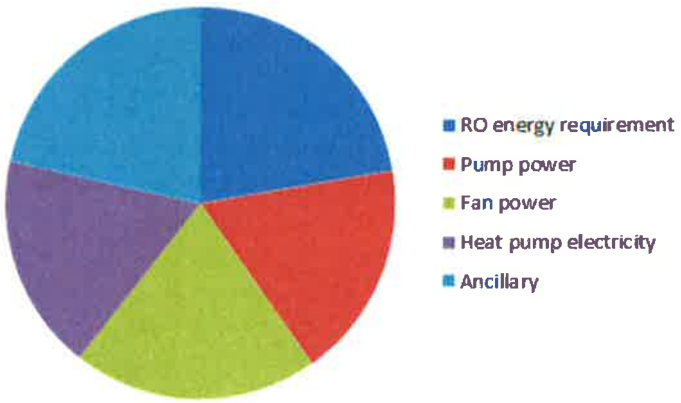
The inflection of the curve at about 24 MWp installed where 7% of the power needs to be imported. The highest return would be around this point and depend on a number of other variables such as the cost of the imported electricity and the value of any surplus, the Large Scale Generation Certificates [LGC's]. The battery aspect is an expensive aspect of the installation and reducing the amount of solar power will reduce the need for batteries but not omit it as the system output will still need to be smoothed. The airport 1 MWp PV array scheme has a 1 MWh battery to do this. Equally expanding the array and size of battery to deal with the tail of imported electricity is not economic as yet.

The provision of the imported electricity in the current scheme can either come from a grid connection or a stand-by generator fuelled with diesel or gas. This is discussed in the technology choices part and we suggest that the stand alone option is used with a standby generator.

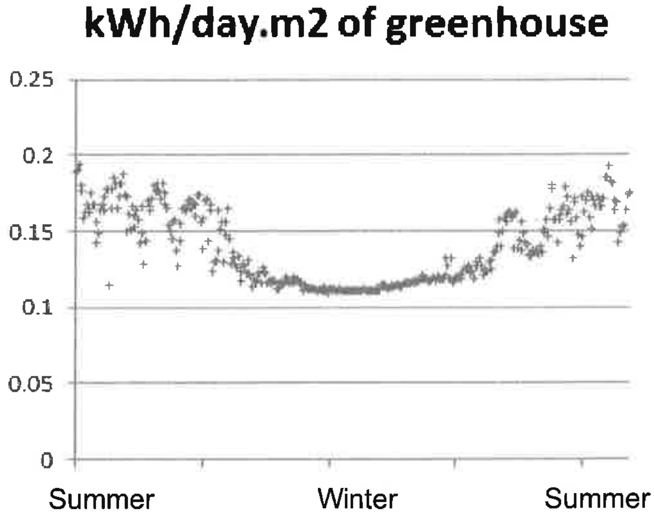
4.4.4 Greenhouse Electrical loadings

The system flows and requirements of the greenhouse have been modelled on an hourly basis using a standard weather year for Karratha from Meteonorm using algorithms developed specifically for the SFP operation and cooling system. The irrigation, ventilation rate and fan speed it calculated to maintain conditions in the greenhouse within fixed parameters. From this data we can establish the water, brine energy requirements on an hourly, daily and monthly basis.

This data is collated to work out the maximum daily energy and water needs for the greenhouse over the seasons to size the RO plant, PV and battery installations. The usage of electricity splits fairly evenly into the various categories listed below:



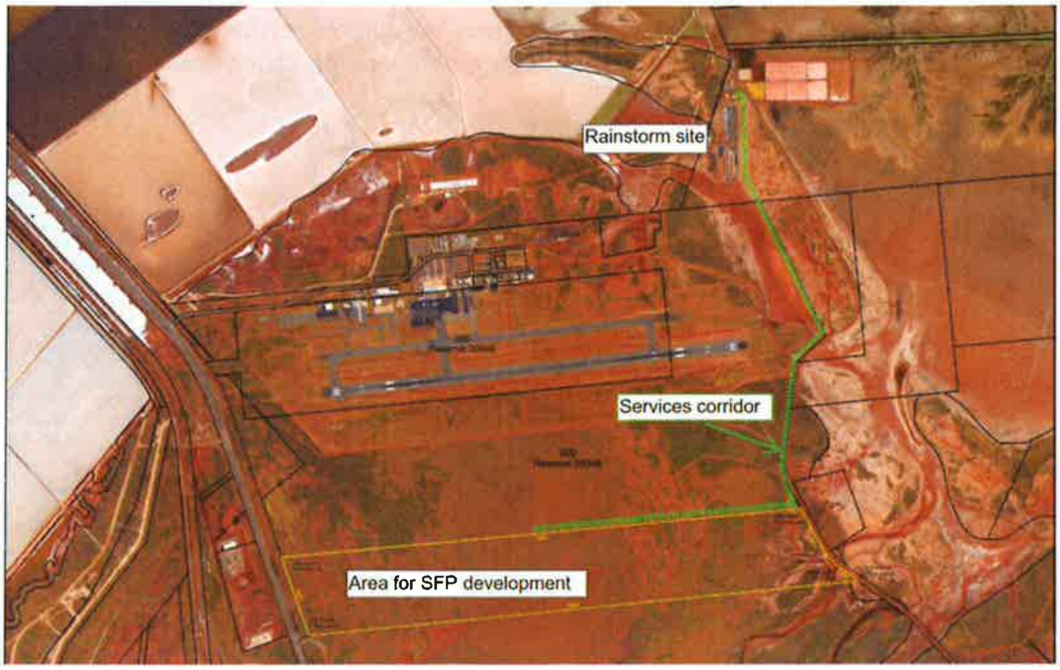
Over the year the daily usage breaks down as shown below. The differences through the year are to do with the amont of cooling and ventilation that is higher in the summer than the winter:



4.4.5 SFP facility design arrangement

We have carried out a scaling and design for a small scale installation with a 2 ha greenhouse, and a larger one with 20 ha of greenhouse. The scheme can be scaled to suit the business case and indeed there is space for up to 30 ha of greenhouse on the land allocated.

The City of Karratha has provided in-principle support to establish the facility on the land indicated in the aerial photograph below. The yellow line indicates the area that has been reserved for SFP activities. This strip of land has been taken out of the land earmarked for airport expansion. It still leaves a considerable area of land that will be empty until such time as the airport does expand significantly. It has been proposed that this land could be used for external planting on a temporary basis until it is needed for airport buildings. This would leave the area within the yellow lines for development of more permanent structures such as buildings, greenhouses and PV arrays.



4.4.6 The seawater connection via Rainstorm

Rainstorm is a commercial organisation who own the lease for the land next to the sea shore shown on the top left part of the aerial photograph. SFP have been in discussions with them and there is a good understanding that the SFP seawater supply can be taken from their site. Furthermore, they have an underused RO plant that could be used by SFP. While new RO units are included in the financing arrangements of the stand-alone SFP sites, the existing RO plant would be suitable for up to a 10-ha greenhouse. After that the RO plant would need to be supplemented with another unit to increase the capacity. The power for the systems and the RO plant would come from PV arrays on the SFP site. Some of the power from the PV through the day would be stored for use at night in batteries on site. Infrastructure would be required between the Rainstorm site and the SFP site to connect the power and water systems. An HV cable will run power from the SFP PV system to the RO unit on the Rainstorm site. Pipework would run the fresh water and brine from the RO unit to the greenhouse and concentrated brine back to Rainstorm's discharge point.

The scale of the power and desalination systems are as set out below for the two sized of project:

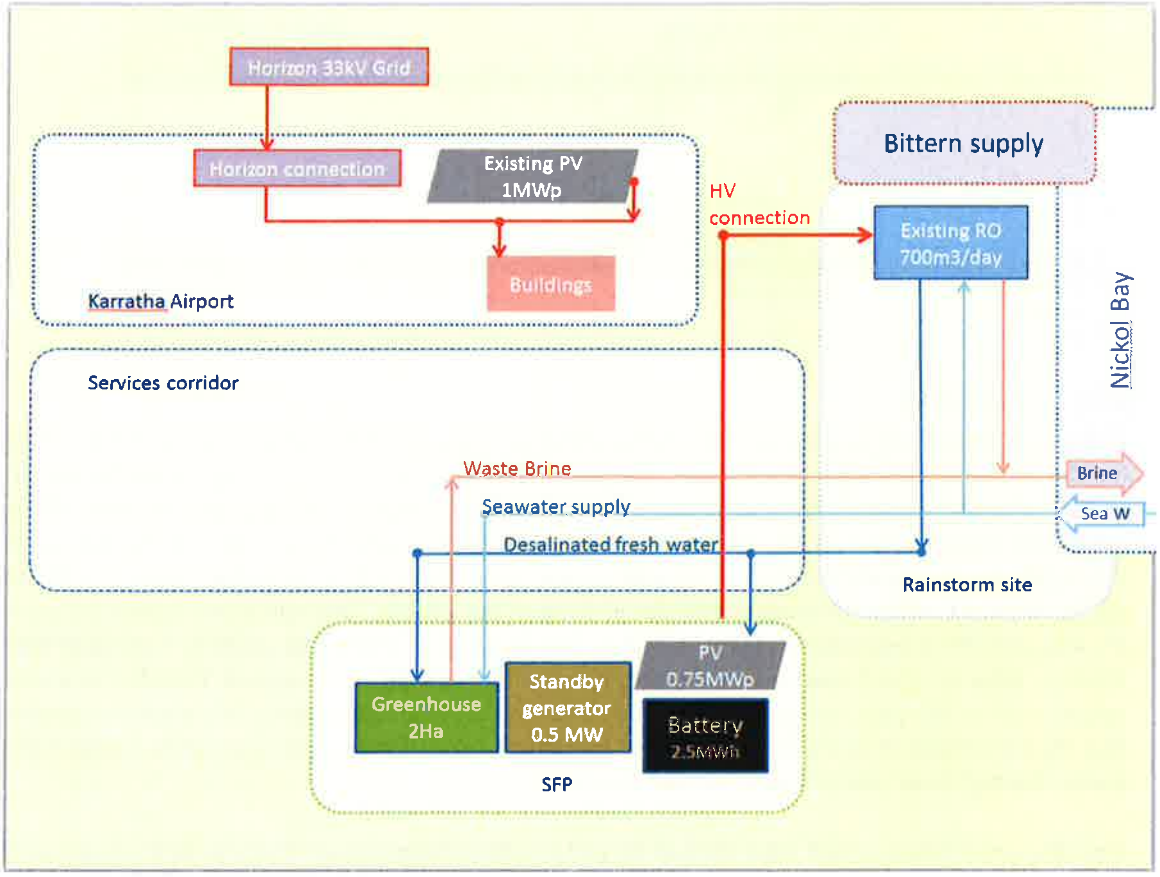
	2 ha greenhouse	20 ha greenhouse
Stand alone	• 0.75 MWp of PV [1.25 ha] • 2.5 MWh of battery • 160 M^3/day.	• 7.5 MWp of PV [12 ha] • 25 MWh of battery • 1600 m^3/day

4.5 System flows and site arrangements

The basic model of system flows for the Sahara Forest Project with the technology choices made is as follows:

- Seawater is desalinated in an RO device
- The fresh water is used in the greenhouse to irrigate the plants inside
- The irrigation run-off from the greenhouse plants is used for external planting
- The brine from the desalination plant is used for evaporative cooling
- After being used in the greenhouse, the concentrated brine is run back to the Nickol Bay along with the brine discharge from the industrial salt works

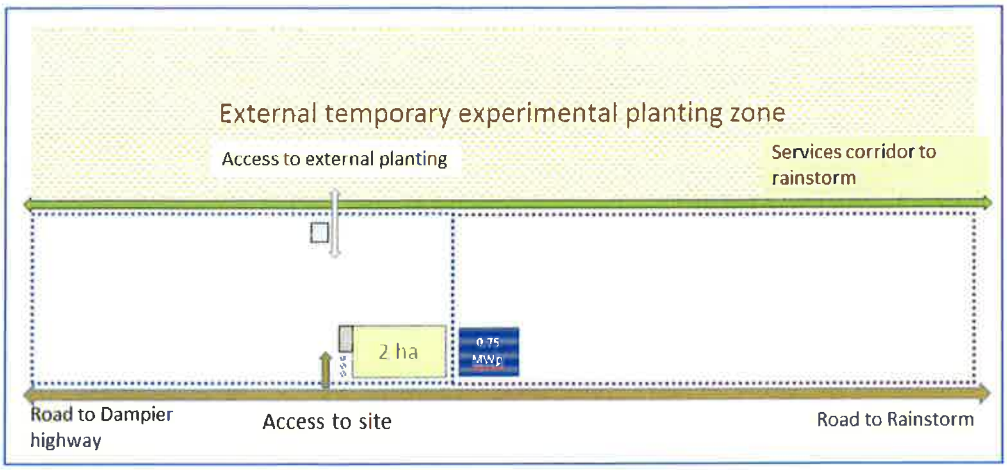
- Photovoltaic panels generate electricity, some of which is stored in a battery system for use in the night
- Back-up power is provided from the grid or standby generator



4.5.1 **Small facility**

The smaller facility that we have considered is as set out above. It has a 2ha greenhouse that will have a small area of 0.2 ha that will be used by the Wanggalili project. There will be ancillary spaces for pack house, staff facilities, cold stores and plant room next to the greenhouse. The facility will be powered with 1.5 ha of PV and battery. The costings have been done with a standalone 160 m3/day RO unit making use of a piped connection to the rainstorm site for a source of seawater and brine discharge. The access to the site will be from a new road from along the south of the site.

The total site area of this facility would be 6 ha to include roads, hard standings and drainage channels. The runoff from the greenhouse will be used to irrigate a portion of the external planting area to the north of the site. The area covered depends on the amount of irrigation required but as a guide the runoff would provide 500 mm of water per year over an area of 2ha.

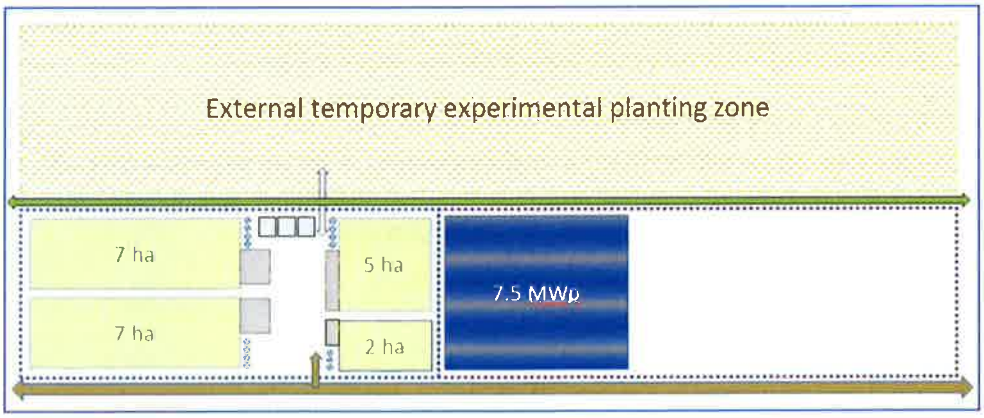


4.5.2 Large facility

The area allocated for by the City of Karratha would allow the greenhouse area to expand to 20 to 30 ha. Our model is for a 20ha greenhouse. The precise arrangement of greenhouses could be varied to suit the phasing required. The area of any one greenhouse would be limited to 7ha to allow differing crop and climate regimes in the different spaces and better pest and disease control. The area for the Wanggalili project would develop at an appropriate rate. The details of how the project at this scale will be serviced will be developed with the phasing of the project. One computer system would run the site, and this is extendable at will. It is likely that the one irrigation unit could be expanded from a 2ha to a 20ha but there may be reasons to split it up for reliability and hygiene. Equally the ancillary spaces such as the pack house could be combined or developed separately. We would recommend that the infrastructure to the Rainstorm site is constructed at a sufficient size to meet the largest facility due to the high fixed cost of trenching and the like.

The 20ha greenhouse would need 15ha of PV and a 1600 m3/day RO unit that has been priced on the site.

With all the ancillary spaces the total site area is 60ha.
With the greater area of greenhouse there would be a greater run off to service 20ha of external planting with 500mm of water a year.



4.6 The *EcoHub* proposal

As part of SFP's discussions about the site locations we have been introduced to other stakeholders who would be interested in developing synergistic arrangements to make use of the shared infrastructure and offering their existing infrastructure for common use to give a better usage from the assets already in place. Within this arrangement the concept of the SFP Food, Water, Energy concept is disaggregated into separate components and all stakeholders take benefit from the synergies developed and the lower costs that come with the economies of scale. This section looks further into this proposal.

4.6.1 Potential partners

Rainstorm

As discussed above Rainstorm is already on the site and has expressed an interest in replacing the off grid diesel electrical generation with PV. They also have an underutilised seawater connection and desalination plant that they are happy to get more benefit from.

Yara

Yara have expressed an interest in making use of solar electricity generated on the airport to make use of the utilities grid network to "wheel" the power from one site to another. The ammonia plant also has a stream of pure CO2 from the industrial process that is being vented to atmosphere that could be used beneficially in growing systems. Yara have also expressed interest to the idea of having a stand-alone Centre of Excellence R&D and demonstration facility on the airport site at some stage in the future.

The Airport

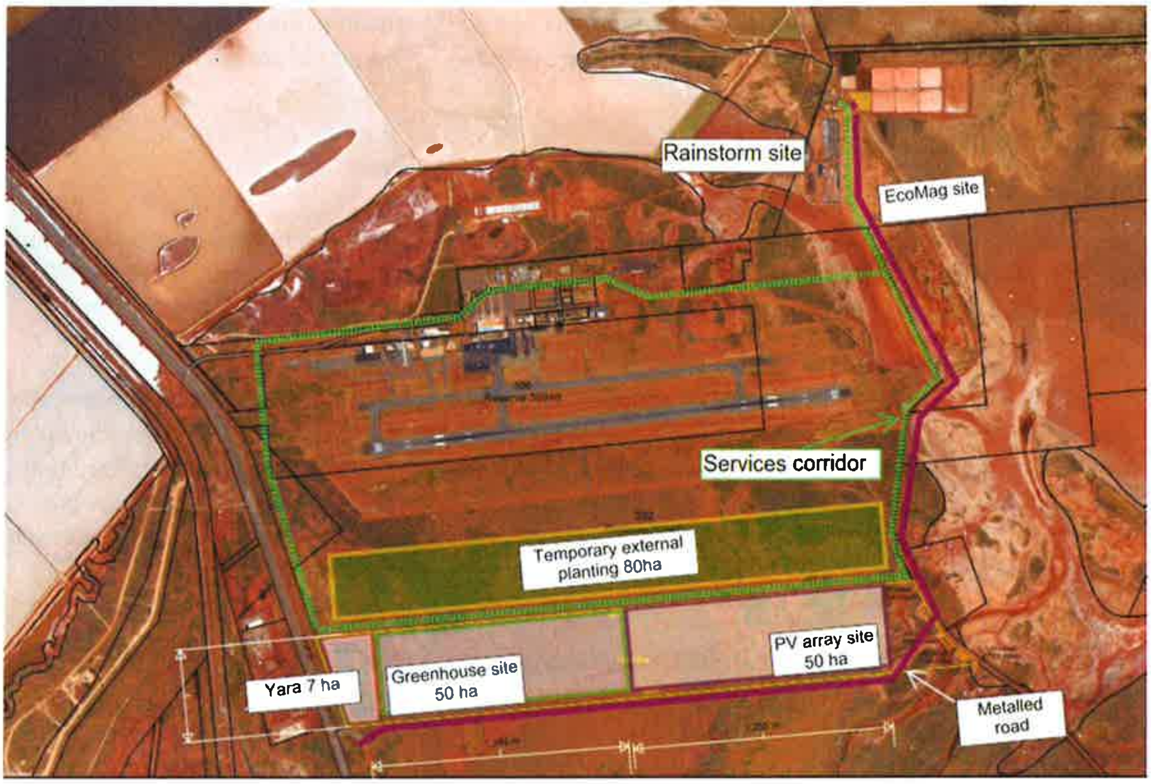
The airport is run by the City of Karratha. They have already installed a 1 MW PV array on site that meets approximately 30% of the airport electrical load. They are interested in increasing the amount of renewable power used by the airport. They already run a 33kV HV electrical distribution system and sub-meter tenants. They have expressed an interest in managing an extended distribution system that would include the other stakeholders.

Eco-mag

This is a new company with a technology to make use of the magnesium in the waste bittern flow coming from the Salt works to make high value magnesium products. Their facility requires large amounts of power on a 24/7 basis, access to the bitterns, and fresh water and a good access to the road network for their product.

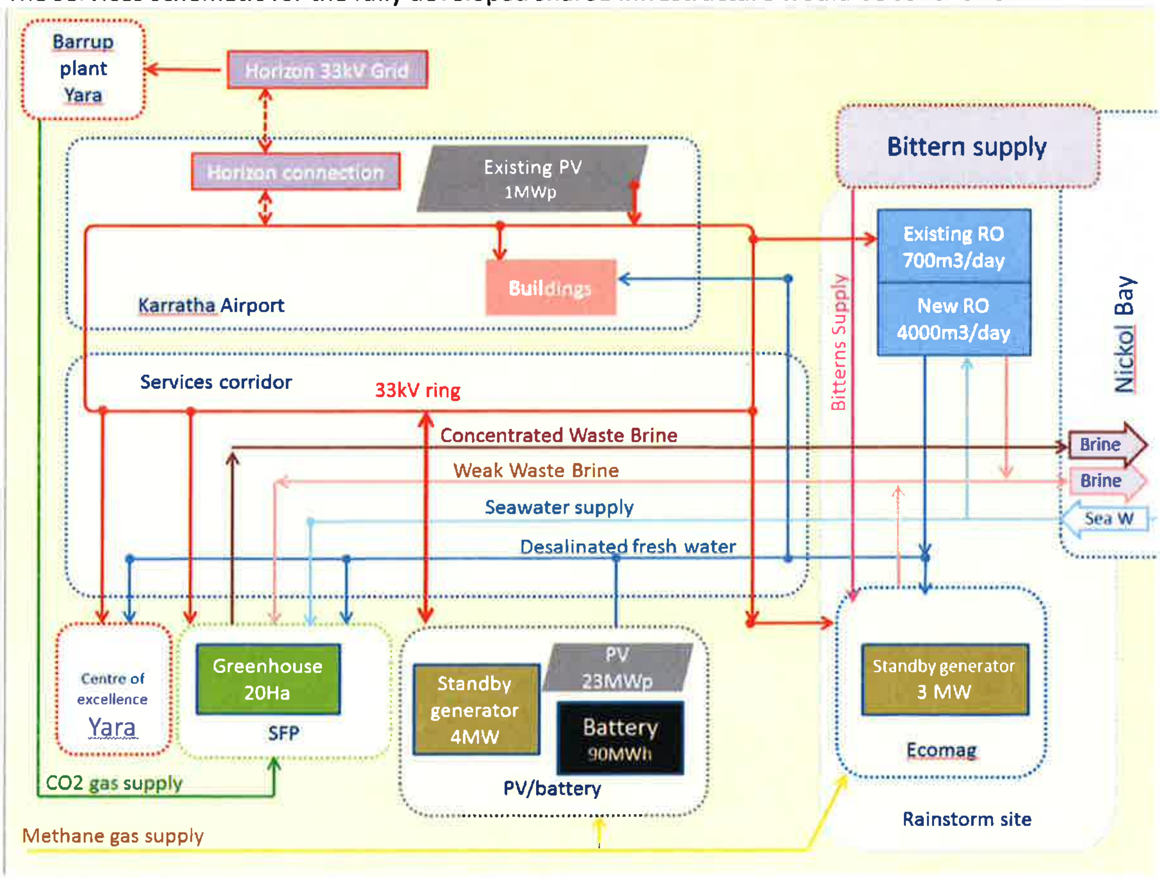
4.6.2 The *EcoHub* scheme

The fully developed scheme is set out below with the various stakeholders:



The Greenhouse, PV and Yara site is on the strip allocated by the City of Karratha. The land to the north is the available space for external planting that can be used until the airport wishes to expand into that space.

The services schematic for the fully developed shared infrastructure would be as follows:



This envisages making full use of the various stakeholders' requirements on the site. The desalination plant would be increased in size to provide fresh water to all the users. The PV and battery system would be expanded to provide power into an HV ring that could be an extension to the airport system. In this way the costs and value of the water and power infrastructure is shared between a number of users who would benefit from the reduction in unit cost due to an increase in scale. The EcoMag process uses the fresh water from the RO plant to wash the NaCl from the $MgCl_2$.

The waste water is a brine of pure NaCl in water without the other salts such as $CaCO_3$ and gypsum that would precipitate out from pure seawater and create an issue with the greenhouse cooling pads. As such this is a preferable source of brine than the waste from the RO plant. There may be other waste products such as CO_2 and heat from the EcoMag process that could be useful in the SFP system.

4.6.3 Total electrical and water loads for the greenhouse and other *EcoHub* stakeholders

The power and water consumption of the various stakeholders were analysed and collated with the data available. The greenhouse data comes from hourly weather data from a Meteonorm weather file. The data has been normalised to give monthly consumption figures for the greenhouse and ancillary spaces. The figures for the airport were based on monthly electricity bills. EcoMag's figures were provided by them based on predicted running consumption of their plant. The figures for Yara are also based on their predicted operation of a small H_2 production facility. The Rainstorm figures were based on their estimates of the operation of various items of equipment. The main usage was for algae production – excluding the power needed for running the RO plant.

	Peak load	Summer consumption	Winter consumption
	kW	*kWh/day*	*kWh/day*
Yara [Off site]	250**	6000	6000
EcoMag	3000	72,000	72,000
SFP Greenhouse [20 ha]	3300	37,500	24,000
Rainstorm	200	1000	200
Airport	1500	20,000	12,000
Totals	8250	136,500	114,200

[***Post final draft note: The demand of 250kW from Yara is no longer required. However their plans have been revised to require 2500 to 5000 kW of power. The report has been based on the 250 kW demand that is not a significant load. Incorporating a the larger supply would be a substantial change that will be looked at in later studies*]

This is based on a 20ha greenhouse. A 2ha one would scale down to 10% of the 20ha facility. The EcoMag usage is a continuous operational plant load and has the highest total demand. The airport and greenhouse will use less in the winter and at night as the loads are driven by cooling and occupancy. A similar analysis has been done for the water requirements:

	Daily fresh water requirement m3/day
Ecomag	2800
SFP greenhouse [20 ha]	1600
SFP greenhouse [2 ha]	160
Airport	150

Again, the water requirement is dominated by EcoMag's use. On the basis of the analysis the size of PV, Battery and RO capacity would be as follows:

	2 ha greenhouse	20 ha greenhouse
Stand alone without other stakeholders	• 0.75 MWp of PV [1.25 ha] • 2.5 MWh of battery • 160 M^3/day. Served from existing 700 m^3/day Rainstorm plant	• 7.5 MWp of PV [12 ha] • 25 MWh of battery • 1600 m^3/day. Served from existing 700 m^3/day Rainstorm plant with additional 1000 m^3/day
With full stakeholder *EcoHub*	• 19 MWp of PV [32 ha] • 65 MWh of battery • 3200 m^3/day. Served from existing 700 m^3/day Rainstorm plant with additional 2500 m^3/day plant.	• 24 MWp of PV [40 ha] • 90 MWh of battery • 4600 m^3/day. Served from existing 700 m^3/day Rainstorm plant with additional 4000 m^3/day plant.

These facilities can be incorporated onto the area around the airport and make use of the land available.

5. STRATEGIC ENVIRONMENTAL ASSESSMENT STUDY

This chapter gives a high level assessment of environmental impacts for establishing a Sahara Forest Project in Karratha, both in terms of challenges and opportunities created. It is not a complete Environmental Impact Assessment study. Such a study will be more comprehensive and carried out when the project is taken to a more advanced stage. This section sets out to confirm the feasibility of establishing a facility in Karratha from a strategic environmental assessment perspective, as well as highlighting necessary future steps and requirements. This work builds on the site identification analysis in chapter 3.6, and the site B3 in particular.

5.1 Existing Environmental Conditions

The site selected is a flat grassy area to the south of the airport. The land is at about +7 m above sea level but this drops towards the coast. The ground is alluvial sandy clay with occasional boulders.

From a report commissioned by the Shire of Roebourne on ground water near the airport runway, the understanding is that the water level is about 2-3 m below ground level and saline. These were monitored over September and October 2013 following a record amount of rainfall at the end of June [270mm over 2 days]. The water levels showed a 5 cm variation following the tide indicating that the water is connected to the ocean. There was a drop in the water level of 10 cm over the monitoring period showing that the water was draining from the soil.

The understanding is further that there are no significant or rare flora or fauna on the site that would be disturbed by the proposed development. Any built structure would affect the rainfall and this will be channelled into swales from the greenhouse.

The ocean has a 0.5m to a maximum of 4.6 m tidal range around Karratha.

5.2 Predicted Environmental Impacts

The seawater intake will make use of the existing tidal facility based on the Rainstorm site. Equally the brine discharge from the greenhouse and the RO desalination unit will make use of the existing facility for brine discharge on the Rainstorm site. EcoMag has discussed this mechanism for their supply and discharge with regulatory bodies who are content with the proposals.

There is a slight risk of glare from a fixed PV array positioned to the south of the airport. This risk is removed by having single axis tracking on the PV. This will be investigated when the detailed proposals are made for the solar power system.

The airport is concerned that there is not an increase in bird activity due to the external planting. The planting will need to be designed with this in mind to reduce the attractiveness to birds.
SFP's initial consultations suggest that there are no "Red Flags" for the use of the site that would cause a problem for its use. A complete environmental assessment will need to be carried out when the project is taken to a more advanced stage.

However, there will be significant environmental benefits to the area assessed, and beyond, such as:

- Water recycling and desalination to produce food, reducing the impact on existing fresh water resources
- Reduced water requirement per unit of food production
- Generate renewable energy through PV
- Potential for biomass to energy future integration
- Low resource production system
- Project provides a near zero carbon footprint, with carbon dioxide in fact planted back and stored in the ground by outside land revegetation
- Project will off set carbon footprint of the Karratha airport precinct
- A restorative approach to land re-generation will enhance and improve the existing land condition, which currently is not used for any beneficial purpose

5.3 Broader Potential Environmental Benefits

- Significant increase to employment and economic development for horticultural in the Pilbara
- Research and development will showcase WA's research capabilities in renewable energy, energy storage and innovative food production systems
- The SFP Project supports the increasing demand for food products from environmentally sustainable and ethical productions systems
- Research and development of the project will showcase WA's research capabilities in renewable energy, energy storage and innovative food production systems
- Continue to lead Australia in the use and development of sustainable recycled water projects

5.4 Assessment of Existing Environmental Legislation

The proposed project will conform with all Environmental Protection Act requirements as per the Office of the Environmental Protection Authority guidelines which may include:

- Referral to the EPA under Part IV of the Environmental Protection Act and, if required, formal assessment under Part IV
- Application for a Works Approval and a Native Vegetation Clearing Permit under Part V of the EP Act

5.5 Environment Protection Objectives

All environmental objectives of the project are designed to confirm with the requirements of the EPA and associated, relevant agencies.

Measures Envisaged to Manage Significant Effects on the Environment

Revegetation of degraded land is a key aspect of an SFP scheme. SFP has joined with the Wanggalili project to develop local desert species with the Yindjibarndi community with expertise from Kings Park Botanic Gardens. The land around the greenhouse will be used to develop these species to make use of the outdoor spaces.

Environmental decision-making Process

Sahara Forest has conducted early stage preliminary studies on the proposed site. Further discussions will be held with key stakeholders such as Department of Parks and Wildlife, Department of Environment Regulation and Department of Water.
All decisions will be the result of collaborative consultation with the relevant Federal and State environmental agencies.

5.6 Monitoring Measures

Further ground investigations and EPA assessment studies will be conducted post-feasibility stage and would form part of a further, wider study incorporating flora and fauna surveys, soil analysis and water assessments.

6. SOCIAL BENEFIT ANALYSIS

The main objective of The Sahara Forest Project is to provide innovative solutions that are good for the environment, good for social development and can provide long term economic benefits to investors. This is the company's triple bottom line approach. After having laid out the economic foundation of an SFP facility in the Pilbara and investigated the environmental consequences and synergies, this chapter focuses on the potential social benefits by understanding the relevant local development issues and assessing the related implementation impacts of an SFP facility. This next section will give an overview of the social benefits that have the potential to strengthen the local communities and support regional growth.

As previously discussed, the rapid growth and heavy reliance on resource exports has put a strain on the local community, resulting in the regions high cost structure and exposure to commodity price fluctuations. The high living and business costs in addition to inflating prices has crowded out other industries, affecting regional towns' ability to possess the critical mass to support certain services and industries.64 Considerable public and private sector investment in amenity and liveability enhancements over the past years has allowed the Pilbara to move towards levels of services to better cater to the size of the population, building a stronger sense of permanency for settlements. However, there are still challenges to growth. The PDC has set out on a path for a coordinated, whole-of-business, government and community approach to achieve a sustainable future for the Pilbara and tackle challenges to growth, develop the communities and diversify the economy. The Pilbara also has a diverse Aboriginal community and like many parts of Australia, the socio-economic characteristics of the Pilbara's Aboriginal residents are below that of the rest of the population. This leads to issues of social welfare and inequity in the region. Eliminating such differences requires an inclusive approach to development which is a priority in the region's strategies development going forward.65

The region has established a strong strategic direction for the future: the Pilbara Regional Investment Blueprint with a Vision for the region up until 2050. One of the goals will be to increase the Pilbara population based on growth, diversification of the economy, and capitalizing on the region's competitive advantages. The social contribution of the businesses that will be part of this future will be a key concern, as they will play an important role in contributing to the aspirations of the region going forward.66

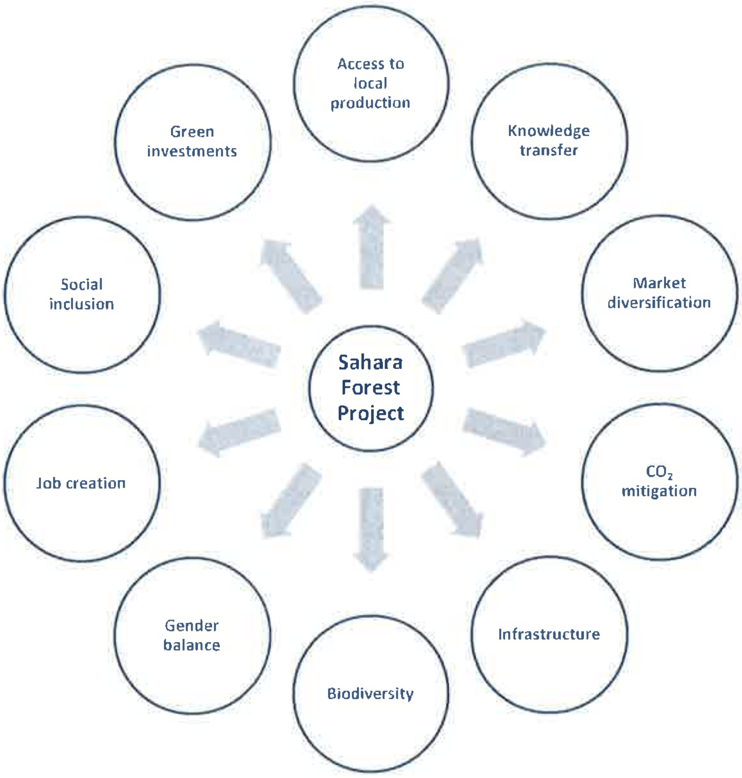
The social dimension of the implementation of an SFP facility is an important part of this study, and this section gives an overview of potential social impacts that can be found in relation to the development of opportunities for people and the communities in The Pilbara. Furthermore, a thorough assessment of how these social benefits can be found in technology use for social inclusion and human capacity building, community engagement, while also the support of infrastructure, land development and economic diversification, will be discussed.

6.1 Analysis

At the Sahara Forest Project, we look beyond problems and use technology for social inclusion, and hence have identified several potential social interactions or impacts that ensure and contribute to better development outcomes for businesses, environment, people and communities, and reduce social exclusion; this process is illustrated, and the impacts listed below.

---

[64] The Pilbara Resources and Beyond, 2014
[65] Pilbara Regional Investment Blueprint Summary Report, 2015
[66] Pilbara Regional Investment Blueprint Summary Report, 2015



SFP impact	Indirect impact	Direct impact
Job creation	(i) job creation tackles social challenges for sustainable economic growth (ii) reducing internal displacement/economic migration	(i) securing green jobs for both genders, for skilled and less skilled people, for the properly educated and overly educated (ii) attracting investors to invest locally, promoting regional growth and hence increasing the job markets (iii) contributing to reducing income inequality
Knowledge transfer	(i) bridging technical networks to benefit from international expertise and improve local abilities (ii) establishing partnerships for sustainable development	(i) setting up collaboration with locals and knowledge diffusion from local, to regional, to national level (ii) providing the local population with access to latest methods of innovation (iii) access to national and global scientific networks (iv) decrease in inappropriate and agricultural practices
Social inclusion	community engagement and integration	(i) access to resources and development opportunities (ii) community involvement in operations (iii) services to professional community and investors
Gender equality	Gender equality in environmental technologies sector	

		(i) securing equal recruitment opportunities to women and men from different backgrounds (ii) contributing to boost gender social inclusion (iii) encouraging women to enter non-traditional professions, for example in green and innovative sectors (iv) securing equal pay (v) ensuring equal decision-making
Ecosystem	(i) biodiversity conservation and restoration (ii) sustainable use of seawater for sustainable development (iii) halting and reversing land degradation	(i) revegetation and land reclamation (ii) sustainable approach to preserve soil quality (iii) creation of arable and productive land (iv) better air and water quality
CO_2 mitigation	climate change mitigation	(i) increase in green spaces (ii) cost-efficient operation (iii) improved crop and land grazing management
Access to local production of food	(iii) addresses regional and national food needs (iv) reducing water-food-energy costs	(i) increase in industrial operations (ii) improve nutrition (iii) increase and attract investment (iv) setting attractive prices for high-quality local produce and increase in income (v) marketing of agricultural produce at encouraging prices
Infrastructure improvements	(i) community access roads (ii) access to green and affordable electricity (iii) increased access to distribution markets	(i) road infrastructure (to site) (ii) water systems (iii) power infrastructure (to site)
Green investments	green economy and modern infrastructure	(i) attracting investors to profitable environmental technologies (ii) access to foreign capital for development projects (iii) revenues and profits from green activities (iv) attracting investors to profitable environmental technologies
Market diversification	Contributing to a diversified, robust regional economy	(i) Introducing new environmental technology (ii) Building capacity around new industry

6.2 Social Impact Opportunity Assessment

Building an SFP facility in the Pilbara would bring new opportunities to the region in general and the community in particular. By equally securing green jobs for both genders, for skilled and less skilled people, for the properly educated and overly educated, the SFP offers opportunities for the broader range of the community to be engaged in innovative, green sources of income.

A cornerstone of SFP's approach is knowledge transfer and developing skills to grow the local knowledge base. Hence, this would entail building strong connections with the local community to learn the value-added processes found in knowledge exchange. The SFP will provide training led by experts in their field, and opportunities for learning and skills development will be a key aspect for the success of the business. The scope of learning is broadened by the range of integrated SFP-know-how from the highest level of greenhouse technology, to its modern environmental technology. The SFP training programs will develop the ability to access, adapt, and create knowledge using environmental technologies, but also the ability to make use of those technologies to engage in meaningful social practices, which is critical to social inclusion and human capacity development.

The working environment in horticulture does rely on a mutually supportive team of people of mixed skills. It does lend itself to being staffed by a close knit group of people like a small community who know each other. This does present opportunities for the Aboriginal communities. To research this SFP have approached REFAP in Karratha who are keen to act as a bridge into employment for Aboriginal people.

SFP have signed an MOU to be part of the Wanggalili project that is seeking to commercialise native plants that are part of the local heritage. Within this project seeds from the Yindjibarndi lands in the Pilbara are being collected by the community using their local knowledge. The seeds will be cultivated and propagated at the Kings Park gardens research facility in Perth. The intention is that the seedlings will be grown in part of the SFP greenhouse using modern climate control and hydroponic irrigation techniques by the Aboriginal peoples who are invested in the project growing the plants they have unique knowledge of. They could then form part or all of the operatives for the other conventional crops and the skills can be developed together.

The Wanggalili project has identified a number of plants that may be useful such as the desert citrus. Other members of the project such as Woolahara Group Pty and Abubdance Produce are downstream users of products and anxious to get a reliable supply chain that this project seeks to develop.

6.3 Evaluation of effects

The SFP facility would represent the integration of a new industry for the Pilbara, where water, energy and food are main end products. This would contribute to diversify the current economic activity in the region. The presence of SFP's multidimensional set-up will positively affect and strengthen the infrastructure of a new industrial site, while also creating business opportunities for other players based on the new industrial infrastructure or as part of the SFP value chain.

The produce from the greenhouse, water, and electricity production are available for different business streams and can support the creation of new businesses or even new industries, where the SFP end products can serve as an industrial input. The SFP agricultural value chain will also be an opportunity for the development of services and inputs, logistics and packaging. The facility alone will allow for a broad range of different sized businesses to prosper.

By making use of desert areas and transforming it into productive land will increase the potential for vegetation and preserve soil quality. This will allow for biodiversity conservation, restoration and land reclamation. The process will also enable local knowledge sharing on the potentials of arid lands development, which can be translated into other value-creating activities.

The presence a concept like SFP with a strong focus on sustainable production and development will be able to attract green investments into the region. In the long term this could build a profile for the Pilbara as a hub for innovative green solutions, and further research and innovation will be facilitated.

The Wanggalili project will generate opportunities to cultivate and create value from native species by the traditional owners. This will be a springboard for more development in other parts of the Pilbara using modern techniques to grow native species in country generating income from the ancient knowledge.

It is clear that the Pilbara is a great place for harnessing solar power. It is likely that many will want to make use of this with solar panels of some sort over very large areas of land. Developing systems of agriculture between the solar panels while looking after the panels is a new skill and land use that we are looking to develop. Again, this would be best carried out by Traditional Owners who know the land and what grows on it.

As an illustration, a land area of 10,000 km2 covered with PV out of the Pilbara's 508,000 km2 would generate the $32bn [equivalent to the mining revenue] from selling electricity even at the very low price of $0.02/kWh that one may expect in the near term.

6.4 Meetings and community

A high level of engagement with local stakeholders and the community is an important part of SFP's approach and philosophy.

An AIPP (Australian Industry Participation Plan) will be submitted to the Australian Government's Canberra-based Department of Industry, Innovation and Science which will outline the specific measures SFP will implement in terms of community engagement.

Part of this will involve SFP conducting a series of awareness-based seminars in Karratha so local companies, prospective employees and local community stakeholders are involved and can participate with the growth of the project in terms of local employment and training programmes.

SFP is in discussion with national and domestic retailers for offtake, however, a high priority in these discussions is the planning, development and implementation of training and apprenticeship programmes that could be linked to, but not limited to:

- Greenhouse growing
- Horticultural programmes
- Food Management
- Greenhouse Management programmes

In support of this, SFP will establish a project web portal with the nationally placed Industry Capability Network which will allow companies to register their interest to participate and work with the SFP development. ICN is an independent organisation, financially supported by Australian and State governments.

On the local side SFP has already entered in to an agreement on the Wanggalili Project, which is a collaboration of local parties, the PDC and CoK to undertake a feasibility and business case preparation to explore commercial growing opportunities around indigenous fruit and vegetation.

SFP is also engaged with the IBA (Indigenous Business Australia) to explore opportunities around IBA involvement and potential investment in the SFP Karratha project. The model for this could be similar IBA's recent funding of the Carnegie Clean Energy/Perth Noongar Foundation solar farm project whereby IBA invested in up to 50% of the project which, over a period of approximately 10 years, will see the IBA position sold down to the previously identified indigenous partner.
This approach delivers a unique combination of private enterprise engaging successfully with indigenous parties to create sustainable business models going forward over the next quarter century. It is also in keeping with SFP's wider philosophy and approach to indigenous engagement.

SFP will look to engage with the TAFE WA/ North Regional and CQ University to explore potential synergies with the SFP development. The nature of the SFP development and its position at the nexus of food, energy and water innovation may lend itself to be included in any TAFE/CQ learning programmes going forward. The following project requirements could aligned with existing TAFE WA/North Regional business and engineering pathway courses:

- Energy System Management
- Process Flow Control Systems
- Solar Energy System Management
- Solar Energy System Operation & Maintenance

6.5 Assessment on stimulating other commercial activity and value creation

The SFP Karratha project can be the stimuli for many industry sectors.

The local and regional horticultural industry will have many marginal businesses that can expand and grow on the back of the SFP project. The local horticultural industry will be complimented and supported by SFP, with perhaps cross training opportunities to be explored and existing supply chains supported.

Synergies with local companies will be explored on the on the logistics side where potential savings in transport and fuel costs (regionally or to Perth) will be examined.
Local suppliers involved in the packing and potentially refrigeration services will also benefit from potential on going involvement in the project. This in turn stimulates the local electricians and general tradesmen market who will be able to secure ongoing commercial activity on the various operational and maintenance aspects of the greenhouse and energy/storage systems.

The *EcoHub* will similarly add value to the local renewable energy market. Job creation will be provided directly in the construction of the SFP facilities as well as the ongoing operation and maintenance of the greenhouse and energy system. Work will be created during the construction stage which will utilise the existing mining skill base in Karratha in areas such as the energy system and storage facility, land clearing, pipeline laying and construction of desalination facilities.

7. BUSINESS DEVELOPMENT EFFORTS TO IDENTIFY PROJECT PARTNERS

The Sahara Forest Project concept is developed to meet a triple bottom line for its activities. That means that a Sahara Forest project facility needs to show results that are good for the environment, good for social development and good for business. As such, it is also at the core of the concept to engage with a wide range of stakeholders and to identify opportunities for cooperation that will strengthen the triple bottom line.

A key objective of the work of The Sahara Forest Project team during the Feasibility Phase has been to initiate stakeholder dialogue with the purpose to develop partnerships for the establishment of The Sahara Forest Project in Pilbara. This business development work has been further strengthened with support from the City of Karratha, The Pilbara Development Commission and Yara as well as with external competence. The result is that The Sahara Forest Project currently has several specific opportunities for cooperation with key stakeholders, including local community and aboriginal groups, supply chain representatives, produce off-takers, industrial collaboration partners, investors and public authorities.

The business opportunities include premium vegetable production from the greenhouses, outdoor plants for industrial purposes as well as energy production and storage. Applying good business conduct, this study will not go into details of these stakeholder dialogues as they are confidential in nature. However, this section describes some of the opportunities at hand.

7.1 Establishment of an *EcoHub* in Karratha

In the spirit if The Pilbara vision of "big thinking" set out by the PDC Blueprint paper to attract people to work, live and invest in Karratha, The Sahara Forest Project has developed a concept for joint industrial cooperation in Karratha for exploring synergies among current and future industrial projects in the area. The idea of such an *EcoHub* also caters to the goals of the White paper on Developing Northern Australia for diversifying economic activities in the region and particularly on the field of agriculture and energy.

The City of Karratha and The Pilbara Development Commission have taken an active part in the development of the *EcoHub* put forward by The Sahara Forest Project. The concept seeks to attract new synergistic industries and supporting positive collaborative opportunities in Karratha to deliver social outcomes and new residential regional jobs. The parties are currently refining the concept to cater for individual timelines and aspirations, and also align investment decisions with public funding opportunities. As such, the concept defined in the Design Section in this report below may be subject to changes. However, the group of partners work together to achieve industrial synergies in the field of energy, water and job creation.

7.2 Supply chain and market off take dialogue

With reference to the design section of this Feasibility Study, a wide range of stakeholder dialogue has been part of collecting and analysing information to provide a cost estimate on both CAPEX and OPEX. The relationships and concept understanding developed together with the supply chain in this phase is particularly important when moving into the Detailed Engineering and the procurement phase of the project. Equally important is the relation building efforts that have been conducted with market players in the off take market, both to provide market information as well as devising market access strategies and future off take agreements. SFP has undertaken extensive research in to the food offtake opportunities in three separated areas – international, national and State.

7.3 Local stakeholders and community engagement

With The City of Karratha, The Pilbara Development Commission and Yara as partners in the Feasibility Study phase, the local stakeholder and community engagement work have received close attention. Land availability and land tenure are typically critical factors that is key to have an understanding of early in the process. In this study we have not only had an early understanding, but the City of Karratha has also actively worked on tenure strategies in parallel with the development of the studies. The Pilbara Development Commission and the Sahara Forest Project team has worked closely together to identify and follow up on meetings with potential business partners as public funding opportunities. SFP's development in Karratha will likely be a mix of debt and equity supported by State and Federal funding initiatives. The Sahara Forest Project concept for Karratha is already included in concept notes for federal programs at the time of delivery of this report.

An important part of the work of The Sahara Forest Project is to cooperate with the indigenous people. The Wanggalili Project is a collaboration of local parties to explore commercial growing opportunities around indigenous fruit and vegetation. The Sahara Forest Project is committed to this project as further described in the Social Benefit section of this study. Other initiatives are developed around the off take infrastructure.

It has been a clear strategy throughout the work of this study to identify, assess and decide the right level of involvement for cooperation for The Sahara Forest Project. In addition to the broader social bottom line, The Wanggalili project is an interesting venture as it opens up for direct cooperation also on core business parameters of The Sahara Forest Project in terms of labour, mixed use of greenhouse infrastructure and effective methods for outdoor revegetation development.

7.4 Triple bottom line

The introduction of Sahara Forest Project concept to Pilbara has the potential to create positive innovative change to the agricultural sector by being an example for climate smart solutions. There are attractive locations for a Sahara Forest Project roll-out in various parts of Pilbara that can be developed to create jobs and careers both directly in the construction and operations of the facility, but also in subsidiary industries. The environmental benefits for the project ranges from the introduction and use of renewable energy technologies to energy efficiency and land restoration.

Further, this Feasibility Study points out opportunities for investors, public authorities, suppliers, local communities and off-takers to enjoy good return on investments from a Sahara Forest Project Facility. In addition, initiatives such as the *EcoHub* and the Wanggalili Project shows the value added potential of building on industrial and local community synergies. As such, there are good opportunities to succeed in realizing a truly triple bottom line for Sahara Forest Project partners in Karratha.

8. SOURCES

ABARES Agricultural Commodities – March quarter 2017: Department of Agriculture and Water Resources (ABARES), Research by the Australian Bureau of Agricultural and Resource Economics and Sciences: Outlook 2017, March Quarter 2017

ABARES Agricultural Commodities – March quarter 2018: Department of Agriculture and Water Resources (ABARES), Research by the Australian Bureau of Agricultural and Resource Economics and Sciences: Outlook 2018, March Quarter 2018

ABARES Economic Survey 2014: Department of Agriculture (ABARES), Research by The Australian Bureau of Agricultural and Resource Economics and Sciences, Authors: Haydn Valle, Tim Caboche and Milly Lubulwa; Australian vegetable-growing farms - An economic survey, 2010–11 and 2012–13

ABARES Economic Survey 2017: Department of Agriculture and Water Resources (ABARES), Research by The Australian Bureau of Agricultural and Resource Economics and Sciences, Authors: Dale Ashton and Aruni Weragoda; Australian vegetable-growing farms - An economic survey, 2014–15 and 2015–16

agric.wa.gov.au: Government of Western Australia, Department of Primary Industries and Regional Development:
agric.wa.gov.au1:
https://www.agric.wa.gov.au/western-australias-agriculture-and-food-sector
agric.wa.gov.au2:
https://www.agric.wa.gov.au/horticulture/agmemo-horticulture-news-september-2017
agric.wa.gov.au3:
https://www.agric.wa.gov.au/vegetables/vegetables-western-australia?nopaging=1
agric.wa.gov.au4:
https://www.agric.wa.gov.au/r4r/pilbara-hinterland-agricultural-development-initiative-phadi

Aus. Dept. of Employment, 2016: Australian Labour Market Update, Australian Government Department of Employment, April 2016

Australian Government Labour Market Portal:
http://lmip.gov.au/default.aspx?LMIP/GainInsights/IndustryInformation/AgricultureForestryandFishing

Australian Horticulture Statistics Handbook Vegetables 2015/16: Horticulture Innovation Australian Limited 2017

Australian Industry Report, 2016: Department of Industry, Innovation and Science; Australian Industry Report, 2016

Australian Vegetable Industry Strategic Investment Plan 2012-2017: Ausveg and Horticulture Australia, March 2012

Australian Vegetable Industry Strategic Investment Plan 2017-2022: Horticulture Innovation, 2017

Ausveg 2014: Ausveg and Horticulture Australia: Cost of Production for Australian Vegetable Growers

Ausveg and Horticultural Innovation Australia Nov. 2015: Ausveg and Horticultural Innovation Australia Discussion Paper 25.11.2015: Analysing Australian vegetable growers' financial performance by farm size

City of Karratha Green Paper 2014: Green Paper on Developing Northern Australia, City of Karratha Submission August 2014

Coriolis 2016: Coriolis: Finding the Sweet Spot: Growing WA Vegetable Exports, November 2016, commissioned by the Western Australian Vegetable Growers Association Inc.

Deloitte for Horticulture Innovation Australia, 2016: Deloitte for Horticulture Innovation Australia: The impact of increasing vegetable consumption on health expenditure, 2016

Deloitte Millennial Innovation Survey, 2013: Deloitte: Millennial Innovation Survey, Summary of Global Findings, January 2013

Government of Western Australia, Department of Primary Industries and Regional Development:
agric.wa.gov.au1:
https://www.agric.wa.gov.au/western-australias-agriculture-and-food-sector

HIA Project Harvest 2016: HIA Project Harvest Monthly Tracker Report: Industry Insights Wave 21: February 2015 – Wave 36: May 2016, Colmar Brunton

Horticulture Innovation Australia: Vegetable Industry Export Strategy – Volume 1: Horticulture Innovation Australia: Vegetable Industry Export Strategy – Volume 1: Background Analysis, Author: Dr. David McKinna, McKinna et al, 2016

Horticulture Innovation Australia: Vegetable Industry Export Strategy Volume 2: Horticulture Innovation Australia: Vegetable Industry Export Strategy Volume 2: Country & Category Analysis, Author: McKinna et al, December 2016

jtsi.wa.gov.au1: Government of Western Australia – Department of Jobs, Tourism, Science and Innovation http://www.jtsi.wa.gov.au/about-the-state/quality-of-life/economy

PDC Strategic Plan 2016/2018: Government of Western Australia, Pilbara Development Commission, 2015

Pilbara Development Commission (pdc.wa.gov.au1): https://www.pdc.wa.gov.au/our-region/region-pilbara

Pilbara Development Commission (pdc.wa.gov.au2): https://www.pdc.wa.gov.au/our-focus/strategicinitiatives/agriculture

Pilbara Regional Investment Blueprint Summary Report, 2015: Government of Western Australia, Pilbara development Commission https://www.pdc.wa.gov.au/application/files/1614/4677/7716/Pilbara_Blueprint_Summary_Report_FINAL_RELEASE_Compressed.pdf

PMSEIC: Australian Government, Prime Minister's Science, Engineering and Innovation Council: Australia and Food Security in a Changing World – Can we feed ourselves and help feed the world in the future? Report of the PMSEIC Expert Working Group October 2010, http://www.chiefscientist.gov.au/2010/12/securing-australia%E2%80%99s-future-pmseic-releases-expert-reports-on-food-security-and-energy-water-carbon-intersections

Roy Morgan Research 2016: http://www.roymorgan.com/findings/7021-woolworths-coles-aldi-iga-supermarket-market-shares-australia-september-2016--201610241542

The Bankwest Curtin Economics Centre, 2016: *The Bankwest Curtin Economics Centre: From Paddoc to Plate – WA's Potential in Agriculture and Agribusiness. Focus on Industry Series, No. 1, September 2016*

The Climate Council, 2015: The Climate Council: Thirsty Country – Climate Change and Drought in Australia, 2015

The Pilbara Resources and Beyond, 2014: Regional Development Australia - An Australian Government initiative: The Pilbara Resources and Beyond, January 2014

WA State of the Economy, Sept.2017: Government of Western Australia, Department of Jobs, Tourism, Science and Innovation, Western Australia Economic Profile Sept. 2014

Western Australia Iron Ore Industry Profile 2017: Government of Western Australia, Department of State Development, March 2017