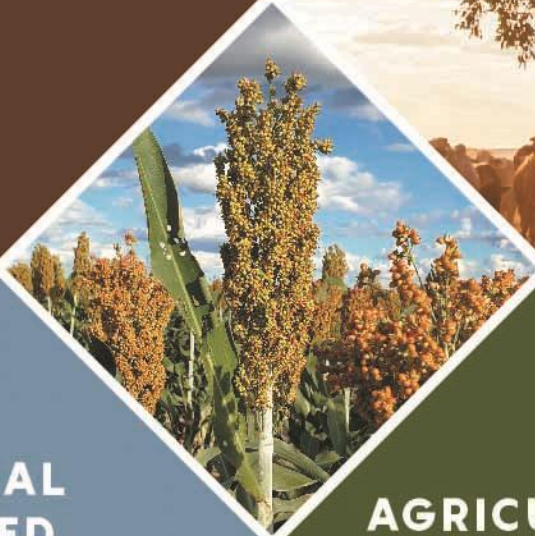


NORTHERN HEALTH SERVICE DELIVERY



TRADITIONAL OWNER-LED DEVELOPMENT



AGRICULTURE & FOOD



Grower reflections of the horticulture sector across Northern Australia

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Acronyms

ABAERS	Australian Bureau of Agriculture and Resource Economics and Sciences
ABS	Australian Bureau of Statistics
CRC	Cooperative Research Centre
CRCNA	CRC for Developing Northern Australia
DITT	Northern Territory Government Department of Industry, Tourism, and Trade
DPIRD	Western Australian Government Department of Primary Industries and Regional Development
FGM	Focus Group Meeting
GDP	Gross Domestic Product
ILUA	Indigenous Land Use Agreements
NESP	National Environmental Science Program
NT	Northern Territory
QLD	Queensland
QDAF	Queensland Department for Agriculture and Fisheries
RDC	Research and Development Corporation
SWOT	Strengths, Weaknesses, Opportunities, and Threats
WA	Western Australia
VET	Vocational Education and Training
VHT	Vapor Heat Treatment



Project Participants



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Executive Summary

The horticulture sector in northern Australia, covering the north of Western Australia, Northern Territory and north Queensland, contributes \$1.6 billion/year to the Australian economy by supplying diverse food commodities to meet domestic and international demand. The main commodities include avocado, banana, citrus, mango, melons, and various other exotic and high-value crops. To date, the Australian Government has funded several studies on developing the north's agriculture sector, however, these focused primarily on land and water resources and omit an integrated, on-ground feasibility analysis, including farmers/growers' perspectives.

This situational analysis of the horticulture industry in the north offers a detailed integrated assessment, highlighting farmers' perspective on the current state of the north's horticulture sector, and the related challenges and opportunities. We conducted a thorough literature review of the industry across northern Australia and several focus group workshops involving growers and experts from government organisations, growers' associations, and regional development agencies.

Our findings suggest that early and 'out of season' production and the availability of land and water are the key factors that can help grow the northern Australia's horticulture industry. However, an in-depth understanding of crops-specific economic viability and the potential for future export markets is essential for developing any future investment plans. Through in-depth discussions with the growers and industry experts, we identified that several key local issues pertaining to crop production, including the availability of, and secure access to, land and water resources, as well as workforce and marketing arrangements (i.e. transport or packing/processing facilities, export opportunities, biosecurity protocols, and the role of the retailers/supermarkets) affect the economic viability



and future expansion of the sector across the region. Our study suggests that any major investment should be aligned with growers' interests and needs from each region, and supported by inclusive research for development, which can help improve economic returns, and the sustainability of the sector as well as of rural communities in the future.



Introduction

Northern Australia produces a diversity of fruits, including avocados, bananas, citrus, mangoes, melons, and a variety of vegetables, including pumpkins, sweet corns, and tomatoes, mostly produced in major horticulture centres spread across northern Queensland (QLD), the Northern Territory (NT) and northern Western Australia (WA; Figure 1).

To provide an overall view of the horticulture industry across the north, bananas represent a major horticultural commodity, accounting for the largest share of all horticultural produce in quantity and value, with 336,000 tonnes produced in northern QLD (2019–2020; ABS, 2021, Hort Innovation, 2020). The second major commodity is water- and musk melons, with 66,000 tonnes produced in the NT (NT Farmers, 2020a); 65,000 tonnes in north QLD; and 21,000 tonnes in northern WA (ABS, 2021). Mangoes comprise the third-largest horticulture commodity, with 32,000 tonnes produced in 2019–2020 in the NT, and 22,000 tonnes in north QLD (Figure 2). Compared to the NT and north QLD, the quantity of horticulture produce in northern WA is relatively small (Figure 2).

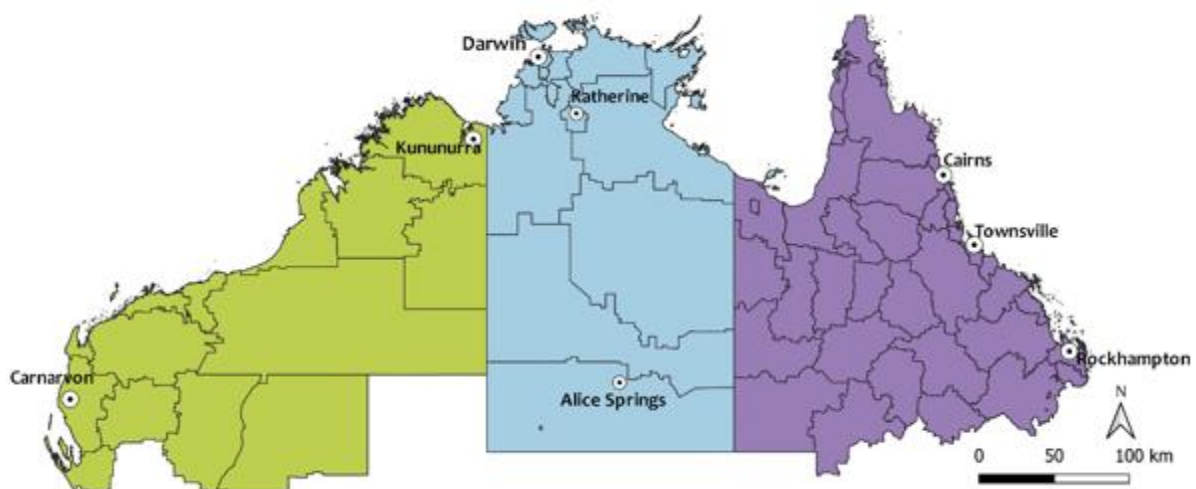


Figure 1. Major horticulture centres (indicated by black dots) across northern Australia.

In terms of the economic value of produce, during 2019–2020, bananas in north QLD were worth \$583m/yr, followed by mangoes in the NT worth \$129m/yr (fetching a much higher price than mangoes from north QLD; \$49m), and tomatoes in north QLD (\$87m/yr; **Error! Reference source**

not found.). Melons were worth \$69m/yr in the NT, \$59m/yr in northern QLD and \$20m/yr in northern WA (2019–2020). Avocados in north QLD, a fast-growing economic commodity, were worth \$63m/yr. Among vegetables, sweet corn and beans in north QLD represented the highest value, i.e. \$76m/yr and \$66m/yr, respectively. In the NT, vegetables (mostly Asian) were worth \$61m/yr, and in north QLD, other vegetables (including capsicum, potato and pumpkin) were worth \$124m/yr (excluding tomatoes and beans).

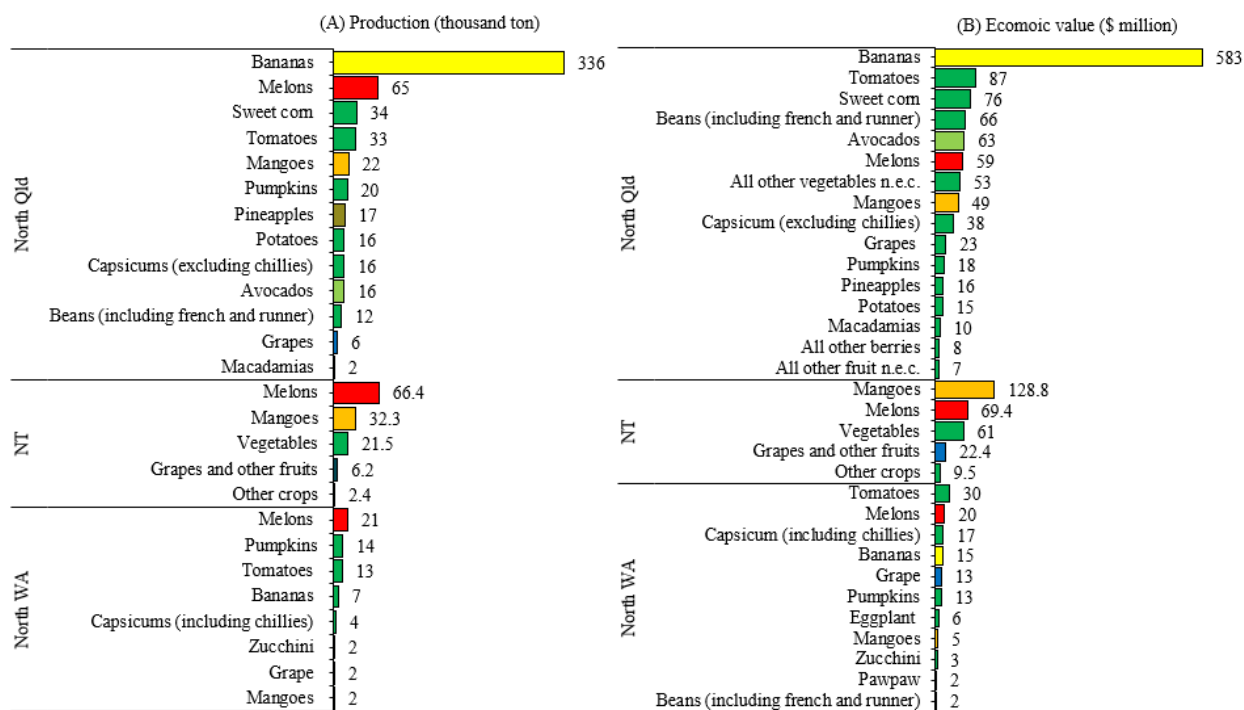


Figure 2. Estimate of the production (A) and economic values (B) of the horticulture commodities produced in northern Australia (north QLD, the NT and northern WA) for 2019–2020 (Sources: ABS 2021; DPIRD, 2021a,2020b,2020c; Hort Innovation, 2021; NT Farmers, 2020a).

The net value of major horticultural produce across northern Australia was worth \$1.6 b/yr in 2019–2020, with north QLD supporting \$1.2 b/yr, the NT, \$291m/yr, and northern WA, \$126m/yr. These estimates exclude several emerging crops, such as durian, jackfruit, lychee, and other tropical commodities, due to a lack of confidence in data sourced from the ABS and Hort Innovation.

This report presents a situational analysis of the horticulture sector in northern Australia including its strengths, challenges and opportunities. It highlights commonalities and differences in the sector among north QLD, the NT and northern WA (Figure 1). All the information has been collected and integrated from published reports, growers through the focus group workshops, industry associations, government agencies and literature surveys.



Methodology

Brief background

The aim of the project is to understand the diversity, complexity, challenges, opportunities, and threats for the horticulture sector in northern Australia, to inform future policies, research and development, and investment, for developing ecologically sustainable, climate-smart, and economically viable horticulture systems in the north.

Approach for data collection and analysis

We applied a variety of methods for data collection including literature review, focus group workshops, and online survey questionnaires with both farmers/growers and experts from the industry and research bodies related to horticulture.

To understand the status and issues affecting the growth and future development of the horticulture sector in the region, firstly we reviewed literature available from the Australian Bureau of Statistics (ABS), Australian Bureau of Agriculture and Resource Economics and Sciences (ABAERS), various government organisations in the NT, QLD and WA, farmers associations, Hort Innovation, peer-reviewed scientific journals and unpublished reports. The main attributes for this review included identifying the type of major commodities, their production volume and area, economic value, and any issues related to the north. Data from various sources were reviewed and collated, which laid the foundation for discussion with the study participants on defined themes (e.g. production, supply chain, workforce, etc. – details below) developed by the research team.

Following the literature review, we conducted focus group workshops with growers from the NT, north QLD, and north WA, and industry experts from the region. The participant growers represented major industries such as mango, banana, melon and other tropical fruits and vegetables. The expert participants were represented by the government horticulture research, development and extension and regional development agencies i.e. the Department of Industry, Tourism and Trade (DITT), NT; the Department of Primary Industries and Regional Development (DPIRD), WA; the Department for Agriculture and Fisheries (DAF), QLD, the Horticulture Innovation Australia, and consultants working on the production, marketing, supply chains and export.

The focus group workshops were of two types: (i) three workshops mainly with growers from each State/Territory to understand State-level issues; and (ii) the main experts' workshop including both growers, and industry and market representatives from the north to understand the situation from a broader northern perspective. Each workshop comprised between seven to 15 participants.



Discussions were held on defined themes. The State/Territory level workshops in the NT and QLD were held face-to-face, except for in WA. The experts' workshop was of mixed mode, with 12 participants face-to-face who were split into two groups of six each, and three online (who could not travel due to Covid-19 restrictions). In all workshops, a structured discussion was followed covering the defined themes: production and economic efficiency; supply chain; workforce; research and development; and policies/institutional support. For each theme, we applied the Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis approach to explore the growers' and experts' perspectives. SWOT analysis is commonly used for analysing and positioning an industry's resources and planning (Phadermrod et al. 2019). With this approach, we were able to critically analyse the current state, challenges, and opportunities for the horticulture industry.

For the experts' workshop, 12 participants joined the workshop in person and three online from QLD and WA. The researcher team facilitated online discussion. The workshop material was communicated to each participant in advance. During the workshop, three online participants formed one group, and after discussion among themselves, they presented and shared their points with the face-to-face group. The online group also later collated their responses using a Microsoft Word document, which was sent to researchers.

For the WA workshop, the research team organised the workshop in collaboration with DPIRD researchers, and growers were invited to the DPIRD office to be together to participate and discuss issues, challenges and opportunities that they experience. The research team organised prior trial sessions with DPIRD researchers to familiarise them with the workshop topics and format, a workshop agenda and outline were sent in advance. On the workshop day, the research team facilitated discussion using the online platform, Zoom.

In addition to focus group discussions on the defined themes, the participants were given a semi-structured questionnaire for each group (both online and face-to-face) to suggest their agreed opinions for each theme on a scale, i.e. very low (1), low (2), medium (3), high (4), or very high (5). For instance, to assess the domestic market, the participants were asked to discuss among themselves and collectively respond to the question, "how would you rate the demand of northern produce in the domestic market of Australia?" This was then followed by three associated questions on domestic market considering the 'weaknesses', 'threats', and 'opportunities for improvement'. For the supply chain, we asked the participants, for example, "how effective is the existing supply chain across the north?" and a few related questions on transport facilities, costs,

market protocols, and consistency in the supply chain. In this way, we were able to deliberately lead the discussion on each of the topical issues to derive conclusions.

Overall, we triangulated information from literature review, focus group workshops and semi-structured group (and online) questionnaires. The focus group workshops delivered mostly qualitative information in the form of text (i.e. statements, notes) and the group surveys presented agreed responses for a specific topic/issue on a Likert scale: very low (1) to very high (5) with a mix of quantitative and qualitative responses. The data were re-checked with the participants from focus group workshops to re-confirm their views. Subsequently, we analysed and collated that information in a summary matrix following SWOT.

This report presents the current situation (2021–2022) of the north’s horticulture sector under three major sections: strengths, challenges and opportunities to describe the industry situation across northern Australia, followed by the specifics for north QLD, the NT and northern WA.



Image: Focus group workshop with experts, industry representatives and horticulture growers of northern Australia (July 2021).



Strengths of the horticulture industry in northern Australia

This section presents the primary strengths of the horticulture sector and highlights the commonalities and differences between northern jurisdictions. Focus group findings are reported in Appendices 1-4.

In terms of horticulture production, the States and Territory that make up northern Australia have maintained a relatively stable production and economic growth over the recent past years. Mangoes, bananas, melons and tropical fruits including rambutan and jackfruit make up the most common crops across northern Australia. The tropical climate of the region favours northern growers to become the major producers and suppliers of mangoes and bananas in Australia, especially to meet the domestic market demand. At present, growers in each northern State or Territory have some level of advantage of early 'out of season' production, and to market their produce in the domestic market, particularly in the case of mangoes, bananas, lychees, rambutans, jackfruit and Asian vegetables.

Northern Australia affords sufficient land and water resources to meet growers' needs for supporting existing production. Most growers have secured water access with irrigation from surface water and groundwater aquifers across the region. Land is generally available for growers if they want to expand their businesses and meet market demands.

Most horticulture growers in northern Australia have small land holdings, and typically manage their farms through a legacy of family-owned and -supported businesses. However, extended professional farm management is needed on many farms to apply advanced and smart farming technology and meet workforce regulations. Most growers have maintained their farming activities for at least the last 30–50 years. As a result, local knowledge in growing horticulture crops is an invaluable asset achieved through family farming, thus affording significant advantages in adaption, as well as exploring and growing crops that suit the tropical conditions. Overall, growers are generally adaptive and capable of managing farm risks, particularly changes in market demand and ongoing workforce shortages.

North QLD accounts for a relatively large, diverse and highly economical horticulture sector when compared to the NT and northern WA. The growers in north QLD continuously improve their crops and diversify to meet the demands of the domestic market. The region accounts for the whole and/or major production of banana, lychee, avocado, as well as other tropical fruits. Mangoes and melons are the most significant crops in the NT, and melons and pumpkins in northern WA. The horticulture industry in the NT has developed fast over the past 20 years, especially with mango industry returning \$149 million/year (2019).



Land for farming is generally available for growers across the north but is relatively more accessible for north QLD growers due to secure land tenure arrangements, allowing land to be developed for agriculture with less over-laying land tenure arrangements. However, water security and related costs are of concern for north QLD growers. The NT and northern WA offer better and cheaper access to water for crop irrigation. Unlike north QLD, there is no external pressure for water allocation on small growers in northern WA or the NT.

The supply chain is extensive for all the northern growers, but relatively manageable for growers in north QLD, with better road and rail transport network than in the NT and northern WA. Some southern Australian States have special protocols for trading certain types of produce, including South Australia (SA) and WA, meaning not all products are accepted in the market without a proper testing procedure. This arrangement offers a significant advantage for WA growers and some north QLD and NT growers who were aware of market niches and followed their specific protocols.

Within the NT, the growers and NT Government Biosecurity team have demonstrated relatively strong collaboration in effectively managing biosecurity related issues, especially when compared to the other northern jurisdictions. Recent successes include the response by, and collaboration of, NT Biosecurity with local growers to eradicate citrus canker. At the growers' level, Asian vegetables growers have a well-established biosecurity model.

In terms of collaboration among the growers in a region, the growers in the Kununurra region of WA expressed a very good collaborative relationship, when compared with those from north QLD or the NT. Overall, the northern Australian growers expressed the need to have formal collaborations among themselves as well as with the peak industry bodies; perhaps competition for the market for growing similar commodities prevents them to collaborate at present.



Image: Horticulture farms in northern Australia. Asian vegetable (top left) and mango farms (top right) in the NT. A mango farm (bottom left) and a citrus orchard (bottom right) in Mareeba-Dimbulah of the Atherton Tableland district in North QLD.

Current state and challenges for the horticulture sector of northern Australia

Our findings provide insights on horticulture production and the availability of land and water resources; important issues and challenges related to the market supply chain; workforce (general and skilled); and research development and extension across the region, as presented below (details in Appendices 1-4).



Production and the availability of land and water resources

The Focus Group workshop participants in this research suggested that the overall performance of commodities, such as mangoes, melons, bananas and vegetables (well-established industries), remains stable across all jurisdictions of northern Australia. At a State level, in general, production levels are relatively high in north QLD, steadily improving in the NT, yet relatively low in northern WA.

At a farm level, respondents identified climatic factors, for instance, an increase in temperature negatively affecting mango flowering and subsequently its production. Since existing crop varieties lacking an improved genetic pool, the respondents highlighted that threat of disease outbreaks and climatic variability are likely to be more frequent and predominant in the future – exhibiting potential major threats to the sector. There is a lack of long-term data on how an increase in temperature will impact mango production across the region, let alone any other commodities. Similarly, the banana industry is highly impacted, with climate change and an increased frequency of cyclones and flooding in north QLD. In particular, respondents indicated that the effects of extreme weather events (i.e. too hot and windy conditions) on horticulture systems are already evident in northern parts of WA (Kununurra & Carnarvon), north QLD, and the NT. In general, northern horticulture systems are quite efficient, however, increasing input costs, mainly for fertilisers, pesticides and transport, constantly challenge the sustainability and profitability of the sector (Appendices 1–4).

In terms of the market economy, high demand for exotic crops, such as avocados, lychees, and mangoes, afford reasonable returns. However, the strong influence of retailers and supermarkets in the Australian markets means commodity prices are determined by retailers rather than growers (Appendix 1). As a result of current market mechanisms, growers receive a much lower price (i.e. 9–10-fold less) than consumer prices (Appendix 2), resulting in declining marginal profitability which exerts increasing pressure on many small and medium scale farmers who are left with no other options than to sell their farms to corporations. This situation has been especially common in north QLD (Appendix 2). Growers expressed serious concerns about the future of their family farms.

Water availability and accessibility for irrigation were reported as key factors in maintaining existing production, as well as in determining the expansion of farms across the north. Most respondents agreed that an adequate supply of water for irrigation is currently available for all existing northern farms however, variability exists between jurisdictions depending upon the source of water. For example, in the NT, growers largely rely on groundwater for irrigation. Allocation of groundwater currently restricts water availability for further horticulture expansion in the region (Appendices 1,



3). The participants reported that ~40% – ~50% of the allocated water remains unused in the Douglas-Daly region in the NT (only 25% – 50% is effectively used in farming). There is little understanding of the impacts of surface water extraction and of long-term use of groundwater resources for expanding or developing new farms in the NT.

Growers in northern QLD and WA, respectively, use relatively less groundwater and more surface water (i.e. river dams). In WA, participants reported that irrigation techniques remain underdeveloped and inadequate for expanding horticulture in the Ord River region (Appendix 4). In north QLD, Tinaroo Dam supplies surface water for irrigation to >700 farms (Appendix 2). Due to the high rainfall in the region, the water supply has remained relatively stable to date, however, there is no alternative source for water security. The horticulture industry in the area is worth greater than \$1b/yr, yet depends solely on the dam, thereby making it vulnerable to declining rainfall and increasing climate change (Appendix 2).

Land availability is not a major concern, as reported by the participants. However, the accessibility and useability of land for expanding horticulture is a significant challenge across all northern jurisdictions (Appendix 1). Each State or Territory in northern Australia has a different set of land legislation. Typically, QLD legislation supports relatively easy access to cultivatable land, especially with large areas under crown or pastoral leases or being freehold land. In the NT, small areas of land are currently available under freehold or crown leases, particularly around Darwin and Katherine. Approximately 50% of land in the NT (63m ha) is registered as inalienable Aboriginal freehold land under Aboriginal Land Rights Act 1976, with the rest being other land parcels, primarily under pastoral or crown lease. Similarly, in WA, significant parcels of land are registered under Aboriginal Land Trust, and the rest, predominantly, is under pastoral lease. Native Title and Indigenous Land Use Agreements (ILUA; mostly prevalent in QLD) are the only common legislations across all northern jurisdictions.

The respondents emphasised that the current policy and regulation barriers further impede the acquisition of, or access to, land for horticultural development. Underdeveloped pastoral areas are also often difficult to convert to alternative land uses, such as horticulture, due to the high levels of investment required for developing road infrastructure and other farm facilities. Furthermore, any investment for farm expansion requires consistent and secure water supplies to make the land productive. Participants, particularly from north QLD, emphasised the need to develop sustainable and economically viable farming systems, rather than expanding or clearing more land for farming, unless export markets are explored and supported by the government (Appendix 2). Overall, the



process to negotiate land tenure and access to land and water resources is quite complex and expensive in WA and the NT, as reported by participants.

Market supply chain

The supply chain comprises all the stages and activities associated with the horticultural production, from the farm gate to the consumers. Existing market demand for horticultural produce from northern Australia was revealed as 'very high' by the participants, however the activity of getting produce from the farm gate to the consumer involves significant costs for transportation and refrigeration due to the great distances involved (Appendix 1). The current supply chain includes several steps, each with associated costs for growers (e.g. transport facilities and costs, uploading, storage, product treatment and unloading), which affect producers' economic profitability (Appendices 2–4). Maintaining consistent temperature is critical for delivering good quality products, however, is a significant issue for long-distance transport. With the availability of data loggers, there have been significant improvements in monitoring product temperature and, hence, maintaining the quality of horticulture produce over the last 4–5 years.

The current market system may also demand consistency of supply for large volumes of a commodity, which is sometimes difficult for growers to achieve, particularly under changing climate conditions (Appendix 1). Currently, there is no stocktake of the quantity and quality of even the main commodities in the region. Overall, the participants ranked the state of the supply chain as 'medium to highly effective' across northern Australia. Across the three jurisdictions, it was relatively more effective in QLD, followed by the NT and northern WA (Appendices 1–4).

The state of existing transportation facilities in terms of transport availability and costs was ranked as moderate to high. Within the region, transport facilities are relatively efficient in north QLD, followed by the NT (Appendices 1–4). Due to the large distances involved, NT and WA growers pay high transportation costs. One of the reasons identified by the respondents is that there is little competition for road freight in the NT and WA (e.g. Kununurra) as growers rely on only a few transport companies.

Typically, the volume of produce and time of the year determine freight availability and costs, which works in northern growers' favour due to 'out of season' production, when compared to their southern partners. In this regard, high-demand commodities (e.g. mango, banana) maintain good transportation options. However, product inconsistency, small volumes and variability of supply of some commodities, such as jackfruit, durian and rambutan, result in higher costs for growers in the NT and northern WA. Small scale growers, particularly of Asian vegetables, are significantly



affected due to limited and expensive transport facilities, such that they often aggregate multiple commodities to save costs (Appendix 2). In addition, there are no opportunities in northern Australia for value-adding to the local produce.

Lack of awareness among growers about the supply chain was another issue reported by many participants (Appendices 1–2). Most growers run family businesses and often lack the ability to understand the market situation or changes in demand and consumer behaviour. Typically, growers were disconnected from consumers, thereby resulting in a lack of understanding among the growers of the need to adapt their products to consumer demand. For example, in the case of several emerging crops (e.g. carambola, jackfruit and dragon fruit), very limited information was available from retail shops on the health benefits of the product or on how to process it, which would thereby aid customers in the decision-making process of purchasing the new commodity. Currently, Asian vegetables and fruits are produced on a small scale, without any proper inventory, purely to meet the domestic market demand. A detailed assessment would help Asian vegetable and fruit growers to understand market situations, address market needs and adapt their produce per consumer needs (Appendices 1, 3).

Another concern raised by participants regarding the supply chain was the lack of uniform market protocols across different Australian States and Territories (Appendices 1, 3). This lack affects the economic viability of the sector. Each State has its own biosecurity policies, regulations and compliance procedures, with growers having to fully comply with those protocols in order to sell their produce in the target market of a State or Territory. Inconsistent protocols incur significant costs to growers as they adapt to the different procedures. At present, growers of high-value products such as mangoes, due to their volume and consistent supply, are able to minimise compliance costs. Low scale producers, however, experience huge costs when complying with the protocols, and sometimes lack the ability to understand these requirements.

These compliance procedures may also be infrequently updated. For instance, irradiation treatment is currently available to enhance product shelf-life without any damage, which is particularly useful for tropical fruits and vegetables. However, retailers in southern markets are not willing to adopt irradiation treatments due to consumer concerns (Appendix 1).

The authors acknowledge that there are a few producers across the north who take the advantage of the specific State and Territory protocols (i.e. to sell lemons and limes in the WA market) as they adapt their product to meet the needs of a particular market, and prefer that targeted market approach.



Overall, key challenges in the supply chain include greater freight distances and transport costs; lack of cooling before, and monitoring of input temperature during transport; lack of awareness among growers and consumers on the whereabouts and the quality of produce (branding, etc.); lack of a stocktake of primary commodities at a regional level; and variability in State and Territory compliance protocols for accessing and selling produce in the various markets. Collectively, these affect the economic efficiency of northern farming systems.

Workforce (harvesting and skilled)

All participants highlighted that the availability of the seasonal workforce to harvest horticulture produce has become a major concern, especially under COVID-19 restrictions, which was not a prior concern (Appendices 1–4). Since most horticultural produce is seasonal by nature, a casual workforce is required, in high numbers, but only for short periods. Due to the on-going pandemic, the current labour shortage is exacerbated by visa changes, leading to limited migrant labour. Participants also identified other issues, such as the remoteness of the farms, inadequate accommodation and language barriers.

Farm management within the horticultural sector is not up to date, when considering the changing demands and strategies of workforce retention (Appendix 1). Human resources management systems exist only on a very few large farms, while most medium- and small-scale farms maintain these skills on a seasonal basis, without a reasonable investment in their workforce. Many growers who rely on intermediaries or workforce contractors to access workforce had also experienced extra costs, demonstrating that there is a lack workforce strategies across the sector. Investing in developing workforce strategies could assist the State or Territory farmers, while demonstrating how they meet workforce needs. The NT Farmers association recently developed a NT Plant Industries Workforce Development Plan that covers some of the aspects mentioned earlier, including listing the required workforce technologies, such as robotics, database management of the farming systems and precision agriculture.

Over the past few years, growers have demonstrated efficiency in managing their farms, with knowledge and skill transfer between family members. However, growers expressed a sober concern regarding the future of family farms due to the declining interests of the younger generations, and the need for agronomic, managerial and technological skills required on the farm (Appendix 2). A lack of interest among younger Australians was raised as a serious concern by all participants, which was partly attributed to the poor public image of the horticultural sector. Currently, only a few options exist for younger Australians to pursue career pathways in the agriculture or horticulture sector at the college or university level. Most small and family growers



cannot afford resources to support such pathways for their children (except for large farms or corporations), thus the youth is often attracted by more rewarding employment options, such as mining. The majority of the participants, especially family growers, showed their willingness to support training opportunities for a new workforce to build their knowledge and skills on the farms (Appendices 1–4).

Research, development and extension

The participants suggested that, in general, existing research support for the horticulture sector is adequate to improve farming systems, domestic and international market access, and to understand the supply chain (Appendix 1). A key issue, as mentioned by the group, is a weak linkage between Research and Development Corporations (RDC) and field interventions, particularly when enabling growers to target commercial production outcomes. The bulk amount of research has been completed in the past years; however it has not always been extended and adopted at the farm level. To date, most of this research has been conducted in north QLD and NT, respectively. There is a lack of understanding about the commercial reality of emerging crops in terms of economic viability, demand, supply chain and sustainable market access. Furthermore, adequate research has only been undertaken on primary commodities such as mangoes, not for emerging small-scale crops (i.e. Asian vegetables and fruits; Appendices 1–3). Additionally, climate change-related research has only covered a few main crops, with the research outcomes yet to be explained to the producers. Due to the changing intensity and frequency of severe weather events, the respondents asserted that the increasing negative impacts of climate change on additional crops should be studied (Appendices 1–4).

The respondents reported that Hort Innovation is one of the key RDCs that has not fully focused on grower-driven strategies for development or innovations in the north. For instance, market access for northern producers is a serious concern which has not been fully addressed to date, partly because of a lack of collective efforts by RDCs and State and Territory Governments. Although Hort Innovation represents over 40 industries, some emerging crops afford limited levy generation with little support mechanisms for research, development and extension, such as the Asian vegetables. The national priorities of industry peak bodies often do not match with local and regional needs. Another major issue is that most research and development-related investment occurs in disrupted, often short, phases due to short-term government grants and a lack of long-term commitment (Appendix 1).



Collaboration

At the grower level, collaboration is limited due to the competitive nature of the domestic market. There is also a very limited collaboration with peak industry bodies and market agents, which currently undermines any opportunity for developing a deliberative, transparent and accountable supply chain for the region's industry. Small-scale growers (particularly Asian vegetable growers in the NT) hardly get the opportunity to represent their views within even local industry bodies.

Overall, there is a need for a collaborative platform across the north to enable growers in the tropical regions of Australia to share their stories with each other. Due to COVID-19 restrictions and workforce impacts, some growers experienced severe setbacks, including mental illness, yet remained reluctant to share their concerns with their community. The small-size production systems are also likely to contribute to increased competition among growers across the north, except for those small regions in northern WA where growers see more value in collaboration. Growers' self-interest determines the level of effective collaboration they may have with others in the sector.

Biosecurity

The State and Territory Governments provide support with funds and technical resources to control pests and diseases across the industry, however, this is generally limited in the north. The current approach is largely limited to a few dominant commodities (i.e. mango or banana) rather than the industry as a whole.

A proximity of the north QLD to the Pacific Islands and the movement of goods across south-east Asian countries will always pose a threat of pest and disease outbreaks. Given the large size of the industry in the Mareeba – Dimbulah region, west of Cairns in north QLD, the biosecurity response is reported to be inadequate due to a lack of staff and resources. A broad coordinated response to secure the diverse tropical fruits and vegetable commodities across the north is much needed.

Post COVID-19 impacts

Since the COVID-19 outbreak, the growers of northern Australia have experienced an increase in production costs, particularly of fertilisers, pesticides, soil stabilisers and machinery repairs. Increased transportation costs correspond to an increase in fuel prices, particularly airfreight as there are fewer flights (1.5 times pre-COVID-19 costs). In addition, the demand for many products (particularly, avocados, pineapples and lime/lemons) reduced when food services industries (cafes and restaurants) shut down to comply with COVID-19-related restrictions.



It has been difficult for many growers to access the workforce, both of harvesting and skilled labour. In order to attract skilled labour for technical support from southern Australia, growers' costs included covering worker's quarantine costs however, many potential employees declined work due to a fear of quarantining twice, both at their home and place of work. The harvesting labour shortage is well documented (Azarias et al. 2020, NT Farmers Association 2020), though for growers, the resultant issues were severe, including worrying about produce wastage, rising debt, and insecurity regarding the viability of future crops. State and Territory border restrictions further impacted the recruitment of the workforce on the domestic scale.

Demand and price for the majority of commodities remained unchanged throughout the COVID-19 crisis, however, the import of certain commodities, such as limes, reduced the value of the domestic product, particularly in north QLD. Overall, exports declined due to travel restrictions.

In general, economic profitability was greatly reduced due to increased input costs and lack of security to harvest and sell produce, as well as uncertainty in the domestic market.

In terms of grower well-being, many felt highly stressed, triggering further psychological and physical health issues. One of the respondents from north QLD outlined these factors as, "*got diagnosed with stress, lost \$0.5 million this year in income, it's a big loss. I'm still on medication and there is additional emotional and physical toll.*" Overall, the COVID-19 pandemic has affected the well-being of most growers involved in the sector, however, there is currently no formal industry-supported platform to share their stories or concerns within their community or with the industry bodies.

Opportunities for improving the horticulture sector of northern Australia

The participants identified several key areas to improve the northern horticulture sector (Appendices 1-4). These include an increased efficiency and transparency in the market price, accessible and effective supply chain; workforce availability; land and water availability and accessibility (& security); and applied research focusing on development and extension to address growers' needs (Appendices 1–4). At the farm scale, increasing business size and improving regularity of commodity supply would benefit small growers (Appendix 1). As there are different types and sizes of commodities produced across the north, a flexible transport system with multi-chambered refrigeration arrangements to accommodate a variety of commodities is essential. As indicated by the participants, improving rail connectivity, truck numbers, and service (chambered refrigeration with controlled temperature), would improve the market supply of tropical fruits and vegetables.



Horticulture growers are generally efficient, yet their capacity to understand complex supply chain processes and the related updates needs to be enhanced in order to operate successful enterprises. A holistic understanding of both production and marketing processes may enable them to oversee production, and to focus more on managing the supply of their commodities. However, the grower usually have to accept the conditions defined by the retailer or wholesaler and, thus, sell their produce without much control (Appendix 2). Building growers' capacity to understand and interpret market conditions is critical for strengthening their capacity for business advancement. The increased capacity will also enable them to identify specialised markets (e.g. organic produce) or to grow crops that do not need storage or ripening (e.g. ginger, turmeric). Some growers of emerging crops (i.e. jackfruit, durian, carambola) also require improved methods of promoting their produce in order to attract and raise awareness among customers about the nutrient qualities of tropical fruits and vegetables (Appendix 1).

To address northern workforce issues, the diversification of large family farms to engage the workforce throughout the year could offer long-term solutions, as suggested by the participants (Appendix 1). This would require new capital investment in enterprise upscaling. Building relationships between different businesses may also provide options for sharing the workforce. At the farm level, a significant investment is required to create liveable conditions for the workforce, including provisioning accommodation and transport, which are generally beyond the capacity of small growers. In this regard, participants suggested that the industry or farmer associations play a critical role in finding collective solutions, and that governments promote seasonal work programmes, such as the Pacific Labour Scheme (DFAT, 2021). The increased demand for a skilled workforce in the sector offers the opportunity to train young Australians in VET and agriculture-related university courses to meet industry needs, as well as enhance the technology applications in farming systems.

Developing strategies and policy frameworks on the sustainable use of land and water resources, especially where more than one party has an interest, such as Traditional Owners with Native Title rights and leaseholders, offers diverse opportunities for considering innovative projects, such as Indigenous bush food.

The current lack of knowledge also requires water modelling to determine surface water capacity, update the regulatory system, and explore trading mechanisms to enhance the efficient use of water resources. As identified by the participants, there is a significant opportunity in facilitating a genuine engagement process with Indigenous peoples to collectively plan for developing northern Australian horticulture systems.



Assisting and informing farmers to understand new information, such as the impacts of climate change and the availability of new and efficient agriculture technologies that may help growers adapt, was stressed as a key priority by participants. For example, appropriate and regulated early burning practices for maintaining mango orchard flowering and pollination was expressed as a key priority of growers in Kununurra, WA; while a good understanding of climate change impacts on mangoes and other crops was likewise favoured by NT growers.

At the market level, finding cost-effective and simple protocols across the States and Territories in order to avoid any unnecessary burden on growers, as well as retailers, is another challenge. In this regard, collaboration between the diverse groups of growers should be strengthened – collaboration is currently restricted within commodity groups, rather than across commodities (Appendices 1–3). There are opportunities to establish local product treatment and marketing facilities in all major northern horticultural centres. Supported by the relevant government, the grower cooperatives may assist in setting up new facilities to reduce the cost and time of treating and irradiating farm produce at a local level. For instance, if lychee growers irradiate their produce locally before export, they could reduce both time and costs. Likewise, mango treatment (i.e. vapor heat treatment [VHT]) facilities should be available within the growing areas of Mareeba – Dimbulah and Darwin – Katherine, such that local growers could benefit and save costs when exporting their treated produce to their target markets.

Under the conditions of the ongoing COVID-19 pandemic and its unforeseen disruptions on the workforce, crop harvest, and the market supply chain, respondents stressed the need to develop a disaster resilience and strategic capacity management system in order to build resilience in the northern horticultural industry (Appendix 1). They emphasised the development of a future disaster management plan, while considering the cyclic nature of disastrous events that the sector has experienced in recent years. There is an opportunity to learn from, and develop adaptive plans across the production and supply chain processes. The Panama disease outbreak in bananas in north QLD, for example, resulted not only in economic loss but also psychological stress among growers. An approximate 30% of the loss in banana production was attributed to labour shortage, as mentioned by the respondents, with the remainder due to many other social factors. Our focus group participants suggested that it is timely to assess domestic capacity in terms of existing risk management strategies, what works well, and identify the gaps across the sector such that future risk management strategies focus on building resilience. Developing a cohesive and integrated resilience system that embraces the diverse fruits and vegetables across the north offers a novel opportunity that will help farming systems plan and adapt to any disasters, in advance.



Key recommendations

The following recommendations are introduced to improve the horticulture sector across northern Australia. These recommendations are based on the findings of this document, which is a synthesis of several resources, including published reports and papers, and focus group meetings with growers, industry experts, and scientists.

1. An inclusive, climate-smart, and holistic farming approach that will improve growers' affordability for growing improved varieties of high demand commodities or introducing the high-density production systems to reduce the input costs and enhance profit margins.
2. Create a transparent, fair and collaborative marketing system, which outlines clear margins for marketing agents and retailers.
3. Establish collaborative/co-operative treatment and value-adding facilities at major horticulture centres across the north.
4. Improve transport infrastructure by developing new and improved road and rail networks.
5. Develop mechanisms and support systems promoting direct local commodity sales
6. Improve extension support for the growers in adapting to, and applying, new technologies, as well as responding to the changing climate.
7. Conduct dynamic and adaptive research that addresses the needs of growers, including topics related to climate change, water use and regulations, supply-chain mechanisms and market economies.
8. Streamline land tenure arrangements, particularly in the NT and WA, for converting pastoral lands to horticultural use.
9. Promote water use efficiency and water source diversification in order to ensure the water security of future cropping systems.
10. Develop a realistic plan for agricultural expansion, as required, with a clear and evidence-based opportunity for the export market, including understanding trading protocols and compliance mechanisms for each export country.
11. Establish a domestic workforce programme with provision for training young local graduates to undertake careers in agriculture, particularly including the application of technology in agricultural systems.



12. Develop policies and programmes to reduce workforce visa requirements for overseas workers, and to provision local quarantine facilities, as required.
13. Establish an ongoing knowledge-sharing platform for ongoing collaboration and engagement between growers, including between peak industry bodies and market agents.



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Appendices

Appendix 1: Experts workshop summary on the situational analysis of the horticulture sector in northern Australia.

Themes	Strengths	Weaknesses	Threats	Opportunities
<i>Productivity and farming systems</i>	<p>Medium to high level productivity of the existing crops (i.e. mangoes, melons, bananas & vegetables)</p> <p>Crop production early in the season compared to the southern States</p> <p>Developed north specific industries (e.g. mango, banana, etc.)</p>	<p>Narrow focus on yield per hectare production</p> <p>Limited improved genetic pools</p>	<p>Climate unpredictability (i.e. too hot weather and less water)</p> <p>Lack of optimum temperature for inducing flowering in mangoes</p>	<p>Improving the genetics of crop varieties</p> <p>Crop diversification through rotation</p> <p>Market window for counter seasonal production to the south</p> <p>Increase organic farming crops</p>
<i>Market economy & supply chain</i>	<p>Domestic market remains attractive to northern produce due to early/out of season supply</p> <p>Availability of appropriate transport/freight services</p> <p>Relatively stable and manageable transport costs</p>	<p>No competition for road freight in the NT and WA</p> <p>Multiple commodities in the same load</p> <p>Inconsistent and variable commodities</p> <p>Lack of cooling and refrigeration during transportation</p> <p>Limited skills of farmers on comprehending supply and demand side</p> <p>Significant biosecurity and environmental costs to meet market protocols</p>	<p>Cost of compliance audits</p> <p>Lack of transparency or honesty in the supply chain process</p> <p>Monopoly/control of direct supply by four Supermarkets</p> <p>External factors e.g. climate effects</p> <p>Use and expense of irradiation treatment for some crops</p> <p>Increased costs of air freight for export after COVID 19 outbreak</p> <p>Lack of awareness of irradiation crop treatment among the retailers and consumers</p>	<p>Increase the size or scale of the business for more control on the supply chain</p> <p>Consolidation or sharing small-scale production loads with other growers for freight</p> <p>Increase the efficiency of rail freight with refrigeration facilities for long-distance transport (excl. far north Queensland)</p> <p>Improvements in compliance technology and raising awareness for its consistent application</p> <p>Harmonisation of the treatments to some extent, i.e. uniform protocols to treat crops and vegetables for transport and marketing across various States/Territories</p> <p>Establishing non-chemical and standardised protocols</p>

Themes	Strengths	Weaknesses	Threats	Opportunities
				<p>Market intelligence for production forecast and management</p> <p>Building consumer awareness for market products</p> <p>Developing processed products (e.g. pharmaceutical)</p>
Land and water	<p>Sufficient land for farming</p> <p>Availability of water for existing farms from ground aquifers and river dams</p>	<p>Limited water for new farming areas</p> <p>Ground water in the NT fully allocated</p> <p>No surface water capture for irrigation exists in the NT</p> <p>Lack of freehold land in the NT</p> <p>Farmers' reluctance to adapt to the reality of changing climate and markets</p>	<p>Low level of political willingness and motivation on land acquisitions (sorting land tenure issues)</p> <p>Environmental lobbying and concerns</p> <p>Climate dependent (i.e. rainfall) recharge of the aquifer</p> <p>Differences in regulation among different jurisdictions</p> <p>Cost of water pumping</p>	<p>Effective regulatory mechanism on water use</p> <p>Water modelling</p> <p>Surface water capture in the NT</p> <p>Water trading to support sustainable water use</p> <p>Streamlining the process of leasing land and accessing water</p> <p>Educating farmers to adapt to climate change impacts</p>
Workforce (casual harvesting and skilled)		<p>Not enough casual workforce for meeting the industry demand for crop harvest</p> <p>Very seasonal and higher demand of casual workforce for shorter period of harvesting time</p> <p>Low skilled workforce</p> <p>Low levels of attraction of new skilled entrants to industry</p> <p>Poor business management systems including Human Resources (HR), employment and staff retention (i.e. middle management)</p> <p>Limited capacity of the growers to pay the skilled workforce</p>	<p>Changes in government seasonal work visa regulations</p> <p>Harsh climatic/working conditions around the farms</p> <p>HR laws and government regulations</p> <p>Poor public image of agriculture career</p> <p>Decreased availability of the skilled staffs after Covid-19 outbreak</p>	<p>Restructure seasonal work program visa for specific Ag visa, and Pacific labour scheme, to offer reliable work opportunities</p> <p>Needs to develop clear description of workers' competencies in the horticulture sector</p> <p>Developing common rules through strategic planning for workforce</p> <p>Developing a disaster risk management plan for the horticulture sector to adapt to any external shocks (e.g. climate, market supply chain, etc.)</p> <p>Upscaling family farms to diversified enterprises for retaining staff all year round</p>

Themes	Strengths	Weaknesses	Threats	Opportunities
		<p>Remoteness, isolation and poor accommodation arrangements around the farms</p> <p>Language barriers with international migrant workers</p>		<p>Building the capacity of the growers/farmers including staffs in IT and Ag tech such as automation, robotics in harvesting, etc.</p> <p>Capital investment to improve onsite accommodation, transport and other living facilities</p> <p>Diversifying enterprises to retain staff all year round</p> <p>Place based skills development (i.e. northern Australia)</p> <p>Night time harvesting to adapt to hot seasonal crops such as mangoes</p> <p>Incentivise staff for doing a good job</p>
Collaboration		<p>Commodity driven collaborations</p> <p>Economy driven interests of the growers</p> <p>Isolated industry</p> <p>Territorial nature (i.e. dis-connectivity of the horticulture industries across the States/Territories)</p>	<p>Competition for contracts, marketing, and branding</p> <p>Biosecurity incursions</p>	<p>Building industry relations within the horticulture sector</p> <p>Developing collaboration between Ag tech providers and farmers</p> <p>Improving Government inputs (streaming process, clear and transparent policies and procedures)</p> <p>Establishing new platform for researchers and growers to share their knowledge</p>
Research, development (R&D) and extension	<p>Research available on existing major crops, e.g. mango</p>	<p>Limited extension and adoption of research outcomes at the farm level</p> <p>Climate change related research, but not translated to growers in a relevant way</p> <p>Insufficient understanding of the commercial reality of diverse crops</p> <p>More focus on pastoral industry than horticulture</p>	<p>Disconnection between Research and Development Corporations, research providers and commercial producers</p> <p>Low levy on small farms, limiting R&D</p> <p>Absent of R&D support and investment for emerging industries</p>	<p>Long-term continuous research</p> <p>Research on all commodities and at a farm scale to capture the situation and find appropriate support</p> <p>Documenting lessons from successful past models</p> <p>Regional delivery partners of research outcomes, and interpretation and communication for the industry</p> <p>Growers' driven research approach</p> <p>Extension and adoption of R&D</p>



Themes	Strengths	Weaknesses	Threats	Opportunities
		<p>Lacking clear knowledge on the status and market potential of Asian vegetables</p> <p>Limited levy of some industries and their lack of desire to invest in R&D</p>	<p>Increasing intensity and frequency of natural/weather events</p> <p>Increased occupational health and safety issues in harvesting</p>	<p>Research on adapting to climatic risks for more crop varieties and places</p> <p>Helping farmers to change and improve their mindset to adapt to climate change</p> <p>Working with partners e.g. National Environmental Science Program on climate change issues</p> <p>Better technology support e.g. research on the early adopters of Ag tech</p> <p>Finding strategies for building collaboration between Research and Development Corporations and industry</p> <p>Sustainable packaging (replacing plastic and use of chemicals)</p> <p>Engagement of R&D researchers</p> <p>Succession plan for retiring researchers</p>

Note: Biosecurity was not covered as a separate topic.

Appendix 2: Workshop Summary of the horticulture sector in north Qld.

Themes	Strengths	Weaknesses	Threats	Opportunities
Productivity and farming systems	<ul style="list-style-type: none"> ▪ Medium to high level productivity across most farms ▪ Automation helps regulating irrigation on some farms ▪ A strong legacy of family farms established in north Qld since 1950-60. Tobacco farming started in 1960s and receded in the early 2000, while horticulture started in 1980s. 	<ul style="list-style-type: none"> ▪ Increase input cost of fertilizers, labor and water (to some extent) ▪ Lack of agronomic activity and expertise ▪ Small family growers struggling to maintain production ▪ Too much production or oversupply to the domestic market ▪ Low profit margin against the production costs ▪ Constantly lessening profit margins across the sector 	<ul style="list-style-type: none"> ▪ Natural disasters such as cyclones and storm surges, flooding, drought, etc. ▪ Weather and climate change including change in temperature and rainfall ▪ Water insecurity ▪ Market competition from other parts of northern Australia ▪ Import of commodities such as lime from Mexico and other countries ▪ Disease outbreak i.e. Panama disease of bananas ▪ Biosecurity to control pest and weed spread 	<ul style="list-style-type: none"> ▪ Availability of local farming inputs mainly fertilizers and pesticides in Australia, to reduce production cost ▪ Development of new varieties of tropical fruits which are disease resistant ▪ Innovation in improving productivity per hectare in terms of crop varieties, IPM and farming techniques ▪ Intensification of production— high density production systems ▪ Special seasonal window of production ▪ Special market opportunity for producing a diverse range of tropical and other horticulture crops (particularly the Mareeba-Dimbulah region is climatically able to support a diverse range of sub-temperate to tropical crops including limes, lemons, grapes, strawberries, mangoes, avocados, beans, etc.) ▪ Increase awareness of tropical fruits in the domestic market ▪ Export opportunity for mangoes and other tropical fruits such as lychees and avocados, particularly to Asia



Themes	Strengths	Weaknesses	Threats	Opportunities
Market economy	<ul style="list-style-type: none"> ▪ High economic profitability especially avocados and papaya ▪ Lychees and bananas have medium economic returns and mangoes low ▪ High market demand of produce from north Qld ▪ 95% of fruit and 100% vegetable grown in north Qld are supplied to the domestic market ▪ Well-known, quality of produce from north Qld ▪ High demand of lime in the hospitality industry ▪ Relatively secure domestic market than the export market 	<ul style="list-style-type: none"> ▪ No increase in the domestic price for a long-time ▪ Strong influence of supermarkets (coles and Woolworths), marketing agents and retailers on setting the price, quantity, and quality of the produce ▪ Supermarkets, retailers and market agents possibly receiving much greater share of the product value especially when comparing the price that growers obtain for their produce and the amount that consumers pay in the market (sometimes a difference of x10 fold or more) ▪ Declining and deteriorating profit margins pushing small-scale growers to the edge ▪ Corporations buying out small growers due to decline in profit margins ▪ High reliance on, or mostly domestic market-oriented demand and supply ▪ Competition with the producers from other regions in northern Australia for the same produce ▪ Lack of recognition of north Qld in lime production as a major producer in Australia, 	<ul style="list-style-type: none"> ▪ Uncertainty in price prediction (banana price highly variable, while low price compels growers to dump their lime) ▪ Imported lemons (polished with wax from California/Mexico) threatens the domestic market ▪ Uncertainty in maintaining a long-term, secure supply to the export market ▪ High price of the Australian produce, above the purchasing capacity of majority of the consumers in the Asian market ▪ Maintaining biosecurity is challenging due to proximity and exposure to neighboring tropical nations ▪ Export market protocols are difficult to follow, and expensive and laborious for growers to apply ▪ VHT treatment damages fruit quality ▪ Lack of irradiation facilities around the Mareeba-Dimbulah area affects the quality of the produce for export purposes (e.g. lychee export to USA) 	<ul style="list-style-type: none"> ▪ More transparency in marketing including the agent/merchant price and cost mechanisms, with well defined profit margins ▪ Maintaining a sustained market flow/flexibility during lockdowns ▪ Export at affordable costs (e.g. using air freight from Cairns to neighboring countries) ▪ Establish export market, possibly with Government support ▪ Applying ethics in determining the product price (fair price) and paying a fair share to the growers with a clear, transparent marketing system incl. the costs/price increments implemented by the retailers and market agents ▪ Summer window for grapes, blueberry production and supply from north Qld to other states ▪ Out of season production ▪ Visibility of the quality horticulture produce from north Qld ▪ Improved technology to extend fruit shelf life ▪ Improved industry protocol and processes, with clear, easier, and relevant support available for the growers to support export

Themes	Strengths	Weaknesses	Threats	Opportunities
		<p>by the horticulture industry, for a long time</p> <ul style="list-style-type: none"> ▪ Closure of hospitality industry due to Covid-19 ▪ Lack of local processing facilities 		<ul style="list-style-type: none"> ▪ Develop a thorough understanding of the market protocols of different export markets ▪ Secure buyers in the Asian market ▪ Extension of Paw Paw market in NZ and Hong Kong ▪ Develop export facilities in Cairns with international airport affording cost effective options for north Qld growers
Market supply chain	<ul style="list-style-type: none"> ▪ Supply chain has improved in the last 5 years ▪ Growers can access road and rail transport for loading and supplying the produce from their farms to the market ▪ Improved streamlining of supply chain ▪ Increase demand of domestic produce due to COVID restriction on the inbound freight ▪ Juice production is higher this year ▪ 2nd and 3rd grade fruits supplied to Bundaberg for juice 	<ul style="list-style-type: none"> ▪ Supply chain is not cost-effective due to long distance and high transport costs (i.e. fuel price, surcharge and others) ▪ Growers bear all transport costs from farm through all the linkage points (unloading and reloading) to the distribution center and final local markets ▪ Linkage problems throughout the transport —handing the produce during shifting, temperature maintenance ▪ Freight with B-double only reaches to Bowen ▪ Rail is not connected directly to Mareeba and Cairns ▪ Road conditions influence the servicing ability of the truck companies and their investment 	<ul style="list-style-type: none"> ▪ Rail transport is hard to manage during storm situation ▪ Declining fruit shelf life while transporting produce over long distances ▪ 	<ul style="list-style-type: none"> ▪ Investment of transport company in Mareeba due to demand for the produce ▪ Hahn highway may be a solution ▪ Subsidy for improving the cost of fuel ▪ Improve inland road with triples may shorten travel hours ▪ Shorten supply chain to improve profit margin ▪ Better technology for monitoring temperature throughout the time of transportation ▪ Develop irradiation plant ▪ Better (cooperative/govt-funded) treatment and marketing facilities ▪ Increase customer awareness to reduce the rejection rate of products

Themes	Strengths	Weaknesses	Threats	Opportunities
		<ul style="list-style-type: none"> ▪ Lack of cooling treatment on farm ▪ Long distance transport and lack of uniform temperature during the transport process ▪ VIC dropped many protocols allowing more access for growers, but of low-quality produce ▪ 		<ul style="list-style-type: none"> ▪ Processing facilities for the 2nd or 3rd grade fruits ▪ Feasibility assessment for processing facilities
Land and water resources	<ul style="list-style-type: none"> ▪ Freehold land ▪ Available and accessible freehold land for expanding production systems in north Qld ▪ Water is adequate to meet existing irrigation requirements (Tinaroo Falls Dam near Atherton supplies water to >700 farms in the region) ▪ Well-developed farms by the first generation growers in the 1950s 	<ul style="list-style-type: none"> ▪ Limited water access to develop new farming areas because 80% of water that is available from Tinaroo Dam is already allocated for agricultural purposes ▪ Relatively less amount of water allocation to small growers compared to increasingly large allocations to a few farming Corporations in the region, mainly due to their farm size and nature of the crop ▪ Small growers typically don't use all their allocated water, whereas now with growing number of Corporations involved in farming in the region, more and more water is being used for irrigation. Both allocation and availability of water is becoming scarce. 	<ul style="list-style-type: none"> ▪ More land opening for farming driven by freehold arrangements can increase pressure on water availability as water is already fully allocated ▪ Corporate/large growers occupying more land for developing farming systems ▪ Corporations further marginalizing many small growers in terms of their choice for what they can produce, where to sell, price for the product, and hence the profit margins. ▪ Corporations also indirectly pressuring small scale farmers, by reducing their profits, to sell their land and water ▪ Corporate/large growers have a much greater say in future water allocations as only they get chance to 	<ul style="list-style-type: none"> ▪ Access to water should be cheaper for small growers ▪ New Dams can be built but to enhance water security not for expanding current farming systems ▪ Greater water security is required given the certainty of market for the produce (mainly export) ▪ Efficient water supply system including covered, well-managed channels ▪ Efficient irrigation systems including sprinklers and drip irrigation ▪ Enhancing water security to sustain the current farming systems, without any further expansion of the agriculture area

Themes	Strengths	Weaknesses	Threats	Opportunities
		<ul style="list-style-type: none"> ▪ Uncertainty in accessing water in the future ▪ Heavy dependence on water supply for >700 farms in the Mareeba-Dimbulah region from a single dam in the area, i.e. the Tinaroo Dam, with no other option to afford water security ▪ Poor water security in circumstances of climate change, esp. decline in rainfall, drought, etc. ▪ No plan B for securing (or complementing) water supply in the region to irrigate >700 farms, in case Tinaroo Dam fails to provide water. <p>14.</p>	<p>represent and on the board/meetings with the water management authorities</p> <ul style="list-style-type: none"> ▪ Low level of willingness among the small-medium growers to build new dams (it requires 50% federal, 25% state and 25% growers funds) ▪ Red tape/bureaucratic processes affect grower's ability to access water ▪ Water insecurity with only one irrigation dam that faces a huge risk of significantly dropping water level if no rain for 7-8 months in the Mareeba-Dimbulah region, supporting >700 farmers <p>15.</p>	
	<ul style="list-style-type: none"> ▪ 	16.		<ul style="list-style-type: none"> ▪
Workforce (harvesting and skilled)	<ul style="list-style-type: none"> ▪ Harvesting workforce just sufficient in 2021 	<ul style="list-style-type: none"> ▪ Low availability of workforce ▪ Growers bear hidden costs in order to get workforce from the middlemen/workforce contractors ▪ Low-reliability on middlemen contracting the workforce ▪ Small growers facing cost burden due to extra burden required to retain workforce 	<ul style="list-style-type: none"> ▪ Shrinking experienced/qualified workforce ▪ Low willingness among the workers to work on farm (especially out on the farm, away from packing sheds) ▪ Family growers struggling to retain their legacy 	<ul style="list-style-type: none"> ▪ National auditing to regulate workforce contractors/middlemen ▪ Building quarantine facilities near the main crop producing areas will benefit small growers ▪ Continuing workforce programme for hiring Papua New Guinea and Islander people

Themes	Strengths	Weaknesses	Threats	Opportunities
		<ul style="list-style-type: none"> ▪ A few training opportunities available for growers, i.e. only for a couple of times in a year ▪ Not enough skilled workforce such as good quality agronomist or Ag tech specialist ▪ No agriculture courses and training available for growers to manage sponsorship 	17. (attracting young family members to stay on farm)	<ul style="list-style-type: none"> ▪ Enhance cooperation among farmers to help each other ▪ Develop domestic workforce programme ▪ Create means and opportunities to enhance willingness among the domestic workforce to work on farms ▪ Growers ready to support new workforce and build their career in the agriculture sector ▪ Self-trained and well-developed skills and knowledge sets available within the family growers that require recognition and support system to continue working on farm ▪ Growers to make available a congenial working environment with affordable accommodation facilities and training opportunities ▪ More high skilled workforce required ▪ More training for students to undertake agriculture/horticulture as the career ▪ Improve crop harvesting with the aid of robot ▪ Small and easily accessible tree variety could ease picking fruits ▪ Packing line efficiency could save time and cost



Themes	Strengths	Weaknesses	Threats	Opportunities
Collaboration	<ul style="list-style-type: none"> Small growers maintain relatively better collaboration than the big ones 	<ul style="list-style-type: none"> Not much collaboration within growers in north Qld Most growers compete for their produce in the domestic market which is limited in size Growers are less open to share the issues concerning farming 	<ul style="list-style-type: none"> Growers concerned about their future existence Less involvement of small growers with the peak industry bodies No common platform for the small growers to share their concerns Some growers having mental health issues due to stress related to farming but hesitate to share among each other 	<ul style="list-style-type: none"> More engagement and cooperation within the growers Develop a common platform to facilitate growers to be open and flexible to share their concerns, and cooperate and learn from each other Reinvigorate the spirits of growers, especially family farmers who hold the legacy, skills and sense of attachment to their land The peak industry bodies developing support mechanisms/initiatives, with a careful consideration of the reality of small-scale family growers
Biosecurity	<ul style="list-style-type: none"> Growers in north Qld are generally aware of maintaining biosecurity and farm quarantine Successful detection and eradication of panama outbreak in banana industry 	<ul style="list-style-type: none"> QDAF has specific project-oriented biosecurity measures/facilities, no activity outside of their focal area Nearby biosecurity facility available in Cairns only which is time-consuming to meet the needs of north Qld growers, e.g. a grower called biosecurity Cairns office which took 8 weeks to send someone to visit the farm and inspect the pest (the experts in Mareeba are much quicker) 	<ul style="list-style-type: none"> Proximity of north Qld to northern island countries affords a high susceptibility to pest infestation Lychee hooper is still unknown as well as the armyworm Movement between Australia, southeast Asia and Torres Straight Island offers great biosecurity challenges 	<ul style="list-style-type: none"> Better improvement of biosecurity facilities More local staff with crop pathology background which is currently available in Brisbane only Better technology for monitoring and quick detection of pests



Themes	Strengths	Weaknesses	Threats	Opportunities
Research, development and extension	<ul style="list-style-type: none"> ▪ Reasonable research support is available for the growers in north Qld ▪ Tobacco farming used to fund research and development in the past years 	<ul style="list-style-type: none"> ▪ Small numbers of research and extension staff in north Qld ▪ No new staff recruited in government research and extension department ▪ Technology aiding farming system including automation is not very common 	<ul style="list-style-type: none"> ▪ Short funding cycle of research and extension in QDAF ▪ No research and extension support on termites which is affecting production in north Qld ▪ Collapse of research stations which were established during tobacco farming in the 1960s 	<ul style="list-style-type: none"> ▪ Research and extension to promote high density production and management systems ▪ More extension staff on full time basis ▪ More skilled people from diverse subject areas (i.e. economics and technology) ▪ Improved ag technology including automation, irrigation, etc. ▪ Precision and efficiency in production and irrigation systems ▪ Developing opportunities for growers to acquire a wide range of skills required for farm improvement—requiring government support to improve learning and understanding of new farming techniques

Appendix 3: Workshop summary of the horticulture sector in the Northern Territory, Australia.

Themes	Strengths	Weaknesses	Threats	Opportunities
Production	<p>Overall production is reasonably stable</p> <p>NT’s horticulture sector growth rate is higher than any other State in terms of GDP</p> <p>Substantial and consistent growth over the past 10 years</p> <p>Farmers are highly efficient in production</p> <p>Asian vegetables offer effective production systems</p> <p>Filling a seasonal window</p> <p>Main melon growers in Australia are located in NT</p>	<p>Increase in input costs across the farming systems and supply chain</p> <p>Flattening of returns</p> <p>Asian vegetables are highly perishable, and their production is highly sensitive to changes in the climate</p> <p>Long distance transport affects the quality of Asian vegetables when supplying southern markets</p> <p>Vegetable production is highly dependent on the price, so growers continuously rotate their crops</p>	<p>Early mango flowering and significantly reduced yields this year (as of surveys in June and Oct, 2021)</p> <p>Climate change a major threat to the mango industry</p> <p>Increasing compliance requirements influence the cost and time of growers</p> <p>Complex regulation for vegetable growers, esp. vegetables requiring chemical treatment during production</p>	<p>Access to innovative and smart farming technology</p> <p>More inclusive farming systems</p> <p>Developing a seed or gene bank for improved varieties</p> <p>Improving efficiency of farming to cope with climate change (e.g. mango varieties that can flower at some increased temperature levels)</p> <p>Better integrated pest management replacing chemical fertilisers and pesticides</p>
Market economy	<p>High demand of the NT produce in the domestic market</p> <p>Mango production in the NT account for nearly half of the national supply</p> <p>Mangoes harvested early in the season in the NT than other states, offering market advantage</p> <p>Melon production has increased over the past 5 years</p> <p>Asian vegetables are generally in demand</p> <p>Specific emerging crops are in high demand in the niche market (e.g. ripe jackfruit)</p>	<p>High sensitivity to market price</p> <p>No persistence economic returns</p> <p>Lack of education or awareness on emerging crops</p> <p>Lack of consistency in supply volume</p> <p>Small export market of mangoes (New Zealand) at present</p> <p>Consistent supply and volume</p> <p>Small window for emerging crops (e.g. rambutan, dragon fruit and pomelo) in the domestic market as it saturates quickly or carambola/star fruit are not so profitable</p> <p>High costs of production and transport of rambutan or carambola against small profit</p>	<p>Short supply window for export from the NT (e.g. Sept-Oct for mangoes)</p> <p>Price volatility especially for Asian vegetables</p> <p>Specific niche market of some produce, e.g. jack fruit in southern market</p>	<p>Economic profitability of small growers</p> <p>Marketing ripe jackfruit as the demand is rising</p> <p>Raising awareness among customers about the tropical fruits (e.g. culinary value of jackfruit)</p> <p>Understanding the market threshold of the emerging crops</p> <p>Consistent supply of emerging crops</p> <p>Developing export market (e.g. mango, pumpkin, rambutan, etc.)</p>

Themes	Strengths	Weaknesses	Threats	Opportunities
		margin		
Market supply chain	<p>Mango growers maintain relatively better supply chain process</p> <p>Mango growers manage their transport due to their well predicted volume and market for the produce</p>	<p>Inadequate and inefficient supply chain</p> <p>High transport costs, time-consuming long-distance transport, lengthy supply chain to deliver a product to the southern market</p> <p>Relatively cheaper transport cost from the NT to Melbourne and Sydney markets than to Brisbane or Perth markets</p> <p>Lack of consistency in temperature throughout the transportation process</p> <p>Mainly dependent on road for transport (trucks)</p> <p>High rate of perishability of Asian vegetables than fruits</p> <p>Not all Asian vegetable growers afford cold treatment after picking vegetables/fruits</p> <p>Processing facilities very limited</p> <p>Lack of understanding on compliance and regulation required for export supply chain</p> <p>Mix consignment (i.e. consolidated produce in the trucks) to supply the market</p> <p>Very few Asian vegetable growers can maintain cool chain after harvesting</p>	<p>Consistency in power (electricity) supply</p> <p>Low profitability of processed produce (i.e. fruit juice), processing is not worth for investment at a local scale processing facility</p> <p>Temperature failures and mis-handling during transport</p>	<p>Use of data loggers to monitor temperature during transport</p> <p>Competitive transport facilities</p> <p>Improving rail network (between the NT and southern capital cities)</p> <p>Streamlined protocols to sell in the southern markets (at the moment these protocols vary for the same produce among the various State/Territories)</p> <p>Improving logistics in the supply chain (e.g. understanding how freight works)</p> <p>Reliability in power supply</p> <p>Improvement of road infrastructure</p>

Themes	Strengths	Weaknesses	Threats	Opportunities
Land and water resources	<p>Land is generally adequate for farming</p> <p>Existing water allocation is just adequate for growers to meet their demand</p> <p>Availability of water for existing farms from ground aquifers</p>	<p>Not a lot of spare land for farm expansion in the Darwin and Katherine region</p> <p>Major expansion of the existing growers' farm area is unlikely</p> <p>Only expandable lands available for horticulture are under-developed/pastoral areas</p> <p>Freehold pastoral lands can be converted to horticulture, but involves complex processes to follow</p> <p>High cost involved for converting crown land to horticulture due to initial payment required for land survey and development</p> <p>No surface water capture procedures for irrigation currently exists in the NT</p>	<p>Policy and regulation on land tenure, it's hard to access new land</p> <p>Very limited freehold land</p> <p>Half of the land used for pastoral activities, and the remaining under native title in NT</p> <p>Climate dependent (i.e. rainfall) recharge of aquifers (largely ground-water dependent irrigation)</p>	<p>Availability of new land (i.e. pastoral)</p> <p>Availability of water for irrigation is highly required</p> <p>Other form of water access i.e. surface water capture, need to be explored</p> <p>Developing water use efficiency techniques</p>
Workforce (casual harvesting and skilled)	<p>Harvesting workforce is just enough for the current 2021 year</p> <p>NT Farmers Association has prepared a workforce development plan</p>	<p>Very hard to get skilled workforce and retaining them on the farms in the NT</p> <p>Geographic location (isolation from the rest of Australia)</p> <p>Gaps in the career pathways for young graduates to enter in the Ag profession; finding skilled workforce is tricky</p>		<p>More education/workforce pathways for locals</p> <p>Developing local Skilled workforce (Ag tech specialists are difficult to find or attract from south)</p> <p>Skilled workforce required for improving supply chain including logistics (how freight works)</p> <p>Increasing the agronomists tailored to the NT horticulture climate</p>
Collaboration	<p>Growers collaborate occasionally or when needed on common issues (i.e. workforce or biosecurity risks such as citrus canker, cucumber mosaic virus in watermelons)</p>	<p>Collaboration is very low</p> <p>Growers in competition with each other or isolated</p> <p>Low density of produce leads to high competition within growers</p> <p>Self-interest of growers</p>		<p>More collaboration required within the growers across the industries</p> <p>Collaboration for collective biosecurity response</p> <p>More collaboration between national peak industry (levy-based industry) and local growers</p>

Themes	Strengths	Weaknesses	Threats	Opportunities
	Ethnicity based collaboration, particularly among Asian vegetable growers (e.g. Vietnamese, Cambodians)			Farmers driven collaboration that meet their urgent need and decision making in time Consistent policy and willingness of government for assisting horticulture industries
Biosecurity	Highly effective biosecurity department, fully engaged with the industry across all levels Well established biosecurity model for the Asian vegetables	Commodity driven response		Improved biosecurity responses required across industries Biosecurity accreditation at the growers level to get credit
Research, development and extension		Not sufficient or suitable for addressing growers' needs More investment is happening in the agriculture sector, but not in horticulture		More research in collaboration with growers More research on understanding the impact of climatic change on flowering (i.e. pollination) is required Research and development for better market access More investment or support from the NT government required on research and development across the horticulture industries Research on tropical fruits of high profitability Research on value-added opportunity Research and development for helping growers understand the compliance, market access and other protocols for domestic and export market

Appendix 4. Workshop summary of the horticulture sector in northern WA.

Themes	Strengths	Weaknesses	Threats	Opportunities
Productivity and farming systems	<ul style="list-style-type: none"> ▪ The overall productivity is generally good ▪ Pumpkin production is medium to high in Kununurra, better than other crops (mangoes, melons, beans, etc.) ▪ Melon is a highly efficient crop, affords better returns than mangoes and pumpkins ▪ Producers are generally efficient ▪ Mainly family farmers/growers in the region, with total farming area of 22,000 ha, supporting 16 mango and other growers in the region 	<ul style="list-style-type: none"> ▪ Lack of commitment among the growers (high leaving rates) ▪ Most farmers left about 8-10 years ago ▪ Low level of mango production ▪ Only one dedicated mango grower in the region ▪ High cost of inputs, including their availability from other countries 	<ul style="list-style-type: none"> ▪ Small farms bought by corporations ▪ Early burning affects flowering and the availability of beneficial insects/pollinators required for pollination ▪ Climate change (including temperature and strong wind) impacting on mango production 	<ul style="list-style-type: none"> ▪ Regulating burning in the area ▪ Developing new mango varieties ▪ Developing climate resistant varieties, e.g. Calypso is better adapted than the KP ▪ Reducing input costs ▪ Developing and encouraging holistic farm management through rotation of horticulture and broadacre crops (e.g. pumpkin/sorghum, chickpea and beans)
Market economy	<ul style="list-style-type: none"> ▪ Highly profitable crop are melons, mangoes and pumpkins ▪ Melon is more profitable than pumpkins and mangoes ▪ Most of these crops are very highly demanded in the WA local market ▪ Broom has created demand of mangoes for tourism purposes 	<ul style="list-style-type: none"> ▪ Cost of inputs including labor and transport ▪ Low price of the produce ▪ High commission for the agents ▪ Complicated compliance processes ▪ Competition with growers from the NT (e.g. mangoes from the NT are produced around the same time as in the Ord Valley) 	<ul style="list-style-type: none"> ▪ Monopoly of retailers/supermarkets 	<ul style="list-style-type: none"> ▪ Expansion of horticulture crop area ▪ Developing economies of scale (more farms) ▪ Marketing mangoes through sea freight to Europe

Themes	Strengths	Weaknesses	Threats	Opportunities
Market supply chain	<ul style="list-style-type: none"> Supply chain is generally effective WA has special protocols, not all products are accepted from outside without a proper testing, which is a main advantage for the WA growers 	<ul style="list-style-type: none"> Low demand in the export market High transport costs Long distance to market does not allow to supply produce to other states/territories Perth is the only closest market for growers in Kununurra within a feasible distance Not enough transport or containers except trucks Lots of paperwork required as part of the compliance process for addressing protocols 	<ul style="list-style-type: none"> 	<ul style="list-style-type: none"> Better access and available transport for mango growers in particular Truck is relatively better choice (directly going to the retailer) than rail (lots of picking and dropping) Developing sea freight and air freight facilities in Darwin could be the best option Investing in processing fruit and value adding (requires significant investment in a regional area) Very low application of chemicals in mango industry
18.				
Land and water resources	<ul style="list-style-type: none"> Very high availability of water for irrigating farms in Kununurra Water is supplied through gravity feed 22,000 ha farm area relies on water sourced from Lake Argyle Water fee is manageable and low compared to other states Land is generally available for farming in consideration with existing tenure arrangement 	<ul style="list-style-type: none"> Climate change Difficulty in developing new land 	<ul style="list-style-type: none"> Future access to land affected by red tape Constraints in transitioning land use particularly from pastoral to horticulture 	<ul style="list-style-type: none"> Developing efficient irrigation systems through automation Land marked for development, but the land clearing and approval processes require streamlining Small growers should be considered equally important for developing land for agriculture, not to just wait for a big player to fasten the processes (as typically is the case) Government support to improve land tenure conditions may offer more land for agriculture, with access to water and diversification of land use
			19.	

Themes	Strengths	Weaknesses	Threats	Opportunities
Workforce (harvesting and skilled)	<ul style="list-style-type: none"> Workforce is generally available for harvesting 	<ul style="list-style-type: none"> Expensive local workforce in Australia than those work on holiday visa Difficult to manage workforce through competitive market e.g. mining industry wage relatively high Shortage of skilled workforce 	<ul style="list-style-type: none"> Border restriction 	<ul style="list-style-type: none"> Extending government support to “seasonal workers” programme for harvesting workforce Allowing the workers freedom of work to work on more than one farms Growers cannot afford over payment to workers (for over time), hence need more workforce More relaxed visa requirements Easing sponsorship procedures if one wants to stay on farm Farming apprenticeship High demand for skilled workforce e.g. IT specialist
Collaboration	<ul style="list-style-type: none"> Very high level of collaboration among the local growers Over the past 35 years, the growers maintained a close interaction with each other in Kununurra 	<ul style="list-style-type: none"> Geographical isolation Relatively farming is young in the region in terms of farm and production size 	20.	<ul style="list-style-type: none"> More collaboration required, especially with market agents Finding one agent for all farms in Kununurra will benefit the growers in sending their produce
Biosecurity	<ul style="list-style-type: none"> Biosecurity measures are effective 	<ul style="list-style-type: none"> Pest and disease Lack of support and funding from government Terrif. 		<ul style="list-style-type: none"> More funding and effective biosecurity measures Better ways to control movements from south to north to protect the north’s horticulture industry
Research, development and extension		<ul style="list-style-type: none"> Not much research and extension support available to growers 		<ul style="list-style-type: none"> More funding from government for industry led research project in Kununurra



Themes	Strengths	Weaknesses	Threats	Opportunities
		<ul style="list-style-type: none">▪ Government support is reactive not proactive▪ Not adequate research and extension support on pest and disease control▪ No priority basis research projects in Kununurra▪ Inadequate technological facilities and internet service.		<ul style="list-style-type: none">▪ Capacity building of the growers is highly required▪ Automation to enhance water efficiency and to forecast weather▪ Building local Ag Tech capacity (IT)