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Abbreviations

ACIAR	Australian Centre for International Agricultural Research
ASLP	Australia–Pakistan Agriculture Sector Linkages Program
AUD	Australian dollar
CAGR	compound annual growth rate
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization Statistical Database
FJD	Fijian dollar
Gy	gray unit (minimum absorbed dose)
HWT	hot water treatment
PHP	Philippine peso
R&D	research and development
SPS	sanitary and phytosanitary measures
UAE	United Arab Emirates
UK	United Kingdom
USA	United States of America
USD	United States dollar
USAID	United States Agency for International Development
VHT	vapour heat treatment
VND	Vietnamese dong

Preface

This report titled *Analysis of mango markets, trade and strategic research issues in the Asia–Pacific* was prepared by Griffith University as commissioned by the Australian Centre for International Agricultural Research (ACIAR). The information and recommendations from this study inform ACIAR in the design of the longer-term research and development program for mango production and trade in the Asia–Pacific region. The report involved the analysis of secondary data, field trips and key informant interviews with stakeholders in mango production, trade and marketing in the region.

The author of the study is Robin Roberts, with revision support provided by Wayne Prowse and Richard Markham. Project inputs were received from Ian Baker, Richard Beyer, Rob Duthie, Peter Johnson, Hugh Macintosh, John Oakshott and Tiago Wandschneider. Thanks also to the regional research partners for preparing the country studies that support this report, including Dr Nguyen Van Hoa in Vietnam, Sohail Ayyaz and Raheel Abbas in Pakistan, Salesh Kumar and Hemalatha Palanivel in Fiji, Ernie Brown in the Philippines, Gokul Patinak in India, Men Pagnchak-Roat and Lim Sophornthida in Cambodia, and Teddy Kristedi in Indonesia.

The research team would like to thank the farmers, collectors, processors and supply chain stakeholders involved in mango production and trade across the Asia–Pacific region, who gave their time and input freely during the compilation of this report.

The views expressed in this report are those of the research team and do not necessarily reflect the views of Griffith University, ACIAR or the Commonwealth Governments of Australia, Cambodia, Fiji, India, Indonesia, Pakistan, the Philippines or Vietnam.

Robin E Roberts

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30 September 2019

Executive summary

This report presents a portrait of the previously undocumented regional mango production, trade and position in the Asia–Pacific region. The study's overarching aim was to significantly increase the income of smallholder mango farmers in the region by identifying and better understanding strategic industry and market development issues, research gaps and opportunities. The report provides an overview of mango production, trade, markets and market dynamics, biosecurity and food processing challenges in ACIAR partner countries. Recommendations to inform future research and development are also given.

Partner country mango production, current research and future opportunities

Pakistan is one of the top five global mango producers, recording 1.69 million tonnes in 2017, mostly from the Punjab and Sindh provinces, with just 2% exported. ACIAR has researched mango production and post-harvest treatment, including improving model nursery infrastructure, best-practice supply chains and market development. More research is needed to understand and solve mango sudden death syndrome.

The Phillipines produced just 748,000 tonnes of mango in 2017 due to typhoons and pest pressures; less than 5% is exported. Most farms are less than a hectare, with just 6% of farms greater than 5 ha. Research programs have included pruning and bagging technologies; improved pre-harvest disease management; and post-harvest technologies, such as hot water treatment, which has been well adopted. Future priorities should include more integrated pest management, extension projects, and a feasibility analysis for post-harvest infrastructure.

Cambodia has mango as its second-largest fruit crop, with around 68,000 tonnes produced in 2017. Exports of some 24,000 tonnes were sent mainly to Thailand and Vietnam at low prices controlled by the importers. Farmers tend to leave the harvesting and marketing to collectors and subsequent actors in the market chain. Research has focused on improving production systems, and farmers would like more programs to help them understand the supply chain and to take more control of marketing, including exports.

Vietnam's mango production was 744,000 tonnes in 2017, mostly grown by smallholder farmers on farms of between 0.5 and 0.6 ha. Exports account for 6% of production. Mango market channels range from farmers straight to consumers, through to a range of alliances of collectors, wholesalers, exporters, retailers and processors. Thousands of mango industry stakeholders have been trained in farm management, cultivating, harvesting and post-harvest technologies. Research is needed to reduce losses, extend shelf life, and increase the scale of production, supply chain efficiency and farm-gate returns.

Indonesia produced 2.57 million tonnes of mango (including mangosteen and guava) in 2017. It is typically a smallholder's crop, often with fewer than seven trees. Almost all mangoes are consumed domestically via traditional channels to wet markets. Though modern retailers can achieve higher returns, they dictate to their suppliers with written contracts, involving complex risks for growers. Pests and diseases are pressing problems. Research has included management of fruit quality and pest infestation to meet technical market-access requirements and improve Indonesia's international competitiveness. Ongoing needs include fine-tuning technologies and farm-management practices to help small farmers adopt new technologies to improve post-harvest out-turns.

Fiji has some 17,000 smallholder mango farms, which produced 275 tonnes in 2017. Exports are almost all to New Zealand and range between 20 to 45 tonnes per year, while the domestic market is dominated by informal roadside stalls and traditional market

channels. In the traditional channels, wholesalers pick the fruit for greater control over quality. Current market research is focused on exports, and there remains a need to help farmers boost productivity, understand tree qualities, and form farming cooperatives to add value by improving supply chain practices.

Australia produced around 50,000 tonnes of mangoes in 2017, with exports of about 8,500 tonnes. The industry contributes to research via a levy system managed by Horticulture Innovation Australia with matched funds from the Australian Government. Research programs cover pest, disease, crop and post-harvest management. Growers would like more investment in new technologies to deal with pest pressures, and in government programs to educate growers in best practices.

Key recommendations

Policy, environment and value chain reform: Existing supply chain management across the region discourages the adoption of production and post-harvest innovations. Poor policy or weaknesses in regulation and enforcement of pesticide use can contribute to inappropriate use. Previous ACIAR-funded policy research has provided the basis for evidence-based advocacy and change.

Varietal development: A better match is needed between mango varieties available to farmers and evolving market demands. Urban and export markets demand fruit traits of colour, size, taste and texture that traditional varieties often do not satisfy.

Production, post-harvest and extension improvement programs: Better orchard management is needed, particularly for smallholders. This includes canopy management; better diagnosis of pest and disease, and reduced dependence on pesticides; irrigation and fertiliser management; and adoption of integrated orchard management options.

Research is needed on flower induction and seasonality to reduce dependence on incautious application of paclobutrazol, instead using selective flower induction to meet market opportunities. Australia's expertise in small-tree approaches to mango growing should be shared, especially in countries subject to cyclone damage, such as the Philippines.

Adaptive research related to production and post-harvest problems using technical solutions is needed. Technologies that function well for local varieties, climate and soils need to be verified. We also need to understand how local smallholder circumstances (economic, social, risk perceptions) affect the adoption of suitable options and engagement with extension support programs in partner countries.

The role of digital technology to share information and improve the adoption of production and post-harvest technologies needs further study. This might include the use of smart phones and digital networking to help producers correctly diagnose pests and disease, assess fruit quality or select cost-effective farming practices.

Trade: Research into international demand patterns and the relationship with mango quality and seasonality of supply is needed in partner countries to inform effective planning and decision-making. Unregulated cross-border trade needs to be identified and quantified to assess the extent of informal mango flows and improve traceability.

Mango processing: The accessibility and uptake of mango-processing technologies in partner countries needs examining, including a clear understanding of the value proposition, varieties and seasonality. Analysing country-specific issues linked to developing a viable sector will help increase saleable production.

Market access: A study that engages with partner countries to document international mango trade standards is needed, with the results made accessible through a central hub to all chain stakeholders. It should focus on advocating best-practice and cost-effective pest and disease management, especially for fruit fly, to facilitate successful export.

1 Introduction

1.1 Study aims and objectives

The aim of this study was to better understand and identify strategic industry and market development issues, research gaps and opportunities for mango production in the Asia–Pacific region. The primary aim is to improve the profitability and livelihoods of regional smallholder tropical fruit farmers through better access to and competitiveness in regional and local markets. The specific project objectives were to:

1. Improve the understanding of regional and country-level mango production, market situation, trends and spatial trade flows.
2. Identify country-level areas of comparative and competitive advantage, and opportunities for mango production, industry and market development.
3. Identify strategic research priorities constraining mango production, industry development, trade and market access, and in turn, highlight those with the most potential for widespread livelihood improvement.
4. Contribute to improved understanding about implications and opportunities for Australian mango production, industry and export market development, including opportunities for overseas direct investment, technical assistance and service provision.

The study provides input into the longer-term perspective to inform ACIAR-funded mango research programs. During the study, we engaged with Australian and partner country researchers, and public and private sector institutions and organisations working on ACIAR-supported projects. We also aimed to improve our understanding of Australian mango production through the involvement of state government agricultural departments (NT, WA, NSW and Qld) and the Australian Mango Industry Association.

1.2 Project background

Mango is the third-most widely grown fruit in the tropics and subtropics, after watermelon and banana. Global mango production has increased by approximately 50% during the past decade. Mango market supply and trade patterns are dynamic around the globe and, in particular, within the Asia–Pacific region. Both domestic demand and export markets are growing steadily and becoming more diversified and sophisticated. Most mangoes in the Asia–Pacific region are grown by smallholder farmers and marketed domestically. Increasing consumer demand for quality, safety, variety, seasonal availability and consistency are creating barriers for these farmers, but also opportunities. Therefore, increasing production, quality, market access and returns for mangoes will directly improve the incomes and livelihoods of many thousands of smallholder farmers in the region.

1.3 Study methodology

The research design and focus were informed by stakeholder consultation, planning workshops and nominated in-country researchers. Relevant government, research, extension, industry, private sector and farmer representatives were involved. A project initiation, consultation and planning meeting was held in Brisbane in August 2015, led by Dr Rodd Dyer. Key mango research stakeholders, including Griffith University, Department of Agriculture and Fisheries, Northern Territory Department of Primary Industries, Queensland Government, the Department of Agriculture and Food Western

Australia and specialist research consultants participated across various workshop-planning activities.

Research study limitations

Information relating to several topic areas was incomplete or unavailable, including:

- national production and planted area data by variety
- market price and volumes traded over time
- accurate export statistics.

This study presents the findings of in-country, rapid-chain appraisal research. For this reason, timeframe, sample size and supply chain management practices observed were necessarily limited. Throughout this study, the word *production* was found to have different meanings depending on the context. It may refer to fruit observed on a tree, fruit harvested and passed through the farm gate, fruit for which income has been derived, and fruit that has been processed.

Trade analysis – International Trade Centre data

Towards the end of the project, we determined that a further analysis of trade and production data be undertaken using a more recent dataset sourced through the International Trade Centre (ITC), and formatted in a consistent manner across all countries. Production data obtained via the Food and Agriculture Organization Statistical Database (FAOSTAT) was updated to 2017 figures to provide a macro snapshot of the most recent production and trade position.

2 Mango production

2.1 Global mango production profile

Mangoes are cultivated in more than 100 countries, most of which are in frost-free, tropical and warmer subtropical climates. The production analysis presented here is based on FAOSTAT records and includes mangoes, mangosteens and guava. While mangoes dominate the sector, mangosteens and guava have a significant share within Thailand (mangosteen 6%, guava 8%) and Indonesia (mangosteen 6%, guava 11%). India is the largest producer of mangoes, accounting for almost 40% of production, followed by China, Thailand, Mexico, Indonesia, Pakistan, Brazil, Bangladesh and Egypt (Figure 2.1).

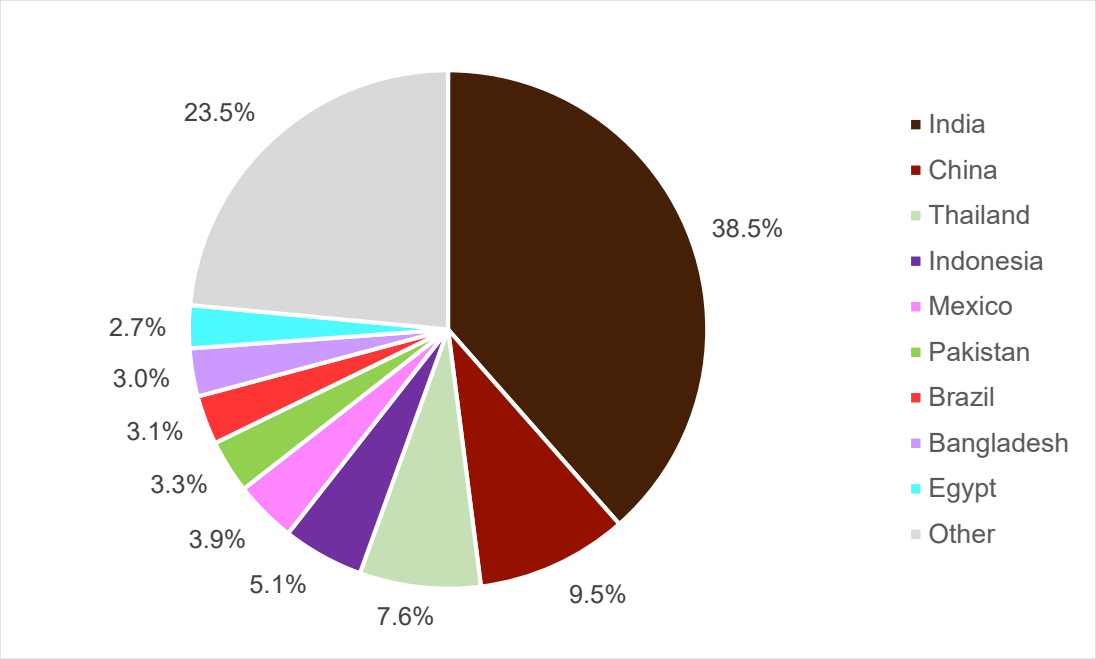

Figure 2.1 Global mango production share, 2017
Source: FAOSTAT, 2019

In 2017, global mango production exceeded 50 million tonnes, having doubled since 2001 (Figure 2.2). Asia accounts for more than 70% of the world's mango production, followed by Africa, the Americas and Oceania (Table 2.1). Global mango production over the past five years has increased moderately by 2.6% per year (compound annual growth rate, CAGR) with the strongest growth shown by Brazil and Bangladesh (Table 2.2). Growth in 2017 was above the longer-term trend, although Thailand and Indonesia recorded higher growth rates. Note that this data may be skewed by a higher share (6–8%) of mangosteens, supported by a rising demand from China.

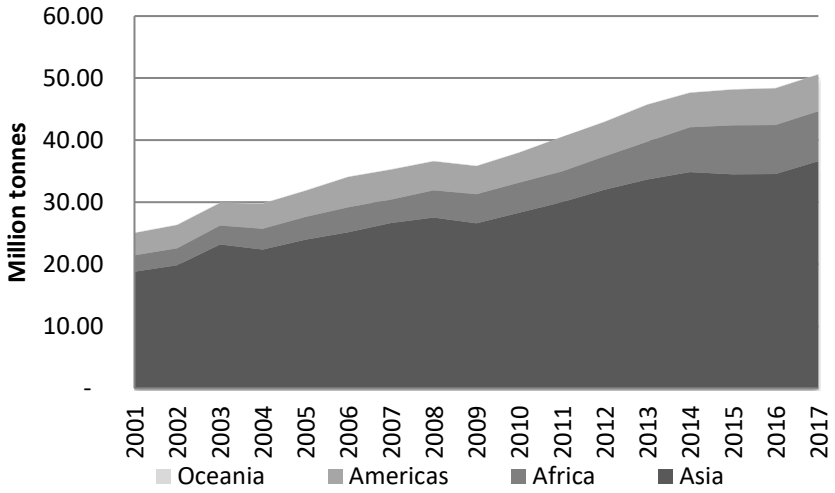

Figure 2.2 Global mango production growth, 2001–2017
Source: FAOSTAT, 2019

Table 2.1 Global mango production growth, 2013–2017

Region	2017 (million tonnes)	Volume share 2017 (%)	1-yr growth (% since 2016)	5-yr CAGR (% since 2013)
Asia	36.62	72.3	6.0	2.1
Africa	8.05	15.9	2.1	7.3
Americas	5.93	11.7	–0.6	–0.1
Oceania	0.05	0.1	2.9	2.4
Total	**50.65**	**100**	**4.6**	**2.6**

CAGR = compound annual growth rate
Source: FAOSTAT, 2019

Table 2.2 Mango production growth in top mango-producing countries, 2013–2017

Country	2017 (million tonnes)	Volume share 2017 (%)	1-yr growth (% since 2016)	5-yr CAGR (% since 2013)
India	19.51	38.5	4.6	2.0
China	4.79	9.5	1.9	2.0
Thailand	3.82	7.6	15.4	2.8
Indonesia	2.57	5.1	17.5	0.5
Mexico	1.96	3.9	–10.9	0.7
Pakistan	1.69	3.3	9.2	0.6
Brazil	1.55	3.1	10.3	12.2
Bangladesh	1.52	3.0	3.5	17.4
Egypt	1.35	2.7	2.1	–4.4
All other	11.90	23.5	–	–
Total	**50.65**	**100**	**4.6**	**2.6**

CAGR = compound annual growth rate
Source: FAOSTAT, 2019

2.2 ACIAR partner countries production profile

Within the ACIAR partner countries, Indonesia and Pakistan are included in the top 10 global producers. Overall, ACIAR partner countries produced 5.9 million tonnes of mangoes* in 2017, accounting for 11.6% of global production (Figure 2.3).

Almost all of these countries are within the Asian region, except for Australia and Fiji. The Asian countries in this study represented 16% of Asian production and 88% of the very small Oceania region, being mostly Australia.

Production in these countries has increased 81% since 2001 from 3.2 million to 5.9 million tonnes, which is below the growth rate of the total global production growth. Most of this growth was in from 2001–2012, reaching 6.1 million tonnes; the latest 2017 figure is 5.9 million tonnes.

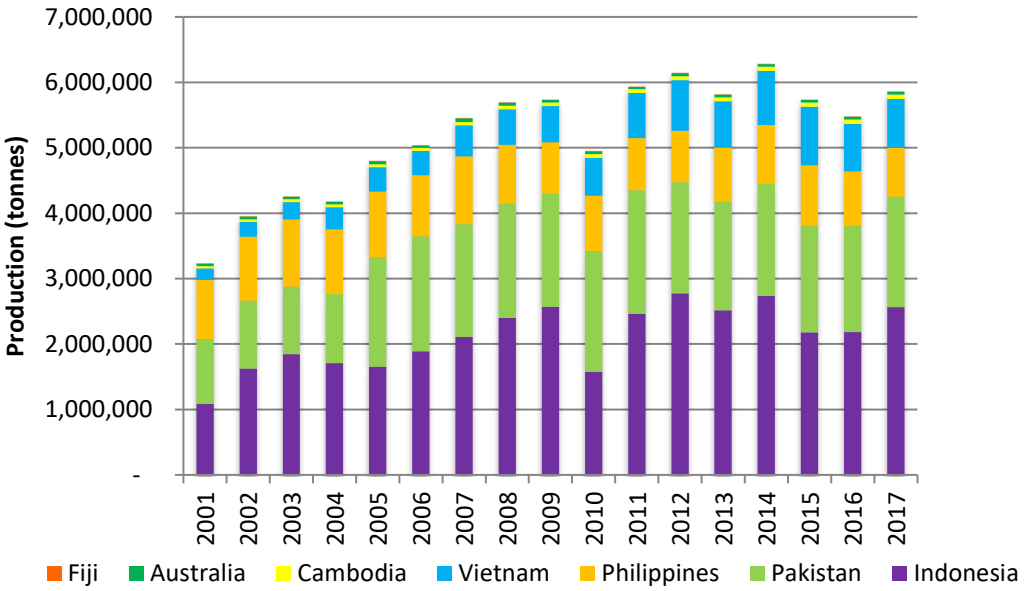

Figure 2.3 ACIAR partner country mango production, 2001–2017
Source: FAOSTAT, 2019

Mango growth rates in partner countries have been marginal (0.2%) over the last five years. In 2017 a 7% increase year on year, driven by Indonesia was revealed. Note that Indonesia's results are skewed by higher-growth mangosteen production (Table 2.3).

Indonesia and Pakistan have the largest mango production in the region, followed by the Philippines and Vietnam, which account for a significant proportion. Australia and Fiji are much smaller volume producers (Figure 2.4). At this time, Asian mango producers are largely confined to trade with neighbouring Asian markets, and mostly domestic, where there are large populations well acquainted with mangoes, for example, India, Indonesia and Pakistan.

Table 2.3 ACIAR partner country mango production growth, 2013–2017

Country	2017 (tonnes)	Volume share 2017 (%)	1-yr growth (% since 2016)	5-yr CAGR (% since 2013)
Indonesia	2,566,046	43.8	17.5	0.5
Pakistan	1,685,304	28.8	3.5	0.4
Philippines	748,957	12.8	–9.4	–2.6
Vietnam	744,425	12.7	2.6	1.3
Cambodia	68,671	1.2	2.6	2.7
Australia	43,748	0.7	2.9	1.8
Fiji	275	0.0	71.9	17.0
Total	**5,857,426**	**100**	**7.0**	**0.2**

CAGR = compound annual growth rate
Source: FAOSTAT, 2019

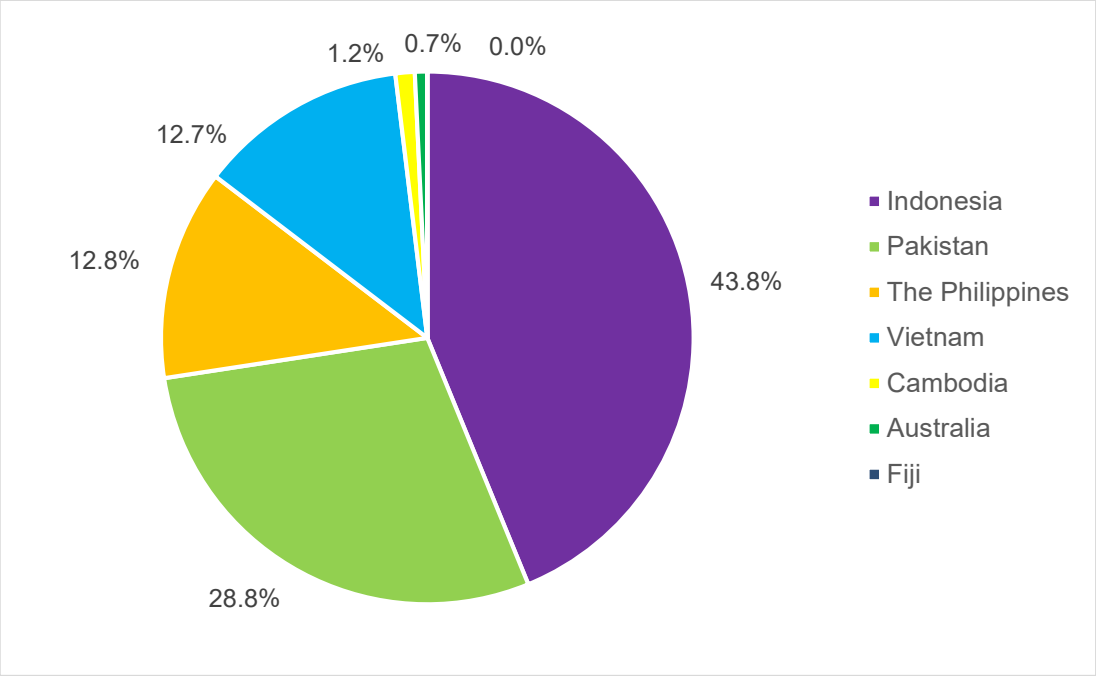

Figure 2.4 ACIAR partner country mango production share, 2017
Source: FAOSTAT, 2019

3 Mango trade

3.1 Global trade profile

Over the last five years, the global mango trade has grown by around 2.4% per annum, with approximately 1.5 million tonnes of mangoes traded globally in 2017 valued at USD2.2 billion (excluding re-exports from Netherlands). However, the total amount of mangoes traded internationally makes up less than 3% of global mango production.

Most fresh mangoes are consumed in the country of production. In terms of mango trade volume, between 2013 and 2017 global exports grew by an average of 2.4% per annum (CAGR). In 2017, almost 60% of total global mango trade was conducted by four Latin American countries, with Mexico showing the highest export value of USD455 million (Table 3.1).

3.1.1 Export growth

The leading exporters, Mexico and Brazil, have substantial growth driven by the demand for mangoes in Europe and the US, which lie outside the tropical production zones. Pakistan notably is showing significant decline, although this appears to be relevant to 2017 only, being 57% lower than the previous year. Early results for 2018 show a return to 70,000 tonnes.

Table 3.1 Mango exports by volume and value, 2017

Exporter	Value (million USD)	Volume (t)	Volume share 2017 (%)	1-yr growth (% since 2016)	5-yr CAGR (% since 2013)	USD/kg
Mexico	454.9	435,815	29.9	18.0	6.5	1.04
Brazil	205.5	179,744	12.3	16.4	10.1	1.14
Peru	191.7	162,653	11.1	0.9	6.3	1.18
Ecuador	44.9	59,006	4.0	–6.6	–1.0	0.76
India	63.6	48,850	3.3	15.5	4.3	1.30
Spain	85.3	41,343	2.8	22.5	21.0	2.06
Ivory Coast	21.9	41,139	2.8	10.1	36.1	0.53
Pakistan	45.5	34,718	2.4	–57.1	–22.7	1.31
China	64.8	33,153	2.3	24.2	75.2	1.95
Thailand	38.9	30,784	2.1	–7.7	–1.7	1.26
All other	1,017.4	392,799	26.9	–	–	2.59
Total	**2,234.2**	**1,460,004**	**100**	**–3.3**	**2.4**	**1.53**

CAGR = compound annual growth rate

Note: Where possible, data is shown for fresh mangoes only

Source: ITC Trade Map, 2019

3.1.2 Export share

Less than 3% of all mangoes produced are recorded for export trade. The largest exporters, Mexico, Brazil, Peru and Ecuador, all export more than 10% of their production (up to 84% for Ecuador), mostly to the US and Europe (Table 3.2). Spain is offset by importing 53,000 tonnes of mangoes mostly from Brazil and Peru, thus re-exporting in addition to supplying locally grown mangoes from the Malaga area. Spain therefore shows exports as a higher volume than production. Although India is the world's largest producer, and fifth-largest exporter, the share of exports relative to production is negligible. China is also a very small exporter relative to production.

Table 3.2 Mango exports production share, 2017

Exporter	Production (t)	Exports (t)	Export share (% of total)	Export share (% of production)
Mexico	1,958,491	435,815	29.9	22.3
Brazil	1,547,606	179,744	12.3	11.6
Peru	385,304	162,653	11.1	42.2
Ecuador	70,160	59,006	4.0	84.1
India	19,506,000	48,850	3.3	0.3
Spain	20,700	41,343	2.8	199.7
Ivory Coast	100,000	41,139	2.8	41.1
Pakistan	1,685,304	34,718	2.4	2.1
China	4,791,271	33,153	2.3	0.7
Thailand	3,824,279	30,784	2.1	0.8
All other	–	392,799	26.9	–
Total	**50,649,143**	**1,460,004**	**100.0**	**2.9**

Sources:FAOSTAT, 2019; ITC Trade Map, 2019

3.1.3 Import growth

Global mango imports increased from 600,000 tonnes in 2001 to around 1.58 million tonnes in 2017. The US was the number one importer (508,000 tonnes), with Europe collectively importing 320,000 tonnes after allowing for internal re-exports. Europe and the US accounted for 52% of the global imports. From 2013–2017, global imports volume grew by an average of 6.5% per annum. Although in theory, global exports should align with global imports, unaccounted re-export trade and other discrepancies affect the results. The average measured import prices (CIF) were USD1.58/kg across all markets, although there were some significant and possibly unexplained variations (Table 3.3). Generally, European prices were higher (more than USD2.00/kg), reflecting the increased logistics to supply the market. The US (supplied mostly from Mexico) recorded USD1.29/kg as the average import price.

Table 3.3 Mango imports by volume and value, 2017

Importer	Value (million USD)	Volume (t)	Volume share 2017 (%)	1-yr change (% since 2016)	5-yr CAGR (% since 2013)	USD/kg
US	656.0	508,724	32.1	9.5	9.6	1.29
United Arab Emirates	98.4	87,504	5.5	–15.4	–5.6	1.12
Germany	202.5	87,206	5.5	18.4	9.8	2.32
United Kingdom	170.9	84,903	5.4	2.4	12.4	2.01
Saudi Arabia	59.8	69,572	4.4	28.6	3.0	0.86
Canada	105.6	65,571	4.1	14.8	4.1	1.61
France	132.9	62,101	3.9	6.9	11.0	2.14
Malaysia	19.9	61,389	3.9	20.0	6.8	0.32
Spain	82.8	43,428	2.7	13.9	14.2	1.91
Hong Kong	58.1	35,461	2.2	9.2	–16.1	1.64
All other	921.1	478,389	30.2	–	–	1.93
Total	**2,508.0**	**1,584,248**	**100**	**8.8**	**6.5**	**1.58**

CAGR = compound annual growth rate

Source: ITC Trade Map, 2019

The main importers are almost fully reliant on imported mangoes for their market consumption (Table 3.4). Since Europe and the US do not produce mangoes (except for a small volume in Spain), all mango must be imported from tropical countries: mostly Latin America, and increasingly from western Africa for Europe. Europe and the US are highly sophisticated markets with stringent quality standards that suppliers must meet. Malaysia and Hong Kong are the only countries in the Asian region to make the top 10, with Hong Kong imports influenced by re-export trade to China. The US is the largest importer of mangoes and sources more than 98% from Latin America, mostly Mexico and Peru (Figure 3.1).

Table 3.4 Mango imports, by reliance, 2017

Importer	Production (t)	Imports (t)	Import reliance (%)
United States	1,006	508,724	99.8
United Arab Emirates	10,588	87,504	89.2
Germany	–	87,206	100.0
United Kingdom	–	84,903	100.0
Saudi Arabia	–	69,572	100.0
Canada	–	65,571	100.0
France	–	62,101	100.0
Malaysia	113,824	61,389	35.0
Spain	20,700	43,428	67.7
Hong Kong	–	35,461	100.0
All other	50,503,025	478,389	0.9
Total	**50,649,143**	**1,584,248**	**3.0**

Sources:FAOSTAT, 2019; ITC Trade Map, 2019

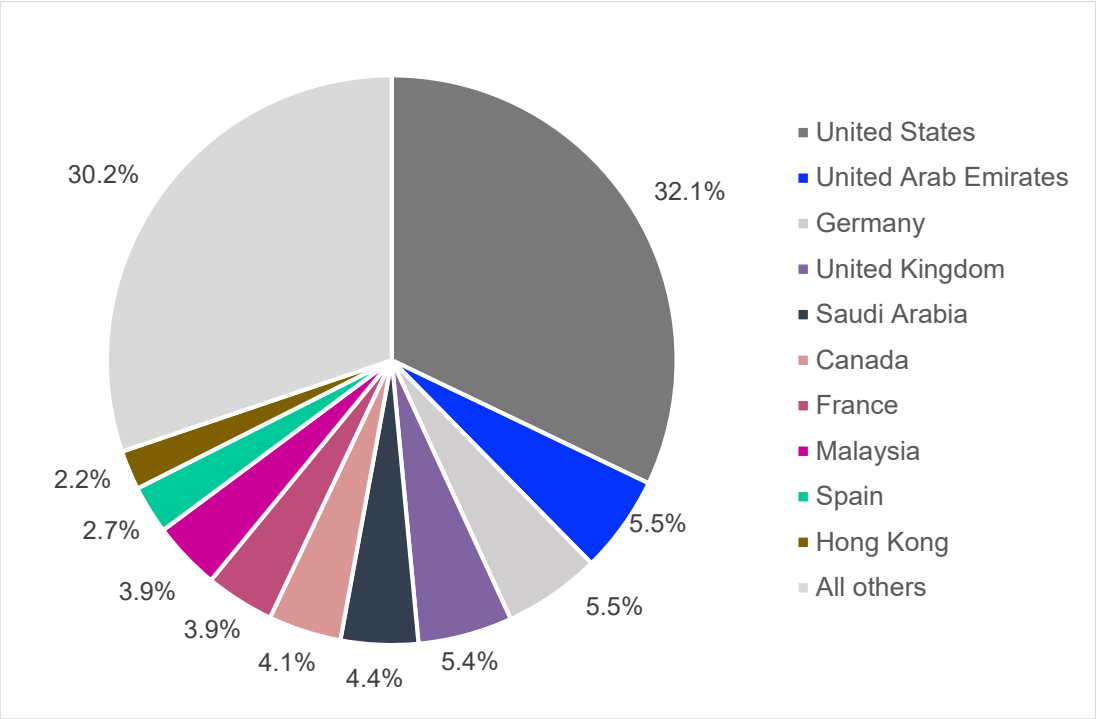

Figure 3.1 Mango imports by share, 2017
Source: ITC Trade Map, 2019

3.1.4 Import share

To understand the major trade flows, we evaluated 2018 data to examine the source of mango trade and share of supply to each of the top six major global importers (Tables 3.5 to 3.10; ACIAR partner countries indicated in italics). Asian suppliers are under-represented in market share of supply regardless of producing more than 70% of the world's mangoes. North America (the US and Canada) imported 36% of all mangoes supplied in 2017 and sourced almost all of them from Mexico, Brazil, Peru and Ecuador. Market-access protocols are required for fresh fruit from these countries.

Europe collectively imported 20% of all mangoes supplied, mostly from Brazil and Peru, and increasingly from west Africa. United Kingdom (UK) and Germany are the largest importers in Europe and have no formal market-access protocols, other than phytosanitary certificates. To sell into major retail chains, the products must meet appropriate quality assurance credentials. Middle East markets, notably United Arab Emirates and Saudi Arabia, import 12% of all mangoes globally and are the only markets in the top six that import significant volumes from ACIAR partner countries (Pakistan and Vietnam). These markets are less restrictive for access and quality assurance than European markets.

The highest-ranking import shares for Asian countries were Malaysia and Hong Kong, with 4% and 2% share of global trade, respectively. Almost all Malaysian imports were from Thailand, while Hong Kong imported mostly from the Philippines. Thailand was also a key supplier to China, Japan and South Korea, all of which imported less than 20,000 tonnes each. These markets have complex market-access requirements.

Table 3.5 United States mango import share, 2017

Exporter	Tonnes	Share (%)
Mexico	332,525	65.4
Peru	51,546	10.1
Ecuador	49,584	9.7
Brazil	32,934	6.5
Guatemala	16,818	3.3
Haiti	9,347	1.8
Nicaragua	4,496	0.9
Thailand	3,827	0.8
The Philippines	*2,932*	*0.6*
Other	4,715	0.9
Total	**508,724**	**100**

Source: ITC Trade Map, 2019

Table 3.6 United Kingdom mango import share, 2017

	Tonnes	Share (%)
Brazil	15,154	17.8
Peru	13,456	15.8
US	6,732	7.9
Germany	5,985	7.0
France	5,109	6.0
Netherlands	4,988	5.9
Pakistan	*4,680*	*5.5*
India	4,600	5.4
Dominican Republic	4,541	5.3
Other	19,658	23.2
Total	**84,903**	**100**

Source: ITC Trade Map, 2019

Table 3.7 United Arab Emirates mango import share, 2017

	Tonnes	Share (%)
India	34,816	39.8
Pakistan	*25,482*	*29.1*
Egypt	7,762	8.9
Kenya	6,870	7.9
Vietnam	*3,414*	*3.9*
South Africa	1,839	2.1
Yemen	1,838	2.1
Thailand	1,742	2.0
Sri Lanka	1,158	1.3
Other	2,583	3.0
Total	**87,504**	**100**

Source: ITC Trade Map, 2019

Table 3.8 Saudi Arabia mango import share, 2017

	Tonnes	Share (%)
Egypt	26,900	38.7
Yemen	22,686	32.6
Pakistan	*6,926*	*10.0*
India	6,904	9.9
Kenya	3,553	5.1
South Africa	1,144	1.6
Australia	*264*	*0.4*
Thailand	131	0.2
Other	1,064	1.5
Total	**69,572**	**100**

Source: ITC Trade Map, 2019

Table 3.9 Germany mango import share, 2017

	Tonnes	Share (%)
Brazil	32,965	37.8
Peru	24,579	28.2
Spain	5,415	6.2
Ivory Coast	4,821	5.5
US	3,597	4.1
Israel	3,487	4.0
Dominican Republic	2,100	2.4
Senegal	2,049	2.3
Other	8,193	9.4
Total	**87,206**	**100**

Source: ITC Trade Map, 2019

Table 3.10 Canada mango import share, 2017

	Tonnes	Share (%)
Mexico	41,242	62.9
Brazil	7,122	10.9
Peru	6,733	10.3
Ecuador	2,236	3.4
Taiwan	1,407	2.1
The Philippines	*1,402*	*2.1*
Thailand	1,199	1.8
Dominican Republic	627	1.0
India	474	0.7
Other	3,129	4.8
Total	**65,571**	**100**

Source: ITC Trade Map, 2019

3.2 ACIAR partner countries trade profile

ACIAR partner country exports

The mango production, exports and export shares of the seven ACIAR partner countries exporting mangoes are listed in Table 3.11. Currently, these countries constitute only a combined 6.7% of total global export volume. In 2017, Pakistan, the Philippines and Cambodia recorded the highest export volumes, while Cambodia and Australia recorded a higher share of export production. Some data for ACIAR partner countries is not as reliable as for other major markets, due to informal trade across land borders. Most ACIAR partner countries, with exception of Cambodia and Australia, have low levels of exports relative to production, suggesting that those countries have export development opportunities. Indonesia's production data is skewed by mangosteens; however, export records are captured for fresh mangoes.

Table 3.11 ACIAR partner country export share of mango production, 2017

Exporter	Production (t)	Exports (t)	Export share (% total)	Export share (% production)
Pakistan	1,685,304	34,718	35.4	2.1
Philippines	748,957	24,639	25.1	3.3
Cambodia	68,671	24,014	24.5	35.0
Australia	43,748	8,554	8.7	19.6
Vietnam	744,425	5,665	5.8	0.8
Indonesia	2,566,046	473	0.5	0.0
Fiji	275	26	0.0	9.5
Subtotal	5,857,426	98,089	100.0	1.7
Global total	50,649,143	1,460,004	–	–
Total share	*11.6%*	*6.7%*	–	–

Source: FAOSTAT,2019; ITC Trade Map, 2019

All partner countries recorded strong export growth over the 15 years since 2001. Mango export value for the Philippines has declined since 2011, while Vietnam exports have grown significantly. The export share of production is negligible in Indonesia and Fiji.

The more recent five-year export trends for the ACIAR partner countries are mixed. The overall trend is 7.2% lower per year over five years; however, several factors contribute to this (Table 3.12). Pakistan, the largest exporter (Figure 3.2) has skewed the 2017 result with a decline of 57% in 2017, recovering to 70,000 tonnes in 2018. Most other countries have recorded strong growth in both five-year and one-year measures, except for Indonesia and Fiji. Due to incomplete data from Cambodia and Vietnam, where in both instances Thailand is the main importer, the results have involved analysis of import customer data (mirror data).

Table 3.12 ACIAR partner country mango export growth trends, 2017

Exporter	Value (million USD)	Volume (t)	Volume share 2017 (%)	1-yr change (% since 2016)	5-yr CAGR (% since 2013)	USD/kg
Pakistan	45.5	34,718	35.4	–57.1	–22.7	1.31
Philippines	82.6	24,639	25.1	19.5	–1.1	3.35
Cambodia	10.9	24,014	24.5	77.7	104.8	0.45
Australia	24.7	8,554	8.7	10.7	14.2	2.88
Vietnam	7.8	5,665	5.8	59.3	61.2	1.37
Indonesia	0.6	473	0.5	–61.9	–25.2	1.35
Fiji	0.1	26	0.0	–13.3	–14.7	2.58
Total	**172.1**	**98,089**	**100**	**–23.1**	**–7.2**	**1.75**

Source: ITC Trade Map, 2019

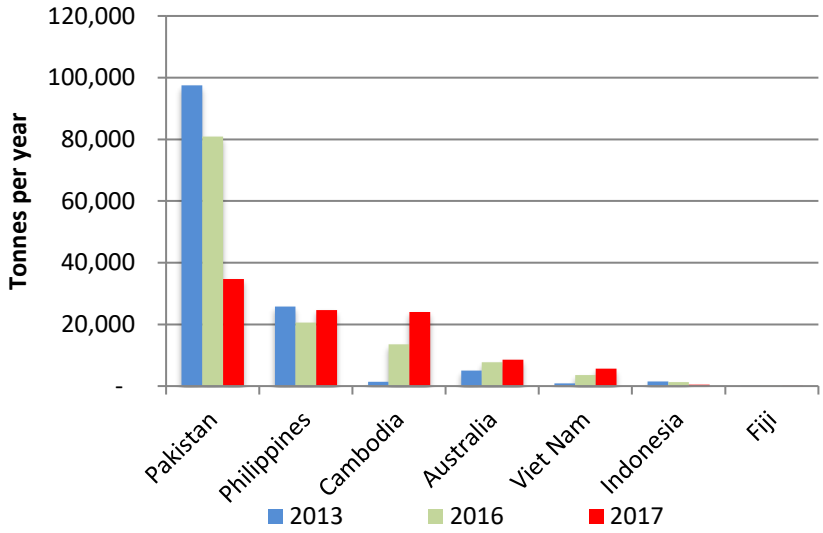

Figure 3.2 ACIAR partner country mango exports by volume, 2013, 2016–2017
Source: ITC Trade Map, 2019

3.3 Discussion

The world's major importers are found in the lucrative and sophisticated North American and European markets, which do not have any local production. They have stringent market-access requirements, either with government-implemented protocols or high-quality assurance schemes, such as GlobalGAP, which suppliers need to meet to become accredited. Investment by large, multinational companies has helped develop the required supply chain infrastructures in Latin American countries to supply supermarkets in North America and Europe.

In 2017, the US finally approved Vietnamese mangoes for import, with records reflecting a shipment of 3 tonnes in November 2018 (ITC, 2019).The Philippines and Australia are the only other ACIAR countries with protocols for trade to the US, although the trade is very small in context of both the US import trade and the share of exports. Pakistan is the only ACIAR partner country with some trade to Europe (UK), although small, and is understood to be niche to meet demand from Pakistani expat communities.

4 Market dynamics in ACIAR partner countries

4.1 Pakistan

Pakistan exports mangoes to more than 40 countries. The top five destinations are all in Middle East, with the exception of the UK, and account for 71% of all exports. The trade has been volatile, exceeding 80,000 tonnes and then falling below 40,000 tonnes (Table 4.1, Figure 4.1). Export volume fell in 2017 due to adverse weather conditions in the growing areas and have recovered to 70,000 tonnes in 2018 (data not shown). The recorded average price points for Pakistani mangoes ranged from USD0.53–1.31/kg.

Table 4.1 Pakistan mango exports, 2013–2017

	2013	2014	2015	2016	2017	Trend 2016–17 (%)	Trend 2013–17 (%)	Share (%)
Total								
Volume (t)	97,472	75,202	42,285	80,910	34,718	–57.1	–22.7	100
Value (million USD)	56.2	40.0	40.0	64.9	45.5	–29.9	–5.2	100
Unit value (USD/kg)	0.58	0.53	0.95	0.80	1.31	63.4	22.8	–
Export destination								
United Arab Emirates								
Volume (t)	49,698	44,254	22,424	44,772	11,306	–74.7	–30.9	33
Value (million USD)	17.3	18.5	16.3	27.3	14.0	–48.6	–5.1	31
Unit value (USD/kg)	0.35	0.42	0.73	0.61	1.24	103.5	37.4	–
United Kingdom								
Volume (t)	9,504	6,601	4,761	11,282	5,808	–48.5	–11.6	17
Value (million USD)	14.0	5.8	7.5	13.9	8.1	–41.8	–12.7	18
Unit value (USD/kg)	1.47	0.88	1.58	1.24	1.40	13.0	–1.3	–
Oman								
Volume (t)	12,138	8,995	4,365	7,200	3,611	–49.8	–26.1	10
Value (million USD)	4.01	3.57	3.14	4.21	4.76	13.0	4.4	10
Unit value (USD/kg)	0.33	0.40	0.72	0.58	1.32	125.3	41.3	–
Saudi Arabia								
Volume (t)	5,406	4,453	3,814	6,440	2,424	–62.4	–18.2	7
Value (million USD)	4.30	3.48	4.58	7.38	3.19	–56.8	–7.2	7
Unit value (USD/kg)	0.79	0.78	1.20	1.15	1.31	14.8	13.4	–
Qatar								
Volume (t)	1,465	1,218	1,089	1,553	1,493	–3.8	0.5	4
Value (million USD)	1.13	1.05	1.44	1.58	1.85	17.6	13.1	4
Unit value (USD/kg)	0.77	0.86	1.32	1.01	1.24	22.3	12.6	–

	2013	2014	2015	2016	2017	Trend 2016–17 (%)	Trend 2013–17 (%)	Share (%)
Afghanistan								
Volume (t)	364	2,543	167	601	381	–36.5	1.2	1
Value (million USD)	0.14	1.00	0.07	0.23	0.45	93.2	33.3	1
Unit value (USD/kg)	0.39	0.39	0.43	0.39	1.18	204.4	31.8	–
Kazakhstan								
Volume (t)	187	–	–	–	2,229	–	85.8	6
Value (million USD)	0.08	–	–	–	2.76	–	145.5	6
Unit value (USD/kg)	0.41	–	–	–	1.24	–	32.1	–
Germany								
Volume (t)	1,527	1,088	633	953	860	–9.7	–13.4	2
Value (million USD)	2.49	1.27	0.93	1.17	1.19	1.6	–17.0	3
Unit value (USD/kg)	1.63	1.16	1.47	1.22	1.38	12.6	–4.1	–
Norway								
Volume (t)	752	742	554	1,026	782	–23.8	1.0	2
Value (million USD)	1.04	0.68	0.86	1.31	1.16	–11.2	2.9	3
Unit value (USD/kg)	1.38	0.92	1.54	1.27	1.49	16.5	1.9	–
Bahrain								
Volume (t)	2,686	574	543	1,182	191	–83.8	–48.4	1
Value (million USD)	1.22	0.35	0.55	1.09	0.20	–81.6	–36.3	0
Unit value (USD/kg)	0.45	0.61	1.00	0.92	1.05	13.9	23.3	–
Other								
Volume (t)	13,744	4,734	3,935	5,899	5,632	–4.5	–20.0	16
Value (million USD)	10.56	4.23	4.63	6.71	7.81	16.4	–7.3	17
Unit value (USD/kg)	0.77	0.89	1.18	1.14	1.39	21.9	15.9	–

Note: Unit value = calculated based as average value
Source: ITC Trade Map, 2019

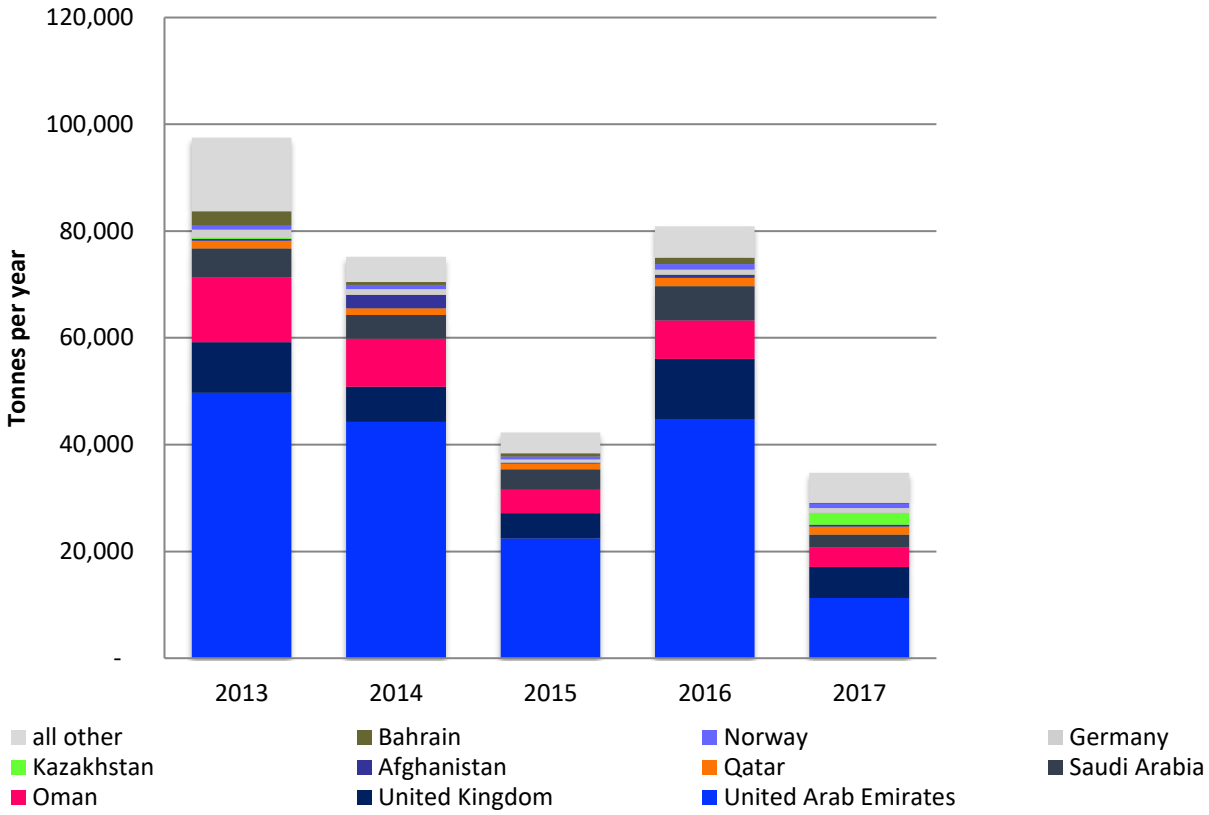

Figure 4.1 Pakistan mango exports by volume, 2013–2017
Source: ITC Trade Map, 2019

Insights

Pakistan has the production capacity and export development focus to be a leading global mango exporter, able to grow market share into the lucrative market of Europe with consistent supply. However, as Pakistan has some volatility in its supply, its trade capacity needs to be developed to meet a steady export commitment.

The higher price of Pakistani mangoes in 2017 appears to relate to a short supply position. This inconsistency in pricing can inhibit export development. The highest prices are consistently recorded from the UK and Norway, albeit the volumes to Norway are small.

Some Pakistani growers are embracing GlobalGAP and trading mangoes successfully to Norway, the UK and Germany. To be successful in Europe, Pakistani exporters will need to define and identify a competitive advantage over Brazilian and Peruvian mangoes. This may be a specific varietal advantage.

4.2 The Philippines

The Philippines is the only ACIAR partner country with a strong focus on trade into north Asia and North America. The top five destinations accounted for 93% of the total exports in 2017. Hong Kong is the dominant destination, and is influenced by re-exports to China. Export trade has hovered around 22,000–25,000 tonnes in the last five years with the exception of a surge in 2014 (Table 4.2, Figure 4.2). The recorded price points for Philippine mangoes range higher than the global average, from USD2.46–3.92/kg.

Table 4.2 The Philippines mango exports, 2013–2017

	2013	2014	2015	2016	2017	Trend 2016–17 (%)	Trend 2013–17 (%)	Share (%)
Total								
Volume (t)	25,738	36,105	23,195	20,618	24,639	19.5	–1.1	100
Value (million USD)	63.4	128.0	91.0	66.9	82.6	23.5	6.8	100
Unit value (USD/kg)	2.46	3.55	3.92	3.24	3.35	3.4	8.0	–
Export destination								
Hong Kong								
Volume (t)	13,826	14,042	8,964	11,484	13,614	18.5	–0.4	55
Value (million USD)	10.8	16.1	15.7	14.4	16.9	17.3	11.9	21
Unit value (USD/kg)	0.78	1.15	1.75	1.26	1.24	–1.0	12.3	–
United States								
Volume (t)	2,561	3,870	3,103	3,165	3,379	6.8	7.2	14
Value (million USD)	15.3	26.7	21.9	23.5	21.6	–8.4	9.0	26
Unit value (USD/kg)	5.96	6.89	7.06	7.43	6.38	–14.2	1.7	–
Japan								
Volume (t)	3,219	4,112	1,597	1,341	1,570	17.1	–16.4	6
Value (million USD)	10.59	21.16	11.25	10.58	14.70	38.9	8.5	18
Unit value (USD/kg)	3.29	5.15	7.04	7.89	9.36	18.6	29.9	–
South Korea								
Volume (t)	2,762	7,446	4,568	1,993	3,048	52.9	2.5	12
Value (million USD)	8.28	19.92	11.85	4.96	7.29	47.1	–3.1	9
Unit value (USD/kg)	3.00	2.68	2.59	2.49	2.39	–3.8	–5.5	–
Canada								
Volume (t)	479	1,547	1,014	633	1,419	124.2	31.2	6
Value (million USD)	3.84	11.33	6.09	2.79	13.14	371.2	36.0	16
Unit value (USD/kg)	8.02	7.32	6.00	4.40	9.26	110.2	3.7	–
United Kingdom								
Volume (t)	67	297	352	81	174	114.8	26.9	1
Value (million USD)	0.73	2.88	4.19	0.90	2.06	129.7	29.7	2
Unit value (USD/kg)	10.88	9.68	11.91	11.07	11.84	6.9	2.1	–

	2013	2014	2015	2016	2017	Trend 2016–17 (%)	Trend 2013–17 (%)	Share (%)
China								
Volume (t)	764	1,934	889	311	312	0.3	–20.1	1
Value (million USD)	5.26	12.87	7.32	2.69	1.70	–36.9	–24.6	2
Unit value (USD/kg)	6.88	6.65	8.23	8.66	5.45	–37.1	–5.7	–
Ireland								
Volume (t)	50	276	239	250	133	–46.8	27.7	1
Value (million USD)	0.28	2.36	1.92	2.47	1.54	–37.5	53.7	2
Unit value (USD/kg)	5.54	8.54	8.03	9.88	11.61	17.5	20.3	–
Other								
Volume (t)	2,010	2,581	2,469	1,360	990	–27.2	–16.2	4
Value (million USD)	8.34	14.74	10.79	4.52	3.67	–18.7	–18.5	4
Unit value (USD/kg)	4.15	5.71	4.37	3.32	3.71	11.6	–2.8	–

Note: Unit value = calculated based as average value
Source: ITC Trade Map, 2019

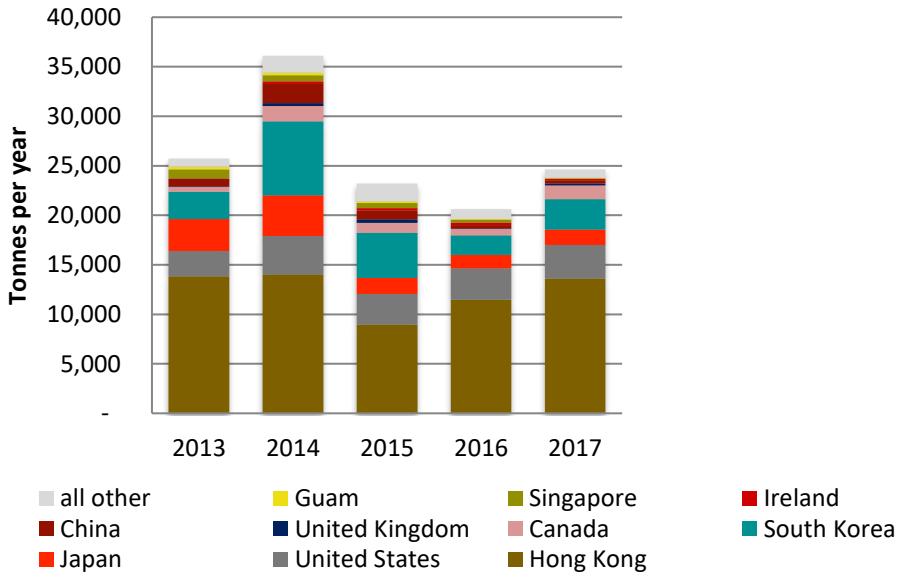

Figure 4.2 The Philippines mango exports by volume, 2013–2017
Source: ITC Trade Map, 2019

Insights

The Philippines is the major banana supplier to north Asian markets. This has assisted the country to gain a market position for other tropical fruit, including becoming a key mango supplier to these markets. However, exports account for less than 5% of the country's production, and local exporters have suggested that it is often difficult to secure sufficient supplies of export-quality fruit. The US is the Philippines' second-largest market for mangoes. The higher price points for the US, Japan and Canada are indicative of the higher returns possible for these more lucrative markets, even though they have higher access costs associated with meeting stringent quality standards.The higher average price point for Philippine mangoes may be influenced by strong demand in Japan and its focus on high-quality fruit.

4.3 Cambodia

The available export data from Cambodia is incomplete. As a result, the datasets were developed from mirror data, relying on importer data from Cambodia. Most exports from Cambodia have recently ramped up into Thailand, although there are records of small volumes into some European countries. The value may be higher, as there is a record in Vietnam for a further USD6.03 million without a volume figure (Table 4.3, Figure 4.3).

The recorded price points for Cambodian mangoes range from USD0.12/kg into Thailand to more than USD5.01/kg for some lucrative markets in Europe (France and Norway). At this stage the data is not reliable to draw significant conclusions.

Table 4.3 Cambodia mango exports, 2013–2017

	2013	2014	2015	2016	2017	Trend 2016–17 (%)	Trend 2013–17 (%)	Share (%)
Total								
Volume (t)	1,365	265	202	13,511	24,002	77.6	104.8	100
Value (million USD)	0.6	0.7	0.2	2.4	10.9	345.8	106.3	100
Unit value (USD/kg)	0.44	2.72	1.23	0.18	0.45	151.0	0.8	–
Export destination								
Thailand								
Volume (t)	1,232	90	143	13,358	23,711	77.5	109.5	99
Value (million USD)	0.1	0.1	0.1	1.5	2.8	86.6	122.7	26
Unit value (USD/kg)	0.09	0.62	0.59	0.11	0.12	5.1	6.3	–
France								
Volume (t)	8	16	1	88	187	112.5	119.9	1
Value (million USD)	0.1	0.1	0.0	0.5	1.0	111.4	102.7	9
Unit value (USD/kg)	7.13	7.38	9.00	5.17	5.14	–0.5	–7.8	–
Hong Kong								
Volume (t)	–	–	–	15	71	373.3	–	0
Value (million USD)	0.00	0.00	0.00	0.09	0.33	283.7	–	3
Unit value (USD/kg)	–	–	–	5.73	4.65	–18.9	–	–
Other								
Volume (t)	125	159	58	50	33	–34.0	–28.3	0
Value (million USD)	0.43	0.55	0.16	0.38	6.74	1682.3	99.3	62
Unit value (USD/kg)	3.42	3.45	2.67	7.56	204.15	2600.4	178.0	–

Notes: Unit value = calculated based as average value
Mirror data used

Source: ITC Trade Map, 2019

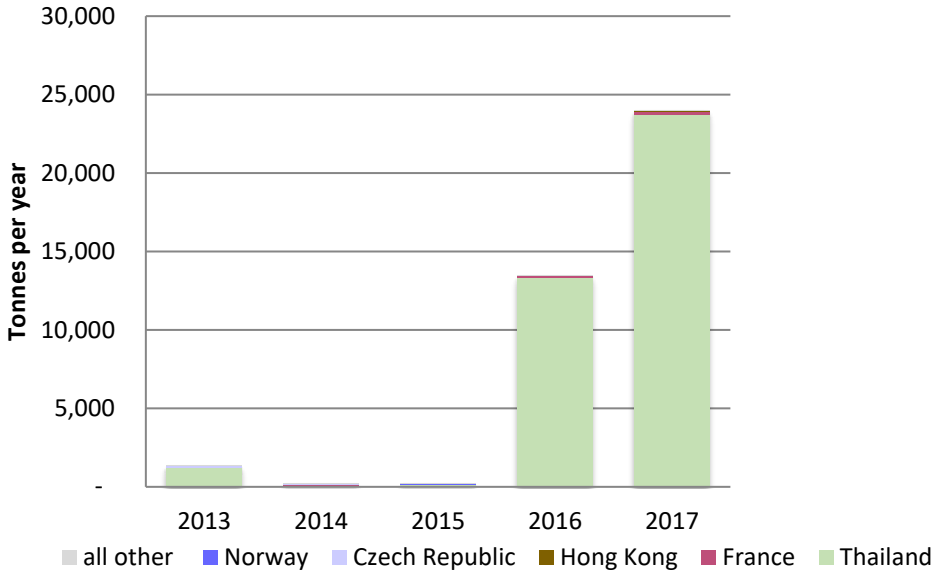

Figure 4.3 Cambodia mango exports by volume, 2013–2017
Source: ITC Trade Map, 2019
Note: Mirror data used

Insights

As mentioned, the available export data from Cambodia is unreliable. Almost all exports cross into Thailand at an unsustainably low value of approximately USD0.12/kg. These observed prices underpin feedback that Thai importers control prices, and that Cambodian growers desire control of their export businesses.

Vietnam is a known export destination for Cambodian mangoes. However, as trade data between Cambodia and Vietnam is scant, these volumes are not known.

4.4 Vietnam

Vietnam recorded very strong growth off a small base, particularly to the United Arab Emirates. South Korea also showed growth after access was achieved in 2014.

Mirror data has been used due to incomplete datasets available from Vietnam. The Vietnam data records the value of mango exports to China as USD340 million. However, this is not verified with China's import data, which suggests USD0.085 million (USD85,000). If the Vietnam data were reliable, the pro rata volume at USD1.50/kg would measure 225,000 tonnes (Table 4.4, Figure 4.4).

Recorded price points for Vietnam mangoes (recorded by importing countries) range from USD1.40/kg to USD2.34/kg, which is mostly higher than global average prices except for 2017.

Table 4.4 Vietnam mango exports, 2013–2017

	2013	2014	2015	2016	2017	Trend 2016–17 (%)	Trend 2013–17 (%)	Share (%)
Total								
Volume (t)	840	904	2,037	3,552	5,665	59.5	61.1	100
Value (million USD)	1.5	2.1	4.6	6.6	7.9	20.6	52.3	100
Unit value (USD/kg)	1.75	2.34	2.24	1.85	1.40	–24.4	–5.5	–
Export destination								
United Arab Emirates								
Volume (t)	33	114	84	1,231	3,414	177.3	218.9	60
Value (million USD)	0.1	0.4	0.2	1.1	2.3	108.3	121.1	30
Unit value (USD/kg)	2.97	3.22	1.99	0.91	0.69	–24.9	–30.7	–
South Korea								
Volume (t)	–	55	211	394	475	20.6	–	8
Value (million USD)	–	0.3	0.7	1.3	1.5	14.2	–	19
Unit value (USD/kg)	–	4.75	3.49	3.37	3.19	–5.2	–	–
France								
Volume (t)	24	39	215	81	293	261.7	86.9	5
Value (million USD)	0.18	0.27	0.52	0.38	0.98	157.0	52.7	12
Unit value (USD/kg)	7.50	6.97	2.44	4.70	3.34	–29.0	–18.3	–
Guatemala								
Volume (t)	–	–	630	905	280	–69.1	–	5
Value (million USD)	0.00	0.00	1.35	1.89	0.56	–70.3	–	7
Unit value (USD/kg)	–	–	2.14	2.09	2.00	–4.0	–	–
Canada								
Volume (t)	56	71	70	152	192	26.3	36.1	3
Value (million USD)	0.22	0.25	0.24	0.37	0.42	12.2	17.7	5
Unit value (USD/kg)	3.86	3.54	3.37	2.43	2.16	–11.2	–13.5	–

	2013	2014	2015	2016	2017	Trend 2016–17 (%)	Trend 2013–17 (%)	Share (%)
Russia								
Volume (t)	11	7	7	7	59	742.9	52.2	1
Value (million USD)	0.06	0.05	0.05	0.04	0.30	676.3	50.2	4
Unit value (USD/kg)	5.27	7.29	6.86	5.43	5.00	–7.9	–1.3	–
Australia								
Volume (t)	5	–	32	56	86	53.6	103.6	2
Value (million USD)	0.01	0.00	0.07	0.14	0.29	106.3	122.3	4
Unit value (USD/kg)	2.40		2.28	2.54	3.41	34.4	9.2	–
Bahrain								
Volume (t)	1	1	1	10	182	1720.0	267.3	3
Value (million USD)	0.00	0.01	0.01	0.13	0.21	55.3	218.2	3
Unit value (USD/kg)	2.00	11.00	8.00	13.20	1.13	–91.5	–13.4	–
Germany								
Volume (t)	3	6	4	33	16	–51.5	52.0	0
Value (million USD)	0.03	0.05	0.03	0.12	0.16	31.5	51.4	2
Unit value (USD/kg)	10.33	7.83	7.25	3.76	10.19	171.1	–0.4	–
Hong Kong								
Volume (t)	188	178	296	109	91	–16.5	–16.6	2
Value (million USD)	0.31	0.29	0.55	0.23	0.16	–28.5	–14.5	2
Unit value (USD/kg)	1.62	1.63	1.86	2.09	1.79	–14.4	2.5	–
China								
Volume (t)	12	–	–	–	226	–	108.3	4
Value (million USD)	0.02	0.00	0.00	0.00	0.09	–	47.4	1
Unit value (USD/kg)	1.50	–	–	–	0.38	–	–29.2	–
Other								
Volume (t)	507	433	487	574	351	–38.9	–8.8	6
Value (million USD)	0.55	0.57	0.83	0.82	0.92	11.2	13.4	12
Unit value (USD/kg)	1.09	1.31	1.71	1.43	2.61	81.8	24.3	–

Notes: Unit value = calculated based as average value
Mirror data used

Source: ITC Trade Map, 2019

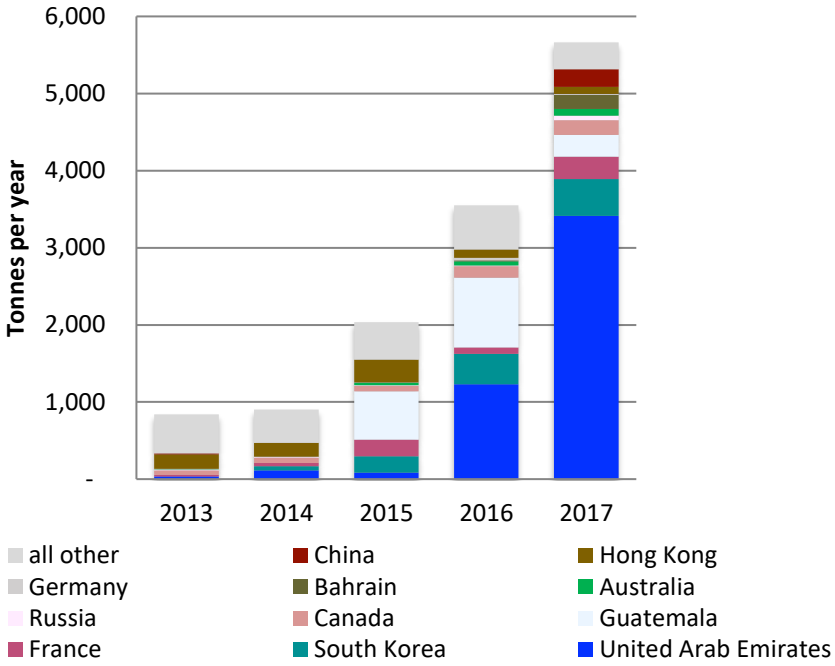

Figure 4.4 Vietnam mango exports by volume, 2013–2017

Source: ITC Trade Map, 2019

Note: Mirror data used

Insights

Vietnam's potential for export to China is likely to significantly increase trade between the two countries. China recorded imports of more than 2,000 tonnes from Vietnam in 2018, up from 226 tonnes in 2017. The actual supply may be higher due to informal border trade crossing into the southern provinces of China, and unrecorded re-export of mangoes to China from Cambodia. A future study of the cross-border trade would therefore be of value. Ongoing trade to the Middle East may be harder to maintain among increasing supplies from Pakistan and other producers. The low price points for the Middle East (UAE and Bahrain) and China must be noted for ongoing viability, particularly as the UAE is a significant import market.

4.5 Indonesia

The main export destinations for Indonesian mangoes are Singapore, the UAE, and to a lesser extent, Malaysia. Exports dipped 62% in 2017 to just 473 tonnes, though have recovered to 790 tonnes in 2018 (not shown) (Table 4.5). Although there has been some growth from 2014 to 2016, the overall trend has been downwards (Figure 4.5).

Recorded price points have mostly ranged between USD1.30 to USD1.57, consistent with global average prices.

Table 4.5 Indonesia mango exports, 2013–2017

	2013	2014	2015	2016	2017	Trend 2016–17 (%)	Trend 2013–17 (%)	Share (%)
Total								
Volume (t)	1,515	1,089	1,149	1,243	473	–61.9	–25.2	100
Value (million USD)	2.2	1.4	1.8	1.8	0.6	–65.0	–26.5	100
Unit value (USD/kg)	1.45	1.30	1.57	1.47	1.35	–8.0	–1.8	–
Export destination								
Singapore								
Volume (t)	489	309	493	491	172	–65.1	–23.0	36
Value (million USD)	0.8	0.5	1.0	0.9	0.3	–62.7	–21.1	50
Unit value (USD/kg)	1.70	1.61	2.05	1.76	1.88	6.8	2.5	–
United Arab Emirates								
Volume (t)	635	462	390	322	174	–46.1	–27.7	37
Value (million USD)	0.8	0.4	0.3	0.3	0.1	–60.1	–38.5	18
Unit value (USD/kg)	1.25	0.92	0.78	0.88	0.65	–25.9	–15.0	–
Malaysia								
Volume (t)	114	66	79	92	21	–77.4	–34.7	4
Value (million USD)	0.28	0.15	0.18	0.17	0.06	–65.7	–32.8	9
Unit value (USD/kg)	2.46	2.24	2.32	1.81	2.76	52.2	2.9	–
Kuwait								
Volume (t)	20	31	25	25	12	–52.3	–12.0	3
Value (million USD)	0.06	0.11	0.09	0.08	0.04	–42.1	–5.4	7
Unit value (USD/kg)	2.75	3.57	3.45	3.02	3.67	21.5	7.5	–
Saudi Arabia								
Volume (t)	120	82	48	146	43	–70.7	–22.8	9
Value (million USD)	0.06	0.07	0.02	0.10	0.03	–68.3	–15.6	5
Unit value (USD/kg)	0.52	0.80	0.50	0.69	0.75	8.2	9.4	–
Oman								
Volume (t)	12	31	32	56	23	–58.0	18.1	5
Value (million USD)	0.02	0.05	0.06	0.13	0.03	–78.6	13.3	4
Unit value (USD/kg)	1.42	1.65	1.94	2.36	1.20	–49.1	–4.1	–

	2013	2014	2015	2016	2017	Trend 2016–17 (%)	Trend 2013–17 (%)	Share (%)
Qatar								
Volume (t)	65	66	42	29	11	–61.7	–35.6	2
Value (million USD)	0.05	0.06	0.05	0.04	0.02	–60.0	–24.4	3
Unit value (USD/kg)	0.75	0.89	1.28	1.37	1.43	4.6	17.4	–
Other								
Volume (t)	60	42	41	82	18	–77.9	–25.9	4
Value (million USD)	0.11	0.06	0.08	0.16	0.03	–83.9	–29.5	4
Unit value (USD/kg)	1.75	1.31	1.90	1.97	1.44	–26.8	–4.8	–

Note: Unit value = calculated based as average value
Source: ITC Trade Map, 2019

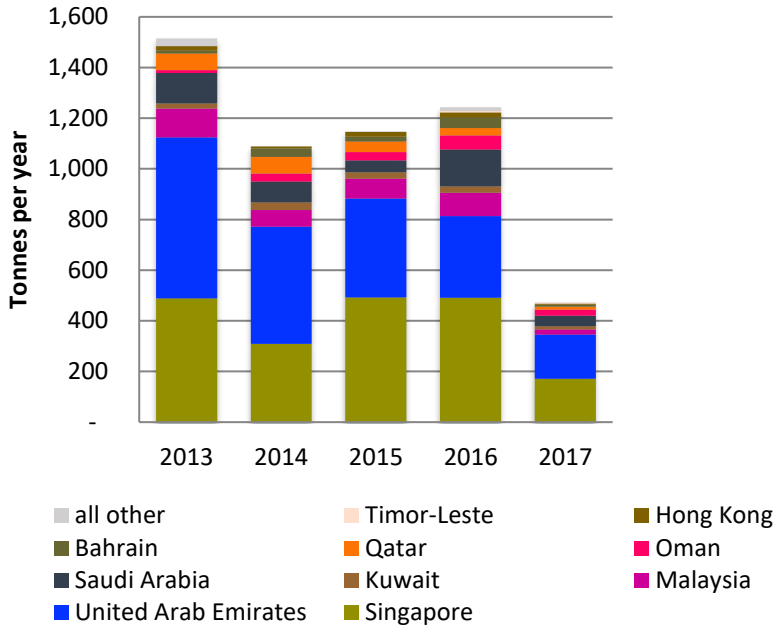

Figure 4.5 Indonesia mango exports by volume, 2013–2017
Source: ITC Trade Map, 2019

Insights

The price points for Indonesian mango appear to be realistic. Low values to some Middle East buyers (UAE and Saudi Arabia) could be flagged as a concern for ongoing viability.

Growth is limited to unregulated markets (Singapore and Malaysia) and the Middle East, as Indonesia does not have market-access protocols for north Asian markets or the US. With a very low share of exports, it appears that Indonesia is far from being export ready.

4.6 Fiji

Fijian mango exports have declined since 2013. New Zealand is the main destination, with small volumes sent to Canada and various other Pacific Islands. There is no trade to major northern markets (Table 4.6 and Figure 4.6).

The recorded price points for Fijian mangoes have increased over the last five years, which is above the global average prices.

Table 4.6 Fiji, mango exports, 2013–2017

	2013	2014	2015	2016	2017	Trend 2016–17 (%)	Trend 2013–17 (%)	Share (%)
Total								
Volume (t)	49	58	50	30	26	–13.3	–14.7	100
Value (million USD)	0.1	0.1	0.1	0.1	0.1	–1.5	–6.3	100
Unit value (USD/kg)	1.78	2.21	1.76	2.27	2.58	13.7	9.8	–
Export destination								
New Zealand								
Volume (t)	42	54	47	28	20	–28.6	–16.9	77
Value (million USD)	0.1	0.1	0.1	0.1	0.1	–10.9	–5.0	85
Unit value (USD/kg)	1.67	1.85	1.68	2.29	2.85	24.7	14.4	–
Canada								
Volume (t)	2	1	2	1	1	0.0	–15.9	4
Value (million USD)	0.0	0.0	0.0	0.0	0.0	66.7	13.6	7
Unit value (USD/kg)	1.50	12.00	3.00	3.00	5.00	66.7	35.1	–
Other								
Volume (t)	5	3	1	1	5	400.0	0.0	19
Value (million USD)	0.01	0.02	0.00	0.00	0.01	400.0	–22.7	7
Unit value (USD/kg)	2.80	5.33	3.00	1.00	1.00	0.0	–22.7	–

Note: Unit value = calculated based as average value
Source: ITC Trade Map, 2019

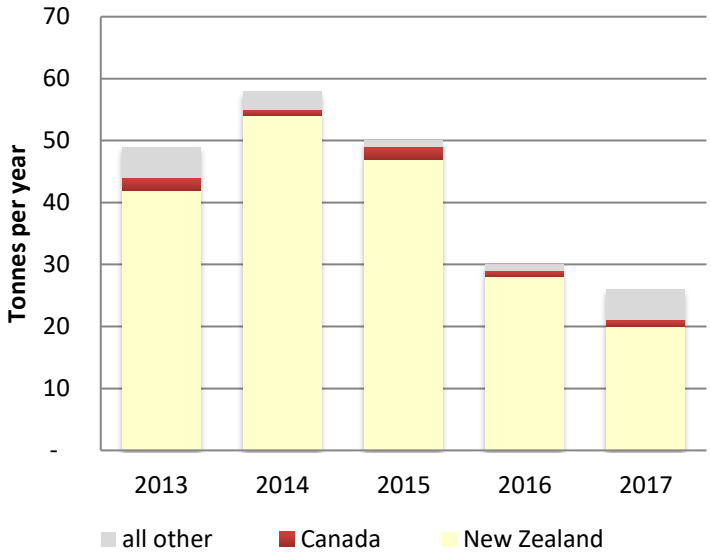

Figure 4.6 Fiji mango exports by volume, 2013–2017
Source: ITC Trade Map, 2019

Insights

The price point for Fijian mangoes in New Zealand is competitive with Australia, though considerably higher than the import prices for other suppliers. Fiji's small production volume and lack of connectivity with major markets will make export growth to markets other than regional Pacific nations difficult. While airfreight to the US could be viable, the investment in market access and developing a supply chain is unlikely to be justified based on the return for effort.

4.7 Australia

Key export destinations for Australian mangoes are Hong Kong, Singapore and New Zealand. Most trade to Hong Kong is redirected to China. Exports have been recording solid gains of 14% per year (Table 4.7, Figure 4.7). The price points for Australian mangoes are generally 80–100% higher than the global average.

Table 4.7 Australia mango exports, 2013–2017

	2013	2014	2015	2016	2017	Trend 2016–17 (%)	Trend 2013–17 (%)	Share (%)
Total								
Volume (t)	5,033	6,322	8,015	7,728	8,554	10.7	14.2	100
Value (million USD)	17.7	20.2	24.5	23.9	24.7	3.4	8.6	100
Unit value (USD/kg)	3.52	3.19	3.05	3.09	2.88	–6.6	–4.9	–
Export destination								
China								
Volume (t)	121	43	135	65	132	103.1	2.2	2
Value (million USD)	1.0	0.3	1.1	0.3	0.7	92.2	–9.4	3
Unit value (USD/kg)	8.14	7.30	7.86	5.31	5.02	–5.4	–11.4	–
South Korea								
Volume (t)	25	55	77	114	68	–40.4	28.4	1
Value (million USD)	0.1	0.3	0.4	0.6	0.5	–21.4	34.3	2
Unit value (USD/kg)	5.92	6.27	5.79	5.38	7.09	31.8	4.6	–
United States								
Volume (t)	–	–	18	100	64	–36.0	–	1
Value (million USD)	0.00	0.00	0.12	0.73	0.42	–43.1	–	2
Unit value (USD/kg)	–	–	6.72	7.29	6.48	–11.1	–	–
Japan								
Volume (t)	63	50	72	64	35	–45.3	–13.7	0
Value (million USD)	0.56	0.41	0.48	0.47	0.32	–32.1	–13.3	1
Unit value (USD/kg)	8.90	8.22	6.69	7.30	9.06	24.1	0.4	–
Hong Kong								
Volume (t)	2,228	2,557	3,207	3,304	3,329	0.8	10.6	39
Value (million USD)	7.45	8.19	10.31	10.56	9.96	–5.8	7.5	40
Unit value (USD/kg)	3.34	3.20	3.21	3.20	2.99	–6.5	–2.8	–
Singapore								
Volume (t)	717	800	1,068	1,143	1,673	46.4	23.6	20
Value (million USD)	2.05	2.15	2.53	2.92	4.23	45.0	19.9	17
Unit value (USD/kg)	2.85	2.68	2.37	2.55	2.53	–1.0	–3.0	–
New Zealand								
Volume (t)	464	749	1,094	906	1,247	37.6	28.0	15
Value (million USD)	1.47	2.14	3.29	2.39	3.01	25.8	19.6	12
Unit value (USD/kg)	3.17	2.86	3.01	2.64	2.41	–8.6	–6.6	–

	2013	2014	2015	2016	2017	Trend 2016–17 (%)	Trend 2013–17 (%)	Share (%)
United Arab Emirates								
Volume (t)	507	817	1,159	803	967	20.4	17.5	11
Value (million USD)	1.72	2.60	2.66	2.30	2.45	6.8	9.3	10
Unit value (USD/kg)	3.39	3.18	2.29	2.86	2.54	–11.3	–7.0	–
Saudi Arabia								
Volume (t)	27	49	79	218	258	18.3	75.8	3
Value (million USD)	0.12	0.17	0.27	0.71	0.82	16.6	62.2	3
Unit value (USD/kg)	4.41	3.49	3.41	3.24	3.19	–1.5	–7.8	–
Qatar								
Volume (t)	114	110	115	100	177	77.0	11.6	2
Value (million USD)	0.40	0.33	0.33	0.27	0.57	114.0	9.3	2
Unit value (USD/kg)	3.48	2.99	2.83	2.65	3.20	20.9	–2.1	–
Other								
Volume (t)	767	1,092	991	911	604	–33.7	–5.8	7
Value (million USD)	2.82	3.51	2.98	2.57	1.75	–31.8	–11.2	7
Unit value (USD/kg)	3.67	3.22	3.01	2.82	2.90	2.9	–5.7	–

Note: Unit value = calculated based as average value
Source: ITC Trade Map, 2019

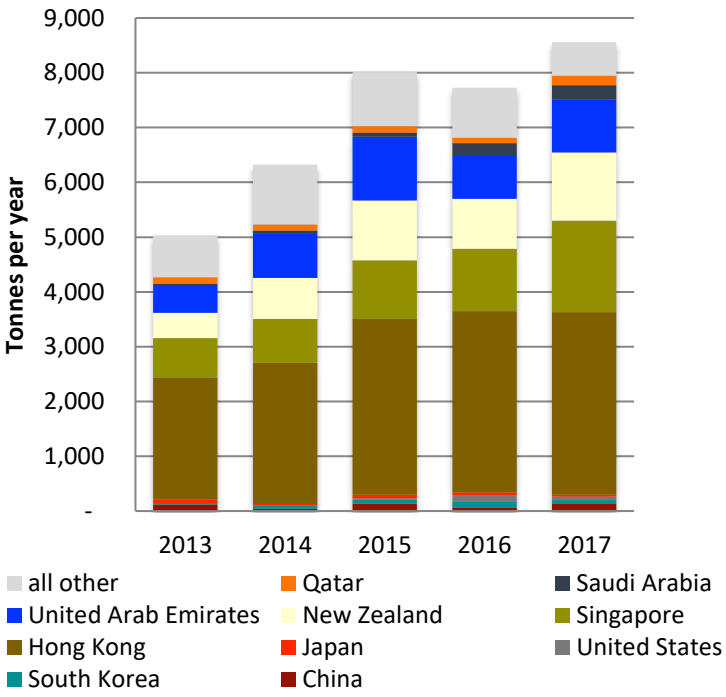

Figure 4.7 Australia mango exports by volume, 2013–2017
Source: ITC Trade Map, 2019

Insights

The Australian mango industry's market-access focus on Japan, the US, Korea and China has yielded very small and arguably unviable results, given the level of investment. The high price points for Australian mangoes confirm the country's position as a premium-priced supplier. However, although some markets are prepared to pay a higher price for Australia's mangoes, the opportunities are niche rather than as a mainstream volume supplier. Hong Kong and Singapore have the major share of trade, while Middle East markets are offering new opportunities.

Australia's geographic position has implications for mango export growth for markets other than New Zealand. Many large mango producers lying between Australia and the more lucrative north Asian markets are in a better position to develop trade. Similarly, the distance/costs to service markets in North America and Europe are challenging against more efficient competitors in Latin America. The premium yellow varieties from Australia attract interest at premium levels; however, these are considered niche, and could be replicated by other suppliers in the future.

5 Market entry and biosecurity

Many importing countries implement strict biosecurity protocols to protect their agricultural crops from pests and diseases. This section presents the results of a desktop review of regional mango import and export requirements via quarantine and non-quarantine pathways, key quarantine pests and management, and biosecurity opportunities and issues.

5.1 Quarantine and non-quarantine pathways

International trade is regulated under the Food and Agriculture Organization's (FAO) Sanitary and Phytosanitary (SPS) Agreement, (WTO, 2010). Under this agreement, trade is encouraged and importing countries have the sovereign right to protect plant and animal health through risk identification and the imposition of risk management measures.

The application of risk management measures must be supported by scientific analysis and commensurate with the level of risk identified. The proposed measures should not be used as a trade barrier. Accordingly, most importing countries have some form of quarantine framework, policies and procedures in place for imported commodities, including fresh mangoes.

Most importing country requirements are embodied within a phytosanitary certificate (PC), which verifies that the imported product (e.g. fruit) has undergone phytosanitary treatment to remove pests and disease. The PC accompanies the exported consignment and is issued by the exporting country's quarantine authority to confirm compliance with the importing country's quarantine requirements.

Compliance with importing country requirements requires a competent export authority to enforce quarantine requirements, and a private sector capable of applying and maintaining the required risk management measures. The costs of compliance are usually shared between the public and private sectors, although newly developed export pathways are often subsidised by government or donor agencies to assist in initial establishment. While costs to comply with importing country quarantine requirements are higher than non-quarantine export destinations, market returns are generally greater.

Quarantine pathways

In compliance with the SPS agreement, the majority of countries in the Asia–Pacific region apply quarantine restrictions, such as PC requirements, on mango imports.

Non-quarantine pathways

Non-quarantine pathways do not require PCs for imported fruit. Hong Kong and Singapore are key non-quarantine mango import pathways in the regional mango markets. Larger import volumes and variable quality generally result in significant market saturation and lower income for the exporting nation.

A significant amount of localised mango trade between bordering nations is not supported by quarantine protocols: for example, from Hong Kong or Myanmar into mainland China. Informal, cross-border trade export is also thought to occur from Thailand to Vietnam and Malaysia, and from Vietnam to China.

5.2 Key quarantine pests

The key quarantine pests identified by importing countries are relatively few (Table 5.1). The primary pests are fruit flies (family Tephritidae), mango pulp and seed weevils (family Coleoptera), and red-banded mango caterpillar (family Lepidoptera). Secondary pests include mealybugs (family Pseudococcidae) and scales (family Diaspididae).

Table 5.1 Key quarantine pests, by importing country or region

Importer	Quarantine pest
Australia	• Mango seed weevil (*Sternochetus mangiferae*) • Mango pulp weevil (*S. frigidus*) • Scale insects (*Parlatoria crypta, P. pseudaspidiotus*) • *Fusarium mangiferae* • Thrips (*Rhipiphorothrips cruntatus*) • Red-banded mango caterpillar (*Deanolis sublimbalis*) • Fruit flies (*Bactrocera correcta, B. dorsalis* (species complex), *B. zonata, B. carambolae, B. occipitalis*) • Mealybugs (*Rastrococcus invadens, R. spinosus*) • Mango bark beetle (*Hypocryphalus mangiferae*)
China	• Fruit flies (*Bactrocera aquilonis, B. frauenfeldi, B. jarvisi, B. neohumeralis, B. zonata, B. correcta, B. cucurbitae, B. dorsalis* (species complex), *B. occipitalis* and *Ceratitis capitata*) • Orange fruit borer (*Isotenes miserana*) • Mango seed weevil (*Sternochetus mangiferae*) • Mango pulp weevil (*S. frigidus*) • Scale insects (*Parlatoria crypta, Lepidosaphes tokionis* and *Aulacaspis tubercularis*) • Bacterial black spot *(Xanthomonas campestris pv. Mangiferaeindica*) • Sooty mould (*Capnodium ramosum*) • *Fusarium moniliforme* var *subglutinans*
European Union	Fruit flies (*Bactrocera correcta, B. dorsalis, B. zonata*)
Hong Kong	No quarantine pests
Japan	Fruit flies (*Ceratitis capitata, Bactrocera passiflorae, B. dorsalis* (species complex), *B. occipitalis, B. cucurbitae and B. tryon*i)
Singapore	No quarantine pests
United Arab Emirates	Mango seed weevil (*Sternochetus mangiferae*)
United Kingdom	Fruit flies (*Bactrocera correcta, B. dorsalis, B. zonata*)

Sources: BICON, 2016; MICOR, 2016; NZMPI, 2016; USDA, 2012; and USDA, 2015.

5.3 Management of pests

Fruit flies remain one of the primary pests for all tropical fruits, including mangoes. Mango seed and pulp weevils and red-banded caterpillar are internal pests that are not easily detected and can cause considerable crop loss. External pests, such as scales and mealybugs, are of secondary quarantine concern. They are generally managed through orchard hygiene, quarantine inspection and remediation.

Fruit flies

Many species of fruit fly (*Tephritidae*) are serious mango pests for numerous horticultural crops worldwide (Allwood et al., 1999). Adult female flies lay eggs within the skin or flesh of the fruit and larvae develop within the fruit.

Shipments of fresh fruit infested with live fruit fly eggs or larvae provide a high risk for the introduction of pest fruit fly species into an importing country. If an importing country does not have the species or it is within a controlled area, the country may impose risk management measures to ensure that it does not enter with fresh fruit.

Treatments to manage the risk of fruit fly infestation within the region are hot water treatment (HWT), vapour heat treatment (VHT) and irradiation.

HWT

This process involves the fruit being submerged completely in a hot water bath, gradually heated to a specified temperature and held at that temperature for a specified time. Temperatures and times vary between countries, fruit fly species and, in some cases, the size and weight of the fruit (Table 5.2).

Table 5.2 Fruit fly hot water treatment requirements, by importing country or region

Importer	Temperature (ºC)	Time (min)
Australia	48	60–90
China	46	20
China	47	15
European Union	48	60

Sources: BICON, 2016; MICOR, 2016; NZMPI, 2016; USDA, 2012; and USDA, 2015

VHT

VHT uses hot, saturated water vapour instead of submergence in hot water. Careful, precise control of humidity and temperature levels is required. Fruit is treated at a temperature of 46.5 °C for 30 minutes, or up to 48 °C for 20 minutes (Table 5.3).

Table 5.3 Fruit fly vapour heat treatment requirements, by importing country or region

Importer	Temperature (ºC)	Time (min)
Australia	46	10
Australia	46.5	30
Australia	47.5	20
European Union	46.5	30
European Union	47.5	20
Japan	47	15
Japan	47	20
Japan	47.5	20
New Zealand	47	20
New Zealand	46	10
New Zealand	48	20
United States	47	20

Sources: BICON, 2016; MICOR, 2016; NZMPI, 2016; USDA, 2012; and USDA, 2015

Irradiation

During irradiation, ionising radiation is passed through fruit and vegetables to disrupt DNA sequences of the developmental stages of various arthropod pests. In most instances, irradiation does not kill the pest, but inhibits its development from larvae to adult.

The use of irradiation as a quarantine treatment is outlined within FAO's International Standard for Phytosanitary Measures (ISPM) No 18 (2005) *Guidelines for the use of irradiation as a phytosanitary measure.* Dose rates for the treatment of specific fruit fly species are outlined within ISPM No 28 (2009) *Phytosanitary treatments pt 7: irradiation treatment for fruit flies of the family Tephritidae (generic)*.

The required irradiation dose rates are supported by a substantial body of scientific research. The rates must be verified by exporting authorities through appropriate dose mapping of treatment facilities and consignments (BICON, 2016). The rates for mangoes are dependent on the pest species (Table 5.4).

Table 5.4 Fruit fly irradiation dose rates, by importing country

Importer	Species	Required dose rate (Gy)
Australia	*Bactrocera carambolae, B. correcta, B. dorsalis* (species complex), *B. zonata*	150
Indonesia	Queensland fruit fly (*B. tyoni*), Jarvis fruit fly (*B. jarvisi*), Mediterranean fruit fly (*Ceratitis capitata*)	150 minimum
United States	Fruit flies (all)	400
United States	*B. cucurbitae, B. dorsalis* (species complex), *B. occipitalis*	150–165

Sources BICON, 2016; MICOR, 2016; and USDA, 2015

Seed and pulp weevils

Mango seed weevil (*Sternochetus mangiferae*) and pulp weevil *(S. frigidus)* infest the interior of mangoes and are difficult to detect. The adult beetle lays eggs within the green mango skin, and the larvae migrate to either the seed or the pulp to develop to mature adults (De Jesus and Gabo, 2000; De and Pande, 1988). Some importing countries have endorsed the use of irradiation for these pests. If irradiation is not approved by the importing country, fruit cutting of a specified percentage of imported product to demonstrate the fruit is free from infestation may be required (Table 5.5).

Table 5.5 Risk management measures for seed and pulp weevil, 2016

Importing country	Measures for seed and or pulp weevil
Australia	Area freedom
Australia	Irradiation at 300 or 400 Gy for seed and pulp weevils
Malaysia	Irradiation at 300 Gy for seed weevil
United States	Area freedom
United States	Irradiation at 300 Gy (minimum) for seed and pulp weevils

Sources: BICON, 2016; MICOR, 2016; and USDA, 2015

Red-banded mango caterpillar

Red-banded mango caterpillar (*Deanolis sublimbalis*) is an internal pest. Adult moths lay eggs on the fruit stalk. Once the eggs hatch, the larvae tunnel into the fruit, where they develop to the pupal stage. The pupae leave the fruit and develop into adults within the soil (Plant Health Australia, 2013).

Risk management for importing countries that do not have this pest may involve area freedom certification (a certified systems approach to control the pest in the field combined with fruit cutting) or irradiating fruit at 300–400 Gy (BICON, 2016).

5.4 Biosecurity opportunities and issues

This section summarises important biosecurity issues and poses several suggestions for consideration to improve risk management and treatment of mango pests and diseases.

5.4.1 Regional import requirements

Quarantine requirements for countries that import mangoes vary depending on the key quarantine pests identified, the level of risk they pose, and the acceptability of proposed risk management measures. In practice, this means that not all countries accept or use all risk management measures for key mango quarantine pests. HWT and VHT are widely

adopted measures for fruit fly, although treatment temperatures and times vary. Irradiation is increasingly being incorporated into import policy documents. However, adoption is slow, due to facility establishment costs and concerns about consumer acceptance (Table 5.6).

Table 5.6 Risk management measures by importing country or region, 2016

Importer	Risk management measures and pest
Australia	HWT and VHT (fruit flies), irradiation (arthropod pests)
Canada	Freedom from light-brown apple moth
China	VHT (fruit flies), orchard freedom (seed weevil), in-field control (some pests and diseases)
European Union	In-field control and visual inspection (all pests), HWT and VHT (fruit flies)
Indonesia	Area freedom, cold disinfestation, VHT and irradiation (fruit flies)
Japan	VHT (fruit flies)
Malaysia	Irradiation (fruit flies)
Thailand	HWT and VHT (fruit flies), irradiation (arthropod pests)
United Arab Emirates	Manual selection and inspection of fruit (seed weevil)
United States	HWT and VHT (fruit flies), irradiation (all pests)
Vietnam	Irradiation (most pests)

HWT = hot water treatment; VHT = vapour heat treatment

Sources: BICON, 2016; MICOR, 2016; NZMPI, 2016; USDA, 2012 and USDA, 2015

5.4.2 Standards for HWT and VHT

Standard temperature and treatment times for HWT and VHT vary between countries. A review of existing efficacy data would help in setting standardised regional temperatures for these treatments.

5.4.3 Irradiation facilities

The efficacy of irradiation as a quarantine treatment against all internal and external quarantine pests of mango is well established. However, the costs associated with establishing and maintaining an irradiation facility are prohibitive for broad adoption. Treatment costs are also relatively expensive, and there is a perceived consumer hesitancy to consume irradiated fruit.

A feasibility study is needed for the development of a regional treatment facility (or facilities) where costs for establishment, maintenance and promotion of irradiation as a quarantine treatment are shared among exporting countries. A partnership approach with the Australian irradiation service provider may be cost effective.

5.4.4 Varietal ability to withstand quarantine treatments

Heat treatments and irradiation cause varying levels of post-treatment fruit damage, which is often variety specific. Unfortunately, when breeders are developing new mango varieties, the ability to withstand quarantine treatments for fruit fly (and other internal pests) is not a consideration. The ability of some established varieties to tolerate heat and irradiation is also unknown. If mango-producing countries seek to expand exports beyond non-quarantine markets to more profitable quarantine markets, this must be a consideration when selecting established varieties or developing new varieties.

5.4.5 Fruit fly taxonomy changes

Export to most quarantine markets requires a treatment for specific species of fruit flies. Mangoes are a primary host for Oriental fruit fly (*Bactrocera dorsalis*), which is widespread throughout the Asia region (Drew and Hancock, 1994).

Until 2014, regional Oriental fruit fly populations were split into several different species (*B. dorsalis*, *B. invadens*, *B. papayae*, *B. philippinensis*), with species-specific quarantine treatments required for all species. If an importing country did not have one of the four species, it could still legitimately require a quarantine treatment for fruit fly. However, following an international collaborative research project that examined morphology, behaviour, ecology and DNA of the four species *B. invadens*, *B. papayae* and *B. philippinensis* were determined to be synonyms of *B. dorsalis* (Schutze et al., 2014).

The market-access implications of these changes remain unclear at the time of writing. However, it is anticipated that the requirement for phytosanitary treatment for *B. invadens*, *B. papayae* or *B. philippinensis* can no longer be scientifically justified if *B. dorsalis* is present within the importing country. Based upon the known distribution of *B. dorsalis,* this situation is likely to apply to mangoes imported into China through quarantine export pathways from neighbouring countries.

6 Mango processing

This snapshot review of fruit processing information was captured from interviews and desktop research in Thailand, the Philippines, India, Pakistan, Vietnam, Indonesia and Australia. The discussion indicates key considerations in relation to sustainable mango processing, lists processed mango products and summarises mango processing data from each country. Strategic research targets for mango processing are also nominated.

6.1 Sustainable processing

Ideally, mango processing should make use of all the raw material without generating waste. The key basics of sustainable processing include:

- automation
- product differentiation
- maximum use of raw material
- defined handling and pre-processing protocols
- contracts to ensure agreement between growers and processors
- determined specifications, volumes and price points of raw materials
- minimised transport of raw material to reduce costs and damage.

6.2 Processed mango products

Processing mangoes reduces wastage during peak production months and smooths out the supply entering domestic markets, thereby helping to maintain a minimum price. It also provides a viable new source of supplementary income for small-scale and cooperative farmers, increasing profit levels from second or third-grade fruit. Examples of processed mango products are given in Table 6.1.

Table 6.1 Processed mango products

Product	Format
Juice	Juice, cordials, fruit drinks, nectars
Frozen	Cheeks, diced, cubed, strips, purees
Dried	Spears, powder, composite drink powders, milk shake base, leathers (fruit straps)
Crystallised	Cubes, spears
Composites	Jams, jellies, chutneys, ready-to-eat desserts
Canned	Syrup, fruit cocktail
Fermented	Wine, liqueur, lactic acid from skins
Cosmetics	Ground skins and seeds

Source: authors' analysis

6.3 Processing in regional countries

The current situation for mango-processing industries in ACIAR partner countries is described in the following sections.

Thailand

Thailand has a well-developed mango-processing sector making use of 1.2% of its total mango production (~36,600 tonnes per annum). The major products are canned (~27,000 tonnes per annum), frozen (~4,000 tonnes per annum), and dried (~600 tonnes per annum) mango. The leading importers of the frozen mango products are Japan, South Korea and the Netherlands, while the leading importers of the dried products are the USA, Hong Kong and the UK. The major processing facilities in Thailand are located in the northern and central regions that produce fresh mangoes for export.

Pakistan

The wide-scale production of pickled mango products is traditional in Pakistan, but this is often at a very small, village scale with only local distribution. At least one multinational company processes mango, and a common pulp extraction facility has been developed in the mango-producing area of Multan to facilitate processing. A current United States Agency for International Development (USAID) project is providing funds to set up a modern drying facility to process one tonne of mango per day.

The Philippines

The Philippines' well-developed mango-processing sector produces a range of processed items, including puree, juice, dried and frozen products. Most of the country's mango-processing companies have been in the business for several decades and typically have vertical linkages through production contracts. Large processors sell their products primarily to institutional markets, such as supermarkets and other food product manufacturers (e.g. mango puree as raw material for mango juice).

The major processing companies are based in Cebu City, Davao City and Manila. In Cebu, these include ProFood International, 7 D Food International and the AEO International Food Corporation. In Davao, these include Philippine Fruits International Corporation (under ProFoods), KF Foods, RML Food Products and South Davao Development Corporation. The major processors in Manila are A&P Foods Corporation, Harman Foods Incorporated, Ramed Foods Manufacturing Incorporated, Boyuz Foods International Incorporated and Hi-Las Marketing Corporation.The major issues in this sub-sector include shortage of fruit supply (especially during the Luzon off season), poor logistics systems, high power costs, and relatively poor support infrastructure and transport system. The logistics system, as well as the overall infrastructure support (e.g. road network), is relatively inferior compared with competitor countries, such as Thailand. The Philippines also has the highest cost of power in South-East Asia.

Price and quality information on fruit sourced from Mindanao for processing has been obtained through other ACIAR projects. One large producer purchases 100 tonnes per day of variable and often poor-quality fruit for PHP7/kg through wholesalers. This fruit is used to make juice, dried and frozen products. Another two processors that only produce frozen products pay a fourfold higher price for good-quality fruit from specific growers at PHP28/kg. Sound post-harvest practices are employed by the processors on receipt of the fruit. One of the two companies produce 1,500 tonnes over six months, while the other produces 3,000 tonnes over 12 months. The frozen products are exported to Japan, South Korea and France, with a landed price of USD4–5/kg.

Vietnam

Our knowledge of current processing procedures in Vietnam is limited, but we know that some frozen products are made, and dried mango is prepared locally for community use. A current ACIAR project is mapping the mango-processing activities in Vietnam (AGB/2012/061).

Indonesia

Very little processing is thought to occur in Indonesia, with the industry comprising a few small-scale, home-based processors who produce dried mango, puree and juice. Constraints on the processing industry include the short mango season, limited domestic demand, lack of product development and marketing expertise, and strong competition with respect to domestic and international markets from well-established processing industries in other Asian countries. Large-scale mango juice processors based in Indonesia mostly rely on local product.

Australia

An estimated 10–15% of Australia's total mango production (~5,000 to 8,000 tonnes per annum) is processed, with the major products being mango puree and frozen mango cheeks. The volume supplied to the processing sector varies on a seasonal basis and is influenced by production trends. Demand for fruit can fluctuate dramatically from year to year, and sourcing fruit can be a challenge in smaller production seasons.

The majority of mango processing in Australia is limited to three or four companies. Two processors only produce puree, while the others handle puree and frozen products. The price paid ranges between AUD0.35/kg and AUD0.55/kg. Manufacturers prefer Australian grown and made product with the flavour profile offered by the Kensington Pride variety. Some manufacturers use imported processed product due to availability and price (~40–45% of the cost of locally produced product) and where the flavour profile is a smaller priority.

Challenges for Australian processors include price, economies of scale and inconsistent supply of raw material. Large distances between some of the major mango-producing regions and individual processors are also an issue.

The competitive nature of processed mango products and the availability of low-priced, imported product makes differentiation from imported products crucial to ensure sustainable Australian processing. With this criterion in mind, one puree processor is seeking to establish a molecular biology technique to prove their puree is derived from Kensington Pride mangoes, given their desirable flavour profile and premium price.

Opportunities for mango processing in Australia include the ability to pre-process fruit close to where it is grown, thereby reducing transport costs and the cost of disposing of peel and seed material (which are not processed); using the peel and seed; and producing novel products with a higher value and competitive advantage. The development of new mango products could include those that have been processed using high-pressure processing, which preserves texture and flavour in a chilled product format. Two Queensland-based companies have high-pressure processing units that may be interested in trialling mango products.

7 Country snapshots

7.1 Pakistan

7.1.1 Sector overview

Mangoes are Pakistan's second-largest fruit crop, after citrus. In 2017 FAOSTAT recorded production at 1.69 million tonnes covering an area of 171,000 ha, with the country being one of the top five global producers. Mangoes are mostly consumed in the domestic market, with only 2% exported and none imported.

Market chain

Market chain participants include growers, pre-harvest contractors, wholesalers, exporters, processing centres and retailers (Figure 7.1). In addition to growers and wholesalers, a network of input suppliers for services inform contractors about forthcoming production. The pre-harvest contractors provide growers with a source of advance income. Pre-harvest contractors based in production areas can control orchard inputs and have first-hand knowledge of crop condition when dealing with wholesalers and export customers. Wholesalers take control of ripening and repacking fruit for retail customers. Approximately 80% of consumers buy mangos from traditional retailers.

Growers – many small, domestic-focused; some large, modern farms to meet international standards

Pre-harvest contractors – buy the crop at flowering stage and sell to wholesalers in the harvest season

Wholesalers – buy, repack and on-sell to retailers or others

Exporters – resourced to buy, wash, grade, repack and sell to foreign market customers

Retailers – traditional (80%) and modern pathways to consumers

Figure 7.1 Pakistan market chain summary

Source: author's analysis

Production

Punjab and Sindh provinces account for almost 95% of mango production, which now stands at 1.69 million tonnes (FAOSTAT 2017) (Figure 7.2). Increased plantings are noted in Khyber Pakhtoon Khawa area. Sindhri is the main variety (70% share) and has better post-harvest attributes, while Chaunsa and Malda have export potential.

The average yield is lower than other mango-producing countries of India, China and Mexico (Memon, 2013). Poor production-management practices and post-harvest losses due to farmers' lack of technical knowledge are major causes of this low yield.

Only a small area is GlobalGAP certified for export markets.

Production – 1.69 million tonnes/171,000 ha

Regions – Punjab (70%) Sindh (23%) Baluchistan, Khyber Pakhtoon Khawa

Season – May to September

Varieties – Sindhri, Chaunsa, Dusehri, Anwar Ratole, Late Ratole No. 12, Sonera, Began Pali, Langra, Malda, Fajri and Sensation

Figure 7.2 Pakistan production summary 2017

Source: author's analysis

Pricing

Prices have been increasing, although variations are caused by the number of product suppliers, quality and the supply and demand on any given day. Despite low exports, prices dipped in 2014 due to the EU threat of a ban, then spiked in 2015 with low production volumes caused by adverse weather. Export prices have increased from USD0.53/kg in 2014 to USD1.31/kg in 2017 (ITC Trade Map, 2019).

Trade

Despite producing a large quantity of mangoes, Pakistan exports less than 2% of its total production (approximately 34,700 tonnes in 2017), which has declined 64% in five years. Middle Eastern markets account for more than 60%, while trade to Europe is less than 20%. Returns are potentially higher from Europe, but are inhibited by a lack of traceability and GlobalGAP certification. There are no measurable imports of mangoes by Pakistan.

7.1.2 Research and development

Various public-sector institutions provide support services, including research, development, extension, market intelligence, market development and industry promotion. ACIAR has researched mango production and post-harvest handling under the Australia-Pakistan Agricultural Sector Linkage Program (ASLP).

Under ASLP (Phases I and II), ACIAR and partners reached the following milestones:

- pre-harvest research and development: improved model nursery infrastructure
- post-harvest research and development: documented ASLP best-practice protocols for high-quality mangoes
- sea and air freighting of Pakistani mangoes: established protocols to extend shelf life during sea freight
- market development
    - established UK, China and Malaysia market potential
    - trialled novel domestic market models (including community-level production and marketing of value-add products from unripe/fallen mangoes to reduce waste and improve livelihoods of rural women)
- capacity building and published material: trained 5000 supply chain workers in best practices (complementing USAID work on establishing commercially viable, international mango markets).

Research gaps and priorities

Production and varieties:

- understand and address the problem of mango sudden death syndrome
- understand and address the factors contributing to lower average yield in Pakistan than in other major mango-growing countries
- evaluate and introduce new varieties that could be used to extend Pakistan's mango season to better compete in international markets

Post-harvest, **quality, consumer demand:**

- understand and address the factors contributing to the current 40% post-harvest losses (e.g. packing injured and healthy fruits together, and general lack of quality standards)
- research shelf life of different varieties, especially to identify the most suitable varieties that can sustain HWT and other post-harvest treament options
- understand consumer preference for Pakistani mangoes in different markets to increase export of more varieties

7.2 The Philippines

7.2.1 Sector overview

Mango is the third-most important fruit crop in the Philippines after bananas and pineapples. Production has declined over recent years, with FAOSTAT recording 748,000 tonnes in 2017, down from 984,000 tonnes over a decade. Mangoes are mostly consumed in the domestic market and less than 5% are exported. In 2017 the Philippines exported 24,000 tonnes, of which 55% were sent to Hong Kong.

Market chain

Market chain participants include growers, sprayer-traders, wholesaler/consolidators, processors, exporters, wholesalers, retailers and consumers (Figure 7.3). Most (74%) of mango tree-owners in the country have less than a hectare of mango farm, while 6% have farms greater than five ha. Sprayer-traders are contract growers who produce mangoes on contracted farms. Wholesaler/consolidators are village-level traders who procure harvests from small farms and assemble these into larger volumes for sale to other wholesalers, processors, retailers or exporters in major centres. The processing sector involves many small-to-medium enterprises producing pulp, purees or dried mangoes and other fruit. Exporters procure mangoes through their buying stations in the growing regions and send them to export destinations.

Growers – small holders or commercial, owner or contract grower

Sprayer traders – operate multiple farms under contract

Wholesalers/consolidators – collect mangoes from growers and transfer to larger centres for on selling

Retailers – obtain mangoes from wholesalers for selling to consumers

Exporters – consolidate in production regions

Processors – multiple small-to-medium enterprises

Figure 7.3 The Philippines market chain summary
Source: author's analysis

Production

Mangoes are produced mostly in the Llocus/Luzon (50%), Mindanao/Davao and Visayas regions (Figure 7.4). Production is increasing in the Mindanao area to reduce the impact of typhoons more common along the Llocus coastal areas in the north. Official production recorded 748,957 tonnes in 2017, though this has declined due to typhoons and pest pressures (FAOSTAT, 2018). Carabao is the main variety grown commercially and harvested April to June.

Production – 748,957 tonnes/194,367 ha

Regions – Llocus, Mindanao, Davao and Luzon

Season – April to June

Varieties – Carabao (80%), Pico Katchamitha, Pahutan, Dubul, Binoboy and Se iorita

Figure 7.4 The Philippines production summary, 2017
Source: author's analysis

Pricing

The monthly wholesale prices of mango in Manila from 2010 to 2014 had considerable seasonal impact on price, influenced by the peak supply periods. Grade one wholesale

prices can be as high as PHP40/kg (USD0.95/kg) though lower-quality mangoes in the season are difficult to sell at PHP5/kg (USD0.10/kg).

Trade

The Philippines is a net large exporter of fruit, dominated by bananas. Mango exports average around 25,000 tonnes, with Hong Kong the leading destination, although the Philippines has access to many countries, including Australia. Exports peaked at 30,000 tonnes in 2014 and have settled to pre-2014 levels since, due to the 2015 typhoons. Imports of mangoes by the Philippines are negligible, and unlikely to be fresh.

7.2.2 Research and development

Considering the enormous importance of mangoes to the Philippines, many R&D activities have been pursued to address the constraints plaguing the industry. Past R&D initiatives with productive outcomes have included pruning and bagging technologies, and improved pre-harvest disease management of anthracnose and stem-end rot. Post-harvest technologies, such as HWT, have been well adopted.

Major R&D programs/projects include:

- *Mango Comprehensive Technology Transfer Program* (1992–1995)
- *Enhancing Productivity of Filipino Mango Industry* (1997–1999)
- *Mango Information Network and Farmers' Information and Technology Services* (FITS) (1997)
- *Molecular marker techniques for mango* (1996–1999)
- *Integrated fruit fly management in Guimaras Island* (1999–2002).

Research gaps and priorities

Pest management:

- integrated pest management should consider the wide agro-climatic, pest dynamics and socioeconomic variability among production areas

Technology adoption:

- low level of technology adoption requires stakeholder engagement to strengthen research-extension linkages, and encourage the participation of farmers in the innovation process

Post-harvest:

- analyse the feasibility of established packhouses to evaluate their financial, organisational and market viability, and for food safety regulation, to ensure compliance for access to export markets

Domestic and processing markets:

- analyse and assess market layering, high transaction costs and information asymmetry to address inefficiencies at the expense of the growers
- assess the major drivers of competitiveness in mango processing

Export market:

- investigate and commercialise the use of controlled atmosphere for long-distance transport
- breed, evaluate and introduce mango varieties with longer shelf life (and other market-preferred characteristics)

7.3 Cambodia

7.3.1 Sector overview

Mangoes are Cambodia's second-largest fruit crop, which increased from 35,000 tonnes in 2001 to around 68,000 tonnes in 2017 (FAOSTAT, 2018). The main production areas are in the south, with two harvest seasons (March/April and October/November). Cambodia is a small though increasing player in the global mango trade and exported some 24,000 tonnes in 2017. Almost all the recorded export trade was to Thailand, which has increased from below 100 tonnes in 2015. Cambodia also exports to Vietnam, but this is not officially recorded.

Market chains

Market chain participants include growers, wholesalers, collectors, middlemen, farm contractors, local retailers, exporters (Thai and Vietnamese traders) and consumers (Figure 7.5). Most farmers only focus on production, and leave the harvesting and marketing to collectors and subsequent actors in the market chain, though larger wholesalers collect fruit directly. The two largest wholesale markets are in Phom Phen, which is the largest assembly point for vegetables and fruits in Cambodia. Mangoes destined for export to Vietnam and Thailand are taken to wholesale markets in Ho Chi Minh City and two wholesale markets in Bangkok, where further grading is undertaken.

Growers – focus on production

Collectors – assemble from local growers and take to wholesale markets

Wholesalers – mostly based in Phnom Penh (Neak Meas for larger wet markets and retailers, Deum Kor for smaller wet markers)

Retailers – larger retailers, mostly supplied from Neak Meas market

Exporters – mostly Thai and Vietnamese traders source product from wholesale markets to Bangkok or Ho Chi Min City for re-export

Figure 7.5 Cambodia market chain summary

Source: author's analysis

Production

Production is mostly in southern and northwest Cambodia. Industry statistics record up to 65,251 ha planted in 2015 though FAOSTAT data records 4,874 ha, indicating enormous production growth as trees mature that may not be recorded (FAOSTAT, 2018; Heam, 2015) (Figure 7.6).

Keo Romeat, which can be consumed both green and ripe, dominates the planted area and production. Keo Chen is the most aromatic and expensive mango variety, and is reknowned for its eating quality.

Production – estimated up to 68,671 tonnes/4,874 ha though internal reports suggest 65,251 ha

Regions – southern Cambodia/Kampong Speu province (77%), northwestern Cambodia (12%)

Seasons – March/April and October/November

Varieties – Keo Romeat (90%) and Keo Chen; others include Prum Sen, Kh'tis, Kh'tis Dangkhteng, Keo Pong Morn, Kbai Damrei and Keo Lamut

Figure 7.6 Cambodia production summary, 2017

Source: author's analysis

Pricing

At a wholesale level, Keo Romeat mango is sold in three different grades at Neak Meas market in Phnom Penh. Prices ranged from USD0.13–0.60/kg for grade 1, USD0.03–0.38/kg for grade 2, and USD0.03–0.18/kg for grade 3.

Trade

Although Cambodian mangoes have been observed in many markets throughout Asia and as far as Europe, almost all mangoes are exported to Thailand or Vietnam for re-export. In 2018, 23,711 tonnes were recorded by Thailand as imported from Cambodia at USD0.11/kg, and 187 tonnes by France at USD4.87/kg. Unofficial estimates put exports around 135,000 tonnes, including Vietnam, which would have implications for the accuracy of production data. Small volumes of mangoes are supplied from Thailand in June to August.

7.3.2 Research and development

Two ACIAR mango projects have been completed in Cambodia since 2012:

- *Building a resilient mango industry in Cambodia and Australia through improved production and supply chain practices (2013–2017)* – to build fruit research capacity through a systems approach to improve production practices and quality out-turn of mangoes in selected markets.
- *Assessing mango production and supply chain practices and research, development and extension capacities in Cambodia (2012–2013)* – an SRA aimed to better understand the growth trends in the industry, the major on-farm production issues, constraints and specific problems in the supply chain and issues for future research.

Research gaps and priorities

Export development:

- take exporting back into hands of Cambodians, rather than Thailand and Vietnam traders, by helping Cambodian exporters understand and address market-access barriers and potential export supply chains

Varieties:

- document the performance characteristics of all varieties in Cambodia
- obtain data on the varieties released by the Cambodian Agricultural Research and Development Institute

Agronomic practices:

- improve sustainable mango yields by improving plant health, understanding soil nutrients and better managing agricultural soils

Pest and disease management:

- reduce reliance on pesticides

Supply chain:

- maximise fruit quality and minimise losses by understanding the key constraints for on and off-season production and for green and ripe fruit

7.4 Vietnam

7.4.1 Sector overview

Mango is the second-most important fruit crop in Vietnam, with a total producing area of 76,711 ha and production of 744,425 tonnes in 2017. Mango cultivation in Vietnam is mostly done by smallholder farmers, typically with farm sizes of 0.5–0.6 ha and with high cost and fluctuation in price. Approximately 45% of growers sell from the farm gate and 44% take their crop to traders. Exports account for 6% of production, of which 60% is imported by the UAE.

Market chain

Market chain participants include growers, collectors, wholesalers, cooperatives, companies, retailers and consumers (Figure 7.7). Key market channels range from farmers straight to consumers through to a range of alliances of collectors, wholesalers, exporters, retailers and processors. A common market chain in local areas involves collectors purchasing mangoes at farm gates and then selling them to retailers. For more distant markets, the chain involves primary and secondary wholesalers before the fruit reaches the retailer. Post-harvest losses increase with the greater distance and number of linkages in the chain.

Growers – cultivate, harvest and sort for sale at farm gate or to traders

Collectors – small traders who buy from growers and sell to wholesalers

Wholesalers – (primary) mostly small businesses in producing areas buy from collectors or growers and sell to secondary wholesalers in consumer markets

Retailers – buy from wholesalers (secondary) and sell to consumers, often in large cities

Figure 7.7 Vietnam market chain summary
Source: author's analysis

Production

Mangoes are grown in four main areas, the largest being the Mekong Delta (Figure 7.8). Mango production increased from 380,900 tonnes in 2005 to 744,000 tonnes in 2017 (FAOSTAT, 2017). However, the area planted decreased slightly from 87,600 ha in 2009 to 76,711 ha recorded in 2017. The Mekong Delta region has implemented technical and development strategies resulting in higher yields than other regions, where severe weather conditions, cultural practices and soil nutrition reduced yields. Cat Hoa Loc is recognised as the best mango variety because of its taste, aroma, sweetness, quality and good appearance.

Production – 744,425 tonnes/76,711 ha

Regions – Mekong Delta (60%) south east, north central, and central coastal

Seasons – April to June and August to October

Varieties – Cat Hoa Loc, Cat Chu and Ghep (Buoi)

Figure 7.8 Vietnam production summary, 2017
Source: author's analysis

Pricing

Price varies depending on grade and variety. The highest price observed in a region is around VND3,000–5,000/kg (USD0.13–0.21/kg) for grade one Cat Hoa Loc mango. Retail market prices may range from VND10,000–65,000/kg (USD0.43–2.77/kg). Prices are typically at the low end during the peak production period of May to June.

Trade

Although China is recorded as the main export destination, the data are conflicted, as the total volume and value recorded as exported to China is greater than the total production. Based on customer data for imports from Vietnam, UAE is the largest export destination, with exports to more than 10 countries, albeit small volumes, with 60% share of 5,665 tonnes. Despite the production volume, Vietnam is a net importer of mangoes and records imports from Thailand and Cambodia. Cross-border trade is porous and much is not officially recorded.

7.4.2 Research and development

Mango-related projects have been implemented in Vietnam by research institutions, international organisations and donor agencies. Key outcomes include disseminating findings and results to mango growers, extension officers and other stakeholders through scientific publications, research presentations and reports, and extension courses.

In the Mekong Delta, the south-east and the central highland regions, thousands of mango industry stakeholders have been trained in farm management, cultivating, harvesting and post-harvesting technologies. Recently, mango rootstocks resistant to saline soil have also been released.

Projects include:

- *Value chain analysis for sustainable and profitable farming systems on the south-central coast* (2009–2012).
- *Integrated control of mango insect pests using weaver ants as a key element* (2001–2005).
- *Improvement of export and domestic markets for Vietnamese fruit through improved post-harvest and supply chain management* (2005–2008).
- *Improving the performance of the fruit industry in Tien Giang and Tra Vinh Provinces* (2001–2003).
- *Business engagement in smallholder agricultural: Developing mango sector in Dong Thap province.*

Research gaps and priorities

Production:

- establish more farmer cooperatives to increase the scale of production

Post-harvest handling:

- improve post-harvest techniques to reduce losses and extend fruit life with new post-harvest technologies

Domestic and export markets:

- identify methods to increase supply chain efficiency, and improve market prices and farm-gate return

7.5 Indonesia

7.5.1 Sector overview

Mangoes are a priority fruit in Indonesia. Production increased from 1.09 million tonnes in 2001 to around 2.57 million tonnes in 2017 (FAOSTAT, 2018). Despite the growth, mangoes remain typically a smallholders' commodity, often with fewer than seven trees. Java island is the main production area. The main harvest period is October–November, although some areas harvest from May through to September. Almost all mangoes are consumed in the domestic market.

Market chain

Market chain participants include farmers, collectors, assembly traders and wholesalers, agro-inputs companies, exporters, processors, and retailers (Figure 7.9). Growers may be smallholders managing their own trees, or renters who manage thousands of trees owned by small holders. There are few large commercial managed plantations. Collectors and assembly traders assemble mangoes from farmers and send them to large, urban markets outside the district and province.

Mango marketing is dominated by traditional market channels to wet markets. Most mangoes from East Java are channelled to traditional retailers through primary and secondary wet-market wholesalers operating in large cities. Modern retailers, a smaller sector for mangoes, dictate to their suppliers with written contract. While achieving higher values, there are complex risks for growers being able to meet retail supply conditions. The few larger commercial plantations mostly serve the retailers.

Growers – grow or manage fruit production

Collectors and assembly traders – assemble mangoes from growers and send to markets

Wholesalers – channel fruit to traditional wet markets throughout the archipelago

Retailers sell only around 9% of the mango crop to consumers, and impose strict conditions on suppliers

Processors – basic, small volume, home-based serving local markets

Figure 7.9 Indonesia market chain summary

Source: author's analysis

Production

Production is mostly in east, central and west Java, and Nusa Tenggara Barat (Figure 7.10). Arumanis is the main variety and is well adapted to the local climate and well accepted by the domestic market, though not suited to export. Gedong is popular in both the domestic and export markets, and is promoted by the government, giving it a premium price. Pests and diseases are pressing issues for Indonesian mango farmers.

Production – estimated up to 2.5 million tonnes / 202,000 ha

Regions – East, Central and West Java, Nusa Tenggara Barat

Seasons – October/November and May to September

Varieties – Arumanis, Gedong, Manalagi and Podang; also Indramayu, Golek and Madu

Figure 7.10 Indonesia production summary, 2017

Source: author's analysis

Pricing

Mango prices vary by grade and supply conditions. Wholesale prices range from USD0.83/kg for grade 1 to USD0.66/kg for grade 2 and USD0.61/kg for grade 3. (Arumanis variety). Peak supply months (October/November) see a larger variation, with grade 3 mangoes more difficult to move at any price.

Trade

Indonesia recorded 473 tonnes of mango exports in 2018, mostly to Singapore and the UAE. Exports have been as high as 1,500 tonnes in the past five years, though are negligible in the scale of production. There were no recorded imports in 2018, though small volumes have been occasionally imported in previous years.

7.5.2 Research and development

ACIAR and Department of Foreign Affairs and Trade mango projects implemented in Indonesia since 2008 are:

- *Management of fruit quality and pest infestation on mango and mangosteen to meet technical market-access requirements* (2008–2014) – focused on improving the international competitiveness of Indonesia's mango and mangosteen industries.
- *Eastern Indonesia agribusiness development opportunities* (2012–2013) – aimed to inform value chain upgrading interventions.
- *Australia–Indonesia Partnership for Promoting Rural Income through Support for Markets in Agriculture* (2010–2017) – partnered with Syngenta to introduce plant growth regulator technology for early flowering.
- *Indonesian Government sponsored project* (2014–2019) – underway to distribute seedlings, the promotion of good agricultural practices, pest and disease management, farm management and research on post-harvest treatment for off-season mangoes in west Java.

Research gaps and priorities

Production:

- fine-tune farm-management technologies to help small farmers adopt them

Post-harvest:

- help small-scale enterprises adopt technologies to improve post-harvest out-turns

Domestic market:

- characterise the domestic market demand
- better match market expectations with key cultivars' characteristics

Export market:

- evaluate and introduce effective technologies for distant markets

Processing:

- characterise, identify and assess key bottlenecks that inhibit mango-processing development
- understand potential impacts on the rural economy

7.6 Fiji

7.6.1 Sector overview

Mangoes are a popular fruit in Fiji. There are believed to be some 17,000 smallholder farms, although FAOSTAT records just 275 tonnes, suggesting considerable production is not recorded (FAOSTAT, 2018). The domestic mango market is dominated by informal mango trade (roadside stalls) and traditional market channels. Exports are almost all to New Zealand and range between 20 and 45 tonnes per year.

Market chain

Market chain participants include growers, pickers, wholesalers, retailers (market and roadside vendors), processors and consumers (Figure 7.11). Informal channels involve daily picking in small quantities to sell to travelling consumers on streetside stalls. Some farmers form groups and take small quantities to wholesale and retail markets in urban areas. The most common formal channel involves the sale of mangoes from farmer to a wholesaler, to urban market centres for domestic retail sale, export or sale to the tourism sector. Wholesalers arrange to pick the fruit and thus have greater control over the quality of fruit reaching the urban markets. Around 360 tonnes per year is supplied to the processing sector for pulp production.

Growers – focus on growing and may sell direct on roadside stalls

Wholesalers – collect mangoes from growers and transfer to larger centres for on-selling

Retailers – obtain mangoes from wholesalers for selling to consumers

Exporters – some 12 active exporters supply mangoes to New Zealand

Processors – Agrana Foods is the main processor and obtains mangoes for wholesalers for pulp production

Figure 7.11 Fiji market chain summary
Source: author's analysis

Production

Fiji has some 17,000 farms, each with an average of four mango trees (Figure 7.12). The three major mango production provinces are Ba, Ra and Macuata. Official production records show that production increased to 275 tonnes by 2017, although a calculated yield from 17,000 farms of four trees at 60–100 kg/tree would generate 4000–6000 tonnes. Kensington, Mapulehu and Tommy Atkins are the main varieties grown.

Production – 275 tonnes/25 ha, internal reports suggest 68,000 trees, yield <4,000 tonnes

Regions – Ba, Ra and Macuata

Season – August to March

Varieties – Kensington, Mapulehu, Tommy Atkins, Edward and Mexican Kent

Figure 7.12 Fiji production summary, 2017
Source: author's analysis

Pricing

Prices vary significantly depending on the supply chain, season and quality. Smallholder farmers can generate around FJD800/tonne (USD0.37/kg), although a price of FJD10 per

30-kg bag (USD0.16/kg) was noted. At a retail level, price per kilogram varied between USD2.75/kg in January to USD2.25/kg in the 2014 season (MOA, 2014). With a lack of provision and initiative to improve post-harvest handling practices, the duration of fresh mangoes in the market is very limited. The price is volatile during the early and late season, compounded by effects of natural disasters such as floods and cyclones.

Trade

Exports range between 20 and 45 tonnes, mostly to New Zealand. Market-access trading protocols, economies of scale, poor quality, inconsistent supply, lack of data and market information have contributed to loss of potential export markets. There are no recorded imports of mangoes by Fiji.

7.6.2 Research and development

Current research and development programs are targeting exports and are supported mainly by the Australian and New Zealand funded Pacific Horticultural and Agricultural Market Access, and European-funded Increasing Agricultural Commodity Trade:

- *Pacific Tropical Fruit Project* – aims to enhance and diversify horticultural production for domestic and export market opportunities, supporting efforts to improve national food security as part of a wider non-communicable disease remediation strategy.

Research gaps and priorities

Technology and extension:

- invest in mango research and extension projects to empower farmers with the technologies and skills required to boost productivity

Data collection and monitoring:

- establish agricultural data collection and monitoring practices to address incomplete, ambiguous data

Organising growers:

- create grassroot structures, such as farmer cooperatives, to deliver better quality product to exporters (and domestic markets) and strengthen Fiji's competitive position

Characterising existing tree qualities:

- characterise growth habit and fruit quality, including post-harvest properties, of available varieties to target different markets

Mango processing:

- evaluate options to use unmarketable surplus of fruit in the high season and so grow and diversify the industry

7.7 Australia

7.7.1 Sector overview

Mango production in Australia increased from 37,000 tonnes in 2001 to around 50,000 tonnes in 2017. The main production areas are in Queensland and increasingly the Northern Territory during the period from September to March. Australia is a small player in the global mango trade and exported 8,554 tonnes (22% of production) in 2017. Most of Australia's mangoes are consumed in the domestic retail market.

Market chains

Market chain participants include growers, wholesalers, processors and exporters (Figure 7.13). The largest producers are Perfection Fresh, Pinata Farms and Manbulloo. Perfection have exclusive marketing rights to the Calypso mango variety, while Pinata have the exclusive rights to the Honey Gold variety. The majority of mango growers work their own farms themselves without additional labour.

Wholesalers are based in each of the capital cities and act as a point of sale between growers and retailers, and may service the retailers with ripening facilities. The larger growers are more likely to deal directly with retailers. Most mangos for the retail trade (91.6%) are transported to major supermarket chains, such as Woolworths, Coles, Aldi and IGA. Supermarkets obtain the mangoes via contractual arrangements with wholesalers, sales and marketing agents, or direct from the larger producers. Most fruit is transported in a mature but unripened state, then ripened using ethylene at dedicated fruit ripening facilities usually located close to the central markets in each state.

The processing sector takes between 10–15% of the total production. Large processors, including Tropico Fruits and Queensland Fruit Processors, and a range of small processors are usually located close to major growing regions or central markets. Approximately 20 businesses are currently registered to export mangoes from Australia.

Growers – 53% of production from individual grower farms, 3 large producers

Wholesalers – mostly based in capital cities – conduit between growers and retailers

Processing – account for 10–15% of total production

Exporters – account for around 20% of production

Figure 7.13 Australia market chain summary
Source: author's analysis

Production

Production is mostly in Queensland and the Northern Territory (Figure 7.14). Industry statistics record that 59% of trees were fruit bearing, indicating that strong production growth is expected as the remaining trees reach production maturity. Calypso and Honey Gold varieties are grown and packed under licence and have a distinctive, rich, yellow flesh, higher yields and less post-harvest disorders than traditional varieties, such as Kensington Pride.

Production – estimated up to 50,000 tonnes / 12,000 ha with 59% fruit bearing in 2017/18

Regions – Queensland 47%, Northern Territory 48%, other 5%

Season – September to March

Varieties – Kensington, Calypso, R2E2, Honey Gold and Keitt

Figure 7.14 Australia production summary, 2017
Source: author's analysis

Pricing

Wholesale prices of mangos are driven predominantly by supply, quality and variety. Early season prices are traditionally higher and as supply builds prices decrease rapidly. In 2014–2015, the average wholesale price of all varieties was AUD3.49/kg, and ranged from AUD1.80–5.87/kg.

Trade

Exports have increased in recent years from 5,000 tonnes in 2013 to 8,554 tonnes in 2017, almost all to Asia and New Zealand. Hong Kong & China combined is the largest market, accounting for 40% share of export volumes. Australia imports a small volume (753 tonnes in 2018) of mangoes counter-seasonally from Mexico, Pakistan, Taiwan, Philippines and Vietnam.

7.7.2 Research and development

Australian growers pay levies, which are collected by the Australian Government and managed by Horticulture Innovation Australia. These levies are matched, dollar for dollar, by the Australian Government to fund research, development and extension activities. Research has focused on the following areas:

- pest and disease management – pests and diseases of biosecurity concern and disinfestation research for fruit fly
- crop management – floral initiation manipulation and canopy management.
- improving post-harvest management through the supply chain – through better control of temperature, ethylene and CO_2
- industry development and extension (e.g. new mango varieties and small trees study).

Research gaps and priorities

Production and varieties:

- new varieties, technologies and methods to deal with changes ranging from pest pressures to consumer preferences

Government extension:

- educating growers to adopt best practice for production through to post-harvest

8 Challenges and opportunities

8.1 Production and post-harvest

8.1.1 Transitioning to market-orientated production

Traditional mango-producing countries in the Asia–Pacific region share many challenges as their economies develop. They are making the transition from producing large volumes of low-quality, familiar traditional varieties for well-understood domestic markets (informal export markets usually across land borders) to supplying a differentiated range of potentially more profitable, demanding and regulated markets: both domestic and export.

This transition, from producing mangoes 'as we have always grown them' to supplying fruit as a business to meet market expectations can be a challenge. Growers and other supply chain stakeholders often may not fully understand the market expectations.

Australia is in a different position from its partners in the region, in that mango is a relatively recently developed industry. It supplies a high-value product to a domestic market that is almost as highly regulated and demanding (in terms of consumer expectations) as many export markets around the region. The greatest challenge faced by Australian mango growers (and other supply chain actors) is probably the high cost of labour, which places great emphasis on the value of innovations to reduce costs and increase profitability.

The priorities and interests of the Australian mango growers (and the broader industry) coincide most obviously with their counterparts in developing countries at the higher-value, export end of the market. Although they may actually be in competition, there are nonetheless opportunities for collaboration in research and development.

One shared challenge faced by traditional mango-producing countries is that although they have similar technical problems, their priorities for research and development differ considerably. These reflect different stages or pathways in the transition mentioned above. In both production and post-harvest phases, the transition implies the adoption of technological innovations that are similar across the region but must be adapted to suit local mango varieties and conditions (climatic, biological, social and economic).

Canopy management for smaller, more productive trees

The most basic transition in mango production is from growing large trees with low levels of management – sometimes effectively 'wild-harvesting' the mangoes from otherwise neglected trees growing along field margins or around dwellings – to establishing intentionally planted orchards of smaller, more intensively managed trees. The basic enabling technology involved is canopy management: essentially, vigorous pruning for reduced size and more efficient form.

Once growers understand and accept the basic conundrum that smaller trees can produce more fruit per unit area or unit investment of labour and other inputs, small trees offer many benefits:

- fertilisers, pesticides (for both pests and diseases) and other inputs are easier to apply and show greater returns
- measures such as flower induction and fruit bagging are easier to do and more effective
- fruit is easier and cheaper to pick
- fruit is of higher quality, because it is easier to choose the right stage of ripeness
- less risk of fruit damage.

Although the need for canopy management was only identified as such in the Vietnam country study, the problem of over-sized, under-productive trees is a shared problem across the Philippines, Indonesia, Vietnam, Cambodia, Myanmar and some parts of India and Pakistan.

In other tree fruits, smaller tree stature has been achieved both through plant breeding (especially the selection of 'dwarfing roots stocks') and major changes in management of tree form (for instance, by trellising or hedging). This has led to transformative change in the respective industries. For mango, such innovations have only been developed in Australia and partially commercialised. There would be scope for introducing such innovations in partner countries: especially those affected by cyclones, such as the Philippines, and where high-value markets would justify the additional investment involved.

8.1.2 Inappropriate use of agrochemicals

The incautious and inappropriate use of pesticides on mango is a challenge in all partner countries. As the value of the crop increases with the development of urban and export markets, growers often spray their trees with excessive quantities of chemicals in an attempt to save more of the crop. However, without proper diagnosis of pest and disease problems and an understanding of their effects (which may be trivial or cosmetic), such treatment is ineffective, especially on large, old trees. Factors that are not understood by most farmers include:

- different options for control (which may include non-chemical methods)
- the chemical's mode of action (e.g. fungicides vs insecticides, selective or broad-spectrum)
- the adverse effect of chemical 'cocktails' (mixtures of products with different modes of action).

As a result, most pest and disease problems are not cost-effectively controlled. They may even be exacerbated: for instance, broad-spectrum insecticides kill natural enemies and lead to secondary pest outbreaks.

Pesticides are typically applied without appropriate training in safe use of products, and without safety equipment or attention to pre-harvest intervals. This can lead to operator hazards and potential issues with residues and food safety. All partner countries have legislation intended to manage the registration and use of pesticides, but in most this is not kept up to date and is enforced weakly, or not at all. None of the partner countries report routine residue testing in domestic markets, though this will surely become more widespread as urban consumers become more prosperous, aware of food safety issues and correspondingly demanding.

In the countries bordering China (especially the Mekong countries), the importation and use of inexpensive, low-grade agrochemicals is a problem. These chemicals may not be properly labelled, or in a language understandable to users. They may not contain the declared level of active ingredient. And in some cases, they may be significantly adulterated with undesirable or ineffective products. More effective regulation, enforcement and education is needed to address these issues.

In Indonesia and the Philippines, some market arrangements involve mango traders purchasing the fruit from growers 'on the tree' early in the growing season. The traders take responsibility for management, including agrochemical application, rather than the orchard owner. Since the trader's priority is to maximise the profits, rather than sustainability, they are less likely to use integrated control methods and more likely to apply inappropriate pesticides.

Flower induction

Flower induction is an agrichemical-based technology that is gaining wider use in the region as a response to market opportunities.

As mango originates from a region with a monsoonal climate, natural flowering is strongly driven by the alternation of dry and wet seasons. This results in a short seasonal peak in fruiting, which may result in temporary oversupply of markets and falling prices. Flower induction can help to shift the flowering/fruiting cycle, so that some fruit is produced during shortages in a high-value domestic market (as for growers in the southern Philippines supplying the Manila market), or during specific export 'windows'.

In the simplest form of flowering induction, paclobutrazol is applied as a soil drench, stimulating flowering shortly afterwards. However, not all varieties respond well to this treatment. Repeated treatments can exhaust the trees, especially when applied by traders who may not share the orchard owner's interest in the trees' long-term health and productivity. In Australia, more sophisticated approaches have been trialled to reduce dependence on paclobutrazol. These combine management of nutrients, pruning and irrigation, and are being further tested in partner countries, such as Cambodia.

8.1.3 Post-harvest technologies

Poor harvesting practices lead to a suite of post-harvest quality problems that are pervasive in domestic markets in partner countries. In informal export markets, such as the cross-border trade from Cambodia to Vietnam, these practices lead to unnecessary deterioration in quality and post-harvest losses.

Such poor practices include:

- picking at inappropriate stages of ripeness and excessive fruit damage
- lack of grading, including damaged fruit with undamaged and different stages of ripeness
- packing in inappropriate containers (e.g. large wooden crates or baskets that fail to protect, or actively damage, the fruit)
- failure to de-sap the fruit (leading to latex burn).

The low-quality standards and expectations in these traditional markets establish norms along the supply chain that are hard to break as the industry evolves to supply more demanding urban and export markets. All partner countries are seeking to improve post-harvest practices, and addressing these issues does not require new research or technology. However, improved practices can be hard to introduce, especially where margins are low and where the management of the market chain fails to provide market feedback or incentives.

Ethylene issues and management

In the Philippines and some other Asian mango industries, carbide is used as an acetylene generator to stimulate colour change. Carbide is highly toxic and is often used incautiously in domestic or wet-market situations in partner countries, posing a threat to users and consumers. A new, non-toxic, ethylene generator from Australia (trade-marked 'Ripe Stuff'), is now being made available in developing countries and is currently under trial in the southern Philippines.

The management of ethylene in the environment of traded fruit is one example of a suite of technologies described as 'controlled atmosphere'. These technologies become increasingly important as supply chains to demanding urban and export markets become longer and more complex. Ethylene, nitrogen, carbon dioxide, and above all, temperature, can be managed to control ripening and deterioration processes in the supply chain, with dramatic effects on shelf life and fruit quality.

Partner countries differ widely in their capacity to establish and maintain temperature and atmosphere control along the market chain. Improving atmosphere control will involve substantial capital investment, running costs and new knowledge.

8.1.4 Mango varietal development

The availability of mango varieties appropriate for local growing conditions and acceptable in target markets represents a universal challenge, affecting various dimensions of production, post-harvest handling, processing and marketing.

From a production perspective, productivity (fruit yield) and resistance to locally prevalent pests and diseases are key characteristics. Consumer preferences determine varieties selected for their colour, taste and texture. Traders and vendors prefer fruit that is physically robust during transport (firm flesh, thick skin) and has a long shelf life. This has only gained importance as higher-value chains are developed to meet market demands.

Partner countries vary in the diversity of mango varieties that are traditionally grown and traded. In some countries, traditional varieties preferred in domestic markets diverge considerably in colour, size, taste and texture; they may, for instance, have green skin and be relatively small. In contrast, those demanded in the highest-value export markets, such as China, may have gold, red or red-blush colouring. Even though Australia has an active mango breeding program, a relatively small range of varieties are commercially grown and traded. This is perhaps because consumers are demanding and market chains are fine-tuned to varietal characteristics to optimise delivery of a high-quality product (preferred stage of ripeness, freedom from blemishes, maximum shelf life).

Growers will initially be unaware of the preferences of foreign consumers and the specific demands of export markets, so there is a challenge for buyers and traders to provide this feedback while building the export pathway. As export markets develop, different technical criteria for the acceptability of varieties become important. For instance, of Pakistan's two premium mango varieties, only one can satisfactorily withstand HWT, which is routinely conducted for export by sea to Europe and has a sufficiently long shelf life for supermarket sales. More generally, as long-distance trade develops to demanding markets in the Middle East, Europe, USA, Australia, New Zealand, Japan and Korea, varieties must be able to support biosecurity treatments (HWT, VHT or irradiation) without damage but still have a long shelf life.

Similar varieties may be required for premium export markets, such as Japan, Korea and China, potentially placing mango-exporting countries in the region in direct competition. In practice, however, the seasonal windows for exporting countries differ (mainly with latitude). This may provide scope for exchanging genetic resources around the region and developing new varieties that could be used by both Australia and its partners that lack breeding programs.

8.2 Export markets

Partner countries vary enormously in the relative importance of their domestic and export markets. Some of the largest-volume producers export a relatively small proportion of their crop, while some of the smaller producers export a much higher proportion. A corresponding divergence is seen in patterns of technology adoption. For example, most growers in Australia use comparatively sophisticated production and post-harvest technologies, while Cambodian smallholder farmers trading to Thailand have limited or no access to these technologies.

Traditionally, a high volume of undocumented or scarcely regulated trade has occurred across land borders in South-East Asia. More prosperous importing countries, such as Thailand – and, to some extent, Vietnam – are moving to regulate this trade in line with

international norms (see Section 8.3). This will pose challenges for both growers and traders and drive the adoption of improved technologies.

The rapidly growing and increasingly lucrative mango export trade with China poses similar challenges. In 1992, 13 border cities were approved as entry points, with profound implications for the regional trade in tropical fruits. Export duties were abolished, while tariffs and value-added tax on goods imported through these channels were significantly reduced. Well-organised market chains have developed to supply this trade, but despite its growing importance, data are not generally included in customs statistics.

Mangos traded across China's land borders are not subject to strict phytosanitary standards or controls, but the demands of Chinese consumers for unblemished fruit has led to an increase in fruit quality and related farming practices, such as fruit bagging.

8.3 Market access and biosecurity

Although internationally accepted norms for biosecurity practices do relate to trade in general, market access is based on bilateral negotiations between exporting and importing countries. These take into account the pests and diseases in both countries and the risk that any new species are perceived to pose to the importing country. Although some technical tools and principles are involved (e.g. pest lists and risk analysis), in practice, importing countries vary enormously in their perception of risks, the rigour of their demands and their approach to negotiations.

The numerous species of fruit fly in the Asia–Pacific region (which may or may not occur in importing countries in other regions) are the overriding biosecurity concern of partner countries and have been the focus of much ACIAR-funded research. This covers disinfestation procedures at the point of export (HWT, VHT, irradiation), as well as fruit fly management and monitoring in the production area.

In turn, fruit fly management and monitoring affects risk analysis and negotiation of protocols. The constant evolution in the policy environment surrounding biosecurity offers both challenges and opportunities. For instance, acceptance of irradiation as a disinfestation measure by New Zealand, Australia, USA, Indonesia and Malaysia may offer new opportunities for exporting countries that can adopt this suite of technologies.

Importing countries and their markets may have food safety-related regulations in addition to biosecurity protocols. Markets such as Japan, the USA, EU and Australia have very strict maximum residue limits for pesticides, and may also monitor biological contaminants, such as *Salmonella* bacteria, which can enter fruit market chains during washing or other handling procedures.

Production environments that involve the excessive, inappropriate and poorly regulated use of agrochemicals are typical of mango growing in many partner countries, and may pose a strong barrier to developing exports to these demanding markets. Meeting strict limits for chemical or biological contamination implies fundamental changes in knowledge, attitudes and practices among producers and actors along the market chain. It also implies the need for a regulatory infrastructure (including analytical laboratories) capable of monitoring and enforcement. Many partner countries will find this hard to provide.

8.4 Technology diffusion and adoption

The structure of the mango industry varies considerably across countries and different regions of the same country. The greater part of the traditional mango-growing industry in partner countries is characterised by low productivity and poor post-harvest handling. This results in high volumes but low quality and poor returns for growers and many other value chain actors. The research and development communities in most partner countries are aware of technological innovations that could improve performance, strengthen

economies and improve both rural and urban livelihoods. However, technology adoption and innovation is impeded by a range of country-specific, cross-cutting issues.

Where land and mango production is largely in the hands of rural smallholders and volumes of fruit are consolidated by traders, the sheer number of people involved in production presents its own challenges. Many of these people also have a relatively low level of literacy and limited access to information, capital and other resources. In this situation, the flow of information and technology may actually be impeded by the trader-consolidators, who often manage the trees themselves and have a vested interest in maintaining the *status quo*. The lack of transparency across the value chain transparency is a serious and pervasive impediment to innovation.

Where mango production is in the hands of larger land owners – who should be easier to reach, given their greater access to information, finance and other resources – there may be other barriers to innovation. Land owners may reside far from their farms, be satisfied with the *status quo* and gain most of their income from urban sources. As a result, they may have little interest in farm and agricultural value chain innovation.

As the investment in, and performance of, conventional agricultural extension services declines in most partner countries, agricultural input suppliers become an increasingly important source of information. Unfortunately, their main economic driver may be the sale of increased volumes of agrochemicals. This is unlikely to coincide with the best interests of sustainable production and industry development as a whole.

In theory, the best hope of introducing innovation and benefiting from mango industry development would be through reforming the value chain and strengthening producer organisations. This would allow such organisations to promote the flow of information and the adoption of well-targeted, innovative technologies, including information-related technologies. However, successful models of how this can best be achieved in practice are very few.

8.5 Fruit processing

The strongly seasonal nature of mango growth provides a potentially important role for food processing to reduce the surplus of fruit during peak production. Processing can make use of lower-quality fruit that do not meet ripe-eating quality requirements. Given the high seasonal variation of mango prices, smoothing supply by diverting low-end volumes into processing can prevent market saturation and price crashes. Creating value-added products such as juices, cakes, biscuits, pickles and chutneys offers opportunities for both improving rural livelihoods and developing niche export markets.

Mango-processing facilities vary considerably around the region. Some countries have highly formal, corporate, large-scale processing facilities capitalising on peak supply volumes to provide pulp to many major international brands. Conversely, small-scale, home or community-based processing is also evident in many rural areas.

The development of a profitable, competitive mango-processing industry is constrained by factors such as:

- seasonality of supply
- lack of product development and market expertise
- strong competition from within the region.

Although these constraints are complex, they are not insurmountable.

9 Conclusion and recommendations

9.1 Conclusion

This study aimed to better understand and identify strategic industry and market development issues, research gaps and opportunities for mango production: globally, regionally and within partner countries. It provides a longer-term perspective to inform ACIAR-funded mango research programs, which strive to improve the profitability and livelihoods of smallholder farming communities. This section draws together the study's main conclusions in four areas: production, trade, market access and processing.

Production

Mangoes are cultivated in more than 100 countries, most of which are frost-free, tropical and warmer subtropical climates. In 2017 global mango production exceeded an estimated 50 million tonnes. Of this, ACIAR partner countries recorded production of 5.9 million tonnes, accounting for 11.6% of global production.

Indonesia and Pakistan are recorded as the largest mango producers in the ACIAR study area, followed by the Philippines and Vietnam. Combined, these four countries account for more than 98% of the study area. Australia and Fiji make up the small remainder.

Trade

Global mango export trade has grown by around 2.4% per annum, with approximately 1.5 million tonnes of mangoes traded globally in 2017 valued at USD2.2 billion (excluding re-exports from the Netherlands). However, the total amount traded internationally makes up less than 3% of global production.

Mexico, Brazil and Peru are the leading exporters, and have sustained substantial growth driven by demand from Europe and the USA. Despite producing 11.6% of the world's mangos, ACIAR partner countries account for only 6.7% of global trade and have not been able to tap into the US and European markets.

Market access

Biosecurity concerns are the greatest constraint to export market access, even though the key quarantine pests identified by importing countries are relatively few.

Fruit flies are one of the primary pests. HWT and VHT are the most widely adopted measures for control, although treatment temperatures and times are inconsistent. Irradiation is increasingly being incorporated into import policy documents. However, adoption of this technology is slow due to facility establishment costs and concerns regarding consumer acceptance of irradiated product.

Internal pests, such as mango seed and pulp weevils and red-banded caterpillars, are not easily detected and can cause considerable crop loss. External pests, such as scales and mealybugs, are of secondary quarantine concern and are generally managed through orchard hygiene and quarantine inspection and remediation.

Processing

Of the wide variety of processed mangoes available on the market, high-quality, quick-frozen cheeks and cubes command the highest prices. However, these products require high-quality fruit that will compete with highest quality fresh fruit available during the season glut. Mango grading (most commonly undertaken by traders) allows optimal use of the supply, with top grade mango in highest demand for fresh and frozen products, and lower grades used for juices, jams, purees, confections and compounded products.

The issue of seasonality and the imperative for processors to maximise throughput rates reduces the value of the total mangoes grown and therefore farmers' return for effort. Standard techniques, such as partial processing of large volume supplies by freezing in bulk, can prevent spoilage. This allows longer use of the frozen product as the raw material base for many other products. Alternative processing techniques may be appropriate for countries where processing can increase farmers' return for effort. This could be extended to transport methods for fresh fruit to increase quality. The return for effort is important for the sustainability of the sector.

9.2 Recommendations

This study's recommendations cover a range of areas for further research and development in ACIAR partner countries and Australia, looking first at cross-sector priorities and then individual country needs. The list is not exhaustive, but highlights important areas for inclusion in a regional research agenda.

Sector research and development

Varieties

- There is a pressing need for a better match between the mango varieties available to growers and evolving market needs and opportunities. Emerging urban and export markets demand traits of colour, size, taste and texture that traditional varieties often do not satisfy. The logistics of supplying these markets may also require new varietal characteristics in terms of shelf life, robustness in handling and ability to withstand phytosanitary treatments (HWT, VHT or irradiation).
- Higher levels of pest and disease resistance would reduce the need for spraying and make it easier for producers to meet maximum residue limits.
- The need for better matched varieties could be met partly by exchange of existing genetic resources and partly by new breeding, for which Australia could serve as the hub. Such an effort would need to start with an analysis of needs and existing resources, as a basis for developing a strategy for germplasm exchange and breeding.

Production, post-harvest and extension studies

- Integrated orchard management needs to focus on adoptability by smallholder growers, and should include
    - canopy management
    - more effective diagnosis and management of pest and disease problems (with greatly reduced dependence on pesticides)
    - more effective management of irrigation water and fertilisers.
- Flower induction and seasonality must focus on reducing growers' dependence on incautious application of paclobutrazol, and instead help them to use chemical flower induction selectively, in combination with appropriate varieties and integrated orchard management practices.
- The growing Australian expertise in 'small tree' approaches to mango growing should be shared, especially with countries subject to cyclone damage, such as the Philippines.
- Novel approaches for cost-effective management of fruit flies, which are being researched in Australia, Indonesia and the Philippines, should be further developed and shared.

- With increasing demand for unblemished fruit, longer shelf life and longer supply chains in both urban and export markets, controlled atmosphere shipping methods need to be developed and fine-tuned for specific, market-preferred varieties. This could be combined with adaptive research and adoption work on standard good-harvest practices, such as de-sapping, grading and protective packaging.
- Underlying production and post-harvest problems and technical solutions have been identified in Australia and to some extent across the region. Further adaptive research is needed to
    - verify that technologies function under local conditions for different mango varieties, climate and soils
    - ascertain the viability for adoption by smallholders under local circumstances (social and economic constraints, perceptions of risk)
    - improve extension efforts to aid smallholders to adopt the most appropriate options.

  These steps may be most effectively combined in iterative cycles of 'participatory action research'. This typically demands building the capacity of agricultural research and extension services to work in this way with producers.
- Digital technologies can improve diffusion of information and adoption of production and post-harvest technologies with greater inclusiveness. Smallholders could use smart phones to correctly diagnose pest, disease and other crop production problems and select cost-effective solutions. Similar approaches could also improve the transparency and equity of value chain relationships.

Trade

- Accurate, detailed information about the context and nature of international demand patterns, mango quality and seasonality of supply is needed to help partner countries make effective trade decisions.
- Unregulated, cross-border trade in ACIAR partner countries needs to be quantified to assess the extent of informal product flows. This will improve traceability of the mango trade in international markets.

Processing

- The mango-processing sector represents an opportunity to counteract losses and boost economic benefits in all ACIAR partner countries and Australia.
- Research is needed into accessibility and uptake of processing technologies suitable for partner country conditions, taking into account mango volumes, value, varieties and seasonality.
- The issues related to mango processing in individual partner countries need to be evaluated and analysed to increase saleable mango products and ensure a viable processing industry.

Market access

- Joint research is needed with partner countries to document international mango trade standards. The information should be disseminated and accessible through a central hub to all stakeholders along supply chains to advocate best-practice pest and disease management, and facilitate successful export consignments.

Policy environment and value chain reform

- In several countries, existing supply chain management arrangements discourage the adoption of production and post-harvest innovations. Poor policy or weaknesses in the regulatory and enforcement environment for pesticides also contribute to the inappropriate use of pesticides. Evidence from some partner countries (e.g. Pakistan, Vietnam, the Philippines) shows that ACIAR-funded policy research can provide the basis for evidence-based advocacy and change in these areas. However, the deeply engrained attitudes and vested interests found in partner countries remain a major challenge.

Country-specific research and development

Pakistan

Production and varieties: Mango sudden death syndrome affects the industry on a vast scale, and the country's per hectare mango production is lower than in other mango-growing countries. New varieties are also needed to extend the season.

Post-harvest: Farmers need to mitigate post-harvest losses, which are reaching the 40% mark. As premium markets demand published research to meet market entry protocols, the suitability of different Pakistani mango varieties to withstand export treatments needs to be determined.

Consumer demand: Consumer preferences for Pakistani mango varieties need to be identified in two export markets to define varieties for production focus.

The Philippines

Production: The country's broad agro-climatic context means that pest and disease dynamics, socioeconomic variability, and geographic and season-specific integrated pest management studies need investigating. Appropriate technology transfer methods for best-practice mango production need to be developed, tested and piloted to improve technology adoption among smallholder farmers.

Post-harvest: Feasibility analysis is required to determine strategic site selection for packhouses. This joint research should capture and analyse financial, organisational and market viability for these facilities. A policy-based study on food safety regulation, with a focus on maximum residue limits, will help Filipino mango farmers understand and access export markets.

Export markets: The use of controlled atmosphere conditions for long-distance distribution of Philippine mangoes needs to be researched. This study should be coupled with conventional and molecular level breeding and selection projects to develop mango varieties with longer shelf life for export markets.

Mango processing: Understanding the major drivers and issues related to the processing sector would aid the development and competitiveness of processing opportunities in the Philippines. An assessment of vertical integration opportunities would help processors achieve viable contracts for mango supply from smallholder farmers.

Cambodia

Export development: Most mango trade occurs across land borders, and farmers and traders have limited understanding of export practices and destination market requirements. Production and post-harvest practices require research and capacity building programs to facilitate domestic and export trade opportunities.

Varieties: Information regarding the performance characteristics of Cambodian mango varieties needs to be collected, documented and made accessible to smallholder farmers and industry groups. Training programs will improve fruit tree nursery management standards, including hygiene, selection of high-performing clonal material and choice of varieties to build economic prospects.

Agronomic practices: Plant health decline needs to be minimised and soil nutrition improved, along with implementing management strategies to increase yields. Current crop manipulation practices need to be assessed against their impact on fruit pesticide residues and long-term plant health.

Pest and disease management: A detailed joint review of pest and disease management practices will capture a complete picture of pesticide usage. An informed understanding is required of the complete spectrum of insects and pathogens, as well as beneficial insects, bacteria and fungi. Pesticide spray guides, compatibility charts and spray application calibration posters (digital/online) are a priority. A comprehensive pest and disease chart for all varieties aligns with export market-access work mentioned in the earlier section of this report.

Supply chain: Potential points of intervention to maximise fruit quality and minimise losses along the supply chain need identifying. Understanding the differences in seasonal and varietal mango pricing to initiate a market information system would be beneficial.

Vietnam

Production: The potential viability of farmer cooperatives to increase the scale of production needs investigating. Pilot interventions could be used to study best-practice agriculture methods, including integrated crop management, fertiliser and soil management, irrigation, tree canopy management and mechanisation of orchard management.

Post-harvest handling: Post-harvest techniques and technologies need improving to reduce losses due to physical damage and extend fruit life. The feasibility of commercial cold storage facilities and logistics to improve conditions during grading, packing, storing and transport needs to be studied for both domestic and export distribution channels.

Mango processing: The challenges and opportunities that affect smallholder farmers and inhibit mango processing growth need evaluating. The processing sector should be characterised in terms of chilled, frozen, pulped and dried products.

Domestic and export markets: Methods are needed to reduce the length and increase the efficiency of supply chains to improve market prices and farm-gate returns. The farm-gate collection system in particular needs improving. Market requirements, seasonality and supply quantities of each variety also require study.

Indonesia

Production, post-harvest and farm technologies: Smallholder farmers need to embrace digital technology and build skill development to increase mango productivity in Indonesia. More understanding is needed of the characteristics and seasonality of Gedong Gincu and Arumanis, which are the preferred varieties and are growing in market share.

Domestic markets: The domestic market needs to be profiled and mapped by volume, value and seasonality of cultivars in each region. This will help production for each cultivar and inform future market development decision-making. The research should include a clear profile of consumer-purchasing behaviours and their responses to different flavours, fruit colours, sizes and seasonality of supply.

Mango processing: The issues and opportunities that affect the rural economy and inhibit advancements in processing require investigation. The Indonesian mango processing sector needs to be fully characterised.

Fiji

Technology and extension: Research and training will enable smallholder farmers to embrace modern technologies and build skills to boost productivity and manage post-harvest handling practices. This would include extension officer and industry 'champion' training programs for teacher-training-style accreditation.

Market monitoring: Real-time data and analysis will inform effective trade and policy decision-making. An agricultural data collection and monitoring system is needed.

Mango cooperative development: The opportunity to create grassroots structures and farming cooperatives to empower smallholder farmers to compete needs investigating. Establishing cooperatives would provide a framework for mango production through consistent grading and packing standards at centralised locations prior to transport for export.

Tree quality management: Tree growth habits, morphology and fruit quality linked to post-harvest properties need to be characterised. This will aid in seasonal supply to target markets and breeding decisions.

Mango processing: The prospects for mango processing to make use of unmarketable fruit in the high season need investigating. A phased approach to processing starting with small-scale juice and preserves would be suitable.

Australia

Research and extension: There is a declining trend in government extension services, with the gap being partially filled by industry and private service providers with limited resources. Research and extension training activities are still required. Sectors of the industry are still not implementing best practice, ranging from production through to post-harvest and supply chain.

Sector development: New varieties, new technologies and innovative pest and disease management methods are vital to sector growth. Studies are also needed into appropriate production sites, supply chains in northern Australia (NT and WA) and demand analysis for export markets. The results will inform and align with development activities in ACIAR partner countries.

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11 Appendix

Country studies

Insights from the following studies provided understandings of in-country perspectives. These documents have been supplied as individual appendices and are separate from this report.

11.1	Cambodia Study	Men Pagnchak-Roat and Lim Sophornthida
11.2	Fiji Study	Salesh Kumar and Hemalatha Palanivel
11.3	Indonesia Study	Teddy Kristedi
11.4	Pakistan Study	Sohail Ayyaz and Raheel Abbas
11.5	Philippines Study	Ernie Brown and John Oakshott
11.6	Vietnam Study	Nguyen Van Hoa