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2 Executive summary

Overview

The distinguishing features of this project are

- Its integrative focus on the whole value chain from farm to consumer
- Its multidisciplinary team whose research integrated across traditional boundaries between disciplines
- Its ability to work at all scales from poor smallholder farmers up to large corporate operations, in both domestic and export markets
- Its research for development involving rural village women

Notable achievements include

- Developing a complete 'best practice' manual from harvest to retail
- Protocols for quality improvement practices such as desapping, disease management, safe ripening, fruit fly management and temperature management
- Controlled atmosphere sea freight from Pakistan to the EU/UK at international best practice levels
- Export market development in the UK and China
- Innovative domestic marketing models for high quality mangoes
- Value-adding to waste and low grade mangoes by women in rural villages
- Capacity building of government and commercial partners, mango growers, academics, researchers and students.

Summary

In the second phase of the Australia-Pakistan Agriculture Sector Linkages Program (ASLP II) from 2010-2015, the project HORT/2010/001 Mango Value Chain Improvement, built on its ASLP Phase 1 (ASLP I) predecessor project, HORT/2005/157 Mango Supply Chain Improvement. In particular, it aimed to adopt a value chain approach to continuing the development and improvement of domestic and export mango value chains, focusing on (i) delivering better quality fruit to consumers (ii) developing and improving markets and (ii) demonstrating value chain principles, with capacity building and the delivery of pro-poor benefits a central tenet and enabler.

Research and development on mango quality improvement concentrated on disease management, ripening, and storage for long distance freight. To reduce disease impact, the project worked with fruit from selected orchards to carry out pathological studies, selection and registration of suitable fungicides, and postharvest handling protocols. To achieve the required colour and maturity levels for distant export markets, work focused on ripening and sea-freight handling protocols. The achievement of successful controlled atmosphere (CA) sea freight of mangoes over transit times of up to 30 days to EU/UK markets represents best practice by world standards and the systems and protocols developed and tested through this part of the project represent significant milestones for the Pakistan mango industry. These shipments demonstrated significant economic potential to increase export volumes as well as accessing higher value markets and market segments. More than 300 tonnes of Sindhri mangoes were exported from a group of 6-8 growers in Sindh province, Sindh Mango Growers and Exporters (SMGE) to the

UK/EU by CA sea freight using on-farm and postharvest systems developed by the project and implemented under the guidance and supervision of team members. These shipments generated export earnings of USD900,000 averaging 2.72 US dollars/kg compared with an industry average for exports of less than USD1.00/kg. Sea freight protocols were also developed for SB Chaunsa, the main variety of Punjab province, and successfully demonstrated to the mango industry through an on-farm static trial.

Research was undertaken in Malaysia, China and the UK to identify the market potential for Pakistan mangoes. Trial export consignments to China and Malaysia were prepared under the technical supervision of the project team, then monitored and results documented, with clear evidence of the potential of these markets for industry development. Consignments prepared using 'ASLP best practices' demonstrated higher quality, longer shelf life and less wastage than traditional export systems. In the UK market, a longer shelf life of 5-7 days as compared to 1-3 days using traditional systems, gave access to the higher value and much larger supermarket segment that previously had been closed to Pakistan mango exports. Research documented the benefits of exposing Pakistan mangoes to this much wider consumer base with potential to pay higher prices for better quality.

Similarly, trial shipments of ASLP best practice mangoes to China demonstrated the potential of this market, as well as creating demand for more consignments. Inconsistent supply was identified as an issue arising from there being no hot water treatment facility in Punjab province, where most of the favoured Chaunsa mango demanded by the Chinese market is produced. To address this issue the project worked with local exporters and the Department of Plant Protection, Pakistan, to upgrade existing packhouses for accreditation for exports to China. The process is under way and the accreditation of new hot water treatment plants in Punjab is expected to increase mango exports to China significantly.

Trial consignments to Malaysia in 2010 and 2011 involved consumer research at point of purchase. The attribute of Pakistan mangoes most preferred by Malaysian consumers was sweetness. A financial analysis comparing ASLP best practice with traditionally exported mangoes concluded that a 1900kg best practice consignment could save around 330 USD mainly due to the reduction of wastage. This can increase the profits of exporters by more than 10%.

Domestic market research in Sindh and Punjab revealed that adoption of ASLP best practices to harvest and market quality mangoes not only increased demand but also achieved higher prices. Growers realised 15-20% higher net returns than for traditionally produced and marketed mangoes. Furthermore, in ASLP best practice consignments wastage rates were 5-10% compared with industry averages of 20-50%. The project facilitated a group of 6-10 smallholder (1-5ha) mango growers in Multan to adopt improved practices and market best practice mangoes directly to consumers, selling more than 30 tonnes in 2015 for a gross return of more than USD20,000. This domestic marketing model demonstrated potential for smallholder growers to increase their gross income by more than 70% and net returns by more than 20%.

Mango value-added products were also a focus of the project. Following trials by project researchers at Sindh Agriculture University to evaluate potential products that could be produced at village level, poor women in two Sindh villages were trained and supported to produce and market mango pickles. Results were encouraging, raising the family incomes of these women by almost 50% during the 2-3 month mango season. In 2014, twelve women from the village Hot Khan Leghari produced more than 500 kg of mango pickles from low grade and waste fruit, generating USD 350 in income. In 2015 an additional second group of women at village Shah Alam Shah Ji Wasi also produced mango pickles using the same model. The two groups produced a net profit of USD 1060. Most importantly, these women state that they are confident

of their ability to carry on in the future without project support and have agreed to put 50% of their profits into a joint bank account in each village for start-up costs in 2016. These two pilot scale examples demonstrate that 1) waste mango such as green fallen fruit can be turned into products that are attractive to consumers and profitable for village level production; 2) village women have the ability and motivation to work together to make value added mango products with the support of their families and villages; and 3) value chain concepts provide an integrating framework for multi-disciplinary R&D teams as well as commercial activities at village level. The underlying model was to first identify market opportunities within the likely limitations of village level production, then consider processing requirements, and finally determine how a village can organise resources to produce and market its value-added products.

Over the 2010-2015 period, 1919 males and 146 females received hands-on training in the areas of postharvest skills, market research, producing value added mango products, adopting a value chain approach, and managing mango sea shipments. Results of project research and development have been documented, communicated to both private and public stakeholders in the mango industry, and disseminated through channels such as 12 published technical guides, 25 workshops, participation in national and international conferences and exhibitions, and publication of quarterly newsletters, quarterly reports and annual reports.

3 Background

Mangoes are one of Pakistan's more important fruit crops with an annual production of 1.65 million tonnes (3.8% of world production) and exports of around 5% of production valued at USD50 million from 86,000 tonnes in 2013-14 (Pakistan Ministry of Food Security and Research, 2015). Until 2008 at least, Pakistan received the lowest average price per kilogram (USD0.32) of any major mango exporting country in the world, largely due to the poor quality of its fruit combined with poor postharvest technologies and ineffective marketing practices. Notwithstanding, Pakistan mango varieties have great potential to satisfy consumers. They produce fruit which is sweet, smooth fleshed and thin skinned, and are locally adapted and productive.

The ASLP Phase 1 project, HORT/2005/157, targeted the postharvest, marketing, supply chain and capacity building elements of the Pakistan mango industry by working at demonstration level with all members of the supply chain, as well as R&D providers and government agencies. In Phase 1, mango postharvest practices and technologies were studied and introduced, demonstrating that by applying improved practices and technologies, and appropriately targeting markets that will pay for better quality mangoes, it was possible to achieve much higher out turns of quality fruit and improved returns. Consumers in international markets such as China as well as consumers in domestic high end markets responded positively to ASLP best practice mangos and were willing to pay for quality. At the same time, growers who had implemented the project's 'best practices' reduced their losses and received better returns.

A challenge facing the project is how to diffuse these best practices and technologies to the whole industry, particularly smallholders. A feature of the Pakistan mango industry is that 90% of mangoes are harvested by contractors, not by farmers themselves. Contractors, usually on behalf of commission agents, provide cash flow to farmers by buying the crop soon after fruit set. Contractors then take on the overall management of the crop. Under such arrangements, contractors are not motivated to manage for fruit quality because they are paid according to harvest volume and cost efficiency. This system uncouples farmers from market signals and provides them with little incentive to adopt improved management practices. The ASLP Phase 2 proposal that was developed, the subject of this Final report, aimed to assist the industry, particularly its smallholders, to address these challenges.

The mid-term review of the Phase 1 project highlighted a need for greater focus on smallholders and women in Phase 2. This conclusion was consistent with global thinking on poverty alleviation, as illustrated by findings from the Global Conference on Agricultural Research for Development (2010) which concluded 1) that there was a need to "develop a new agricultural research for development architecture that is geared toward reducing both hunger and poverty through innovative approaches far from business as usual", and 2) that "investing in gender is non-negotiable". It was the intention of the Phase 2 proposal to address both these challenges, in particular through a partnership with another project, HORT/2010/2003 (the Social Project), whose focus was on pro-poor value chains and developing more effective mechanisms for engagement with smallholders and women.

The specific focus of HORT/2010/001 was to continue to develop and improve domestic and export value chains, focusing on (i) delivering better quality fruit to consumers (ii) developing and improving markets and (ii) demonstrating value chain principles with capacity building and the delivery of pro-poor benefits a central tenet and enabler, as shown in the figure 1 below.

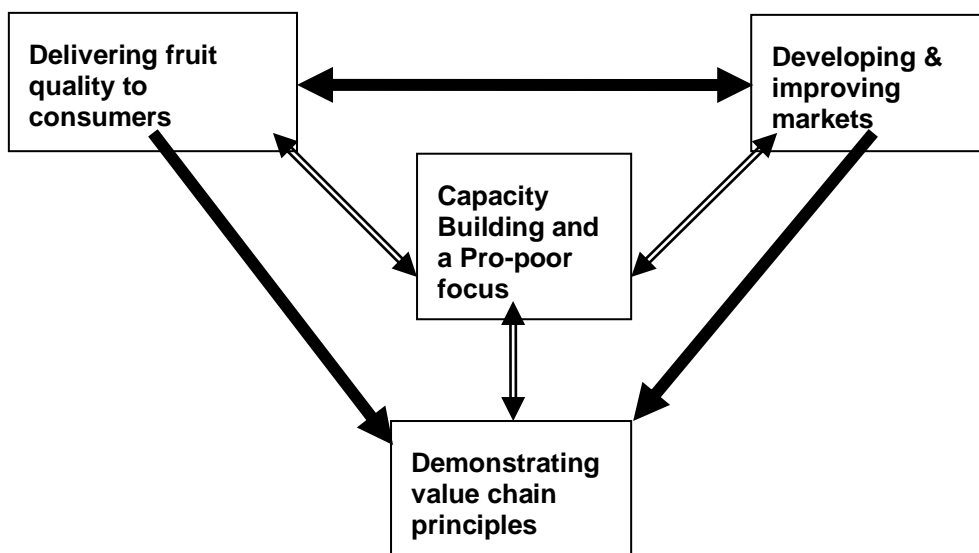


Figure 1: HORT/2010/001 Mango Value Chain Improvement Project Concept

From the perspective of the Australian mango industry, the Phase 2 project was supposed to deliver benefits on three fronts. Firstly it undertook preliminary investigations of irradiation as a market access technology, based on trials with Australian mangoes in Japan. Secondly, it provided to the Australian industry data on existing and new export markets being researched for Pakistan, such as China. This will inform the Australian industry’s efforts to develop its own export markets. Finally the project evaluated the benefits of adopting a value chain approach to improving competitiveness, and helped the Australian industry to interpret these results for its own benefit.

4 Objectives

Based on this model, the project originally had four objectives, each with associated activities as detailed below. A fifth objective was added in 2014 as part of a no-cost extension of the process to cover the 2015 mango harvest season. This objective focused on carrying out an on-project assessment of outcomes and impacts, and an examination of scaling-up and scaling-out issues.

HORT/2010/001 Objective 1 In collaboration with the pre-harvest component research team (HORT/2010/006), to improve mango quality and safety in domestic and export markets, using the results to inform market development, value chain improvement and capacity building activities.

Focus of activities: Improve sea freight performance; reduce fruit quality and food safety hazards, especially those associated with fruit ripening; improve market access; reduce the impacts of postharvest disease; improve the performance and use of postharvest infrastructure; reduce losses in markets; support training and certification activities associated with fruit quality and safety

HORT/2010/001 Objective 2 To improve the market opportunities for Pakistan mangoes, using the results to inform quality improvement, value chain development and capacity building activities.

Focus of activities: Increase access to improved quality mangoes by consumers in domestic and export markets; identify opportunities for value added products in domestic markets; improve the performance of existing, and establish new, value chains; identify collaborative marketing opportunities and communicate them to stakeholders.

HORT/2010/001 Objective 3 To work with a range of selected value chain participants, including smallholders, to create demonstration value chains for Pakistan mangoes.

Focus of activities: Continue to involve stakeholders from all parts of the value chain and identify options for enhancing engagement and pro-poor benefits; apply results from fruit quality improvement and market development activities using a value chain management framework; provide training and monitoring for all value chain building activities.

HORT/2010/001 Objective 4 To work with universities, government agencies, institutions and commercial stakeholders to develop the capacity of stakeholders at all levels in the chain, and implement improved pro-poor value chain management approaches and practices

Focus of activities: Ensure exemplars and demonstration activities are successful from a capacity building perspective; improve the skills, knowledge and practices of smallholder participants and actively foster opportunities for the poor and marginalised; increase the involvement of women in the mango industry; engage in co-planning and implementation of joint activities involving universities, agencies and commercial participants.

HORT/2010/001 Objective 5 To examine project performance across the above four objectives as a basis for providing strategic direction for future investments in mango industry development

Focus of activities: Conduct on-project assessments of outcomes and impacts with a focus on opportunities for scaling up and scaling out; validate findings with stakeholders and make recommendations for future similar investments in programs and projects that are value chain led.

5 Methodology

In keeping with its value chain conceptual framework, an integrated multi-disciplinary methodology has been adopted in this project. Integration is important because it ensures that research results from one discipline, postharvest science for example, are interpreted in the light of what is known from other disciplines, such as market research or social research involving women. Multi-disciplinarity ensures that the project research has sufficient breadth to cover all the major dimensions of the problem being studied. Both integration and multi-disciplinarity are necessary because value chain approaches are systems-based by definition, so research and development activities need to consider features of systems such as boundaries, emergent properties and governance and control. There is growing evidence of the adoption of value chain approaches in research associated with overseas development assistance programs (Collins et al., 2016). This project's approach incorporates research and development activities from production, postharvest, marketing, food processing (for mango value added products) and community development, each complementing the other and being undertaken through cooperation and collaboration involving researchers from different disciplines, as well as public and private sector stakeholders. Results from these activities are integrated to support the development of demonstration scale mango value chains that are responsive to local contexts and project needs.

Objective 1: In collaboration with the pre-harvest component research team, to improve and maintain the quality and safety of Pakistan mangoes at all stages from harvest to the consumer in both domestic and export markets

1. Sea freight improvement: building on knowledge from Phase 1, incorporate findings from postharvest disease research, disease status block accreditation system, and Sindhri skin colour development research into a sea freight system; apply and integrate these findings through commercial trials to Europe, and if successful, extend to China.
2. Reduction of fruit quality and food safety hazards: conduct ethylene ripening trials and develop ripening protocols; optimise management of ripening while minimising loss of shelf-life; provide input into the development of a HACCP based food safety system.
3. Reduce losses from harvest to the consumer: building on Phase 1 findings, monitor value chain performance and develop best practice systems; support infrastructure development activities of other projects and programs.
4. Support training and certification activities: apply research findings to the disease block accreditation system, HACCP based food safety system and best practice standards.
5. Collaboratively develop post-harvest disease management strategies: co-ordinate with the mango pre-harvest project to research and develop postharvest disease management strategies with an emphasis on capacity building in Pakistan; develop a postharvest disease management protocol for long-distance sea freight.

Objective 2: To continue the development of existing domestic markets and selected export markets, using the results to inform quality improvement, value chain development and capacity building activities

1. Increase access to improved quality mangoes by consumers in domestic and export markets: undertake domestic and export market research to identify development opportunities; apply findings from fruit quality research to handling, ripening and postharvest disease management; conduct research on the impact of irradiation on fruit quality in Australia and Pakistan and consumer research in Japan for market access to Japan by both Australia and Pakistan; identify new markets/market segments.
2. Identify opportunities for value added products in domestic markets: conduct small scale value added product development/verification, guided by a knowledge of women's interest, skills and capacity.
3. Improve the performance of existing, and establish new, value chains: building on Phase 1 achievements, consolidate existing value chains through workshops targeting commercial activities; identify opportunities for market development such as Malaysia and China; identify opportunities to link market research findings with smallholders and women.
4. Identify collaborative marketing opportunities and communicate them to stakeholders: undertake market research in domestic and targeted (existing and new) export markets; use research findings to develop through-chain strategies for stakeholders; communicate research findings to the Australian mango industry as appropriate.

Objective 3: To work with a range of selected value chain participants, including smallholders, to create demonstration examples of the benefits of collaborative value chain management approaches

1. Continue to involve stakeholders from all parts of the value chain: work with existing stakeholders in demonstration value chains; focus on increasing involvement of contractors and commission agents through demonstrations, forums and workshops; target opportunities for smallholders and women to become involved in commercial scale demonstration activities.
2. Apply results from fruit quality improvement and market development activities using a value chain management framework: integrate activities of stakeholders along all demonstration value chains through a focus on equitable, commercial outcomes for all stakeholders.
3. Provide training and monitoring for all value chain building activities: conduct beginning of season, through-season and post-season workshops for planning, on-going monitoring, evaluation and review; train agency stakeholders and selected commercial participants in value chain analysis through a "Walking the Chain" activity based on the Malaysian export market; develop appropriate training packages and modalities; extend lessons to the Australian mango industry as appropriate.

Objective 4: To work with universities, government agencies, institutions and commercial stakeholders to 1) improve the knowledge, resources and skills required to understand the value chain management approach to development, and 2) implement improved value chain management practices

1. Ensure exemplars and demonstration activities are successful from a capacity building perspective: adopt participatory approaches to planning and execution; monitor processes and outcomes for evidence of capacity building; provide ample opportunities for participant feedback; seek evidence of understanding of value chain principles and their practical application.
2. Improve the skills, knowledge and practices of smallholder participants: Working with the Social Project, identify one or two demonstration smallholder groups for targeted project activity; work closely with these groups with the objective of improving commercial returns through participation in demonstration value chains that adopt the project's research findings; develop appropriate training packages and modalities.
3. Increase the involvement of women in the mango industry: Working with the Social Project, identify target group(s) of women and work with them on value-added mango product development and if possible incorporate results into value chain opportunities (even if modest and very localised in scope); positively discriminate in favour of women on project team activities such as postharvest and market research; highlight the existing role of women in the project team at seminars and conferences.
4. Engage in co-planning and implementation of joint activities involving universities, agencies and commercial participants: adopt a multi-agency, multi-stakeholder approach to planning wherever it is possible and practical to do so; ensure that this approach is publicised to key figures in government, industry and academia.

Objective 5: To examine project performance across the above four objectives as a basis for providing strategic direction for future investments in mango industry development

1. Collate and analyse project performance data: gather data and conduct quantitative and qualitative analyses of net benefits from 'ASLP best practice' in objectives 1 to 4 above.
2. Collaboratively with stakeholders, interpret findings of the above analyses: interpret and validate findings with stakeholders, focusing on options for scaling up and scaling out the project's results.
3. Make recommendations for future strategic investments: focus on optimizing returns from value chain led development approaches; identify and document best practice case examples drawn from the project.
4. Identify how future investments can leverage existing programs: utilize resources, personnel, infrastructure and other opportunities associated with complementary programs such as other ACIAR and Australian government development projects, UNIDO, Punjab Supply Chain Improvement Project and USAID.

6 Achievements against activities and outputs/milestones

Objective 1: *In collaboration with the pre-harvest component research team, to improve and maintain the quality and safety of Pakistan mangoes at all stages from harvest to the consumer in both domestic and export markets*

no.	activity	outputs/ milestones	completion date	comments
1	Develop and refine sea freight protocols for commercial evaluation; conduct skin colour and postharvest disease trials;	Sea freight protocols established. Handling recommendations for Sindhri to improve skin colour development are established; main postharvest diseases identified and management protocols identified; low disease blocks accredited. Commercial trials conducted and evaluated	Y1-4 m5-9	<ul style="list-style-type: none"> • Protocols were developed for sea-freighting Sindhri mangoes to Europe and commercially tested and validated with Sindh Mango Growers and Exporters' (SMGE) sea-freight consignments to Europe during 2012, 2013, 2014 and 2015. • From 2012-15 the project has audited the mango processing and packhouses facilities of SMGE and provided technical assistance for sea shipments. • A sea freight protocol for S.B. Chaunsa variety was developed and an on-farm static trial was conducted in Multan for sea-freight of S.B. Chaunsa to UAE (Dubai) and similar distance markets. The protocol recommends gradual cooling of fruit to 12°C for 8-12 hrs followed by shipping to Dubai at 17°C and 80-85% RH. • Detailed orchard rating studies were conducted to identify low disease blocks of Sindhri, S.B. Chaunsa and Sufaid Chaunsa in Punjab. Orchard rating studies during 2011 involved 7 orchards both for Sindhri and S.B. Chaunsa. During 2012, 5 orchards were included from Sindh (ambient studies only), and 12 orchards from Punjab. S.B. Chaunsa studies included 19 orchards from Punjab. 2013 studies included 13 orchards for Sindhri and 19 orchards for S.B. Chaunsa. During 2014, for orchard rating studies on

				<p>mango Sufaid Chaunsa, fruit sampling was taken from 7 different orchards of Punjab.</p> <ul style="list-style-type: none"> • Detailed work was conducted at UAF to develop strategies for skin colour development for S.B. Chaunsa. The evaluated measures included temperature management, pre-cooling coupled with reefer and CA storage at higher storage temperature (17°C; 80-85%RH); and modified atmosphere packaging (MAP) studies. The studies so far show sea-shipping potential for S.B. Chaunsa to markets within 7 to 10 days sailing time if the fruit are initially precooled to 12°C for 8-12 hrs and then followed by shipping at 17°C. • The performance of harvested fruit from selected orchards of Punjab was studied under ambient (28±1°C; 60-65%RH) and low temperature storage (12±1°C; 80-85% RH) conditions. The findings showed the significant role of orchard practices on postharvest disease development. Orchard hygiene, plant protection measures, nutrition and environmental issues are the key to managing post-storage disease development. Orchards from different districts displayed significant differences in disease development at fruit ripe stage. • Studies were conducted on low temperature chilling injury alleviation in S.B. Chuansa. Two different chemicals (1mM spermine and 0.1mM methyl jasmonate) were tested for their efficacy over storage periods of 10, 20 and 30 days. The impact of immediate precooling (8°C and 12°C) coupled with MAP was compared with non-MAP with
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			<p>subsequent storage at 12°C and 17°C for different storage periods (10, 20, 30 days). Fruit dip treatment in 1mM spermine caused increased fruit skin discolouration while the fruit subjected to fumigation with 0.1mM methyl jasmonate showed no statistical difference in skin colour discoloration with untreated fruits (control). Both MAP bagged and non-bagged fruit precooled to 8°C had significantly higher fruit skin discoloration as compared with those subjected to precooling at 12°C.</p> <ul style="list-style-type: none"> • The impact of on-tree bagging was evaluated on postharvest cosmetic and internal fruit quality parameters of three major mango cultivars (Sindhri, S.B. Chaunsa and Sufaid Chaunsa). Results showed that on-tree fruit bagging can improve cosmetic quality by avoiding physical and insect associated skin defects and punctures - however the type of bagging material and phenological stage of bagging are very critical to achieving intended out-turns. • The effect of extended hot water treatment (HWT) (48°C for 60 minutes) on mango cultivars Anwar Ratole, Dusehri, Langra, Kala Chaunsa, Fajri and Late Ratole was studied with pre-treatment wet brushing at lab scale and commercial scale (Dusehri only). All varieties showed no HWT injury for the tested protocol. However, in the commercial trial it was noted that commercial wet brushing caused bruising to the fruit skin, which resulted in non-acceptable brown coloured skin blotches on the skin of Dusehri mangoes.
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1.2	Develop commercial ripening protocols; food safety research	Ethylene ripening protocols established. Assistance provided for developing food safety system and extended to industry	Y1-4 m5-9	<ul style="list-style-type: none"> • Ripening studies were conducted to establish the effects of gaseous ethylene and ripening conditions on fruit quality. Fruit were sourced from commercial mango orchards at proper maturity. Fruit quality characteristics were assessed at ripening. There was a significant difference in optimum ripening temperature for Sindhri (24°C) and Chaunsa (32°C) for best results. • Ripening protocols were established for Sindhri and S.B. Chaunsa. These protocols are being communicated to the industry in order to replace the traditional practice of using calcium carbide. • Chemical analysis of the contents of commercially available ripening gas releasing sachets was conducted at PCSIR laboratories, Lahore. Analysis revealed the sachet contents to be based on calcium carbide, a banned compound, however similar sachets containing ethephon could be an alternative option, still needing to be studied.
1.3	Reduce through-chain quality losses (see also activity 1 above); monitor value chain performance, establish best practice guidelines; link with infrastructure initiatives in other programs	Fruit quality parameters and chain losses documented. Best practices documented and incorporated into demonstration value chains. Opportunities taken to link with infrastructure projects	Y1-4 m5-9	<ul style="list-style-type: none"> • The impact of irradiation was studied on the fruit of three major mango cultivars with a focus on optimization of irradiation dose for commercial application and to study the effect of irradiation on quality and shelf life of locally produced mango cultivars. Mature fruits were harvested and treated with Gamma radiation of 250-1000Gy. Fruit quality assessment was carried out under ambient conditions (30±2°C; 50-60% RH) and after cold storage (11°C; 80-85% RH). A commercial dose of 400Gy was verified to be suitable to three tested varieties without

				<p>negative impacts, although bruising caused by wet brushing on the processing line resulted in brown coloured skin blotches after irradiation.</p> <ul style="list-style-type: none"> • ASLP best practices with reduced postharvest wastage were demonstrated during all domestic mango value chain improvement initiatives. • Based on orchard rating and postharvest studies, best practice guidelines have been developed. • Technical guidance was provided for establishment and accreditation of Punjab hot water treatment facilities for export. • New industry linkages were established with private sector operators Fauji Fresh n Freeze.
1.4	Postharvest disease management strategies and disease-based block accreditation system	Reduced postharvest losses particularly in relation to long distance sea freight. Postharvest disease expertise/capacity developed in Pakistan.	Y1-4 m5-9 Y1 m9, Y2 m6	<ul style="list-style-type: none"> • A range of potential fungicides (Nativo, Cabriotop and Scholar) were tested for controlling postharvest diseases. Encouraging results were obtained by the application of Nativo to control stem end rot. Scholar provided good control of postharvest diseases through pre-harvest application (20days before harvest). • Extensive pathological studies focused on isolation and identification of pathogens associated with postharvest diseases. Fungicide efficiency against these pathogens was also studied. • Validation trials for registration of Nativo as a postharvest fungicide were conducted in collaboration with Bayer CropScience. With the support and facilitation of this project, 'Nativo' and 'Rovral' have been registered in Pakistan as

				preharvest and postharvest fungicides for mango respectively.
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PC = partner country, A = Australia

Objective 2: *To continue the development of existing domestic markets and selected export markets, using the results to inform quality improvement, value chain development and capacity building activities*

no.	activity	outputs/ milestones	completion date	Comments
2.1	Domestic market research: Training of trainers in market research (Y1); conduct market research (Y1-2); monitor market performance (Y3-4)	Training module completed; market research completed in 4 domestic markets; monitoring in 4 domestic markets completed	Y1,2 m5-9 Y3,4 m5-9	<ul style="list-style-type: none"> • Training on mango market research was conducted at UAF in 2011. A total of 23 participants from academia, provincial agricultural extension and marketing departments, PHDEC and industry were trained. • In 2011, SAU conducted preliminary domestic market research in Karachi and the results were documented • In 2012, six project personnel (3 SAU & 3 UAF) were trained so that they could conduct domestic market research independently in Sindh and Punjab provinces. • Domestic market studies were conducted in 2012 in Karachi and Faisalabad to test market responses to ASLP best practice mango. Results were encouraging and were shared with industry during post-season workshops at Karachi, Sindh Agriculture University Tandojam and Multan. • An exclusive outlet approach was taken during 2013 in Multan for testing and promoting ASLP best practices mangoes, and was scaled up and tested at larger markets in Lahore. High quality mangoes were marketed through superstores Metro Cash & Carry and HyperStar. • An exclusive outlet approach for promoting ASLP best practice mangoes grown and managed by

				<p>smallholders was undertaken with the Kissan Foundation. In 2014 and 2015 more than 43 tonnes of ASLP best practice mangoes packed in attractive cartons were sold by this group of Multan smallholder growers. Direct marketing from their own stall, home delivery, and on-line ordering and payment formed the basis of their value chain model.</p> <ul style="list-style-type: none"> • Results of the above studies were analysed and shared with industry.
2.2	<p>Value added product development: Small scale value added product development; market evaluations</p>	<p>Product development and evaluations completed and documented; women involved</p>	<p>Y1-4 m5-9</p>	<ul style="list-style-type: none"> • Preliminary research on mango value added products was carried out during 2012. A study on raw mango slice development was conducted at the Institute of Food Sciences and Technology, Sindh Agriculture University (SAU), Tandojam. In this study raw mango slices were treated with different sugar as well as moisture contents. Results were shared with industry during post-season workshops. • A study on Shikarpur pickle value chains was conducted in 2013 to provide a baseline for pickle production by women in rural villages. • Out of 21 different value added products developed at SAU under the project, three products (pickles, dried mango slices and mango powder) were identified as having potential for village level production. • XThirty rural women were trained at SAU in preparation, packaging and marketing of these three products. • Follow-up research was conducted on factors affecting whether these women would apply their training to develop micro-businesses at village level. • Mango pickles were developed at commercial scale by women of

			<p>village Hot Khan Leghari (Sindh) and village Shah Alam Shah Ji Wasi (Sindh) under the training and supervision of ASLP team members at Sindh Agriculture University. Products were successfully marketed in 2014 and 2015.</p> <ul style="list-style-type: none"> • Market research and financial evaluations of the developed mango pickles chains were conducted. Results were documented and shared with industry.
2.3	<p>Improve market performance of value chains: conduct workshops with stakeholders; undertake marketing initiatives in China and Malaysia; link with smallholder and women project initiatives</p>	<p>Workshops held; market development in China and Malaysia undertaken, evaluated and documented; smallholders and women involved</p>	<ul style="list-style-type: none"> • Mango trial consignments were sent to China in 2010, 2011 and 2012, and Malaysia during 2011 and 2012. The consignments were monitored, evaluated and results documented. • The project facilitated the preparation of documents for stakeholders to have their processing and hot water treatment units accredited by the Chinese Quarantine and Inspection Authority (AQSIQ). The project also facilitated a meeting between Pakistan Department of Plant Protection and Chinese Quarantine authorities to move accreditation processes forward. • Out-turn assessments of sea-freight consignments from SMGE to EU/UK were conducted from 2012-15. Three SMGE members and three project team members from Pakistan were trained through participating in out-turn assessments in destination markets in the EU/UK. • Promotion of ASLP best practice mangoes in wholesale markets of Multan were conducted. Exclusive outlets were also established at two different locations in community residential areas of Multan.

				<ul style="list-style-type: none"> • Guidance and technical support was given to two upgraded hot water treatment plants (ZARPAK Horticultural, Shujabad and Lutfabad Mango Farm, Multan) for meeting Chinese accreditation requirements. After inspection by officers from the Department of Plant Protection (DPP), these two plants were registered with DPP. • With support from the project, DPP has sought administrative approval from their Ministry to invite AQSIQ officers from China to inspect and accredit these HWT facilities.
2.4	Continue market research and use findings to develop through chain strategies; preliminary exploration of irradiation technologies for market access; communicate results to Australian industry as appropriate	Research undertaken in new and existing markets; information available to Australian industry		<ul style="list-style-type: none"> • Extensive EU/UK market research was conducted and documented during 2011-2015 when ASLP best practice sea shipment mangoes were presented in EU/UK markets. • Market research was conducted in Malaysia and China in 2011 and in China in 2012. Results were shared with industry • Export protocols for the China market were developed in preparation for industry-wide commercial consignments to China. • Promotional materials (fibreboard boxes and brochures in English and Urdu languages on mango fruit quality and marketing) were developed and tested with mango consumers in local markets, and distributed to industry • Market research results from both domestic (Multan and Lahore) and export (UK) markets have been widely disseminated through industry workshops and other presentations.

PC = partner country, A = Australia

Objective 3: *To work with a range of selected value chain participants, including smallholders, to create demonstration examples of the benefits of collaborative value chain management approaches*

no.	activity	outputs/ milestones	completion date	comments
3.1	Engage stakeholders in value chain activities: Hold pre-season, on-going and post-season workshops; target commission agents, contractors, women and smallholders for greater involvement; monitor and evaluate performance	Workshops held and participants attended; involvement of commission agents, contractors, women and smallholders	Y1-4 m5-9	<ul style="list-style-type: none"> • The first national workshop on Mango Sea-freight Technology was held to take stock of the mango sea-freight situation and to draft measures to help boost Pakistan mango exports by sea. About 150 stakeholders from across the sector from Punjab and Sindh attended the workshop. • Each year from 2011 to 2015 the project conducted pre-season and post-season workshops in Sindh and Punjab to share project plans and results. Mango growers, exporters, commission agents, academics and government personnel attended these workshops. • In 2012 a seminar on Mango Exporting was held at Sindh Agriculture University, Tandojam. • A seminar held at UAF on 23 November, 2013 attracted 111 participants including 94 males and 17 females. • Three end-of-project workshops were conducted in Karachi, Multan and Islamabad to share project outputs and outcomes with a broad range of stakeholders from the mango industry. • Annual end of season meetings were held with SMGE to discuss the outcomes of mango sea freight and market development activities

				in the current season and opportunities for the coming season.
3.2	Apply research results to demonstration chains: Chains utilising postharvest and market research findings in commercial applications	Commercial outcomes that relate to creating and sharing greater value	Y1-4 m5-9	<ul style="list-style-type: none"> • The project facilitated 14 controlled atmosphere sea-freight consignments, each of 22 tonnes, to Europe/UK by SMGE between 2011 and 2015. The preparation and out-turn of all consignments was technically monitored by Australian and Pakistani team members. Growers, researchers, logistics companies, exporters and importers participated in the preparation and processing of these consignments. Outturn assessments were undertaken by team members plus grower representatives of SMGE. • One on-farm static trial of SB Chaunsa was conducted at Lutfabad Mango Farm to simulate sea shipment conditions and to demonstrate the relevant protocols for SB Chaunsa to be shipped by sea to Gulf countries. Mango growers, exporters, commission agents and researchers participated in this trial. • One trial consignment of White Chaunsa was sent to Malaysia under ASLP best practice protocols. A grower, preharvest contractor, exporter and importer in Kuala Lumpur participated in this trial. • Five trial consignments of White Chaunsa and SB Chaunsa were sent to China using ASLP export protocols developed by the project. These trials involved growers, a processor, exporters and an importer in China.
3.3	Training and monitoring for	Workshops held, value chain	Y1,3,4 m7-9	<ul style="list-style-type: none"> • Sea-freight training was carried out for two faculty members from Sindh

	value chain activity: (see also 3.1 above); conduct training in value chain analysis through Walking the Chain activity; develop training packages and modalities.	analysis training completed; packages developed	Y2 m7	<p>Agriculture University, a private extension expert from Sindh and 10 postgraduates and researchers from UAF.</p> <ul style="list-style-type: none"> • One 'Walking the Chain' activity was conducted by UAF in 2015. More than 40 Agribusiness and Horticulture undergraduate students were involved. Walking the Chain activities included field visits, packhouse/processing unit visits and retail and wholesale market visits. Students documented, analysed and reported on the characteristics and performance of the case study value chain. • A one-day seminar on "Integrated Value Chain Approaches to Delivering Quality Mangoes to Consumers" was conducted at UAF on 1st April, 2015. More than 100 participants from academia, industry and government organisations participated.

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Objective 4: *To work with universities, government agencies, institutions and commercial stakeholders to 1) improve the knowledge, resources and skills required to understand the value chain management approach to development, and 2) implement improved value chain management practices*

no.	activity	outputs/ milestones	completion date	Comments
4.1	Exemplars and demonstration activities as capacity building: Adopt participatory approaches to stakeholder involvement;	Approaches developed and applied; evaluations complete and documented	Y1-4 m5-9	<ul style="list-style-type: none"> • Introductory training on mango sea freight systems was conducted for Sindh Mango Growers and Exporters. Technical assistance to SMGE for CA sea freight consignments was provided. • Training was conducted for SMGE supervisory staff on post-harvest handling for sea shipments • The technical teams of SMGE were invited to participate in the

	<p>monitor and evaluate outcomes for understanding and commercial results</p>			<p>complete handling and management process during all sea-freight consignments from 2011 to 2015. Through this process the participants were trained to apply to their own businesses the sea freight systems and protocols developed by the project.</p> <ul style="list-style-type: none"> • A demonstration workshop on SB Chaunsa sea freight protocols was conducted in Punjab for 35 participants including growers, exporters and research personnel. • Three sea freight export supply chains were developed and all members in each chain were trained to adopt ASLP best practices.
4.2	<p>Improve skills, knowledge and practices of smallholders: Identify target group(s); develop appropriate training packages and modalities; engage in value chain development activities</p>	<p>Group(s) targeted; training delivered; results monitored and documented</p>	<p>Y1-4 m5-9</p>	<ul style="list-style-type: none"> • In 2013, three field workshops on Mango Quality Improvement were conducted in Sindh for smallholders. More than 100 smallholders, field workers and preharvest contractors were trained. • In 2014, four field workshops in Sindh and three in Punjab were conducted. More than 200 participants were given hands-on training in orchard management and postharvest operations within a value chain framework. • In collaboration with the UNIDO/TRTA-II Code of Practice project, on-farm training was given to growers and workers to improve harvesting and handling practices. Growers were also trained in developing and managing small-scale packhouses. • Ten smallholders were involved in domestic market promotion of ASLP best practice mangoes as part of participatory training on mango marketing.

				<ul style="list-style-type: none"> • Two day training of trainers (ToT) workshops were held at Sindh Agriculture University and Multan, attracting 52 men and 5 women for training from the Agricultural Extension and Research wings of Sindh Agriculture Department, teaching staff of SAU, and progressive mango growers. The workshop included in-house lectures, group discussions, exercises and field demonstrations on mango fruit quality, profitability comparisons, harvesting and handling. • One Export Coaching Program was held at Karachi for 30 participants from Government Departments, pre-shipment inspection companies and exporters.
4.3	<p>Increase involvement of women: Identify target group(s); develop appropriate training packages and modalities; engage in value chain development activities based on value-added mango products; involve women in project activities as researchers; promote role of women in project research team</p>	<p>Group(s) targeted; training delivered; results monitored and documented; women involved in project team as researchers</p>	Y1-4 m5-9	<ul style="list-style-type: none"> • A 12 day training program on mango value added products was conducted at Sindh Agriculture University, Tandojam for 30 poor women from Hot Leghari Village, which had been identified by the ASLP Social Project. • Training material was developed and distributed to the industry/trainers in Punjab and Sindh. • Two groups, each of 10-12 rural women, were trained in village level production and marketing of mango pickles. The Mango Value Chain Project worked with the ASLP Social Project to facilitate these activities. • The women members of the project team were given preferential opportunities to present at workshops and seminars whenever possible.

Objective 5: *To examine project performance across the above four objectives as a basis for providing strategic direction for future investments in mango industry development*

no.	activity	outputs/ milestones	completion date	Comments
5.1	Collate and analyse project performance data	gather data and conduct quantitative and qualitative analyses of net benefits from 'ASLP best practice' in objectives 1 to 4 above.	Y5 m1-9	<ul style="list-style-type: none"> Impact assessment training of 17 ASLP Pakistani researchers was completed in Islamabad in March 2015 by ex-ACIAR program manager Interview guide designed and tested (see Appendix) In-depth face to face interviews conducted with 33 stakeholders Data collated and analysed
5.2	Collaboratively with stakeholders, interpret findings of the above analyses	interpret and validate findings with stakeholders, focusing on options for scaling up and scaling out the project's results.	Y5 m1-9	<ul style="list-style-type: none"> Following analysis of data, results were member-checked with interviewees for validation and further interpretation
5.3	Make recommendations for future strategic investments	focus on optimizing returns from value chain led development approaches; identify and document best practice case examples drawn from the project.	Y5 m1-9	<ul style="list-style-type: none"> Both researchers and stakeholder interviewees contributed to making future recommendations. Best practice case examples were identified and documented. They were presented at end-of-project and ACIAR workshops, and the 2015 international mango conference in Darwin. A separate report has been submitted to ACIAR covering Objective 5. Recommendations from 5.3 are presented in section 8 of this report.
5.4	Identify how future investments can leverage existing programs	utilize resources, personnel, infrastructure and other opportunities	Y5 m1-9	<ul style="list-style-type: none"> As above, both researchers and stakeholder interviewees contributed to identifying leverage opportunities from other programs.

		associated with complementary programs such as other ACIAR and Australian government development projects, UNIDO, Punjab Supply Chain Improvement Project and USAID.		<ul style="list-style-type: none">• A separate report has been submitted to ACIAR covering Objective 5.• Recommendations from 5.4 are presented in section 8 of this report.
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7 Key results and discussion

The aim of HORT/2010/001 activities was to continue to develop and improve domestic and export value chains by

- (i) delivering better quality fruit to consumers
- (ii) developing and improving markets and
- (iii) demonstrating value chain principles
- (iv) with capacity building and delivering pro-poor benefits a central tenet and enabler

Based on this aim, the project had four objectives, each with associated activities for 2011 to 2015.

Objective 1: Improving mango quality

Mango quality is ultimately defined by the market and is affected by many factors along the chain from production, to postharvest handling, through to consumption. Research showed that the two most important quality issues in markets for Pakistan mangoes were variations in maturity and incidence of blemish. Phase 1 of the project developed detailed protocols for harvesting, maturity assessment and sap burn management. Phase 2 of the project focused on disease management in fruit, achieving desired fruit quality attributes, and safe ripening procedures. To reduce disease impact, the project monitored selected orchards, conducted disease identification and pathological studies, and established protocols for postharvest handling and fungicide treatments. Fruit colour, maturity and disease levels were a particular focus for research associated with CA sea freight.

Disease management research focused on four areas:

- In collaboration with the ASLP mango production team, orchard rating studies were conducted to establish the likelihood of using low disease orchards from which to source fruit for export by CA sea freight. Wide variations in disease profiles from orchard to orchard were measured, with some orchards having inherently low disease levels as a result of better management practices.
- To study the relationship between orchard management practices and disease development, fruit was harvested from selected orchards of Punjab and studied under ambient (28+1°C; 60-65%RH) and low temperature (12+1°C; 80-85% RH) storage conditions. Findings showed that orchard hygiene, plant protection measures and nutrition were the main management factors associated with postharvest disease development. There were also significant differences from district to district in terms of disease development at the fruit ripe stage.
- Studies were conducted to isolate and identify the main pathogens associated with postharvest diseases. Fruit were sampled from orchards in Sindh and Punjab province that were used for orchard rating studies. *Colletotrichum gloeosporioides* and *Botryodiplodia theobromae* were the two most prevalent pathogens isolated from both Sindhri and S.B. Chaunsa varieties. *Alternaria alternata*, *Phomopsis mangiferae* and *Aspergillus niger* were also isolated under storage conditions. These studies identified which organisms should be targeted by pre- and postharvest management strategies aimed at reducing disease impact.
- A range of disease control chemistry fungicides, some new to the market, were subjected to performance validation trials. Products included Nativo, Scholar, Cabrio Top, Amistar and Sportak. Among the tested fungicides, Nativo and Scholar were highly effective against stem end rot and *Alternaria* rot; Sportak, Amistar and Cabrio Top

against anthracnose; while Tecto was effective for *Alternaria* rot only. The commercial CA sea-freight trial shipments to UK showed Scholar and Amistar as highly effective broad-spectrum postharvest fungicide treatment options for disease control in mangoes. However, none of these fungicides are yet registered in Pakistan for postharvest treatment in mangoes. Hence, the postharvest fungicide registration remains a significant area in future R&D scope. Moreover, from food safety perspective (managing the risk of chemical residues), there is need to conduct R&D for identification and registration of effective fungicides for pre-harvest application also. Some preliminary work on preharvest application performance of these fungicides was conducted under ASLP mango value chain project; which needs to be validated and multiplied through further R&D and database.

To achieve the optimum combination of colour development and maturity levels for different markets, research focused on three areas:

- Ethylene based ripening protocols were established for the two main varieties. For Sindhri, the recommendation is 100ppm ethylene for 48hrs at 24°C, while S.B. Chaunsa requires ripening at higher temperatures of 32-35°C for proper colour development. These protocols were communicated to the industry along with information about the dangers of using the banned chemical calcium carbide for mango ripening.
- Whole-farm systems-based protocols for ensuring colour development and correct maturity levels in controlled atmosphere sea freighted Sindhri mangoes to Europe, were developed and commercially tested with SMGE members over the 2012-2015 seasons. These have been documented and communicated to industry.
- For S.B. Chaunsa mangoes, protocols to ensure correct colour development and maturity for shipment by sea to UAE (Dubai) and similar distance markets were developed at lab scale and tested commercially by an on-farm static trial. Results were demonstrated to industry at the completion of the static trial.

Following the banning of Indian mangoes in EU markets and threats to similarly ban Pakistan mangoes in the 2014 season, fruit fly management research was given immediate priority so that the project team could continue its development of CA sea freight protocols by incorporating fruit fly management strategies. A number of studies were conducted, assisted by Dr Francis De Lima, an Australian international expert in fruit fly management.

- Optimizing the irradiation dose level for commercial mango varieties and the effect of irradiation on quality and shelf life were studied.
- In season 2015, orchards in Sindh were monitored for fruit fly incidence and infestation levels, and samples taken for species identification. The efficacy of hot water treatment for fruit fly control across a range of different fruit sizes was evaluated.
- Systems-based protocols for managing fruit fly through a combination of trapping, baiting, field sprays, harvesting at hard green mature stage, and long term exposure to controlled atmospheres, were accepted by DPP for trialling by SMGE in 2016 so that hot water treatment was not required for sea freighted Sindhri mangoes. Mandatory HWT would eliminate the possibility of CA sea freight.

The combination of reduced disease impact, optimum colour development and maturity, and successful fruit fly management, has allowed demonstration-scale development of markets in the UK/EU. In doing so, internationally acceptable standards of quality, consumer acceptance, waste reduction, and financial returns have been achieved, as evidenced by retailer satisfaction, consumer acceptance, repeat orders, and grower willingness to continue collaboration. At this scale at least, there is confidence that the systems-based value chain approach and its

associated protocols can serve as a model for the whole Pakistan mango industry. Similar results have been achieved at laboratory and static trial scale to conclude that other markets such as the UAE could be developed in the same way.

Objective 2: Developing and improving domestic and selected export markets

Fresh mango marketing in export and domestic markets

In ASLP Phase One, export markets for Pakistan mango were examined, showing that the EU/UK, China and Malaysia had potential for development. Mapping those markets identified market access issues, marketing channels, importer requirements, consumer perceptions, quality requirements and likely returns. The performance of any existing Pakistan exports to these markets was also documented. The ASLP Phase Two project aimed to continue the development of these markets.

In Pakistan domestic markets, research in ASLP Phase One revealed that there were higher end market segments in which consumers sought, and were willing to pay a premium for, better quality mangoes. Although there were clear signals of this potential to improve returns to all members of the value chain, in particular to growers, current domestic mango marketing systems could not deliver high quality mangoes to these segments. The Phase Two project focused on finding innovative approaches to addressing this opportunity.

The results of market development research and development are described in more detail below.

1. **EU/UK markets:** The project's research in the UK market began in Phase One, but intensified when the first CA sea freight consignments of Pakistan mangoes were sent by SMGE to the UK. Monitoring of fruit from harvest in Pakistan to consumers in the UK involved real-time documentation of storage conditions, detailed quality assessments, studies of waste, and evaluating retailer and consumer response to the product. At the same time, results from air freighted Pakistan mangoes were used as a basis for comparison of the benefits of adopting ASLP best practice protocols for sea freight. In each year from 2012 to 2015 two Australian and one Pakistan project team member were accompanied by one or two SMGE members to conduct in-market research in the UK. For Pakistani members involved in the research, this was a period of intensive hands-on training and capacity building. In general, results showed that:
 - The traditional target market segment for Pakistan mangoes in the UK is the south Asian community, which is price sensitive and any price increase at retail level has the potential to dampen demand.
 - Modest demand for the small quantity of Pakistan mangoes sold through UK supermarket chains could be enhanced by improvements in quality and traceability. Development of this market segment has the potential to increase the volume and value of Pakistan mangoes entering the UK by appealing to a broader customer base who have the capacity to pay higher prices for a quality product offering an enjoyable eating experience.
 - Pakistan mangoes by CA sea shipments from SMGE successfully entered UK supermarket chains. The success of these shipments by SMGE under the project's technical guidance increased the confidence of Pakistani growers as well as UK importers and demonstrated the significant economic potential to increase export volumes as well as prices. Since 2012 about 330 tonnes of mangoes were exported to the UK/EU by SMGE, generating export earnings of USD900,000

averaging USD 2.72/kg compared with an industry average for exports of less than USD 1.00/kg. The success of CA sea freight of Pakistan mangoes over transit times of up to 30 days followed by in-store shelf life of 5-7 days is best practice by world standards and the protocols developed and tested through this project represent a milestone for the Pakistan mango industry.

2. The China market: ASLP Phase One demonstrated, through several trial shipments of Chaunsa mango to China, that Chinese consumers are willing to pay premium prices for high quality Pakistan mangoes. In Phase Two, through the application of ASLP best practices along demonstration value chains, mango quality of trial shipments has been improved continually, with a focus on colour development, maturity and reduction in vlemish, particularly through sapburn. However, reliability and consistency of supply of high quality product was found to be the main bottle neck in developing this market. One main cause of these problems was that there was no HWT facility in Punjab, where most Chaunsa mango is produced. This meant that mangoes from Punjab province had to be sent to Karachi for HWT treatment, some 24 hours away by road, involving double-handling, greater physical damage and lower shelf life and less attractiveness upon arrival in China. Additionally, the HWT plant in Karachi usually closed down before the late Chaunsa season had finished, a time when the Chinese market could pay premium prices for high quality mangoes. In combination, these factors resulted in extreme difficulty in building Chinese importers' and retailers' confidence in Pakistan mangoes and in developing this market.

To address this issue the project worked with Punjab growers, an importer in China and the Pakistan Department of Plant Protection (DPP) to register on-farm newly developed HWT facilities in Punjab. With guidance and technical support from the project, two HWT plants (ZARPAK Horticultural, Shujabad and Lutfabad Mango Farm, Multan) were upgraded according to the quarantine requirements of AQSIQ, China. DPP officers inspected them and after minor modifications these two HWT plants were registered with DPP for export. The AQSIQ accreditation process is underway at the time of writing this report and once these facilities are accredited, direct exports from Punjab to China should markedly improve the opportunities to develop the market for Pakistan mangoes.

3. The Malaysian market: Market research by the project team in Malaysia showed potential for market development. Trial consignments prepared using under ASLP best practices were sent to Kuala Lumpur in 2010 and 2011 and consumer response documented through in-store surveys. Sweetness was the highest ranking attribute affecting consumer satisfaction and willingness to pay. A financial analysis comparing ASLP best practice mangoes with mangoes produced and exported using traditional practices was carried out. Results showed that each 1900kg air shipment prepared using ASLP best practices could save around USD 330 in comparison with traditional practices, mainly due to reduction in wastage. This represents an increase in profits to exporters of more than 10%.
4. Domestic markets: Domestic market research established that there is a market for superior quality mangoes, but the ability to supply such a product reliably and consistently was limited. Under the traditional marketing system, retailers sourced mangoes directly from wholesale markets, often on a daily basis. They then graded the fruit for size, firmness and colour, as there was always considerable variation in fruit size and maturity

within each 11-13kg wooden box. On average, retailers reported a wastage rate of 10% due to physical damage and rots/blemishes. Retail prices varied between Rs50-80/kg, and the fruit had a shelf life of 2-3 days. For these reasons, traditional mango marketing channels did not have the systems or ability to deliver ASLP best practice mangoes to domestic consumers. Phase Two of the project has worked on developing more innovative approaches to marketing high quality mangoes to help deal with this problem.

In Phase Two a cluster of small scale (<5ha) growers in Nawabpur, Multan, was formed in 2013-14 with the financial and technical support of the project. The leader of this cluster, Mr Sadaqat Sheikhana, had in 2012 been awarded an Australia Pakistan Agricultural Scholarship to undertake a four week “Pro-poor Marketing” training course in Australia. His cluster of small scale growers successfully marketed ASLP best practice mangoes at premium prices in 2014 and 2015. The cluster involved 6-10 farmers who were willing to work cooperatively under the project to improve the quality of mango and jointly market their fruit directly to consumers. The project provided specific training in postharvest handling, grading, packing and marketing, and provided financial support for the design and purchase of start-up quantities of fibreboard cartons. As a result of these activities, 13 tonnes of mangoes in 2014 and more than 30 tonnes in 2015 were sold to local consumers. In 2015 the average price was Rs 96/kg compared with Rs 52/kg if the same mangoes were sold through traditional markets. This represents an increase in gross income of 77%, or more than 20% once the added costs of production and marketing were accounted for. Three direct marketing strategies were employed:

- *Home Delivery:* In 2014 two marketing boys were hired to get orders for ASLP best practice mangoes from different market areas in Multan City. More than 1000 boxes of 5kg were sold through this approach. In 2015, households could order by phone and mangoes would be home delivered. About one-third of sales were made in this way.
- *Promotion and Retail Stall:* One promotional and retail point was set up nearby the growers’ village on the outskirts of Multan. This stall was manned by growers for the whole harvest season and most consignments were sold through this outlet in 2014 and about one-third of total sales in 2015.
- *E-commerce Marketing:* In 2015 a Facebook page was set up promoting these growers’ branded high quality mangoes and offering delivery to distant cities such as Peshawar. Purchasers could pay by direct funds transfer using their mobile phones and mangoes would be despatched by bus to their city. In 2015 about one-third of total sales were made in this way.

Domestic market research in Sindh and Punjab revealed that adoption of ASLP best practices to harvest and market quality mangoes not only increased demand but also achieved higher prices. Growers realised 15-20% higher net returns than for traditionally produced and marketed mangoes. For example, best practice mangoes packed in fibreboard trays sold at an average price of Rs 77/kg in Multan and Rs105/kg at Metro Cash and Carry and HyperStar supermarkets in Lahore at the same time as the highest prices for traditionally produced mangoes in Lahore ranged from Rs 65-75/kg. Furthermore, in ASLP best practice consignments wastage rates were 5-10% compared with industry averages of 20-50%. These domestic marketing models demonstrate that consumers have the demand and ability to pay higher prices for better quality mangoes. At these prices, growers who deal outside traditional channels by participating in value

chains that bring them closer to the consumer, can significantly improve the profitability of their small scale operations.

Developing and marketing value added mango products produced by village women

Developing, producing and marketing value added horticultural products in poor rural villages can improve local livelihoods but presents significant challenges across three distinctly different fields – product development, marketing and community development. While many international development projects contain experts in each of these fields, integrative value chain-focused research approaches remain far less common than discipline-based research. In Phase Two of this project, pilot scale examples of value added mango products produced and marketed by women in poor villages in Sindh have been developed. They highlight how integrated research enabled women to improve family income without leaving the village. The research approach adopts a value chain perspective to first identify market opportunities, then consider processing requirements, and finally determine how a village can organise resources to produce and market the product. As a research for development initiative, it was critical to provide participants with training and support, while also achieving co-ordination and integration across the production, marketing and community development fields. In 2014, following training at SAU in how to make value-added mango products, a group of twelve women from the village Hot Khan Leghari in Sindh produced more than 500 kg of mango pickles from low grade and waste fruit, generating about USD 350 in income. In 2015, a second group of about ten women at village Shah Alam Shah Ji Wasi was added, producing and marketing mango pickles using the same model. In 2015 the two groups between them processed more than 2000kg of mango pickles from fallen unripe mangoes that would otherwise have been waste. Total sales of USD 2060 resulted in a net profit of USD 1060. This increased the income of each woman's household by almost 50%. For 2016 each group of women has agreed to put aside 50% of 2015 profits into a bank account to provide start-up funds for the following season.

In the case of the Hot Khan Leghari women, the ASLP Social Project provided a community centre in their village with access to water and power. Village Shah Alam Shah Ji Wasi provided their own working and storage area in 2015. In both villages the Mango Value Chain project provided training, in-village support by women project team members from SAU, purchase of equipment such as cooking pans and scales, and start-up funds for consumables such as spices, bottles and labels. This project activity demonstrated that

- 1) waste mango can be turned into products that are attractive to consumers and profitable for village level production;
- 2) village women have the ability and motivation to work together to make value added mango products; and
- 3) the value chain provides an integrating framework for multi-disciplinary R&D teams.

The remaining challenges are to provide any on-going support these women might need, to ensure product quality and safety as the groups expand, and to scale-up these successes to other villages in mango producing regions.

Objective 3: Demonstrating value chain approaches

The project conducted a number of trial consignments to demonstrate value chain approaches to the stakeholders, including

- ***KL-Malaysia (one consignment)***
 - ***Beijing-China (five consignments)***
 - ***United Kingdom (annual consignments for four years)***
 - ***Domestic markets (four domestic supply chains)***
- The project used these demonstration chains to train members and demonstrate the benefit of the value chain approach to the broader mango industry.
 - The project also conducted a static trial on SB Chaunsa to demonstrate the value chain approach for sea freighting this variety to the Gulf and Far East markets.
 - The activity with village women producing and marketing value-added mango products was another example of a demonstration value chain, and its results have been widely disseminated within Pakistan, at workshops, and to an international audience at the 2015 mango conference in Darwin, Australia.
 - As detailed in the previous section, value chain improvement workshops were conducted throughout the project's life to demonstrate to stakeholders across the mango industry the benefits of adopting a value chain approach to improving technical and economic performance. Likewise, examples drawn from these demonstration chains were used in training activities.

Objective 4: Building the capacity of mango industry stakeholders

Capacity building elements were built into the design and delivery of every area of activity in the project, from field days to static trials on-farm, to marketing research, to export out-tuym evaluations, to women's value-adding initiatives. The typical method of delivering capacity building was by direct hands-on participation in activities such as diverse as learning to de-sap mangoes, pack a sea container, conduct market research, assess fruit quality, make pickles, train trainers, and write policy. Even the annual project review and planning cycle targeted the development of team members' skills in research planning, budgeting, negotiation and teambuilding. Thus in every objective described above and below, capacity building took place.

Specifically, over the five year life fo the project 1919 males and 146 females were trained in the areas of postharvest skills and technologies, market research, producing value added mango products, adopting value chain approaches, and integrated systems for long distance sea shipment of mangoes. Most importantly, these activities emphasised the critical importance of adopting a whole of chain or systems approach in solving problems and addressing opportunities.

Four PhD and 26 Masters theses were directly associated with the project's research, as detailed in Appendix 1.

Objective 5: To examine project performance across the above four objectives as a basis for providing strategic direction for future investments in mango industry development

To achieve the desired outputs from this objective, a one-week course in impact assessment was developed with input from ACIAR's present Assessment and Evaluation program manager and delivered in Islamabad in March 2015 by an ex-ACIAR program manager. Seventeen Pakistani members of ASLP project teams participated. For members of the Mango Value Chain Project team, this training consolidated their skills and knowledge to the point where two of them could take responsibility for conduct of the required data collection and analysis.

An interview guide was developed and responses from other team members used to refine it for application in the field. Face to face interviews with 33 stakeholders across the mango industry were completed mid-year. Results were analysed and interviewees asked to validate findings as

a member-checking validation process. Interpretations and recommendations were communicated to project team members for feedback and a full report prepared for submission to ACIAR.

Issues and problems faced during project execution

The project's execution in general presented few difficulties that could not be dealt with as they arose. However, for the benefit of future projects in Pakistan, the following explanations may help to avoid issues and problems that the project faced.

- Training of women in Pakistan is expected to be conducted by female trainers, however very few women in Pakistan are available and capable of providing the kind of training that the project needed. This led to under-representation of women on the project team and in project activities generally, as well as probably limiting the willingness of women to attend some activities run by male trainers.
- There could have been more integration of Mango Value Chain and Social Project activities. One problem was the relatively late start of the Social Project and the long lead time before that project was familiar enough with the on-ground situation to provide input into other projects. As a result, mango project activities were delayed by having to wait to identify villages to work with, learning how best to work with village women, and having access to women trainers. Secondly, the value chain research approach was more active and interventionist while the social project's approach emphasised observation, description and reflection, with a tendency to avoid direct involvement in actions to improve situations being studied. This reliance on two different methodologies, while entirely defensible for each project, added a further layer of complexity in terms of working to mutually agreeable timetables.
- Within the Mango Value Chain project team, there were some difficulties in achieving effective teamwork among people from different academic fields and institutions in Pakistan. At times team members struggled to work together as an integrated team on particular research activities with agreed overarching objectives and methodologies. These differences were not obvious or even raised at annual review and planning meetings, but arose once on-ground planning and activities commenced.
- The project faced enormous bureaucratic barriers and setbacks when trying to achieve accreditation of hot water treatment plants by the Pakistan DPP and Chinese quarantine authorities. DPP processes in particular proved slow, cumbersome and unpredictable. On many occasions responses were promised but not received without a great deal of effort by Australian and Pakistan partners.
- As is common in value chain research for development, powerful vested interests can exert their influence whenever proposed changes to the system are perceived to threaten their traditional ways of business, even if those changes are for the betterment of other chain members. Powerful chain members can influence government decision-making, circulate misinformation about project activities and achievements, place barriers in the way of improvement initiatives, and reduce the motivation of weaker and dependent chain members to become involved in project activities. All of these actions by vested interests were experienced in this project. None of them totally prevented any particular activity but most of them reduced the project's reach and effectiveness in some way.
- At the date of this report the project's major partner in Pakistan, the Pakistan Horticulture Development and Export Company, had just been reviewed by government and a new

CEO and board put in place. While this review of PHDEC was taking place it was not possible to route project funds through PHDEC to SAU.

7.1 Scientific impacts – now and in 5 years

Value chain led research for development is relatively new but attracting increasing attention in overseas development assistance programs. The mid-term and end-of-project external reviews of this project have concluded that the application of its conceptual framework to the problems of value chain development in the Pakistan mango industry has been both appropriate and successful. One impact of the project in the next five years may be the adoption of such an approach in other industries, such as through the new Agricultural Value Chains Collaborative Research Program in Pakistan. Another impact may be the continuing development of the mango industry in Pakistan, led by the achievements of this ASLP Phase Two project.

Research and development conducted by the ASLP Mango Value Chain project on quality improvement and safety, export and domestic market development and consumer response, has been accepted for presentation at national and international forums, conferences and exhibitions, indicating the scientific and commercial worth of the project's activities and results. Scientific publications by team members (see Appendix) and downloads by other researchers indicate the value of this work to the scientific community.

The success of CA sea freighting of mangoes over transit times of up to 30 days is absolute best practice by world standards and the protocol developed and tested through this project represents a milestone for the Pakistan mango industry. Domestic marketing models developed under the project are good examples of pro-poor market development.

The integrated multi-disciplinary methodology that has been used in the development of mango value added products by women in poor rural communities has been documented and has attracted academic interest. This approach, integrating across five discipline areas to create value chains that improve poor household incomes, can be adapted readily to other horticultural industries in Pakistan and in other developing countries.

The project's demonstration value chains, successful as they have been already, may prove to be exemplars for other agricultural industries over the next five years.

In general, the lessons learned and best practices generated from this project are envisioned to provide a conceptual basis for value chain research and development in other crops, and possibly in animal based industries. If this proves to be the case and such successes are documented and subject to peer review, the scientific impact of this project will be multiplied considerably.

7.2 Capacity impacts – now and in 5 years

Over the five year life of the project, 1919 males and 146 females received formal training in the areas of postharvest skills and technologies, market research, producing value added mango products, and adopting value chain approaches and systems for long distance sea shipment of mangoes. Those trained included mango growers (small, medium and large scale), pre-harvest contractors, commission agents, processors, mango exporters, mango importers, representatives of agricultural chemical companies, packaging companies, shipping companies and pre-shipment inspection companies, researchers from academia and government research organizations, students, and governments functionaries from extension, marketing and export regulatory departments. Many of these stakeholders are now in a position to train others, and they will play a critical role in the improvement of Pakistan mango industry beyond the life of this project.

The 30 or so students who earned their Masters or PhD degrees as a result of their involvement in this project will go on to contribute to the scientific, community and commercial sectors of Pakistan in the next five years. In a country where postgraduate qualifications in horticulture and value chain management are uncommon, the capacity of these graduates will be significant in bringing science-based decision-making to the problems and opportunities of agricultural development.

7.3 Community impacts – now and in 5 years

7.3.1 Economic impacts

The success of CA sea freight shipments by the SMGE group under the project's technical guidance, has increased the confidence of Pakistani growers and importers in EU/UK in Pakistan mangoes. These shipments demonstrated significant economic potential to increase export volumes as well as prices. Since 2012 about 330 tonnes of mangoes have been exported to the UK/EU by CA sea freight using on-farm and postharvest systems developed by the project and implemented under the guidance and supervision of team members. These shipments have generated export earnings of USD 900,000 averaging UAD 2.72/kg compared with an industry average for exports of less than USD1.00/kg. This CA sea freight technology has opened the door for Pakistani mangoes by sea and the next five years could see a manifold increase in mango exports by sea.

Domestic market research in Sindh and Punjab revealed that adoption of ASLP best practices to the harvesting and marketing of high quality mangoes not only increased demand but also achieved higher prices. Growers realised 15-20% higher net returns than for traditionally produced and marketed mangoes. For example, best practice mangoes packed in fibreboard trays sold at an average price of Rs 77/kg in Multan and Rs 105/kg at Metro Cash and Carry and HyperStar supermarkets in Lahore at the same time as the highest prices for traditionally produced mangoes in Lahore ranged from Rs 65-75/kg. Furthermore, in ASLP best practice consignment wastage rates were 5-10% compared with industry averages of 20-50%. These domestic marketing examples provide compelling economic evidence of the benefits of adopting ASLP best practices for growers at all scales, but especially for small and medium sized growers.

Export trial consignments of mangoes to China and Malaysia demonstrated the economic potential of these markets. An important aspect of these benefits was reduction in wastage, alongside improvement in quality. Less waste provides direct economic benefits to chain members in whatever part of the chain that waste is reduced. In the Malaysian market, the main economic benefit was in achieving less waste, as Pakistan mango quality in this market was already close to the standard that met the market's requirements. In China, however, ASLP best practice Late Chaunsa mangoes were new to the market and were very favourably received for their sweetness. This resulted in the importer asking for more consignments prepared in the same way. It is expected that once Punjab HWT plants are accredited for export to China by air, there could be potential to export 20 per cent of Punjab mango production to China over the next five years.

Mango pickles produced and marketed by rural village women in Sindh have demonstrated significant economic potential if scaled out to other villages and perhaps to other crops that can be processed in a similar way. Groups of 10-12 women increased household incomes by almost 50 per cent in the 2-3 months of the mango harvest season. The groups

processed and marketed about 1000kg of pickles from fallen unripe mangoes that would otherwise be waste, for sales of more than USD 2000 and a net profit of more than USD 1000. An end-of-project review of two years' working with these women's groups revealed high levels of confidence and motivation among the women that they could, and would, carry on with their micro-enterprises without external assistance once the project finished. If this proves to be the case, the project will deliver increasing economic impacts over the next five years, especially if similar groups are formed in other mango producing areas.

7.3.2 Social impacts

Social impacts of the project are experienced directly by stakeholders who benefit from improved value chains, such as consumers and growers, and indirectly by government and community members.

As a result of the project, consumers have improved access to safer and better quality mangoes with longer shelf life, improved nutritional value and less waste.

Local communities benefit when mango growers and other value chain participants are equipped with the skills and technologies to improve their business performance, their profitability and ultimately their livelihoods. A good example is the project's support and development of SMGE's capacity to export mangoes to the UK using CA sea freight. This group has improved its profitability but equally importantly it has demonstrated to others in the region and in the wider mango industry the benefits of growers collaborating to show leadership in value chain development. These impacts will multiply over the next five years.

The social impact of the project through developing small enterprises run by women in rural villages has a number of dimensions. Increasing the incomes of poor women and their households not only improves their social status but also represents an opportunity to use this income for their childrens' education and health. The community centre of one village used for women to produce mango pickles has become a place to attract village women to learn skills and discuss new business opportunities as well as community issues. It is expected that in the next five years more women will be trained and involved, with similar social impacts on other villages. Poor smallholder growers who engaged in direct marketing of ASLP best practice mangoes have experienced similar benefits to the village women. Their incomes have risen substantially, along with their local profile and status. Other individuals and villages want to copy what they have done, so over the next five years it is expected that these social and economic impacts will spread to other regions, and perhaps other crops.

The introduction of ASLP best practices has created many job opportunities for local communities in the mango industry. Traditionally mango is harvested and packed in the field without desapping and proper grading and packaging. This traditional practice involves less effort and lower returns but is suitable to supply local markets with low quality cheap mangoes. The introduction of ASLP best practice aiming to supply international markets as well as high end domestic markets requires more people to be trained and employed in postharvest activities. It also requires existing staff to acquire new skills. It is expected that in the next five years the increase in high value mango exports to the EU/UK and China, combined with increasing demand from high end domestic markets, will result in thousands of new jobs for better trained and qualified workers in the mango industry.

The project has impacted on government through advice and guidance in developing policies and improving delivery of services to the industry. An example is the project's contribution to the Department of Plant Protection, where it has provided direct input to the development of a fruit

fly management strategy (team scientists wrote the draft strategy) and technical support for quarantine accreditation of hot water treatment plants for export to China. DPP has begun implementing the project's recommended fruit fly management policy for the 2016 mango season.

7.3.3 Environmental impacts

Continuing research, development and training by the project promotes the use of ethylene for mango ripening as a replacement for the traditionally used, dangerous and now illegal calcium carbide, with associated benefits for worker and consumer welfare as well as the environment.

Similarly, the project's promotion and demonstration of plastic returnable crates as a replacement for wooden boxes is aimed at reducing pressure on scarce timber resources as well as improving fruit quality. It is expected that these practices will be adopted more broadly by the Pakistan mango industry, quickly in the case of ethylene use and more slowly in the case of wooden boxes.

A PhD by Dr Hammad Badar (2014) using this project as a case study, showed that the influence of consumers should be incorporated into triple bottom line considerations of the Pakistan mango industry's future sustainability. Results have been presented at international conferences in Australia (IHC) and the US (IFAMA).

7.4 Communication and dissemination activities

As was the case with capacity building activities described in section 7.2 above, the results from each activity of this project were incorporated into training, communication and dissemination initiatives. In many cases, capacity building became the main communication and dissemination vehicle. For example, the benefits, techniques and skills associated with de-sapping mangoes were disseminated to industry through many hands-on workshops, but supported by the publication of guides and manuals that could be distributed more widely. This approach applied to most of the knowledge dissemination initiatives of the project.

Over the life of the project, communication and dissemination activities spanned the production of 12 technical guides including a Best Practice Manual, holding 25 workshops, publishing a Code of Practice in conjunction with UNIDO, participating in two national conferences and exhibitions as well as three international scientific conferences, and publishing quarterly newsletters, quarterly reports and annual report (see Appendix 2 for details).

Print and audio/video media were also used to disseminate project activities and results. Interviews with project team members were broadcast through local radio (FM 101) and a short documentary on mango postharvest was telecast on BCC. The project frequently used mass print media (national and regional newspapers) to disseminate its achievements.

8 Conclusions and recommendations

8.1 Conclusions

In presentations at the end-of-project workshops in Pakistan and Australia, two statements were made that encapsulate this project's performance and its systems-based focus:

“There have been many achievements, from technical ‘fixes’ of problems, to better understanding markets, to getting people working together, to building new capacity. It is wrong to argue that any one achievement is more or less important than any other. Every achievement plays a role in improving the value chain as a system.”

“The defining feature of this project's approach and achievements has been its focus on the value chain as a system. This may become the project's greatest legacy to horticultural research for development in Pakistan.”

As mentioned in the Executive Summary, the project's distinguishing features can be summarised as:

- Its integrative focus on the whole value chain from farm to consumer
- Its multidisciplinary team whose research integrated across traditional boundaries between disciplines
- Its ability to work successfully at all scales from poor smallholder farmers up to large corporate operations, in both domestic and export markets
- Its research for development involving rural village women.

An overview of the project's achievements highlights the following:

- Nine years' research for development with a team of 10-15 for a direct investment of less than USD300,000/year
- Demonstrated practical and theoretical importance of applying a value chain focus to research for development
- The introduction of the concepts, protocols and skills of “ASLP best practice” to the mango industry
- Achievement of world class results for the first time in Pakistan, such as controlled atmosphere sea freight to long distancemarkets in the UK
- The provision of science-based input into strategy, policy and decision-making eg fruit fly management
- Demonstration of the benefits of multidisciplinary, integrated, cross-institutional research teams.

As a result of these achievements, the following lessons have been learned:

- The ASLP value chain research for development model should, with caution and insight, be transferable to other industries, especially in horticulture
- It is difficult, if not impossible, to rearrange the pieces of the old puzzle to make a new picture – traditional models will always serve a purpose but have little potential for innovation from within

- Value chain research for development can provide policy makers, regulators and research leaders with new perspectives
- Collaborative entrepreneurship may be the key to smallholder and women's empowerment
- The keys to success of a value chain-led research for development project such as this are knowing what markets and consumers want, being able to produce and deliver that product and share the benefits equitably, and working with people committed to change.

8.2 Recommendations

The problem of when and how to finish a project such as this remains unresolved. Because of its multidisciplinary nature, large team and multiple points of focus, there are a number of research initiatives left unfinished in this project. They are summarised below.

- The SMGE case study has one last element that requires more work to avoid the risk that all the achievements to date will be subsumed by recent developments that could not have been tackled earlier. This is the integration of fruit fly management into sea freight based export systems. The threat that lack of fruit fly management could close down EU/UK exports arose only in 2014, and if the future of Pakistan mango exports is to rely heavily on sea freight to high value markets such as the EU/UK and China, then fruit fly management will remain a key unresolved issue without further research. Given what was achieved in 2015, one season's work in 2016 should produce the required modifications to incorporate DPP-sanctioned fruit fly management into the already proven and accepted CA sea freight protocols. Incorporated with this effort should be full scale commercial trials to one high value supermarket in the UK, building on limited evidence gathered in 2014 and 2015. The supermarket segment represents by far the highest value target for export development in the EU and UK markets.
- The China market remains the largest untapped export market for Pakistan mangoes. Left to its own devices, there is a high risk that the Pakistan mango industry will repeat the short-sighted and ultimately damaging practices that it has applied to most other export markets. However, the Mango Value Chain project has demonstrated how much value there can be in this market if a whole of chain approach is adopted with a focus on meeting the needs of targeted segments of Chinese consumers. The remaining missing link in achieving such a result is the lack of accredited hot water treatment plants in Punjab province, where the varieties sought by the Chinese market are grown. There is a pressing need for accreditation to take place, and once this is achieved it will be critical for technical and marketing support to develop the first trial export shipments to China. These will serve as a demonstration of how to achieve the high value potential of this market by collaboration among all chain members.
- Considerable success has been achieved in working with smallholder growers on value chain development based on direct marketing, and with village women in building value chains based on value-added mango products. However, these successes have been at demonstration scale with limited numbers of participants.

Questions about how to scale up such models require further research, and all of the project's case study groups would be available to provide a platform from which to pursue such a research question. Shedding more light on how to scale up pilot scale value chain groups would make a major contribution to this research field.

- Finally, projects such as this one are inevitably limited by the resources of people, time and funds. Therefore they can at best achieve demonstration level examples of what might be adopted by whole industries or sectors. There is a risk that, while the demonstration examples may prove innovative, profitable and socially desirable, there is little understanding of how to replicate them more widely or grow them to full commercial scale. In concert with the points made in the previous paragraph, there is a need for research into questions of how demonstration scale examples can lead to industry-wide impact, and what are the enablers and barriers to these processes.

It is therefore recommended that ACIAR give consideration to providing the funds for each of these research challenges to be addressed in 2016, perhaps as part of the new Agricultural Value Chains Collaborative Research Program in Pakistan.

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9.2 List of publications produced by project

Research Papers

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Thesis produced under the project

- PhD Thesis = 4 (2 UAF + 2 UQ)
 1. Integrated approaches for improving fruit quality and shelflife of two commercial mango cultivars of Pakistan (Mr. Muhammad Amin-2012, Institute of Horticultural Sciences, University of Agriculture, Faisalabad) (ASLP funded activity)
 2. Evaluation of controlled atmosphere and modified atmosphere conditions for the transport of mangoes to distant markets (Mr. Omer Hafeez Malik-2014; Joint Output in collaboration with PARB)
 3. Evaluating the Effectiveness of a Whole of Chain Approach in Rural Industry Development in Developing countries: A case of Pakistan Mango industry (Mr. Mubashir Mehdi-2012, UQ Gatton, Australia)
 4. Value chain performance improvement for sustainable mango industry development in Pakistan (Mr. Hammad Badar-2015, UQ Gatton, Australia)
- MSc (Hons) Theses Completed = 26 (13 Horticulture - 12 males, 1 female; 07 Plant Pathology- 2 females, 7 males, 1 marketing- male, Food Technology-3 females)

Papers Presented at the International Mango Symposium 2015, Darwin, Australia

1. Tony Dunne: New market segment development—the challenges facing exporters from developing countries
2. Ray Collins: An integrated approach for developing value added horticultural products at village level in developing countries: a case study of producing and marketing mango pickle by women in a poor village in Pakistan
3. Muhammad Ismail Kumbhar: Study of mango marketing system in selected districts of Sindh Province, Pakistan
4. Sohail Ayyaz: Direct marketing of fresh mango: a case study of mango smallholder in Pakistan
5. Mubashir Mehdi: Opportunities and constraints in building improved domestic mango value chains in Pakistan
6. Muhammad Ismail Kumbhar: Impact of mango preservation technology training on knowledge and adoption of rural women in Sindh Pakistan
7. Zohaib Ali: Evaluation of acoustic firmness technology for non-destructive maturity and ripeness assessment of mangoes
8. Abdul Rehman: Research and development in mango postharvest disease management in Pakistan
9. Muhammad Amin: Dynamics of under skin browning and management prospects under low temperature stored mangoes

10. Aman Ullah Malik: Mango value chain development through postharvest research and development—a developing country case study
11. Muhammad Amin: Pre-cooling duration significantly affects post-storage skin colour development, enzymatic activities and organoleptic properties of S.B. Chaunsa mango
12. Ahmad Sattar Khan: Exogenous application of PUT, SA, OA and CaCl₂ delayed fruit ripening and maintaining fruit quality of 'Samar Bahisht Chaunsa' mango
13. Abdul Mubeen Lodhi: Influence of fungicide treatments on mango stem end rot development in commercial export consignments and colony growth of *Lasiodiplodia theobromae*
14. Muhammad Amin: Orchard practices and fruit peel mineral contents influence postharvest disease development and severity of stem end rot in mangoes
15. Abdul Mubeen Lodhi: Monitoring of postharvest diseases and pathogens in mango export farms of Sindh, Pakistan

Papers Presented at International Conferences during 2014, Darwin Australia (Papers under Publication)

Sr. No	Title of Paper	Conference	Publishing Journal/ Proceeding
1	Influence of low temperature storage and exogenous ethylene treatment on physico-chemical fruit quality of Sindhri and Samar Bahisht Chaunsa mangoes	4th International and 13th National Conference of Plant Scientists. Saheed Benazir Bhutto University, Shringal, Dir (Upper), KPK, Pakistan (27-30 Aug, 2014)	Pakistan Journal of Botany
2	Impact of pre-cooling and cold storage on post-storage peel colour development & other physico-chemical and physiological attributes of mango cv. Samar Bahisht Chaunsa		
3	Tree and fruit biological factors associated with mango fruit maturation	International Horticultural Congress (IHC), 17-22 Aug 2014 Brisbane, Australia.	Acta Horticulturae
4	Advances and challenges in value chain development in Kinnow and mango industries of Pakistan		
5	Production Locality and Orchard Practices Influence Postharvest disease development and Quality in Mangoes		

10 Appendixes

10.1 Appendix 1: Capacity building activities conducted by ASLP mango value chain teams

	Activities/ Date	Objectives	Audience	No of Participants	
				Male	Fem ale
1	Mango Market Research Training (UAF)	<ol style="list-style-type: none"> 1. Understand the role of market research in the development of firm’s strategies and in the management of pre and post-harvest activities of mango supply chain. 2. Understand tangible, intangible and service attributes of mango products 3. Understand the importance of the focus on the quality that consumers prefer 4. Understand market research processes and tools 5. Learn how to conduct depth interviews 6. Learn how to conduct laddering interviews 	<ul style="list-style-type: none"> • Agricultural Marketing Research Staff (Universities) • Extension and training people • Agricultural Marketing Department Staff (Government) 	19	04

		<p>7. Learn how to conduct focus groups</p> <p>8. Learn how to conduct market surveys</p> <p>9. Understand the theory and concept of conjoint analysis and learn how to conduct conjoint analysis</p> <p>10. Learn how to sample for market surveys</p>			
2	<p>Post Season Workshop (Rahim Yar Khan)</p> <p>15 Feb 2012</p>	<p>To share the project findings including orchards rating, postharvest, disease management and international markets with stakeholders</p>	<ul style="list-style-type: none"> • Mango Growers • Mango Exporters • Extension and training people(Government of Punjab) • ASLP project team 	45	0
3	<p>Post Season Workshop (Karachi)</p> <p>13 Mar 2012</p>	<p>Same as above (i.e. Sr. # 2)</p>	<ul style="list-style-type: none"> • Mango Growers • Mango Exporters • Sindh Agriculture Department • Sindh Agriculture University • UNIDO • Processing Industry • Shipping Company • Grower Association • ASLP project team 	30	01
4	<p>Training on Mango Sea Freight Container Technology (UAF)</p> <p>10 Oct 2011</p>	<ul style="list-style-type: none"> - To train the UAF postharvest research staff to operate the sea-freight containers - To develop the local capacity on sea-freight 	<ul style="list-style-type: none"> • UAF postharvest research staff • SAU horticulture staff 	12	02

		container technology			
5	<p>First National Workshop on Mango Sea-Freighting under National Initiative on Mango Sea-Freighting (NIMS) (UAF)</p> <p>13 Oct 2011</p>	<ul style="list-style-type: none"> - To take a stock of the current status of mango sea-freight supply chain - To develop a road map for promoting sea-freight for substantially increasing export volumes in next 5 years - Enhancing collaboration among the stakeholders from business perspectives 	<p>Stakeholders across the country</p> <ul style="list-style-type: none"> • Mango growers • Exporting companies • Freight forwarders/ Logistic companies • Shipping companies • Relevant Government organizations • Research organizations • Funding agencies • Other projects • Faculty and Students 	245	20
6	<p>Initiation Workshop, (SAU, Tando Jam)</p> <p>31 May, 2012</p>	<ul style="list-style-type: none"> - Sharing of 2011 season findings - Discussion about future targets 	<ul style="list-style-type: none"> • SAU team members • ASLP Production team (Sindh) • SMG 	14	03
7	<p>Project Initiation Workshop (Multan)</p> <p>04 June 2012</p>	<ul style="list-style-type: none"> - Sharing of 2011 season findings - Discussion about future targets 	<ul style="list-style-type: none"> • ASLP Production team (Punjab) • Mango Growers 	29	0
8	<p>Training on Mango Sea Freighting</p>	<ul style="list-style-type: none"> - To guide the Sindh Mango Growers (SMG) for 	<ul style="list-style-type: none"> • Sindh Mango Group (Seven Growers) 	13	0

	Hyderabad	<p>better out-turn in their planned CA sea-freight export to EU</p> <ul style="list-style-type: none"> - To improve the capacity of SMG in sea-freight technology 	<ul style="list-style-type: none"> • Sindh Agriculture University • Agribusiness Support Fund • Sindh Investment Board 		
9	<p>Training on Mango Packhouse Commissioning (Haider Shah Farm, SMG)</p> <p>29 May, 2012</p>	<ul style="list-style-type: none"> - To train the SMG workforce for improved packhouse operations - Guidelines for improvement of packhouse infrastructure 	<ul style="list-style-type: none"> • Sindh mango growers • Packhouse team/workforce 	11	0
10	<p>Training on Mango Post Harvest Handling for Sea Shipment (Mustafa Agri. Farm, SMG)</p> <p>27 May, 2012</p>	<ul style="list-style-type: none"> - Training of farm supervisors and labour regarding best practices to be adopted during harvest and handling of mangoes for sea-freight shipment 	<ul style="list-style-type: none"> • Sindh mango growers • Technical staff of SMG farms • Harvest and handling Labour/ workforce 	45	0
11	<p>CA/MA Seminar (Joint activity with PARB CA Project, UAF)</p> <p>26 June, 2012</p>	<ul style="list-style-type: none"> - Updating the stakeholders regarding research findings and advances made on CA/MA storage of apple, mango, Kinnow and Chilies in Pakistan - Developing technical capacity in CA/MA storage 	<ul style="list-style-type: none"> • F & V growers • Investors • Exporters/Traders • Cold storage owners • Faculty and Students 	104	07

1 2	Post Season Workshop (Karachi) 22 Jan 2013	To share the project findings including orchards rating, postharvest, disease management and international markets with stakeholders	<ul style="list-style-type: none"> • Mango Growers • Mango Exporters • Extension and training people • ASLP project team 	34	02
1 3	ASLP Seminar on Mango Export (SAU) 23 Jan 2013	To share the project findings including orchards rating, postharvest, disease management and international markets with stakeholders	<ul style="list-style-type: none"> • SAU Faculty Members • Sindh Govt Researchers 	49	11
1 4	Post Season Workshop (Karachi) 19 Feb 2013	To share the project findings including orchards rating, postharvest, disease management and international markets with stakeholders	<ul style="list-style-type: none"> • Mango Growers • Mango Exporters • Extension and training people • BZU Faculty Members & Students • ASLP project team 	99	07
1 5	Four Field Workshops for Smallholders 2013	To train the small mango growers on ASLP best practices for postharvest handling of mangoes	<ul style="list-style-type: none"> • Small mango growers 	120	0
1 6	2 Days ToT on Mango Quality Improvement and Value Chain Management 17-18 June, 2013	<ul style="list-style-type: none"> - To create awareness among participants regarding the ASLP best practices and the importance of their role in developing demonstration mango supply chains. - To improve the participant's understanding about the concept of mango quality, 	<ul style="list-style-type: none"> • Researchers • Government Functionaries • Growers • Exporters 	22	05

		<p>how it is lost and what practices can be adopted in maintaining the quality from harvest to consumers.</p> <ul style="list-style-type: none"> - To highlight the ASLP best practices for improving mango value chain. - To demonstrate how recommended practices can be implemented into traditional Pakistan mango supply chains. - To implement ASLP best practices in Pakistan mango value chain for delivering quality mangoes to customer as per their expectations. 			
17	<p>Training of SMG supervisors & managers on harvesting, packing and sea freight export 2013</p>	<ul style="list-style-type: none"> - Training for SMG supervisors was conducted at Mustafa Agri Farm, Kotri in which capacity building of Sindh mango growers, their farm/packhouse supervisory staff and workers for sea-freight 	<ul style="list-style-type: none"> • Growers, • Supervisory staff • Labour 	300	0

		<p>consignment preparation.</p> <ul style="list-style-type: none"> - trained in mango harvest and handling preparations for commercial sea-freight shipments <p>-</p>			
18	<p>2 Days ToT on Mango Quality Improvement and Value Chain Management</p> <p>19-20 Aug, 2013</p>	<ul style="list-style-type: none"> - To create awareness among participants regarding the ASLP best practices and the importance of their role in developing demonstration mango supply chains. - To improve the participant's understandings about the concept of mango quality, how it is lost and what practices can be adopted in maintaining the quality from harvest to consumers. - To highlight the ASLP best practices for improving mango value chain. - To demonstrate how recommended practices can be implemented into traditional 	<ul style="list-style-type: none"> • Researchers • Government Functionaries • Growers • Exporters 	30	0

		<p>Pakistan mango supply chains.</p> <ul style="list-style-type: none"> - To implement ASLP best practices in Pakistan mango value chain for delivering quality mangoes to customer as per their expectations. 			
19	<p>Demonstration Workshop on Static Trail on SB Chaunsa</p> <p>Sept, 2013</p>	<ul style="list-style-type: none"> - Demonstration workshop was conducted on SB Chaunsa Protocol for Sea Freighting was conducted 	<ul style="list-style-type: none"> • Growers • Exporters • Research personnel 	35	0
20	<p>12 Days Training on Mango Value Added Products</p> <p>Aug-Sept, 2013</p>	<ul style="list-style-type: none"> - To train rural women in product preparation of mango products using modern technology. - To transfer mango production technology to rural women regarding value added product. - To train rural women regarding agribusiness planning and management to market their product. 	<ul style="list-style-type: none"> • Poor Women from Hot Khan Leghari Village (ASLP Social Project Identified Village) 	0	30

2 1	ASLP Seminar, UAF, 2013	- To share the project findings including orchards rating, postharvest, disease management and international markets with stakeholders	<ul style="list-style-type: none"> SAU Faculty Members Sindh Govt Researchers 	94	17
2 2	Post Season Workshop (SAU) 1st Dec 2013	To share the project findings including orchards rating, postharvest, disease management and international markets with stakeholders	<ul style="list-style-type: none"> Mango Growers Mango Exporters Extension and training people ASLP project team 	26	07
2 3	Post Season Workshop (Multan) 28 Nov 2013	To share the project findings including orchards rating, postharvest, disease management and international markets with stakeholders	<ul style="list-style-type: none"> Mango Growers Mango Exporters Extension and training people ASLP project team 	45	0
2 4	Export Coaching Program 13 May, 2014	To Train the exporters on ASLP Best Practices for mango quality improvement	<ul style="list-style-type: none"> Exporters Government functionaries Growers 	24	01
2 5	Four Field Workshops for Smallholders (Sindh Province) May 2014	To train the small mango growers on ASLP best practices for postharvest handling of mangoes	<ul style="list-style-type: none"> Small mango growers 	125	0
2 6	Three Field Workshops for Smallholders (Punjab Province) June, 2014	To train the small mango growers on ASLP best practices for postharvest handling of mangoes	<ul style="list-style-type: none"> Small mango growers 	110	0
2 7	Post Season Workshop	To share the project findings including orchards rating,	<ul style="list-style-type: none"> Mango Growers Mango Exporters 	42	06

	(Multan) 21 st Feb 2015	postharvest, disease management and international markets with stakeholders	<ul style="list-style-type: none"> • Extension and training people • ASLP project team 		
	Post Season Workshop (SAU) 23 rd Feb 2015	To share the project findings including orchards rating, postharvest, disease management and international markets with stakeholders	<ul style="list-style-type: none"> • Mango Growers • Mango Exporters • Extension and training people • ASLP project team 	26	10
29	Evaluation Training for Agricultural Research Projects: Orientating, Designing and Evaluating Projects to Make a Difference	To train the project teams' members in evaluating the project impact.	<ul style="list-style-type: none"> • ASLP mangoes project teams (Pre & Postharvest) • ASLP Citrus Project • ASLP Dairy Project 	16	02
30	ASLP Seminar on Mango Domestic Marketing: Potential and Prospects (Multan)	To share the project findings on Domestic Marketing Research and identify the potential mango growers for ASLP domestic marketing initiative for mango season 2015	<ul style="list-style-type: none"> • Mango Growers • Mango Commission agents • Mango Retailers • Researchers 	52	00
31	ASLP End of Project Workshop (Karachi) 17 th Sep, 2015	To share the project findings including orchards rating, postharvest, disease management and international markets with stakeholders	<ul style="list-style-type: none"> • Mango Growers • Mango Exporters • Government Functionaries • Packhouses Companies • Shipping Companies • Academia Researchers 	40	07
32	ASLP End of Project Workshop (Multan)	To share the project findings including orchards rating, postharvest, disease management and	<ul style="list-style-type: none"> • Mango Growers • Mango Exporters • Researchers 	45	

	19 th Sep, 2015	international markets with stakeholders	<ul style="list-style-type: none"> • Government Functionaries • Academia 		
3 3	ASLP End of Project Workshop (Islamabad) 21 st Sep, 2015	To share the project findings including orchards rating, postharvest, disease management and international markets with stakeholders	<ul style="list-style-type: none"> • Donor Projects • AHC • PARC • ASLP Program 	18	04

10.2 Appendix 2: Details of communication and dissemination

Technical Guides

1. Factsheets for mango fruit pre & postharvest management (2015)
2. Mango fruit harvest maturity guides (Sindhri, S.B. Chaunsa & Sufaid Chaunsa) (Revised 2015)
3. Mango skin colour guides (Sindhri, S.B. Chaunsa & Sufaid Chaunsa) (Revised 2015)
4. Mango defects guide (2008)
5. Frequently Asked Questions- Hot water treatment in mangoes. Australia-Pak ASLP-II Mango Value Chain Improvement Project, Pakistan (2014).
6. ASLP-Primer (Short version) entitled “Current Best Practices Guidelines for Mango Supply Chain Management in Pakistan: Concepts and Definitions” having guidelines for the industry has been published and is being distributed to industry at mass-scale.
7. Project Newsletters were published and distributed in project stakeholders
8. ASLP Trial Shipment Monitoring Reports (China, KL, EU)
9. China & EU Market Research Reports
10. Domestic Market Research Report
11. Auditing Report of SMG HWT facilities
12. Train the Trainers Manual on Mango Quality & Value Chain Management

Project Displays at Conferences and Exhibitions

1. International Agriculture Conference and Exhibition, Pak-China Friendship Centre, Islamabad, Pakistan 27-28 February 2015
2. World Mango Conference and Exhibition, Islamia University, Bahawalpur, Pakistan 24-25 June, 2014

Quarterly Newsletter

1. April-June, 2011
2. July-September, 2011
3. October-December, 2011
4. January-March, 2012
5. April-June, 2012

6. July-September, 2012
7. October-December, 2012
8. January-March, 2013
9. April-June, 2013

Quarterly Reports

10. April-June, 2011
11. July-September, 2011
12. October-December, 2011
13. January-March, 2012
14. April-June, 2012
15. July-September, 2012
16. October-December, 2012
17. January-March, 2013
18. April-June, 2013
19. July-September, 2013
20. October-December, 2013
21. January-March, 2014
22. April-June, 2014
23. July-September, 2014
24. October-December, 2014
25. January-March, 2015
26. April-June, 2015

Annual Reports

1. 2011-2012
2. 2012-2013
3. 2013-2014
4. 2014-2015

Training

2. Training the mango workforce (labour and supervisory staff) on mango postharvest handling for sea shipment. 80 Participants, all male
3. Training three SMGE farm managers in fruit fly data collection and management
4. Pre/post-season stakeholder workshops and meetings were held in Sindh and Punjab. Results, information and lessons learned were shared with participants. 121 male + 9 female = 130 participants
5. Seven mango quality improvement field workshops were conducted in Sindh and Punjab. More than 200 small mango growers and field workers participated in these workshops.
6. An ASLP Agricultural Project Evaluation Training Workshop was held at Serena Hotel, Islamabad, from 2-7 March, 2015. This workshop was a project initiative, developed for

the benefit of all ASLP projects. Seventeen persons participated from the ASLP program (5 Mango Value Chain Project, 2 Mango Production Project, 5 Dairy Project and 5 Citrus Production Project) and two from Agricultural Extension (one each from Punjab and Sindh Agricultural Extension Departments).

7. A one-day seminar on “An Integrated Value Chain Approach to Delivering Quality Mangoes to Consumers” was conducted by project team members at the University of Agriculture Faisalabad on 1st April, 2015. More than 150 participants from academia, industry and government organisations participated in the seminar.
8. Training on the Mango Market Research/Outturn Assessment, July, 2013
9. Seminar on Mango Export, Nov, 2013
10. Training on sea freight postharvest handling of Sindhri mangoes, June, 2013
11. 02 Train the trainers, May-June, 2013
12. Mango value Addition training for rural women, 2013
13. ASLP Field Workshops for small mango growers, 2013
14. Postseason workshops, November, 2013
15. Export Coaching Program, May, 2014
16. Training on the Mango Market Research, June, 2012
17. Seminar on Mango Export, Feb, 2012
18. Training on Postharvest Handling of Mangoes for Sea Shipment, April, 2012
19. Project Development Officer got training in Australia on Pro Poor market Development, Nov, 2012
20. Seminar on CA/MA, June, 2012
21. Training on the Mango Market Research, 30th May to 4th June, 2011
22. Introductory Training on Mango Sea Freight Technology, 30th March, 2012
23. Training on Sea-Freight Container, November, 2011
24. Postgraduate Student training on Mango Post harvest at DEEDI, Australia
25. Training on the Mango Post Harvest handling for Sea Freight, May, 2012
26. Training on the Mango Packhouse Commissioning, May, 2012

10.3 Appendix 3: List of Interviewees for impact assessment study

Growers, Commission Agents and Exporters

- Mr Ghulam Sarwar Abro (President SMGE-Mustafa Agri Farm, Kotri)
- Mr Mahmood Nawaz Shah (Member SMGE-Shah Agriculture Farm, Tando Allah Yar)
- Dr Inam Bhatti (Representative Murtaza Agri Farm, Sakrand)
- Mr Junaid Hyder Shah (Member SMGE-Hyder Fruit Farm, Tando Allah Yar)
- Mr Hadi Bux Leghari (Farm Manager-Asim Agriculture Farm, Tando Allah Yar)
- Mr Imtiaz Hussain (Mango Export-Imtiaz Enterprises-Karachi)
- Mr Farid Khakwani (Mango Grower-cum-Exporter, Shujabad)

- Mr Ghulam Qadir Bhutta (Mango Grower-cum-Exporter, Jalalpur Multan)
- Mr Major Tariq Khan (Mango Grower-cum-Exporter, Nawabpur Multan)
- Dr Agha Habib (Mango Exporter, Multan)
- Mr Sadaqat Sheikhana (Small Mango Grower, Multan)
- Mr Azam Sabri (Sabri Enterprises, Multan)
- Mr Arain

Suppliers (Inputs, logistics, machines etc)

- Mr Hamid Ali Meo (CEO-Koldware Industries-Karachi)
- Mr Danish Ali Meo (Koldware Industries-Karachi)
- Mr Aziz Malik (NedPak Packages-Karachi)

Domestic Retailers

- Mr Ahmad (Trader, Lahore)
- Mr Imdad (Representative Metro Lahore)

Researchers

- Dr Hameed Ullah Khan (Director, Mango Research Institute, Multan)
- Mr Abdul Ghafaar Grewal (Horticulturist, Mango Research Station, Shujabad)
- Director (Sindh Horticulture Research Institute, Mirpur Khas)
- Dr Mubarak Ali (Director General, Department of Plant Protection)
- Dr Mubeen Khan Lodhi (Sindh Agriculture University, Tandojam)
- Dr Syeda Rehana Shah (Sindh Agriculture University, Tandojam)
- Dr Tehmina Mangan (Sindh Agriculture University, Tandojam)
- Mr Mumtaz Ali Joiyo (Sindh Agriculture University, Tandojam)
- Dr Saghir Ahmad Sheikh (Sindh Agriculture University, Tandojam)
- Ms Aasia Akbar Panhwar (Sindh Agriculture University, Tandojam)
- Dr Abdul Rehman (University of Agriculture, Faisalabad)
- Dr Ahmad Sattar Khan (University of Agriculture, Faisalabad)
- Dr Muhammad Amin (University of Agriculture, Faisalabad)
- Dr Mubashir Mehdi (University of Agriculture, Faisalabad)
- Mr Adnan Adeel (University of Agriculture, Faisalabad)