Food and Agriculture Organization of the United Nations

Food loss analysis: causes and solutions

Case study on the mango value chain in the Republic of India

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Field studies in Andhra Pradesh the districts of Vizianagarm and Chittoor
April to June 2016

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Contents

TABLES

FIGURES

Foreword

Widescale global food losses and waste affect the sustainability and efficacy of food and nutrition systems. Currently, high loss estimates in developing countries are linked to food supply chain failures but insufficient data limit the scale and scope of food loss measurements.

While numerous studies have been undertaken to quantify food losses at the national level, information regarding the critical loss points, or areas where food loss in a specific food supply chain is most prevalent, is often unclear. Compounding the challenge, the underlying reasons for loss-inducing food supply chain failures also require further examination.

To improve global, regional and local knowledge about the underlying reasons for food loss, as well as to assess where critical loss points occur, FAO undertook a series of case studies involving

numerous food supply chains in developing countries. Utilizing a defined food loss and waste analysis framework, the Organization and its partners identified nationally-important food products and commissioned local-level studies of the losses in these chains. The findings of the study will be used to develop technically, economically, environmentally and socially feasible solutions to reduce food losses. These solutions will be developed both in the chains examined, as well as in similar chains in other countries, with due considerations for economic parity, agro-ecology and social conditions.

The Republic of India is the world's largest supplier of mangoes, with an estimated 20 million tonnes produced in 2015/2016. Exported to major markets in Europe and the Near East, the crop holds a significant share of India's fresh and processed horticultural exports. Largely operated by smallholder farmers, mango production contributes an average of 30 to 40 percent to smallholder household incomes in states like Andhra Pradesh. As a result, supply chain inefficiencies and failures can lead to a reduction in essential profits for these individuals and their families. The study covered the state of Andhra Pradesh, the second largest mango producer in India. Andhra Pradesh contributes approximately 6 percent to global mango production, 15 percent nationally. Findings will be used to generate solutions to address major losses in the mango subsector, with a focus on smallholder reductions.

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Executive summary

The present study is intended to highlight the patterns of food loss in the important subsectors in the state of Andhra Pradesh, India and to identify the causes and possible solutions applicable to the individual subsectors. Owing to its economic and cultural importance to the state, mango was selected as one of the subsectors.

The present study was conducted using a case study methodology, which focuses on identifying the symptoms and causes of food loss and finding relevant solutions. The methodology of the study is designed to collect first-hand information on food loss by direct observation, direct interaction with chain actors and a load tracking exercise, so that the results are comparable. The case study methodology comprises a one-time assessment of the selected supply chains; the situation in the following season, another geographical area or in different climatic conditions could be different. Therefore, it is very important to conduct as many case studies as possible to cover many different geographical areas and time periods, so that the results are representative and can be extrapolated. The study was carried out in a phased manner employing a '4S' approach comprising Screening, Survey, Sampling and Synthesis. With this approach the dominant food supply chains in the subsector are identified and studied, the losses are quantified and the activities are observed thoroughly across the food supply chain and by interacting with all the stakeholders and experts in the subsector.

The Republic of India is the world's leading producer of mango with a production of around 20 million tonnes in 2015–2016, followed by China, which produces 5 million tonnes. Mango is a large share of fresh and processed horticultural exports from India to major Near East and European markets. Andhra Pradesh contributes to 6 percent of global mango production and 15 percent of India's mango production, making it the second largest producer of mangoes in the country. There are two important supply chains in the state's mango subsector: fresh fruit and pulp processing. The district of Vizianagarm was chosen for the case study of the fresh fruit food supply chain (FSC) and Chittoor district was selected for the study of pulp processing, as these FSC are dominant respectively. In both the FSCs small and marginal holders form a majority share of the producers and mango contributes to a significant share of their income.

As part of the study, both food supply chains were studied in greater detail by interacting with various stakeholders across the value chain ranging from farmers, traders, transport agents, packing-house experts, processing companies to horticultural experts. The food losses at individual stages were analysed for both qualitative and quantitative losses. A load tracking exercise was conducted to validate the losses at each of the individual stages. Environment, gender and socio-economic status of the actors were also evaluated to determine how these factors are related to the root causes of food losses and also the impact of food losses and the solutions proposed.

Analysis of the FSCs revealed that harvesting plays an important role in defining the losses in the later stages in both fresh and process food supply chains. Harvesting is a critical loss point (CLP) in both the supply chains. Transportation of mangoes in pulp processing is efficient and is a low loss point (LLP), while transportation in the fresh fruit FSC is a major CLP. Losses are high at the ripening stage in the pulp processing FSC, when the fruit is naturally ripened as compared to the use of ripening chambers. Other important causes of food losses observed included improper packing, non-standard storage and ripening conditions.

A food loss reduction strategy was formulated with the help of experts, after analysing the solutions for their suitability in terms of economic viability, technological feasibility, impact on the environment, social and cultural relevance, and by comparing better practices from similar supply chains globally. The most important solution recommended was to train farmers and farm workers about the importance of proper harvesting techniques and post-harvest care. Other recommendations include the development of low cost packaging structures for the fresh fruit FSC and development of standard conditions and methods for traditional ripening. Farm and post-harvest service enterprises have been proposed to address the problem of the availability of skilled labour. During a stakeholder meeting the findings of the report were appraised and key action points were identified to address food losses in the mango subsector.

Abbreviations and acronyms

AP	Andhra Pradesh
AGMARK	Certification system for products from India
AEZ	Agri-Export Zones
APEDA	Agriculture and Processed Foods Export Development Authority
CaC2	Calcium Carbide
CFB	Corrugated Fiber board Box
EIC	Export Inspection Council of India
ETP	Effluent Treatment Plant
FSC	Food Supply Chain
FSSAI	Food Safety and Standards Authority of India
GAP	Good Agricultural Practices
GMP	Good Manufacturing Practices
HACCP	Hazard Analysis and Critical Control Points
INM	Integrated Nutrient Management
IPM	Integrated Pest Management
MIDH	Mission for Integrated Development of Horticulture
MNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
NREGS	National Rural Employment Generation Act
PM	Processed Materials
RKVY	Rastriya Krishi Vikas Yojana
RM	Raw Materials
USD	United States Dollar
VHT	Vapour Heat Treatment
VZM	Vizianagaram

Chapter 1

The mango subsector – Introduction and background

STATUS AND IMPORTANCE OF THE MANGO SUBSECTOR; DEVELOPMENTS OVER THE LAST 15 YEARS

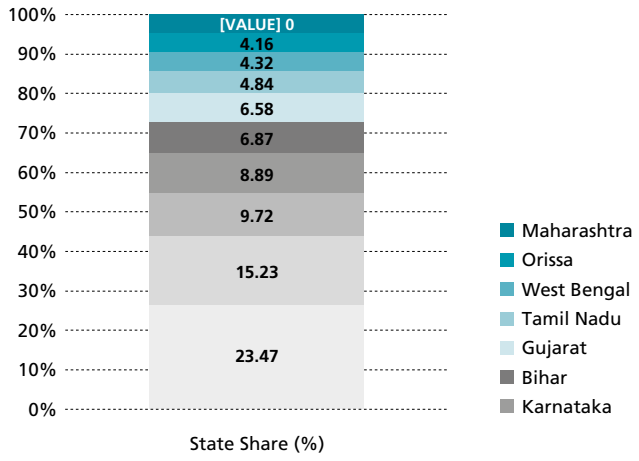
Mango (*Mangifera indica*) is the national fruit of India and is considered the king of fruits on account of its nutritive value, taste, aroma and health promoting qualities. Its cultivation, consumption and use are recorded in ancient Indian texts and literature. Mango thrives in a tropical climate and is cultivated throughout the Republic of India as a commercial crop. It is also a common sight in the backyards of homes, along field boundaries and roadside avenues. Across the country, mango is the most cherished fruit, eaten fresh or processed into different products. Mango is used at all stages of its development: as raw fruit it is used to make pickles, chutney, mango sauce and green mango beverages. The ripe fruit is processed into jams, jellies, frozen slices, canned products, dehydrated slices and ready-to-serve beverages.

Mango is nutritionally rich and provides energy to the extent of 74 Kcal/100 g. The fruit contains nearly 81 percent moisture, 0.4 percent fat, 0.6 percent protein and 0.7 percent fibre. It contains nearly 17 percent carbohydrates and 0.4 percent minerals (NIN, 1989). It is also a rich source of vitamin A and C. The mango kernel contains up to 10 percent good quality fat, which is used in the soap industry and also as a substitute for cocoa butter in confectionery.

Mango production in Andhra Pradesh

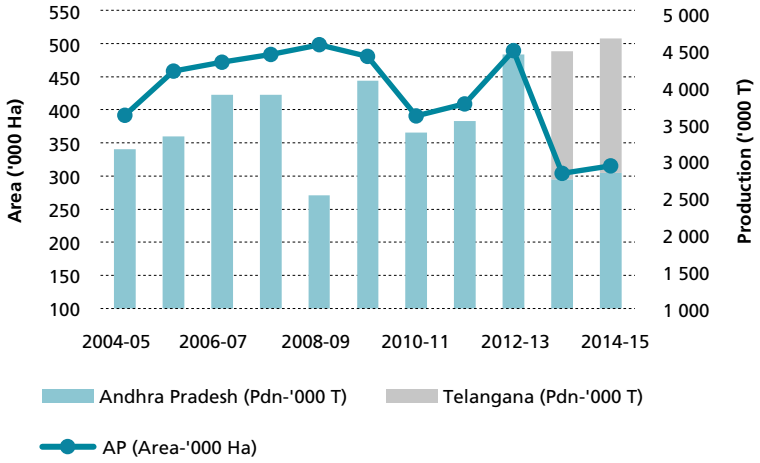
India is the leading producer of mango, followed by China, with an area of cultivation estimated at 2.22 million ha in 2015–2016 with a production of 19.51 million tonnes and with an average productivity of 8.8 tonnes per ha. Over the past fifteen years, it has been observed, that the mango production area for cultivation has been increasing with an average annual growth of 5.7 percent

FIGURE 1
Mango production (2014-2015), Top 10 States



Source: The Andhra Pradesh State Horticulture Department

FIGURE 2
Trend in mango production in Andhra Pradesh (2004–2015)



Source: The Andhra Pradesh State Horticulture Department

from 2001. Mango contributes to a major share of fresh and processed horticultural exports from India to major markets in the United Arab Emirates (UAE), The Kingdom of Saudi Arabia, The Kingdom of the Netherlands, The State of Kuwait and the State of Qatar. The country exported 36.3 thousand tonnes of fresh mangoes and 128 thousand tonnes of mango pulp to the world worth USD 49.5 million and USD 121 million respectively in 2015–2016.

In India, mango is cultivated extensively in the states of Uttar Pradesh, Andhra Pradesh, Telangana, Tamil Nadu, Karnataka, Maharashtra, Gujarat and Bihar. As estimated for 2014–2015, Andhra Pradesh ranked first in the country with an area of 315.69 thousand ha under mango cultivation and ranked second in production with 2.84 million tonnes, which contributed 15.27 percent to production with a productivity of 9.0 tonnes/ha. This translates to about 5.6 percent of global mango production. The Andhra Pradesh State Horticulture Department estimated the value of the produce in 2014–2015 at USD 333.30 million with a market price of USD 120 per tonne of mango.

The districts of Andhra Pradesh, Chittoor, Krishna, Vizianagaram, Anantapur and Kadapa in Andhra Pradesh are the predominant mango growing districts, where the fruit is grown in perennial orchards. Nearly 76 percent of mango farmers are small and marginal with land holdings of not more than two hectares, while the remaining 24 percent are medium and large farmers with land holdings of approximately four and ten hectares respectively. In 2014 the state of Andhra Pradesh was split into the two separate states of Telangana and Andhra, the area under mango cultivation in Andhra Pradesh fell from 4 406 to 3 040 hectares. However, the area under mango cultivation in the new state of Andhra Pradesh is constantly increasing at an average of 3.5 percent each year.

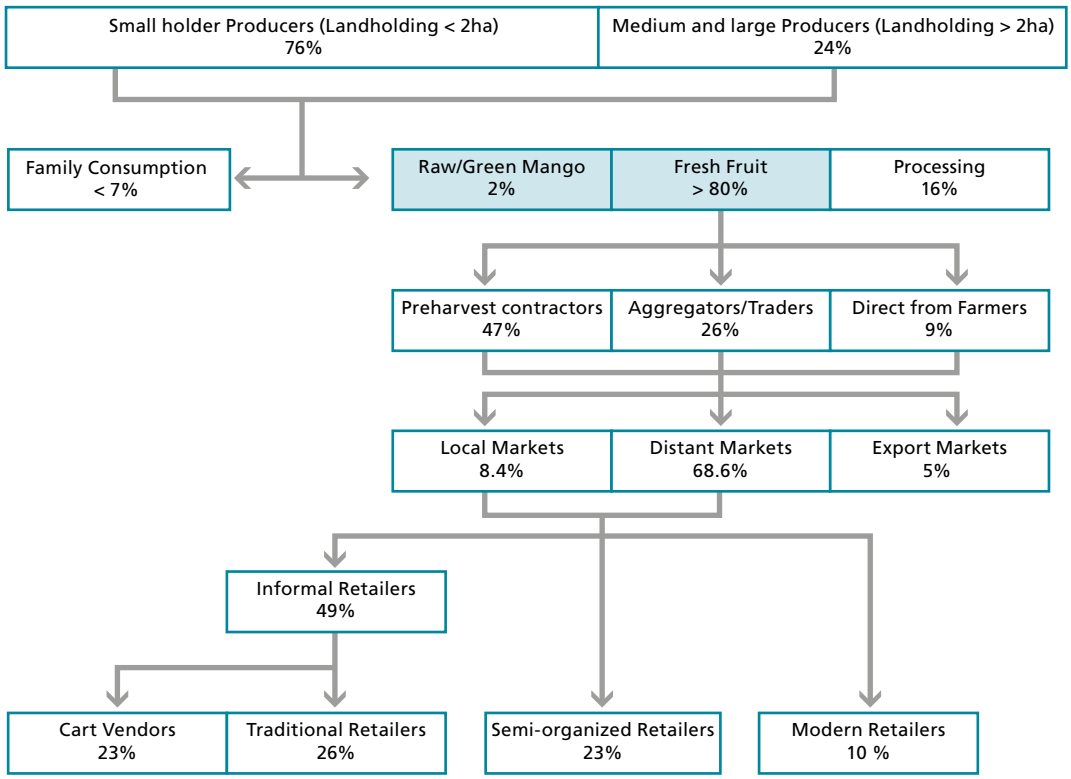
In the region, the main mango varieties produced for consumption as fresh fruit are Banginapalli, Suvernarekha, Chinna rasalu, Pedda rasalu and Neelam. Two varieties namely Tothapuri and Alphonso are produced exclusively for processing, however, their consumption is also quite popular for their distinctive taste and flavour.

State production information on the fresh fruit subsector – actors and product flow

The role of various actors at different stages in the FSC is as follows:

Producers – Farmers holding less than two hectares of land are classified as smallholder producers and account for nearly 76 percent of total farmers, the remaining 24 percent are classified as large holder producers. Farmers in the mango pulp FSC are comparatively more knowledgeable than those in the fresh fruit FSC in terms of post-harvest handling and market information. Most farmers in this FSC have direct links with processing plants and supply directly to them.

FIGURE 3
Actors and product flow in the fresh fruit subsector



Source: field data

Traders and preharvest contractors – The traders in the mango pulp FSC act as commission agents between the producers and the processing plants. They aggregate the produce collected from small farmers in market yards and supply them to processing plants by charging a commission of four percent on the sale price. They play an important role in maintaining a continuous supply of fruit to the processing plants in the limited production season by procuring fruit from other regions at the beginning and end of the season.

In the fresh fruit FSC, traders and aggregators procure fruit from the local producer, aggregate the fruit and ship it to traders at distant markets across the country. The preharvest contractors also operate in a similar manner; in this case, they contract with the mango producer for the entire production for one or more seasons and, in turn, finance the farm operations for that particular season.

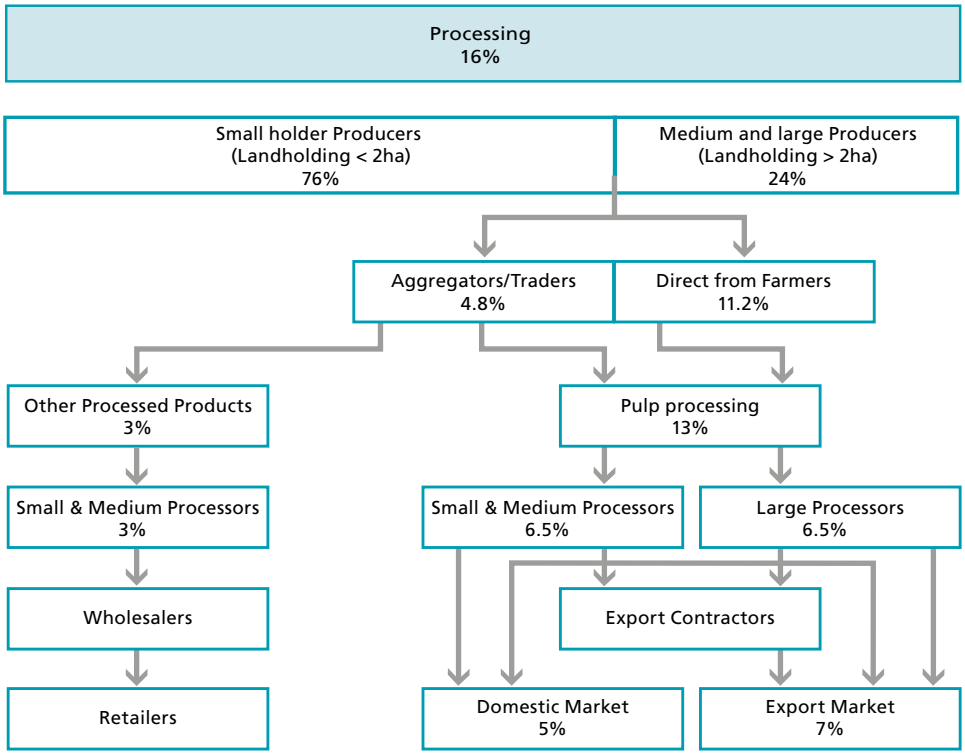
Pulp processors – Most are small but medium-scale processors can produce up to 100 tonnes of mango pulp per day. About five percent of the total are large producers that contributee about 50 percent to total production. The main products produced in this FSC are aseptic and canned mango pulp and pulp concentrate.

Processors of other products – such as mango jelly and pickles are manufactured by small or cottage-scale processors with capacities of less than two tonnes per day.

Export contractors – are licensed to export the pulp and have good down-stream linkages. They procure and supply pulp to the export market, mostly from small processors who are not represented at terminal markets. In some cases, export contractors finance the operations by entering into toll production agreements.

Wholesalers and retailers of processed products – procure large quantities of processed mango products and distribute them further on in the supply chain. They are usually involved in the trade of multiple commodities. Retailers procure

FIGURE 4
State production information on the processing subsector – actors and product flow



Source: field data

smaller quantities of the products from wholesalers, sometimes on a line of credit, and sell them to the final consumer at the terminal market.

Wholesalers and retailers of fresh fruit – are usually located in the market yards in distant markets. They procure fruit directly from the farmer or in most cases from the traders of mango producing regions. Retailers, depending on the scale of their operations and markets, can be classified into cart vendors, traditional retailers in fruit and vegetable markets, organized fruit and vegetable store retailers and modern trade channels like supermarkets and hypermarkets.

On-farm consumption of mango in both the FSCs is limited to less than one percent, and usually accounts for self-consumption by the farmer's family and farm labour. In most cases, it also involves good will distribution to the neighbourhood. The major portion of the fresh fruit goes to distant markets as there is a high demand during the lean season; about 16 percent of the produce is processed into various value-added products. Because mangoes are perishable, and are difficult to store, processing plays an important role not only in improving the product shelf-life but also in generating sustainable income for the producer through value-addition and by creating better access to markets. During the season studied, the production cost incurred by farmers for one hectare of production was between USD 210 to 300.

Food safety management mechanisms

Food safety practices are critical throughout the mango FSC. However, the importance of food safety is more widely understood and practiced in the mango pulp FSC as well as in the fresh fruit FSC destined for export markets. The following explains the level of implementation of food safety management mechanisms and the responsible agencies at different stages of the supply chain.

TABLE 1
State production information on the subsector

	Annual production (tonne/year)	Cultivated area (ha)	Average yield (tonne/ha)
2013-2014	2 737 008	304 111	9
2014-2015	2 822 075	315 415	8.94
2015-2016	3 040 168	325 845	9.33
Average annual growth over the last 3 years (%)	31.35	391 896	9.07
Average cost of production (USD/tonne)	38		

	On-farm consumption	Marketed
Percentage of production	1	99

	volume (tonne/year)	value (USD/year)
Market product #1, Fresh Mango	2 024 752	
Market product #2, Pulp	395 000	
Market product #3, Other Products	12 000	

Number, gender, age of	Female	Male	Total
	Total	Total	
Total producers in the state	3 345 754	98 23 660	13 169 414 (Total Farmers)
Mango producers	92 577	271 822[1]	364 399
Traders			
Processors			65
Retailers #1			

	Small	Medium	Large
Level of processing operations	76	20	4

[1] Specific data on women and men mango farmers are not available; numbers are based on the assumption of general land holding pattern for all other crops. There are a total of 364 399 mango landholdings.

Source: field data

Good agricultural practices and produce standards

Good agricultural practices (GAP) are followed by all producers exporting fresh fruit and by suppliers of fresh produce to the processing plants. Although AGMARK standards are applied to fresh fruit, they are not stringently followed by any actors in the FSC. Instead, in many cases, voluntary standards are followed according to local market norms. Some important GAP practices that are currently followed by producers are soil testing, integrated pest and nutrient management, sensible use of agrochemicals and proper post-harvest handling.

Food Safety and Standards

The Food Safety and Standards Authority of India (FSSAI) issues mandatory rules for registration of manufacturing facilities and standards for products, which are stringently followed by processors. It also monitors and controls the use of ripening agents or chemicals for fruit. Most processing plants are Hazard Analysis and Critical Control Points (HACCP) certified and follow good manufacturing practices (GMP).

Export inspection standards

In the export value chain, the regulations of respective countries and their regulatory systems are applicable, and the Export Inspection Council (EIC) oversees the testing and certifying of these parameters.

INVENTORY OF ACTIVITIES AND LESSONS LEARNED FROM PAST AND ONGOING INTERVENTIONS

In Andhra Pradesh, in order to improve the mango subsector and horticulture as a whole, the horticulture department started providing limited subsidies using a cluster approach by supporting canopy management, rejuvenation, integrated pest management. Support was extended to improve post-harvest practices by providing plastic crates, and establishing grading, packing and processing units at a 50 percent subsidy. These initiatives are supported by both the state government, as well as the central government, under the Rastriya Krishi Vikas Yojana (RKVY), Mission for Integrated Development of Horticulture (MIDH) and other state schemes.

The state government also launched the AP Micro Irrigation Project (APMIP) in 2003 to conserve the available groundwater and increase the productivity of horticulture crops. This initiative was intended to help small and marginal farmers by promoting micro-irrigation technologies for the cultivation of high-value horticulture crops. According to Horticulture Department estimates, adoption of drip irrigation for mango, increased yields from 50 to 70 percent with a minimum of 53 percent water savings per hectare per season and 53 percent saving in energy, as compared to flood irrigation (AP Socio-economic Survey 2015-2016). In the past three years, a total area of 25 765 ha in Chittoor and 3 418 ha in Vizianagaram were brought under micro-irrigation. Mango farmers, particularly in the mango pulp FSC, are progressive in their adoption of drip irrigation to counter the effects of climate change, such as uneven trends in rainfall and drought, and to ensure better productivity and reduced fruit loss. The Government created the Agri Export Zones (AEZ) during 2002 for mango, grapes, gherkins and chillies to promote quality production and exports. However, some Agri Export Zones were established for mango, chillies and grapes to promote quality production for export, later these zones became non-functional because of lack of demand and proper implementation.

TABLE 2
Situation in the food supply chain

Controller	Control	Actual situation in the FSC		Responsible agent
Government regulation and requirements	National food safety/ quality standards	Exists and applies to the whole FSC	X	Food Safety Officer, Food Inspectors
		Exists but not rigorous		
		None		
	Frequency of checking (None, Low, Medium, High)	Harvest	None	Processors, Exporters Quality control personnel within the processing unit
		Transport	None	
		Storage	Low	
		Process	High	
		Market	Low	
	Obligatory registration of the food processing/ preparation unit	Exists	X	Processor, Food safety Officer, Export Inspection Laboratory
		None		
FSC actors - food safety management system	GHP/ GAP/ HACCP/ voluntary standards	GAP, HACCP		Farmers, Processors
	Identification and control of potential hazards Physical: foreign matter Chemical: pesticides, lubricants, calcium carbide etc. Biological hazards: insects-fruit flies, pathogenic microbes		Medium	Processors, Food Inspectors, Certifying agencies

Source: field data

Some past strategies for development of horticulture include:

- Convergence of the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) with the Horticulture Department for better use of labour and empowerment of under-developed communities.
- Improving marketing facilities through *rythu bazaars* (farmers' markets), vegetable markets, and collection centres and refrigerated vans so that farmers obtain remunerative prices for their produce.
- Promotion of precision farming through micro-irrigation, fertigation, greenhouse cultivation, mulching for better water conservation and quality of production.
- Encouragement in the use of modern farm machinery and tools to save time and labour and to improve the harvested fruit quality.
- Promotion of post-harvest management practices through the establishment of packing-houses, cold storage, ripening chambers and the reduction of post-harvest losses thereby increasing horticultural exports.

Interventions by actors in the FSC

Processing companies play a crucial role in awareness-building among mango producers on the importance of post-harvest handling in the processing value chain. Currently, fresh fruit is handled gently and transported in plastic crates as opposed to the earlier practice of dumping. The importance of ripening chambers is well understood by all levels of processors who have upgraded their technology through the scheme provided by the Agriculture and Processed Foods Export Development Authority (APEDA) or National Horticultural Board. Intermediate storage sheds mounted on concrete were constructed without ripening chambers; fruit could be ripened using the traditional method. Processing units that started as canning units slowly transformed by adopting aseptic packaging technology. Interventions were adopted at processing plants including: interventions such as mechanical washing of fruit, upgrading to pasteurizers from open steam jacketed kettles, improving the can-sterilization system and use of rotary continuous can filling machines. Operators at processing plants also understood the importance of quality assurance and implemented quality systems and HACCP standards. These steps have improved quality, food safety, reduced food losses and environmental impact.

POLICY FRAMEWORK OR NATIONAL STRATEGY

The Centrally Sponsored Scheme of National Horticulture Mission (NHM) has been implemented since 2005–2006 in Andhra Pradesh. In April 2014 NHM began operating under the Mission for Integrated Development of Horticulture (MIDH) to promote holistic growth of the horticulture sector. Today, NHM is being implemented in 11 districts of AP. The Mission's main activities are production and distribution of quality planting material, area expansion, rejuvenation of senile plantations, creation of community water resources, protected cultivation, integrated pest management (IPM)/integrated nutrient management (INM), organic farming, development of post-harvest management and marketing infrastructure and human resource development.

Run by the Government of India, the MIDH today incorporates six schemes for horticulture development, including NHM, and covers nine districts, including Chittoor but not Vizianagaram.

Agri-export Zones (AEZ) were promoted by the state government to boost the export of horticulture products. The Chittoor AEZ is the most successful in the state and in the country. Before the establishment of the AEZ the annual turnover of pulp exports from Chittoor were USD 1.22 million, which increased to USD 49.4 million in 2012. Besides the modernization of several units and support for HACCP certification, the Government has exempted sales tax on all inputs and packaging materials used for exports. Processors have made other demands, but on the whole, the industry is responding well to the policy support.

Support is also being extended to post-harvest management through the following agencies and schemes.

Rashtriya Krishi Vikas Yojana (RKVY) assists fruit processors with soft loans to upgrade technology at the plants.

The Agriculture and Processed Foods Export Development Authority provides support in setting up integrated or individual post-harvest infrastructure such as packing-houses, pre-cooling units and cold chain units, adoption of quality assessments and food safety systems, assistance in training and skill development of personnel in units destined for export.

Mega Food Park Scheme provides financial assistance through the Ministry of Food Processing Industries (MoFPI), to establish mega food parks to link production areas to markets

with processing facilities, support infrastructure and improve value addition, minimizing wastage, increasing farmers' income and creating employment opportunities, particularly in the rural sector. There are two mega food parks in the mango pulp FSC: Srini Food Park and Sricity Food Park where there are improved processing facilities that have catalyzed the increase in demand for pulp.

The Credit Linked Capital Subsidy Scheme (CLCSS), through the Ministry of Micro, Small and Medium Enterprises, has extended support by promoting small-scale industries and technology by providing a subsidy of up to USD 22 000 to upgrade plant machinery.

Implementation of the **Total Quality Management System** including **ISO 9000, ISO 22000, HACCP, GMP and GHP** through **the MoFPI** assists in expansion by reimbursing up to 50 percent of expenditure for consultant fees charged to processing units by the Certification Agency, for plant and machinery, technical civil works and other expenditure covering implementation of the Total Quality Management System including ISO 9000, ISO 22000, HACCP, GMP and GHP.

RELEVANT INSTITUTIONS AND THEIR ROLES

The Department of Agriculture, Cooperation, and Farmers Welfare (DAC&FW) is responsible for formulating and implementing national policies and programmes to achieve rapid agricultural growth through the optimal use of the state's land, water, soil and plant resources. The Department focuses on agriculture, marketing agricultural produce, horticulture and sericulture. The objectives of the Department are to assess the requirements for agriculture inputs, regulate their production, and monitor the timely supply of seeds, fertilizers, pesticides, implements and credit to farmers. The Department also performs statutory functions under various acts and regulations such as quality control, to ensure the supply of quality inputs to farmers for example seeds, fertilizers and pesticides.

The Department of Horticulture covers all issues related to the horticulture sector and coordinates the implementation of schemes conducted by various bodies such as the National Horticultural Board. The Department of Horticulture also supports farmers with technical advice about the cultivation of horticultural crops, executing various schemes, training and demonstration visits for farmers, organizing meetings to advocate new technology, and evaluating the need for assistance after a natural disaster.

The Ministry of Food Processing Industries (MoFPI) is responsible for overall policy-making, in terms of infrastructure development and development of the food processing sector. MoFPI draws up the overall strategy for promoting food processing and supports, through various schemes, the establishment of mega food parks, cold chain infrastructure, waste utilisation plants and skill development through training of stakeholders.

The Food Safety and Standards Authority of India (FSSAI) issues and monitors regulatory standards for intermediate products: aseptically processed mango pulp, canned mango pulp, pulp concentrate and tertiary consumer products such as jams, pickles, beverages and candied fruit. Companies producing any of these products are obliged to register with the FSSAI as a Food Business and Operator (FBO) and follow the applicable product, packaging and processing standards.

Agricultural and Processed Foods Export Development Authority (APEDA) ensures processing companies and export merchants are registered with APEDA for the export of fresh mangoes that are processed overseas. The APEDA sets standards for exported products, coordinates with various regulatory agencies and notifies all stakeholders of changes and developments in standards, trade notifications or restrictions in the respective countries. The APEDA also promotes the export of food and agricultural commodities through various interventions such as financial assistance, Infrastructure development, markets and quality development. The APEDA was instrumental in establishing four Vapour Heat Treatment (VHT) plants, two in Krishna district and two in Chittoor, and a common aseptic packaging plant in Chittoor AEZ to promote the export of fresh mangoes and mango pulp respectively.

The Export Inspection Council (EIC) ensures products adhere to the respective standards for the export market. The EIC facilitates testing of samples at laboratories at the Export Inspection Agencies located at various ports of entry and exit across the country and issues certificates including certificate of origin, phytosanitary, preshipment inspection.

TABLE 3A
Mango supply chains in the subsector

No. of FSC	Geographical area of production	Final product	Area under mango (ha)	Volume of mango production (tonne/year)	Number of smallholder producers/total farmers (%)	Market for final product, location, buyers	Project support
1	Chittoor	Pulp, fresh fruit	73 977	665 793	71 000 / 92 000 (77 %)	Near East, Europe, Japan; Pan India	MIDH, RKVY, NREGS, APEDA
2	Krishna	Fresh fruit, pulp	63 475	507 800	42 500 / 53 500 (80 %)	Pan India, Japan, Near East	MIDH, RKVY, NREGS, APEDA
3	Vizianagaram	Fresh fruit	44 403	532 836	55 400 / 65 800 (84 %)	Pan India	RKVY, State Plans, NREGS,
4	Anantapur	Fresh fruit	47 686	381 484	1 300/ 3 400 (39 %)	South India	State plans

Source: field data

TABLE 3B
The importance of mango supply chains at the national level

Type of Food Supply Chain	Economic Importance	Generation of foreign exchange	Contribution to national food consumption	Contribution to national nutrition	Impacts on environment and climate change
Chittoor: mango pulp FSC	3	3	2	2	2
Krishna	3	2	3	2	2
Vizianagaram: fresh fruit FSC	2	1	2	1	2
Ananthapur	2	1	1	1	2

Source: field data

TABLE 4
Economic importance of food supply chains for smallholder farmers

Type of Food Supply Chain	Percentage of produce		Contribution to income generation (Percentage share of total annual income)				
	Smallholders	Other	Farmers	Intermediaris	Processors	Wholesalers	Retailers
Mango pulp FSC	76	24	70	50	80	NA	NA
Fresh fruit			40	50	NA	50	25

Source: field data

OVERVIEW OF THE FRESH FRUIT AND PULP FSCS

In 2015–2016 mango was cultivated on close to 326 000 ha in Andhra Pradesh, which produced approximately 3 000 000 tonnes. Chittoor, Krishna, Ananthapur and Vizianagaram are the leading districts for area under mango cultivation.

Vizianagaram was selected for the study of the fresh fruit supply chain because of the area under cultivation, the number of small farmers, the level of infrastructure and the presence of a market value chain for fresh mango fruit. Chittoor was selected for the mango pulp FSC because of the variety of mango produced, which is suitable for processing and also the presence of the entire processing supply chain. Table 3A identifies and lists the main FSCs in the subsector by geographical area, final product and market for the final product.

The mango pulp FSC in Chittoor is a major contributor to foreign exchange earnings for Andhra Pradesh and to a major share of exports. In 2014 about USD 89.8 million worth of pulp was exported. Mango pulp is also traded extensively on the domestic market, valued at USD 104.7 million every year.

Mango contributes to nearly 40 percent of the total income of small and marginal farmers

TABLE 5
Preliminary screening of food losses in the selected food supply chains

FSC #1 <Chittoor>, <Mango Pulp>			
Stage in the FSC	**Expected critical loss points**		**Comments/Remarks**
	Quantitative %	**Qualitative %**	
Production and harvesting	5-10	5	▪ Preharvest losses resulting from climatic conditions, diseases, and pests ▪ Physical damage of fruit due to improper harvesting
Sorting and grading	10	2	▪ Culled fruit are sometimes lost completely or sold for less value depending on the demand
Ripening–Traditional process	10-15	20	▪ As a result of improper handling and non-standard process
Ripening – Ripening chambers	3-6	10	▪ Because of internal injuries, fungal infections, over maturity

FSC #2 <Vizianagaram>, <Fresh fruit>			
Stage in the FSC - VZM	**Expected critical loss points**		**Comments/Remarks**
	Quantitative %	**Qualitative %**	
Harvesting	10-15	5	▪ Immature fruit, sap injury, mechanical damage ▪ Diseases such as stem-end rot and pest infestations
Grading	5	5	▪ Physically damaged fruit, blemished and bruised fruit
Transportation	10-15	20	▪ Physical damage to fruit in the boxes ▪ 5-10 sold at lower cost
Retail - First point of delivery	5	25	▪ Storage diseases such as anthracnose, Fungal rot, etc. ▪ Loss of quality because of shrivelling, physical injuries

Source: field data

TABLE 6
Intermediary products and conversion factors in the food supply chain

Activity in the process	Duration[2]	Product out	Weight from 100	Cumulative Error (± %)	Conversion Factor
Harvesting	8 hours	Mango	100		1.0
Transportation	2-3 hours	Mango	100		1.0
Ripening	6-10 days	Ripened mango	92-94	± 2 %	1.06-1.08
Pulping	8 hours	Mango pulp	50	± 5%	1.81

[2] Only applicable to processes determined by length of time, independent of the quantity of product and the amount of labour, such as drying, fermenting, ripening, storage, transportation.

Source: field data

whose annual net income is from USD 1 500 to 1 750 per annum. In the off-season farmers work as farm labourers to supplement their income, or cultivate other crops such as paddy or sugarcane. As mango is the main crop in the region, most work in the mango pulp FSC is directed towards this fruit and farmers are also employed in other jobs or businesses in the sector. During the off-season processors process papaya and guava. The net income from mango processing is about 20 percent of the processors' net annual income of USD 30 000 to 75 000. Wholesalers and retailers are usually involved in the trade of multiple commodities and mango only partially contributes to their total income.

Presumed food losses in the selected food supply chains

Food losses were observed to vary in both FSCs. In the mango pulp FSC, the perception of losses among the actors is relatively low as compared to that of the fresh fruit FSC. In both cases, farmers at all levels agreed that losses during harvesting are about 10 percent. Losses in transportation are high in the fresh fruit FSC whereas in the mango pulp FSC transportation is minimal, efficient and is a low loss point. In the mango pulp FSC critical losses were observed during the traditional ripening process.

Chapter 2

The food supply chain – Situation analysis

THE MANGO SUBSECTOR

The study took place in April, May and June 2016 and covered Badangi, Garividi, L. Kota and Merakamudidam blocks of Vizianagaram district for the fresh fruit FSC and Chittoor, Kanipakam, Bangarupalyam, Tirupathi, Mapakshi blocks of Chittoor district for the processed fruit FSC.

Vizianagaram

With around 47 630 ha under mango cultivation, Vizianagaram district is in third place contributing about 0.43 million tonnes of production and fresh fruit as the main FSC. The area under mango is increasing as a result of the area expansion programme implemented by the government and also because of the shifting of many upland farmers to mango cultivation because of water scarcity and labour problems. The popular mango varieties cultivated in the region include Banginapalli (50 percent), Panukulu (20 to 25 percent), Suvarnarekha (15 percent) and Totapuri (5 percent) with the rest being other varieties. Panukulu, Suvarnarekha, and Banginapalli are very popular in distant markets such as Kolkata. Panukulu is an early season variety in terms of fruit bearing and maturity, followed by Suvarnarekha, Banginapalli and Totapuri. Many farmers in the fresh fruit supply chain maintain orchards with a mix of varieties to spread the availability of produce, and as a diversification strategy to minimize the risks related to crop losses and climate. More than 90 percent of the area under mango cultivation in Vizianagaram district is rainfed. The district is prone to cyclones and several mango orchards were severely affected

FIGURE 5
Map of districts selected for the study in Chittoor and Vizianagaram

Source: Author's elaboration

by the Hud-Hud cyclone in 2014. More than 80 percent of the mango cultivators are marginal and small farmers.

Chittoor

With around 71 000 ha under mango cultivation, Chittoor district is first, contributing about 0.68 million tonnes of production and pulp processing as its main FSC. The increased cost of labour for other crops, less dependency on irrigation, support from government and better market facilities encouraged farmers to switch from conventional crops to mango cultivation. About 70 percent of the total production is for the Tothapuri variety, followed by Alphonso, Neelam, Baneshan, Imam Pasand, Pulera and Kalepadu. Most farmers have adopted drip irrigation with the support of government or independently. The mango pulp-processing sector is called the Chittoor fruit-processing cluster and is the largest of its kind in India. There are about 67 registered units in the mango pulp industry, of which 55 were operational in 2016.

MARKETING SYSTEMS IN THE MANGO SUBSECTOR

Small-scale producers

Mango pulp FSC (Chittoor)

Most mangoes produced in Chittoor are processed into pulp, which accounts for about 70 percent of the region's total production. The main varieties Tothapuri and Alphonso are processed into aseptic mango pulp or pulp concentrate.

Direct sale to processors – Most large and medium farmers own larger orchards and collaborate with processors to supply harvested fruit directly for processing after sorting and grading at the orchard level. Large processing companies also buy produce from small farmers, provided they have a good quality harvest.

Traders – Farmers with very small orchards take their harvested produce to the market and sell it to traders, who in turn sell to the processor after sorting and grading. This means farmers receive about 5 percent less for their produce. The traders usually provide financing during the off-season to the small farmers for farm inputs and thus they are bound to sell their produce to the same trader, however they are also free to sell their produce to others depending on the prevailing rates at that time. There are five market yards in Chittoor, which are governed by the Andhra Pradesh Agricultural Marketing Department, and cover the major mango producing regions. Most produce leaves these market yards for processing and a smaller share goes to distant markets as fresh fruit. The market yard in Tirupathi also houses a vapour heat treatment plant to serve export markets, as heat treatment is a prerequisite for many importing countries.

FIGURE 6
Mango trader in market yard

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The produce is transported by fellow farmers who own tractors or by transport agents. The produce does not have to be transported far as all processing plants are evenly distributed across the district. The average distance travelled is around 50 km, which takes about 3 hr. At the beginning and end of the season, mangoes are procured from relatively distant markets to extend the production period. In this case, they are procured from the neighbouring states of Karnataka, Tamil Nadu and other markets in Andhra Pradesh.

Processing plants – Most processing plants in the district are small and medium enterprises and a tenth of them are large. The processed mango pulp is used as an ingredient in a range of products such as beverages, jams, ice cream, etc. and is procured by companies on the basis of prior contracts. More than half of the pulp produced is exported to countries in the Near East, Europe, the United States and the rest is consumed on the domestic market.

Fresh Fruit FSC (Vizianagaram)

More than 90 percent of the fresh fruit produced in Vizianagaram goes to distant markets across the country such as Delhi, Raipur and Kolkata.

TABLE 7
Detailed description of the food supply chain – basics

Mango pulp FSC										
FSC stage[3]	Geographical location[4]	Months of the year[5]		Main products[6]	Quantity (ton)	By-products	Quantity of By-products (ton)	Duration/ Distance[7]	Services	Food safety and quality controls applied by that part of the chain
		From	To							
Primary Production	Chittoor	August (Previous)	May	Mango	665 793	NA	NA	8 months of production time	Irrigation, fertilizers, farm management	GAP
Harvest	Chittoor	June	Aug.	Mango	665 793	NA	NA	day/ ha	Farm labour, Implements	GAP
Post-harvest handling	Chittoor	June	Aug.	Mango	599 214	Culled fruit	66 579	1 day/ha	Farm labour, Crates	GAP, GMP
Storage		NA	NA	Mango	NA	NA	NA	NA	NA	NA
Transportation	Chittoor	June	Aug.	Mango	599 214	NA	NA	50 km	Truck	GMP
Market sales	Chittoor	June	Aug.	Mango	432 765	NA	NA	3 months during harvesting	Sorting and grading, loading and unloading, sales	GMP
Agro-processing	Chittoor	June	Aug.	Mango pulp	466 055	Peel, Stone	116 513- Peel 93 211- Stone	6 tonne/ hour	Ripening, cleaning, pulping, thermal processing and packing	GMP/HACCP, FSSAI

[3] If one stage in the FSC has two different features, another row should be inserted. For example, if in the same FSC there is both crib storage and warehouse storage.
[4] Village or town where the FSC stage is located.
[5] Timing of the stage in the FSC.
[6] 'Final' product produced by stage in the FSC.
[7] How long does the process in the FSC stage take / what is the distance (and duration) of transportation.

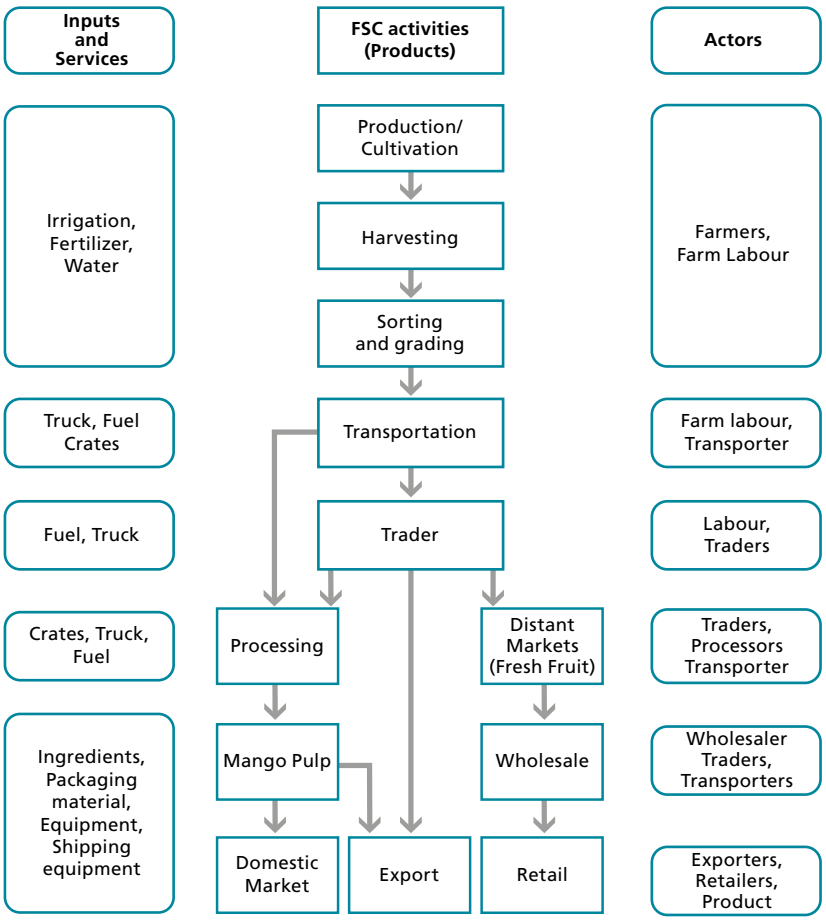
TABLE 7
(Continued)

Mango fresh fruit FSC										
FSC stage[8]	**Geographical location[9]**	**Months of the year[10]**		**Main products[11]**	**Quantity (tonne)**	**By-products**	**Quantity of By-products (tonne)**	**Duration/ Distance[12]**	**Services**	**Food safety and quality controls applied by that part of the chain**
		From	**To**							
Primary Production	Vizianagaram	July (Previous)	March	Fresh fruit	532 836	NA	NA	8 months	Irrigation, fertilizers, farm management	GAP
Harvest	Vizianagaram	March	May	Fresh fruit	532 836	NA		1-30 days	Farm labour	
Post-harvest handling	Vizianagaram	March	May	Fresh fruit	506 194	Culled fruit	26641	1 day	Farm labour	Good hygienic practice / GHP
Storage		NA	NA	NA	NA	NA	NA	NA	NA	NA
Transportation	Vizianagaram	March	May	Fresh fruit	362 328	NA	NA	800 to 1 000 km	Loading Packaging and transportation	GMP
Market sales	Delhi, Kolkata	April	May	Fresh fruit	362 328	NA	NA	4 months	Unloading, ripening, repacking	FSSAI – Control on use of ripening agents

Source: field data

[8] If one stage in the FSC has two different features, another row should be inserted. For example, if in the same FSC both crib storage and warehouse storage exist.
[9] Village/town where the FSC stage is located.
[10] Timing of the stage of the FSC.
[11] 'Final' product produced by stage in the FSC.
[12] How long does the process in the FSC stage take / what is the distance (and duration) of transportation.

FIGURE 7
Flow diagram of the selected food supply chains



Sources: field data

The remaining 10 percent is sold at the local markets in Vishakhapatnam and Vizianagaram districts.

Preharvest Contractors (PHC) and Commission Agents – Nearly 80 percent of the mango farmers in the region sell their produce through preharvest contractors (PHC) or commission agents who pay cash in advance to these farmers at the pre-flowering stage and procure the entire produce, then the fresh mangoes are transported to traders at distant markets. Farmers use the advance for farm operations and to meet the cost of inputs. These agents collect a 10 percent commission on the transaction value. Few farmers and traders or aggregators can invest in, or arrange, their own transport and send the produce directly to distant markets, which accounts for about 20 percent of the total produce in the region. The agent informs the farmers of the dates of transportation and the contract farmers harvest, grade and pack the produce for shipment on the day of harvest.

Local aggregators – Some small farmers sell the produce to local aggregators who pay the farmers cash immediately. These aggregators do not give an advance for farm operations, but pay at the time of sale, which in this case provides an incentive to the farmer.

Farm contractors – Some small farmers lease out their farms to agents or traders, who act as farm contractors for 2 to 3 years, and are not involved in any farm operations, but the farmers work as farm labourers for the agent. Most farmers do not know the destination market, as agents collect the

produce at a fixed price and do not inform them of the destination or final agent receiving the produce. The produce remains with the agent who decides the destination market and, depending on the demand and produce quality, the final contractor pays the market price.

Farmers suggest there should be a mechanism that will let them know the sale price of their produce, which currently is not in place as they are paid less, compared to the market price. There are about 14 market yards in the district and some mainly handle horticultural products. During the study period, it was noted that fewer mangoes were being taken to the market yards, as most farmers or traders prefer not to use the market yard facilities to avoid paying tax. A small portion of the produce and fruit culled from sorting and grading is sold at the local market to the cottage industries involved in manufacturing mango jelly.

The different steps involved in the FSC are as follows:

Production and cultivation

In Vizianagaram, several mango orchards are very old plantations and canopy management has been adopted by a few farmers and is also being encouraged by the Horticulture Department. Some farmers prefer not to cut the branches as they prefer the branches to be higher to allow tractors to move beneath facilitating mechanical harvesting. However, when harvesting large trees, there is a higher risk of mechanical damage to fruit (5 percent) because fruit may fall to the ground during harvesting. High-density plantations, with smaller trees are easier to harvest, however, they are not yet popular in the region. Farmers plough the fields twice after the harvesting season, June to July, apply fertilizer in August and spray three times to protect the crop November to December. Over 90 percent of the area is rainfed and no irrigation is provided after the rainy season.

In Chittoor, the tree canopy is medium to small because of the age of the plantations, variety and soil conditions. The orchards are better managed and most are drip irrigated. High-density plantations are slowly gaining importance and the government and the local processing industry provide support. Farm management practices include tilling in the off-season and before rains, pruning before the season induces reproductive growth. Fertilizer and crop protection sprays are applied similar to practices in Vizianagaram.

Harvesting

Harvesting is the most important factor governing the post-harvest management of mango. In the fresh fruit supply chain in Vizianagaram, farmers harvest two to three times in a season with a gap of one week in between each harvest. Ideally, the fruit should be harvested at a mature stage when they turn slightly yellow on the tree. It is common practice in the region to harvest fruit early in the season (premature stage) to capture the early market. The farmers also harvest fruit in a state of panic when the market prices fall, this usually occurs 15 days after the first harvest. The farmers harvest everything and send the produce to the market to salvage whatever price they can get. Farmers harvest early to prevent losses from unpredictable weather such as storms and winds. Many farmers harvest the fruit using a long pole with a net basket and a blade at the end. If the trees are large, a worker climbs the tree and throws the harvested fruit to another worker standing under the tree. With this method of harvesting, up to 5 percent of the fruit can be mechanically damaged. The fruit is placed on the ground under the tree, directly exposing the partially damaged fruit to the ground, which is a common source of infection.

In the mango pulp supply chain in Chittoor, harvesting is usually at one time, when 85 percent of the produce in the orchard is mature. Depending on the canopy and height of the trees, the fruit is harvested using a pole with a net or by dropping the fruit to the ground. In comparison, farmers in this FSC understand the value of post-harvest handling and fruit is managed better. Harvesting commences in June and lasts until July, as the main variety grown in Chittoor, Tothapuri, is a late season variety. During harvesting, care is taken to prevent sap burn or injury, which is caused by the resinous sap touching the fruit skin. This leads to browning caused by Polyphenol Oxidase and Laccase enzymes in the fruit skin. Desapping is carried by leaving a lengthy petiole, or stem, of 5 cm and by inverting the fruit on raised bamboo platforms to remove the sap. Desapping is not done extensively in both the FSCs.

Sorting and grading

For the fresh fruit chain in Vizianagaram, fruit is graded based on variety and no other standards are followed for grading in this region. After removal of the damaged, spotted and diseased fruit, farmers grade all the produce into top grade and second grade, which is indicated on the package. The graded fruit are packed in boxes (weighing about

FIGURE 8
Mango harvesting (left); Net apparatus for harvesting (right)

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FIGURE 10
Packaging for transportation in coated cardboard (CFB) boxes and plastic crates

©FAO/Sathguru

15 kg) and then transported. There are no major exports from this region and hence no standards have been adopted.

In the mango pulp FSC in Chittoor, there is no grading, but the mangoes are sorted on the farm to remove small, immature, irregular and damaged fruit. The produce may be directly sold to a processor or the mangoes are sorted in a market yard if sold to a trader. Many fresh mangoes are exported from Chittoor, so in this case, the mangoes are stringently graded by weight and size at the packing-house for export. The rejected fruit often conforms to local market standards so is then sold by the farmers or traders at the local market.

FIGURE 9
Culled fruit after sorting and grading

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FIGURE 11
Transportation using plastic crates

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Transportation

More than 90 percent of the fresh fruit from the Vizianagaram region goes directly to distant markets in Delhi, Raipur and Kolkata. Mangoes are transported long distance by trucks and trains and there is no refrigeration. It takes 3 to 4 days for the mangoes to reach the distant markets, during transport the fruit touching the sides of the boxes and those on the bottom layer are damaged (10-15 percent). The use of crates could reduce these losses considerably; however, the main problem is to return the crates from distant markets, which would incur additional transport costs. The current practice is to use corrugated boxes that are generally provided by the contractor or the aggregator. In Chittoor, the average transport distance from farm to processing centre is no more than 50 km, which takes from 3 to 5 hrs. The sorted fruit is dumped into trucks or tractors and covered with a tarpaulin.

Ripening

There is no major requirement for ripening mangoes in the fresh fruit supply chain for distant markets as the fruit ripens during the 3 to 4 days of transport. Wholesalers ripen fresh fruit at the market, as this stage is not handled by the agent or transporters. The region's local market is very small and, as calcium carbide has been banned as a ripening agent, the study team noted in 2016 that the market had become smaller. The ban on calcium carbide had no impact on the long distance market. In the mango pulp supply chain processors ripen the mangoes in ripening chambers, or use traditional or natural processes where fruit is carefully heaped and covered with paddy straw or coconut leaves and left for 6 to 7 days to ripen. It is generally perceived, in this FSC, that fruit ripened naturally has a better flavour. In both ripening methods about 6 to 8 percent of the weight is lost because of moisture loss.

Artificial ripening of fruit has been practiced in wholesale and retail markets for a very long time. Mostly calcium carbide (CaC_2) was used that, when reacting with water or humidity releases acetylene gas. Similar to ethylene, acetylene also triggers ripening in fruit, although it is not as efficient. As the fruit may be contaminated by arsenic or toxic reaction compounds such as phosphorus hydride (Phosphine), CaC_2 is considered harmful to the health of consumers. Mostly, artificial ripening is misused to ripen immature mangoes, to force a surface colour without any development of the flavour, it is also used to shorten the actual ripening time so that the fruit can be sold earlier. Recently, the FSSAI banned the use of CaC_2 as a ripening agent for all fruit including mango. During the study, various actors in the FSC were questioned about the effect of the ban on CaC_2.

Mango pulp food supply chain

In the mango pulp supply chain, the ban on CaC_2 did not affect any of the actors. The process of ripening is highly controlled in ripening chambers where ethylene is used, which is a permitted ripening agent under the right temperature and humidity conditions. In the traditional method, the fruit is carefully heaped and covered with paddy straw or palm leaves. In this case, even if the losses can be high, the quality of ripened fruit is perceived to be superior. The actors are well aware of the importance of ripening and its direct relation to quality of the pulp. Calcium carbide is not used in this FSC and hence it did not affect any of the actors.

Fresh fruit food supply chain

The main objective of the ban was to control the prevalent use of CaC_2 in the fresh fruit supply chain. However, the farmers are not directly affected by the ban, but repercussions have been noted such as delayed payments from traders. The ban mainly affected actors at the local fruit markets rather than at distant markets. In Vizianagaram, much of the fruit is transported to distant markets in Delhi and Kolkata, which are about 800 to 1 500 km away. The three to five-day transit time means the mangoes ripen however CaC_2 was used at the local markets to expedite sales.

The ban affected traders, wholesalers and small-scale retailers in the fresh fruit supply chain. In Vizianagaram, the share of produce going to the local market decreased, because of the lack of nearby markets and hence the effect of the ban was relatively low, as compared to other important fresh fruit FSCs, such as Vijayawada, where there are many nearby markets. The authors of the study found the traders are currently using unknown chemicals to ripen the fruit, referred to locally as 'China Chemical or Powder or Red powder'. This suggests there may be a lack of innovation in addressing the problem and emphasises the need for research in developing safe alternatives or infrastructure.

Case Study 1: Effect of the ban on calcium carbide

Processing

In Vizianagaram, the quantity of fruit used for processing is minimal as it is used to produce mango jelly in a cottage scale industry. Apart from the good quality fruit, culled fruit are also used to make jelly. Chittoor has a well-developed mango pulp supply chain where 70 percent of

FIGURE 12
Mango pulp processing

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small-scale industries mainly produce aseptic and canned mango pulp. After ripening the fruit is washed, pulped and the stones removed. The pulp is then thermally processed to make aseptic mango pulp or pulp concentrate. The pulp is packed in an aseptic bag or in drums or cans and stored at room temperature. It is then shipped to the terminal markets.

INVOLVEMENT OF ACTORS IN THE SUPPLY CHAIN BENEFITS, JOB CREATION AND INCOME

Socio-economic aspects and gender participation in the various steps

Production and cultivation

In both the FSCs small and marginal farmers make up more than 80 percent of the total mango farm holdings, with large farmers being the remaining 20 percent. Small farmers involve family members including women and children in farm operations, whereas this is not a practice followed by farmers with medium to large farm holdings. Culturally, more women participate in farm activities in Chittoor district, as compared to the coastal districts including Vizianagaram.

There are many women farmers as per the land titles, however, they are not actively involved in farming in the region and have no role in financial decision-making. Mostly men supervise the farms. Where there are old orchards with large trees, men are preferred for harvesting over women. Women are also employed, though, in the fresh fruit supply chain, where their role is restricted to collecting and carrying the harvested fruit to the grading location. Men grade and pack for the fresh fruit FSC and both men and women are involved in the mango pulp FSC. In general, men and women are hired in a 40:60 ratio. Wages for

TABLE 9
Detailed description of the food supply chain – social structures

STEPS in the FSC	Involvement of women		Involvement of men		Who is mainly involved	Organization level of actors in the FSC[13]	Gender / social patterns Observations and remarks that explain the chosen qualifiers and/or give additional information
	Girls	Adults	Boys	Adults			
	Qualifier[14]						
Primary production		3		3	Men, Women	Individuals	Men are relatively more involved in farming operations than women, however, the difference is small. The number of women farmers is relatively low.
Harvest		2		3	Men, Women	Individuals	Men and women take part equally in harvesting operations. Women slightly outnumber men as farm labour for daily wages or for the entire operation. Women earn 20 % less than men. Men are expected to do the heavy work: climbing trees during harvesting
Post-harvest, handling							
Transportation				3	Men	Individuals	Men are exclusively involved in transportation. Women are completely absent as they lack the skills and for cultural reasons
Market sales				3	Men	Individuals	In market yards, traders are exclusively men. Both men and women are employed as seasonal labour to sort and grade, pack, etc.
Agro-processing		2		3	Women, Men	Individuals	Women and men are employed at processing plants for support activities: loading, unloading, sorting, culling and packaging. Women are usually employed for less laborious activities and pay disparity is about 20 % less.

Source: field data

[13] NB: Individual/Household level/Cooperative
[14] Qualify the equipment, conditions, access to services and training, 4: excellent, 3: good, 2: moderately good, 1: bad.

women are USD 2.25 to 3.75/day and men are paid more USD 4.5/day. No one under 14 years old is engaged as farm labour but farmers' family members, including children, are involved in farm operations.

Trading and processing

Women are conspicuously absent in trading activities. Men perform all trading operations in the market yards. However, both men and women are engaged in grading, sorting and packaging. These people are typically landless labourers who are hired from the surrounding areas or are migrant labourers. Workers are usually employed for the entire season and they live in the market yards for the season and afterwards they return home or go on to another job. Chittoor fruit processing cluster has created employment for about 20 000 people, directly at processing plants and indirectly in allied services. Fewer women than men are employed at processing plants, employed in operations, quality assurance, planning, and management. An equal

TABLE 10
Detailed description of the food supply chain – Economics

Stage in FSC	Main Products	Cost of operation USD/ tonne	Cost USD/ tonne final product	Cumulative cost USD/ tonne	Value USD/tonne final product	Value-added/ Margins USD/kg	Remarks
Primary production	Mango	21					▪ Cost of ploughing, pesticide spraying, fertilizers, farm management, labour, average production of 10 tonne/ha
Harvest	Mango						▪ Manual harvesting using labourers
Post-harvest handling		6		27			▪ Manual sorting and grading
Storage	NA						
Transportation	Mango	14.3		41.2	210/tonne of Mangoes	168	▪ Transportation to a distance of about 50 km ▪ Valuation is based on current year prices ▪ Price fluctuation is very high from season to season ▪ Interest paid by farmer results in reduction in the actual margin earned
Market sales	Mango	4		45.2	214/ tonne of mangoes	168	▪ Trader charges processor or farmer or both a 2 % commission depending on the market situation
Agroprocessing	Mango pulp	70		280	USD 400 for 550 kg of mango pulp	120	▪ Labour, equipment, RM, PM, utilities – value excluding trade and cost of logistics and taxes ▪ Approximately 0.55 tonnes of mango pulp is obtained from 1 tonne of mango
Storage	Mango pulp	10		290	USD 400-500/0.5 tonne of mango pulp	110- 120	▪ Sale in off-season; price highly dependent on demand ▪ Margins, excluding trade and cost of logistics, taxes and overhead expenses. Actual margins are lower than the calculated values

Source: field data

number of men and women were observed to be taking part in processing operations as workers.

In the fresh fruit supply chain, farmers have very little choice in decision-making regarding harvest time and follow the contractor's transport schedule. Farmers will even harvest the produce at immature stages anticipating high prices, or out of fear of changes in the weather. The small farmers do not have the purchasing or negotiating power to deal with the contractors. Mango contributes to nearly 30 to 40 percent of the mango farmers' income; other sources are upland rice and pulses. An important source of income for some farmers with job cards is the Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA). The percentage contribution through MNREGA is significant for those households holding multiple job cards for 2015–2016, and provided an average employment per household of 71 days. Since MNREGA contributes substantially to the annual income of the household, the wages earned by women has enabled them to improve their role in decision-making on issues related to their home.

Women have been able to save money, which also helps their families face climate-related crises. Attempts are also being made in Vizianagaram to combine the objective of social protection and climate resilience through the MNREGA scheme. Under this scheme, work on tanks or ponds to re-generate groundwater resources has allowed some farmers to dig bores to provide a reliable source of water year-round, and has enabled farmers to plant crops in both planting seasons. In the mango pulp FSC, dealings are fairly transparent because of established links and farmers have more control over harvesting and the sale of their produce. Farmers suggest, however, there should be a basis for fixing the price of produce as currently no agency is monitoring prices.

Description of the food supply chain – environment

The factors affecting the environment in both the FSCs were assessed during interaction with experts, local farmers and research of the literature and are presented in Table 12.

TABLE 11
The inputs required for the production of mangoes on 1 ha of land

Production		**Quantity**	**Unit**
Tools, equipment, facilities	Farm implements inclusive of harvesting equipment, tractor	10	NA
	Planting material	60	MA
Materials, chemicals	Water	1 200	mm
	Fertilizers	250	kg
	Pesticides	3-5	litres
Energy	Power- Thermal or Hydroelectricity from grid line	18	Kwh
	Diesel	20	litres
Water		1 200	mm
Land		1	ha
Transportation		**Quantity**	**Unit**
Tools, Equipment, Facilities	Tractor	1	NA
	Crates for loading	10	NA
Energy	Diesel	20	litres
Processing		**Quantity**	**Unit**
Tools, equipment, facilities	Ripening chambers, pulp processing line	1	NA
Water		5 000	litres

Source: field data

FIGURE 13
Drip irrigation in mango cultivation

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FIGURE 14
Farm ponds to regenerate groundwater

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TABLE 12
Factors in food supply chains that affect the environment

Factors	Description	Details
Type of production system	Horticulture, perennial, agroforestry	
Land preparation practices	Tilling, composting	Tilling in the off-season during weeding and fertilizer application. The rotten, infected fruit and those of no economic value are dumped into composting pits to produce organic manure.
Soil quality and land degradation	Low to medium soil nutrients, soil erosion	Nutrient content status in both districts is low for N, low for P in Chittoor and medium in Vizianagaram; K status is high in both districts (IISS, Bhopal, 2012) Moderate soil erosion occurs in Bobbili Seethanagaram. Moderate water erosion and waterlogging and flooding are major degradation process in Vizianagaram, Pusapatirega, Denkada, Gantyada and Bhogapuram. Slight and moderate erosion is major degradation process in Kothavalasa. Moderate to extreme water erosion is degradation problem in Kurupam and Gummalakshmipura (2015).
Water regime	Low water table. Rainfall dependent, irrigation from bore wells	Irrigation using furrows near trees. Farmers are adopting microirrigation because of water scarcity. Chittoor is more progressive in terms of shifting towards drip irrigation. Irrigation using drip and bore wells need electricity.
Ecosystem impacts	Uneven rainfall and decreasing water table	Decreased rainfall and water availability is causing farmers to shift to mango from other crops-
Sources of GHG emissions	Production, irrigation, transportation, processing	Use of agrochemicals, fertilizers, fuel used in transportation and energy used during processing mango pulp.
Climatic factors	An uneven trend in the rainfall and higher temperatures during flowering season	Rainfall is a deficit in both the regions and has been declared as drought-hit districts by the government. Higher mean temperature during flowering season severely impacts fruit bearing, leading to lower fruit yield.
Use of residues in the supply chain	Stones and peels	Degraded peels are used as manure, dried stones are used as fuel. Sometimes both are discarded.
Re-use of food losses	Sorted fruit at processing plants and market yards	Sometimes culled and relatively clean fruit are used for cooking. Culled fruit from processing plants are used as cattle feed.

Source: field data

Chapter 3

The food loss – study findings and results

LOSS POINTS, TYPE AND LEVEL OF FOOD LOSSES

Production factors that can contribute to food loss are highly variable and are linked to climatic conditions such as high temperatures, untimely rains, incidence of pests and diseases, varietal resistance or susceptibility. Awareness of the farmer in dealing with these factors can play an important role in controlling losses.

Harvesting method, age, canopy of the plants, harvesting equipment, and training and motivation level of the harvesting labour play an important role in losses at this stage. The above factors lead to losses resulting from falling or broken fruit, internal damage, improper sorting and grading and cross contamination from broken fruit.

Transportation factors such as proper packaging material such as plastic crates, condition of the vehicles, transportation distance, road conditions, cold chain, play a key role in reducing food loss. Fruit may also be damaged because of improper handling.

Ripening and processing losses depend on factors such as the ripening method, handling of fruit from prior steps, the maturity level of the lot, sanitary conditions and availability of plastic crates.

CRITICAL LOSS POINTS

Food losses were observed at various levels in both the fresh fruit as well as the processed fruit FSCs and were varied owing to the differences in practices and nature of the supply chain. The losses at various steps of the FSC are described below.

Production

The quality of the fruit is highly dependent on the variables during production. Climatic conditions and presence of pests and diseases determine the quality and quantitative losses in the subsequent steps of the value chain. During the case study, mango production in Vizianagaram district was severely affected by a delay in flowering, low incidence of flowering and low fruit set. As a result of reduced difference between day and night temperatures most flowers were unable to withstand the heat, which led to premature dropping of mangoes resulting in losses of between 1 to 5 percent. Lack of irrigation compounded the problem resulting in crop losses. In Chittoor, although there was low overall rainfall, rain fell at the appropriate time during the season, which resulted in better quality fruit. However, the farmers stated there was a 50 percent reduction in mango production for that year.

Harvesting

In Chittoor, harvesting for pulp production is carried out in a single instance at optimum maturity level of the fruit in the orchard. In this process, there is a quantitative loss as fruit is harvested at an immature stage. Also, the use of improper mechanisms for harvesting means a fraction of the fruit to be physically impacted. Sorting and grading is carried out at the farm level to separate the immature, small, irregular and damaged fruit. Quantitative losses, such as left over fruit on the farm and qualitative losses such as fruit with bruises, or internal damage were observed in the mango pulp FSC in Chittoor. The pattern of these losses is dependent on the demand for culled fruit in the nearby cities and location of the farm.

In Vizianagaram, the fruit is harvested in two to three stages. Sometimes farmers harvest early, leading to qualitative losses because of immature fruit and harvesting at the improper stage accounts for the highest post-harvest losses. Other harvesting losses include mechanical and sap damage, stem-end rot and other diseases, which account for nearly 10 percent of losses and results in up to a 50 percent reduction in market price or complete salvaging of the fruit. Farmers with good post-harvest management practices are able to keep losses below 5 percent.

TABLE 13
Food loss risk factors

Variable	Unit	Parameter – relation to food losses	Value of variable
Crop variety	Y/N	Quality and disease – varietal resistance to pests, diseases and physiological stress leads to lower losses	Y
Good agricultural practices (GAP)	Y/N	Impact on final quality – determines the other factors that lead to food loss such as rate of insect occurrence	Y
Rainfall during production	mm	Impact on fruit bearing – optimum rainfall during the growth phase leads to better yield and fruit retention	
Incidence of pests – fruit fly	L/M/H	Impact on quality and quantity with high prevalence of fruit fly and other pests	High
Duration of transport	Hours	Lower duration of transport corresponds to lower losses	2 hours in mango pulp FSC; 3 to 5 days in fresh fruit FSC
Production supply/demand ratio	Ratio	Glut in market leads to higher losses – Lack of price incentive	<1
Rainfall during harvest phase	L/M/H	Fruit drop – Higher rainfall during harvesting time leads to higher losses	Low
Post-harvest technology	L/M/H	By better handling during harvesting and post-harvest operations such as sorting and grading, ripening leads to lower losses.	Medium: mango pulp FSC
Low: Fresh fruit FSC			
Processing technology	L/M/H	Impact on product quality – High level of automation and availability of ripening chambers decreases food loss.	High
Good Manufacturing Practices (GMP)	Y/N	High quality and food safety is achieved by employing GMP	Yes
Packaging materials and facilities	L/M/H	Impact on product quality – Nature and type of packaging materials	High
Market information	L/M/H	Determination of price – deciding on the time of harvest, demand for culled fruit	Medium
Price incentive for quality	Y/N	Motivates farmer to harvest and handle properly	Yes
Knowledge of FSC actors	L/M/H	Impact on product quality – Determines the care employed in handling, food safety and use of lost fruit	High

Source: field data

Transportation

The Chittoor mango pulp FSC has marginal from transport because of sorting and grading and the average distance travelled is short. In the fresh fruit FSC the fruit travels about 800 to 1 000 km over 3 to 5 days. This leads to a quantitative loss of about 10 to 15 percent because of the damage to the side and bottom layers of fruit in the transport vehicle.

Ripening

In the mango pulp FSC, fruit is ripened either in ripening chambers or using a traditional process. The losses during the traditional process are higher because of the uncontrolled conditions and improper storage conditions. The losses observed are still higher if the prior handling of fruit during harvest is not correct. In ripening chambers, the reported losses are comparatively lower, both in terms of quality and quantity. Quantitative losses were observed in this step such as rotten fruit (biological) and qualitative losses such as partially rotten fruit and uneven ripening. In the fresh fruit FSC, no separate ripening step is carried out as the fruit are left to ripen during transit, however improper grading during prior steps leads to qualitative losses that result in reduced market value.

TABLE 14A
Quality scoring of food products

PRODUCT:	Mango –Totapuri variety	
Quality score	Description of the quality	Percentage reduction of market value
0	Fully damaged fruit – rot – biological damage	100
1	Bruised and broken fruit – physical damage	90
2	Irregular, small, immature fruit, blemished, sap burn – non-compliance, physiological damage	50
3	Sorted uniformly matured, high variance in size	20
4	Sorted, uniformly matured, uniformly sized	0

Source: field data

TABLE 14B
Quality analysis of sampled units

Unit evaluated	Overall quality score	Type of damage (deterioration) if any	Potential cause and symptoms
1	2	Irregular sized, immature and broken fruit; improper handling or harvesting	Culled fruit from harvesting
2	3	Uneven size, fairly good quality	Uniformly graded at ripening chamber
3	4	Uniformly	Uniformly graded at export packing house
REPORT: Average score: 3.25			

Source: field data

LOAD TRACKING

Load tracking was conducted at different steps in the mango pulp FSC. Different loads were tracked at individual events, as there was a long interval between the events.

Harvesting – During harvesting the total truck-load was considered as a sample, since weighing the produce on-farm was not feasible and is generally not done by the farmers or the aggregators. The weight of the truck was recorded after harvesting, after reaching the processing plant. The weight of leftover fruit was noted by approximation and averaging.

Transportation and unloading – The load was from an orchard in a nearby village and the produce travelled a distance of 30 km in less than 2 hours. The losses during the transportation were recorded during unloading, before going into the ripening chambers. The entry and exit weight of the truck was recorded on a weigh bridge and the fruit on a weighing machine.

Traditional ripening process – The mangoes received at the processing plant, where the study was carried out, are ripened using the traditional method. The ripened lot was opened for production and sorting; spoiled fruit was removed during grading. Four crates of completely and partially spoiled fruit were separated from the lot and segregated. The weight of the spoiled fruit was recorded on a platform balance at the processing plant. The fruit in the particular lot was not handled properly during the prior stages and losses were observed to be higher than average.

TABLE 15
Presentation of load tracking and sampling results

A	**Product**	**Mango**			
B	Event	Harvesting, sorting and grading			
C	Duration of the event	8 hours			
D	Location	Sarakallu, Chittoor			
	Before the event	**Experimental Unit**	**Weight of unit**	**N. of units**	**Total weight**
E	Load	Tonnes	5 tonnes	1 truck15	5 tonnes
F	First stage sample				
G	Second stage sample				
		Value (score / %)	***Observations / Causes***		
H	Sample size Second stage				
I	Average quality score (0 – 4)	4	The fruit harvested was sent to a processing plant. Sorting and grading was done on-farm to separate sound, mature and uniform fruit		
J	Percentage unfit (< 1)				
K	Percentage low quality (2-1)				
	After the event	**Experimental Unit**	**Weight of unit**	**Nr of units**	**Total weight**
L	Load	Tonnes	4.4 tonnes	1 truck	4.4 tonnes
M	First stage sample				
N	Second stage sample				
		Value (score / %)	***Observations / Causes***		
O	Sample size Second stage	2 kg			
P	Average quality score (0 – 4)	4			
Q	Percentage unfit (< 1)				
R	Percentage low quality (2-1)				
	Quantity loss	**Value (%)**	**Observations / Causes**		
S	Percentage lost (E-L)/E	0.6 tonne/ 5 tonne= 12 %	The study was conducted on a farm in the interior. Both unfit and low quality fruit were left on the farm, since transporting them was not lucrative. In other cases usually low quality fruit is sold at much lower value or used as cattle feed		
	Quality loss	**Value (%)**	**Observations / Causes**		
T	Percentage lost (Q-J)				
U	Percentage quality reduction (R-K)				

A	**Product**	**Mango**			
B	Event	Transportation – Unloading			
C	Duration of the event	2 hours			
D	Location	Manjunatha fruit processing industries, Kanipakam, Chittoor			
	Before the event	**Experimental Unit**	**Weight of unit**	**No. of units**	**Total weight**
E	Load	kg	4 200	1 truck	4 200

TABLE 15
(Continued)

F	First stage sample				
G	Second-stage sample				
		Value (score / %)	***Observations / Causes***		
H	Sample size Second stage				
I	Average quality score (0 – 4)	4	Initial sorting and grading was carried out on-farm to separate low quality, immature and non-uniform fruit. The overall quality of the lot was good.		
J	Percentage unfit (< 1)				
K	Percentage low quality (2-1)				
	After the event	**Experimental unit**	**Weight of unit**	**No. of units**	**Total weight**
L	Load	kg	4 180	1 truck	4 180
M	First stage sample				
N	Second stage sample				
		Value (score / %)	***Observations / Causes***		
O	Sample size Second stage				
P	Average quality score (0 – 4)				
Q	Percentage unfit (< 1)				
R	Percentage low quality (2-1)				
	Quantity loss	**Value (%)**	**Observations / Causes**		
S	percentage lost (E-L)/E	0.5	The fruit is graded on the farm nearby, the distance travelled was less than 30 km.		
	Quality loss	Value (%)	Observations / Causes		
T	Percentage lost (Q-J)				
U	Percentage quality reduction (R-K)				

A	**Product**	**Mango**			
B	Event	Ripening - traditional process			
C	Duration of the event	6 days			
D	Location	Suvera fruit processing industries, Kanipakam, Chittoor			
	Before the event	**Experimental Unit**	**Weight of unit**	**No. of units**	**Total weight**
E	Load	kg	101.4 kg	4 crates	101.4 kg
F	First stage sample				
G	Second stage sample				
		Value (score / %)	***Observations / Causes***		
H	Sample size Second stage				
I	Average quality score (0 – 4)	3			
J	Percentage unfit (< 1)				
K	Percentage low quality (2-1)				

TABLE 15
(Continued)

	After the event	**Experimental unit**	**Weight of unit**	**No. of units**	**Total weight**
L	Load	kg	81.3	4 crates	81.3
M	1st-stage sample				
N	2nd-stage sample				
		Value (score/ Percentage)	***Observations / Causes***		
O	Sample size Second stage				
P	Average quality score (0 – 4)	3			
Q	Percentage unfit (< 1)	8.4	Fruit are spoiled completely, broken and ready to spoil		
R	Percentage low quality (2-1)				
	Quantity loss	**Value (%)**	**Observations / Causes**		
S	Percentage lost (E-L)/E	19.75	Improper harvesting and handling at prior stages		
	Quality loss	**Value (%)**	**Observations / Causes**		
T	Percentage lost (Q-J)				
U	Percentage quality reduction (R-K)				

Source: field data

Summary of results of food losses

TABLE 16A
Losses in the mango pulp Food Supply Chain

FSC stage/ Process	Type of loss Qn/Ql	Percentage lost in this process Quantity	Percentage of the product that incurred quality loss in this process	Percentage of product that goes through this stage (#)	Percentage of loss in the FSC (#)	Cause of loss/ Reason for low loss	Reduced market value	CLP / LLP	Destination of food loss	Impacts on the environment/ climate change/ natural resources	Impact/ FSC actors affected (men / women)	Loss perception of FSC actors (men / women)	Suggested solutions
Harvesting, sorting and grading – mango pulp FSC	Qn & Ql	12	5	100	12	Improper harvest, maturity, damaged fruit	50%	CLP	Low value/ culled	Environment, natural resources and agri-inputs employed in production	Income of farmers	Not significant	Small enterprises for processing food waste, training
Transportation – mango pulp FSC	Qn	0.5	NA	100 (88)	0.5	Short transportation distance, better road infrastructure	100%	LLP	Discarded	Environment	None	Nil	To be sent to plant ETP
Ripening – Traditional process	Qn & Ql	19	20	100 (87.5)		Improper handling	100%	CLP	Discarded	Environment, natural resources	Processor- loss of yield and quality	High	Development of standardized methods; training in harvesting and handling
Ripening – ripening chambers	Qn & Ql	3-6	10	100 (87.5)	3-6%	Improver harvesting, internal bruises of fruit	100%	CLP	Discarded	- Environment, natural resources - Power and water used in running ripening chambers	Poor product yield going to the processor	Low	Training in harvesting and handling

Source: field data

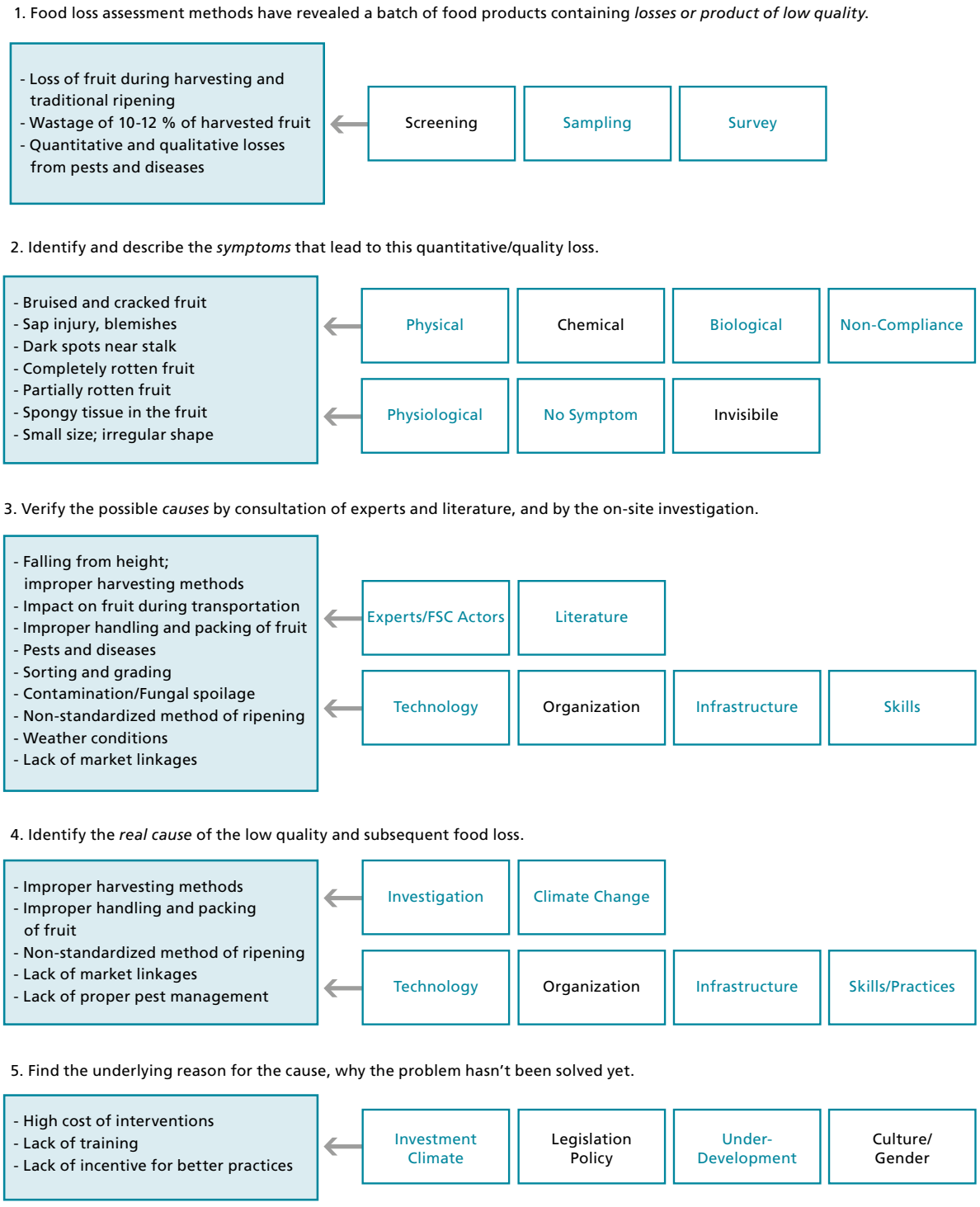
TABLE 16B

Losses in the fresh fruit supply chain

FSC stage/ Process	Type of loss Qn/Ql	Percentage lost in this process Quantity	Percentage of the product that incurred quality loss in this process	Percentage of product that goes through this stage*	Percentage of loss in the FSC*	Cause of loss/ Reason for low loss	Reduced market value	CLP / LLP	Destination of food loss	Impacts on the environment/ climate change/ natural resources	Impact/ FSC actors affected (men / women)	Loss perception of FSC actors (men / women)	Suggested solutions
Harvesting in the fresh fruit FSC	Qn & Ql	15	5	100	15	Improper harvesting, Canopy of trees	50 %	CLP	Low value/ culled	Environment, natural resources and agri-inputs employed in production	Farmers' income	Not significant	Small enterprises for processing food waste, training
Sorting and grading	Qn & Ql	5	5	100 (85)	5	Irregular small fruit, improper desapping	50 %	CLP	Low value/ culled	Agri-inputs employed in production, Environment	Farmers' income	Not significant	Training in desapping operations
Transportation of fresh fruit FSC	Qn & Ql	15	20	100 (80)	15	Long distance of transportation, Improper sorting	100 %	CLP	Discarded; sometimes sold for lower value	Environment- Disposal in the retail market, Fuel used for transportation	Traders, consumers because of elevated prices	Moderate	▪ Research in packaging designs ▪ Creation of efficient linkages
Retail in the fresh fruit FSC	Qn & Ql	5-10	25	100 (65)	5-10	Transportation over long distances, lack of demand, improper handling	100 %	CLP	Often sold for lower value; sometimes discarded	Environment# - disposal problems; labour and packaging employed	Retailers, consumers	Low	▪ Creation of efficient linkages ▪ Training in handling and optimum storage conditions

* The figures in the bracket show the percentage of the product after accounting for losses in the previous stages.
Source: field data

FIGURE 15
Cause finding diagram for the mango FSC



Source: field data

CAUSES OF THE LOSSES AND IDENTIFIED LOSS REDUCTION MEASURES

Losses during cultivation

Both qualitative and quantitative losses during the production are caused by factors such as climatic conditions, the prevalence of pests and diseases, physiological stress on the trees. These losses are highly variable across crops seasons and regions.

Losses during harvesting and sorting

During the mango harvesting stage quantitative losses resulted from broken and damaged fruit because of improper harvesting as fruit was dropped directly on the ground, diseased fruit with stem-end rot was observed in both FSCs. Qualitative losses were related to immature, irregular and bruised fruit because of improper handling. By following proper methods for harvesting and post-harvest handling, losses could be reduced.

FIGURE 16
Low losses during transportation in the mango pulp FSC (from a load of 12 tonnes)

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FIGURE 17
Mango spoilage from post-harvest diseases and improper handling during ripening

©FAO/Sathguru

Losses during transportation

There were losses in the fresh fruit FSC because of the lack of nearby markets, the produce is transported almost 800 km leading to a loss of about 10 to 15 percent. These are quantitative losses because of damaged and rotten fruit and qualitative losses related to irregular ripening, softening and breakage of the bottom layer of fruit in the load. Plastic crates are currently not used extensively because of the lack of effective trade links; as a result, returning the crates to the source is an issue. Use of proper packaging materials and designs and controlled conditions during transportation could reduce the losses at this stage.

Losses during ripening

With the fruit in the mango pulp FSC, when ripened using the traditional method, there were higher quantitative losses from rotten fruit and qualitative losses related to partially rotten fruit, irregular ripening was observed as a result of fungal rot, improper handling, uncontrolled and non-standard conditions. Development of standardized conditions and better handling of fruit for prior steps could reduce losses in the traditional ripening process.

LOW LOSS POINTS, AND GOOD PRACTICES LEADING TO LOW FOOD LOSSES

- Transportation in the mango pulp FSC is very well managed and is considered as a low loss point. The produce is transported immediately after harvesting over a short distance. The observed losses were only 0.5 percent.
- Ripening of mangoes in ripening chambers leads to considerably lower losses than the traditional method because of better handling and controlled conditions. However, proper handling of fruit during and after harvesting could help in further reducing losses.
- The importance of GAP is understood and followed by farmers in the mango pulp FSC, consequently leading to lower losses.
- The mango pulp FSC is an ideal example for promoting horticultural production where the losses across the stages are considerably lower because of the availability of market and processing facilities.

- There is more use of crates when handling the fruit in Chittoor, leading to fewer losses and better quality of fruit.
- Intensive training of farmers in both FSCs is gradually making them aware of the importance of quality and food safety aspects and the relation to returns.
- Policy support for adoption of micro-irrigation systems is helping to increase the productivity of the orchards as well as conserving water.
- Ultra-high density and high density plantations are characterized by trees with smaller canopies leading to less difficulty in harvesting, better handling of fruit and increased productivity.

Chapter 4

Food loss reduction strategy – Conclusions and recommendations

IMPACT OF FOOD LOSSES ON THE MANGO SUPPLY CHAINS

The impact of food losses on different actors and stages of the food supply chains is described below.

Farmers – Small and marginal farmers make up a major share of mango growers in both the FSCs. The loss of produce directly impacts the income of the farmers as mango contributes 30 to 40 percent to their annual income. Usually a nominal quantity of losses during harvesting and other operations are factored into consideration during price negotiations, however, when these losses are coupled with conditions such as untimely rains, hailstorms, low yield and high pest incidences they can lead to significant loss of income and additional stress being placed on the repayment of or raising a loan for future crops. These conditions, can lead to extended difficulties where an alternate income is sought to meet loan repayments. The diverse nature of losses related to quality and quantity each season is leaving farmers with no viable alternatives to processing or using the current on-farm wastage.

Traders' income in the fresh fruit and mango pulp FSC depends on the volume of fruit traded. The on-farm wastage and production losses are a lost opportunity for sales in the market yards and, indirectly, taxes earned by the government. The overall quality of the fruit during the season determines the price and consequently, the commission earned by the traders. The impact on commissions earned may also be reflected in the loan dispersals to small farmers who are dependent on collateral free loans that are the basis of the informal financial market.

Processors – The qualitative and quantitative losses in the mango production seriously affect the profitability of the pulp processing business. Qualitative produce losses lead to a product with lower quality, and lower income. The nonlinear relationship between the raw material costs and price of the pulp on the international market highlights the importance of quantitative losses of produce, which would otherwise enter the mango pulp FSC.

Retailers – Quantitative loss of mango impacts the direct sales income of retailers at all stages. Qualitative losses are negatively impacting the ability to prolong the sales period, possibility of obtaining a premium price for the fruit and possible cross contamination with other fruit. The major share of mango in the fresh fruit FSC is still traded by small retailers such as cart vendors. Quantitative and qualitative losses greatly affect the selling price and thereby the volume of sales, causing loss of or possible change in livelihood.

Moreover, qualitative losses can lead to problems related to the disposal of spoiled fruit. Indirect losses are incurred such as for packaging material and labour, which need to be factored in as losses at the retail stage.

Environment – About 1 600 kg of CO_2/ha is generated in the mango FSC, from production to processing both from direct and indirect emissions. The quantity of fruit wasted at all stages represents the proportional wastage of resources and impact on the environment. Fertilizers and pesticides are used in both FSCs in line with general guidelines and contribute about 286 kg of CO_2 from one hectare of mango production. Besides, there is possible runoff of excess pesticides into the environment apart from that coming from produce. Irrigation during fruit bearing and off-season play an important role in determining the quality of the crop. In both the FSCs mango is taken up as a rainfed crop, as well as using other forms of irrigation such as micro-irrigation or flooding, in place of paddy and sugarcane because of erratic rainfall and these crops' water intensive nature.

In the mango pulp FSC, huge quantities of kernel/stone, which is obtained as by product is currently used as boiler fuel after drying, or the kernels are discarded in open areas, which leads to bad odours nearby and proliferation of pests.

COST-BENEFIT ANALYSIS OF THE FOOD LOSS REDUCTION MEASURES

In the mango pulp FSC, the actors do not significantly perceive losses, many believe the losses are low and are part of the process. During the interaction with stakeholders in the fresh fruit chain, the farmers and traders were comparatively aware of the losses and stated that lack of proper technology, its availability, and retention of skilled labour are important factors that lead to food loss.

Another important cause of losses observed was the lack of effective training, particularly in post-harvest handling of the fruit by farmers and farm workers.

Technological interventions across the different stages of the FSC that can be implemented to reduce food losses are as follows:

Cultivation practices – High density plantations characterize shorter trees with smaller canopies and a greater number of plants, an estimated 600/ha, instead of 50 trees/acre in a conventional harvesting system. This results in better harvesting and handling of fruit and increased productivity.

Irrigation plays an important role, not only in maintaining productivity but also in determining the qualitative factors of the fruit and fruit loss during bearing. Mango cultivation in both the FSCs is rainfall dependent. Micro-irrigation methods such as drip irrigation are being initiated to cover a small area, this method should be extensively promoted to bring a greater area under drip irrigation.

Harvesting methods are important in reducing the losses that occur in subsequent stages, apart from those that occur during harvesting. Use of a 'Net Basket (Dapoli)' harvester should be promoted. Care should be employed when harvesting the fruit to reduce mechanical damage. Fruit should be heaped on a plastic sheet, rather than left on the ground. This would reduce the chances of bacterial and fungal infections that can lead to post-harvest losses. Desapping should be carried out immediately, especially in the fresh fruit supply chain, to reduce losses related to sap injury and fungal infections at later stages.

Transportation – Use of crates during transportation should be extensively promoted particularly in the fresh fruit FSC. Currently, crates are used to carry fruit during harvesting. Use of better packaging containers and controlled temperature and humidity during storage should be explored.

Ripening - High losses have been observed during the traditional ripening process, mainly because of the non-standard methods and un-controlled conditions. Development of a standard method with optimal conditions and corrective actions for variations will help reduce losses. Hot water treatment plants could be explored to address the issue of pest infestation, particularly fruit fly. This would lead to a reduction in quantitative and qualitative losses caused by the larvae. As there are no external symptoms, the pest infestation is often neglected in the domestic market. Attention to pest infections would also be effective in addressing bacterial and fungal infections, however, control of following re-contamination could be challenging.

The suggestions below have been evaluated to achieve reduced losses:

Farm and post-harvest services by private entities

Farmers' lack of proper training and the unavailability of skilled labour to carry out the farm and post-harvest operations is hindering the better handling of produce in both the FSCs. The proposed intervention comprises the establishment of private enterprises or service providers for scientific delivery of pesticides and fungicide application, pruning, rejuvenation of senile plantations, harvesting, desapping and post-harvest handling. These private enterprises could collaborate in delivering support programmes extended by government agencies.

This would lead to:

- addressing the problem of the unavailability of skilled labour;
- training of local labour and absorbing trainees into the enterprises thereby creating employment;
- increasing efficiency in delivery of the support programmes;
- reducing the financial burden on farmers for mechanisation, as the equipment would be procured by the service provider and would be used by multiple orchards;
- all-round improvement in preharvest and post-harvest activities as they would be carried out scientifically.

On-farm training

Currently, farmers are trained at a central location, with limited audio-visual support. Farmers stated that it was difficult to link the solutions so they could be implemented. The proposed intervention suggests on-farm training with effective use of audio-visual support using portable projector kits. On-farm training would also involve the creation of new content in the local language and delivery of training modules before or at the start of harvesting operations, with demonstrations being given on the farm. Training should also cover the links between better practices and returns to the farmer in the short and long term. Farmers stated that it is often difficult for them to quantify the benefits and to justify the additional resources deployed. Access to training content should be created for deployment across multiple platforms such as mobile phones, central kiosks or desktops at the village or block level.

This would lead to:

- increasing participation in training as instruction would be given at the village level;
- increasing the implementation of training by giving instruction before the start of harvesting operations;
- improving tracking and training by evaluating implementation at the village level;
- adapting training to address prevailing specific crop conditions, for example post-harvest diseases;
- increasing interaction among farmers through peer-based learning.

Rental of plastic crates

Use of plastic crates is currently limited to the fresh fruit FSC, as it is not economically feasible to transport the crates to the point of origin. This is leading to the use of improper and alternate packaging methods leading to quantitative loss of fruit, accounting for a loss of almost 10 percent during transportation.

TABLE 17
Budget calculation for food loss reduction

	Item	Value	Unit	Calculation
a	Product quantity	532 836	tonne/year	Production of Vizianagaram
b	Product value	210	USD/tonne	
c	Loss rate	10.00	Percent	Quantitative and qualitative
d	Anticipated loss reduction	30	Percent	
e	Cost of intervention	39 000	USD	Audiovisual kits, Content creation
f	Depreciation	5	Years	Average life span of kits
g	Yearly costs of investment	7 800	USD/year	e / f
h	Yearly costs of operation	20 000	USD/year	Travel and other costs during the training
i	Total yearly costs of solution	27 800	USD/year	g + h
j	Client costs per tonne product	0.0522	USD/tonne	i / a
k	Food loss	53 283.6	tonne/year	c * a
l	Economic loss	11 189 556	USD/year	k * b
m	Loss reduction	15 985.08	tonne/year	k * d
n	Loss reduction savings	3 356 866.8	USD/year	m * b
o	Total Client costs	27 800	USD/year	a * j = i
p	Profitability of solution	3 329 066.8	USD/year	n - o

Source: field data

To address this issue, the proposed intervention suggests market yards would rent crates to transport the fruit to the distant markets. Plastic crates would be procured by the government or market yards or private agencies in the mango-producing region. The traders or farmers who intend to transport fruit would procure the crates from a source market yard by paying in advance, which would be repaid on returning the crates to the terminal market. In the mango off-season these crates could be used in another region for other horticultural produce.

This would lead to the following improvements:

- better handling of fruit and reduced qualitative and quantitative losses;
- improved participation at the market yards leading to the formation of effective and well-integrated supply chains that could be extended to other horticultural crops;
- realistic data capture for production, trade volumes and food losses.

Reduced load on the environment as reusable packaging material would be used.

FOOD LOSS REDUCTION PLAN AND STRATEGY

Mango cultivation in the state of Andhra Pradesh has two main FSCs, which are the fresh fruit and mango pulp FSCs. Other minor, but no less important FSCs, such as for the mango jelly and pickle industry are important locally. Though these food supply chains are not considered because they are small, the proposed strategy also helps to address food losses in all food supply chains, as most practices are similar and widespread throughout all FSCs. The causes of food loss were observed to be complex ranging from technical, skill gaps, lack of awareness, economic and policy. To address these issues, apart from the proposed above-mentioned solutions, an overarching strategy is proposed comprising the following aspects.

TABLE 18
Budget calculation for food loss reduction

	Item	Value	Unit	Calculation
a	Product quantity	1 83 828.4	tonne/year	50% of produce going to distant markets from Vizianagarm
b	Product value	210	USD/tonne	
c	Loss rate	15 %	Percentage	Quantitative and qualitative
d	Anticipated loss reduction	20 %	Percentage	
e	Cost of intervention	13 756 524	USD	50% of the cost of crates, considering they are used for other fruit and vegetables in the off-season
f	Depreciation	5	years	Average lifespan of crates
g	Yearly costs of investment	2 751 305	USD/year	e / f
h	Yearly costs of operation	105 000	USD/year	Cost of transportation of crates at start of season and washing
i	Total yearly costs of solution	2 856 305	USD/year	g + h
j	Client costs per tonne product	5.3606	USD/tonne	i / a
k	Food loss	79 925.4	tonne/year	c * a
l	Economic loss	16 784 334	USD/year	k * b
m	Loss reduction	15 985.08	tonne/year	k * d
n	Loss reduction savings	3 356 867	USD/year	m * b
o	Total client costs	2 856 305	USD/year	a * j = i
p	Profitability of solution	500 562	USD/year	n – o

Source: field data

TABLE 19
Assessment of social implications of specific food loss solution suggestions

(How) Does the suggested solution …	Description of the potential impact	Gender dimension of the impact (how women and men may be affected differently)	Suggestions to mitigate negative impacts
Farm and post-harvest services by public–private partnership			
1. …impact the employment situation of FSC actors?	Improve the employment situation in the FSC. Creates employment for the local agricultural graduates who start enterprises or go to work as technical supervisors. This will also create demand for trained farm workers.	The employment situation for female graduates will also improve, as it is an essential step in catalysing the participation and involvement of women farmworkers in the programme.	
2. … increase or reduce the workload of FSC actors?	Decrease the workload on farmers by partially taking ownership of the activities. Farmworkers workload will be optimized through employment in multiple activities during the crop season.	Will affect both genders equally.	
3. …raise or increase the need for training to apply solutions?	Increased training is an inherent part of the solution and will be taken up by the service providing enterprise.	Participation of women is dependent on the presence of female trainers.	
4. …distribute benefits to the FSC actors? (income access and control)	Distribution of the benefits to the actors will be uniform and judicious as it improves the earning potential of workers by employing them in multiple activities. Farmers benefit by reducing their risk of capital and appreciated returns for improved quality.	Women with better access to training and with institutional employment can obtain a fair income.	Controls should be put in place to ensure benefits are transferred to all stakeholders.
5. …impact dynamics of power in the FSC? (WHO has ownership of solutions?)	Will not alter the dynamics of the FSC, but would allow farmers to negotiate a better price and farm workers better wages for improved services.	Will affect both genders equally.	
6….take into consideration mobility restrictions of FSC actors?	This will not affect the mobility of farmers. Migration of farmworkers would be reduced, as they will be employed for multiple activities and crops.	Will affect both genders equally.	In any required case, the workers can be mobilized to optimize the availability of work and demand in the area
7. …coincide with cultural and social norms and be culturally and socially acceptable?	This will not alter the cultural or social norms of the FSC.	Women with better conditions and flexibility in institutional employment can perform other roles easily.	
8. …cause for some actors' exclusion from the FSC activities?	This will lead to a gradual reduction of the intermediary and input suppliers in the FSC by rolling out services covering the whole FSC.	The participation of women in trading activities is minimal, hence the employment of men will be more affected.	The gradual roll out of services will help the movement of intermediaries into other activities.
9. …….impact the environment adversely?	Reduces the negative effect on the environment resulting from the controlled use of farm inputs such as irrigation and pesticides.	Will affect both the genders equally.	

TABLE 19
(Continued)

(How) Does the suggested solution …	Description of the potential impact	Gender dimension of the impact (how women and men may be affected differently)	Suggestions to mitigate negative impacts
Training on the farm:			
1. …impact the employment situation of FSC actors?	Training will improve knowledge of fruit handling, which will lead to a marginal increase in farm labour requirement.	Employment opportunities will increase equally for women also.	
2. … increase or reduce the workload of FSC actors?	Training will eventually increase the workload of farmers and farm labour. Accessibility to training material will reduce the workload of extension officers.	Will affect both genders equally in terms of increase or decrease in workload. Female extension officers should be included in the sessions to ensure participation of women.	The increased workload would be marginal and is a necessary intervention to reduce food losses. The price incentive for better produce should justify the expenditure on labour.
3. …raise or increase the need for training to apply solutions?	Training will be required for extension officers on use of Audio-visual units and new content-	Female extension officers should be trained to ensure woman participate and tailoring of the information.	
4. …distribute benefits to the FSC actors? (income access and control)	Price incentives earned should be distributed among the actors to ensure the viability of the solution.	Women will be paid the same as men for similar operations.	Because of the lack of transparency, traders may not transfer the benefits to farmers. A mechanism for knowing or estimating market prices should be a part of training.
5. …impact dynamics of power in the FSC? (WHO has ownership of solutions?)	Farmers will get a better price for their produce for improved quality, the solution would not alter the overall dynamics.	Training would empower women and create a level playing field.	
6….take into consideration mobility restrictions of FSC actors?	Increased travel for extension officers, farmers and farm labour would need to travel less.	Increased travel is a point of concern for female extension officers.	Travel would be limited to mandal or block level, where it is currently allocated. The number of trips might increase as training would be carried out before interventions in different modules.
7. …coincide with cultural and social norms and will be culturally and socially acceptable?	Will not alter the current cultural and social dynamics.	Participation of women can be low.	To ensure the participation of women, female extension officers should be a part of training contingent.
8. …cause for some actors' exclusion from the FSC activities?	Will not alter FSC structure.		
9. …….impact the environment adversely?	Eventually, will lead to improvement as a result of increased awareness among the actors.		
Plastic crates on rental basis			
1. …impact the employment situation of FSC actors?	Will not change the employment situations for exiting actors in the FSC. May create additional jobs in the area of crate handling.	Will not affect women specifically.	
2. … increase or reduce the workload of FSC actors?	Marginally may initially increase the workload on all the actors when streamlining all activities. Automation at later stages to lift the crates at the market yard will decrease the work load.	Will not affect women specifically.	

TABLE 19
(Continued)

(How) Does the suggested solution …	Description of the potential impact	Gender dimension of the impact (how women and men may be affected differently)	Suggestions to mitigate negative impacts
3. …raise or increase the need for training to apply solutions?	Marginal increase in training needs for all the actors.	Will not affect women specifically.	
4. …distribute benefits to the FSC actors? (income access and control)	Traders will benefit from the additional quantity of fruit available for sale. The intervention will only be sustainable if benefits are transferred to the farmer.	Will not affect women specifically.	Since farmers will be encouraged to bring their produce to market yards, a mechanism should be identified to observe the benefit transfer to the farmer.
5. …impact dynamics of power in the FSC? (WHO has ownership of solutions?)	The ownership of the solution lies with the government. It will not change the dynamics of the FSC actors.	Will not affect women specifically.	
6.…take into consideration mobility restrictions of FSC actors?	An additional stage of transportation to the market yard either by trader or farmer.	Will not affect women specifically	Upon streamlining of the activities of the FSC actors, in the subsequent years, additional stage of transportation will be removed.
7. …coincide with cultural and social norms and culturally and socially acceptable?	Will not change any cultural or social dynamics.	Will not specifically affect women.	
8. …cause for some actors' exclusion from the FSC activities?	Might cause loss of business to companies currently supplying packaging materials.	Will not specifically affect women.	
9. …….impact the environment adversely?	Reduce the use of disposable packaging material.	Will not specifically affect women.	

Source: field data

Extension training through Information and Communication Technology and Videos

Training and capacity-building is observed to be a serious gap in both the FSCs. The farmers in the mango pulp FSC are fairly aware of the importance of post-harvest care. However, because there is no incentive to take additional care, there is general carelessness in the handling of produce. There is, therefore, the need for capacity-building in the following areas:

- Training in harvesting and produce handling practices, desapping, grading for farmers as well as farm labour, focussing on demonstrating the impact of good practices using videos and success stories of the farmers who adopted good practices.
- Training on disease control to address preharvest diseases by following IPM and eradication measures at the cluster and individual level to address among others post-harvest diseases such as anthracnose, stem-end rot.

Value-added products for reducing food losses

The preharvest fallen fruit at marble stage (around 10 to 20 percent) can be converted to an additional source of income. These wasted mangoes can be used to make *Amchur* (dried and powdered raw mango), brined mango slices and pickles. The main problems in processing this produce are lack of machinery, and available labour. The following steps need to be followed when processing raw mangoes into *Amchur*: remove stones, chop and dry, dehydrate and mill. Several farmers can adopt the processing with the availability of machinery and labour. Small-scale pickling units can be set

TABLE 20
Summary of food losses, causes and solutions

Critical Loss Point	Magnitude of losses in the FSC			Cause of loss	Intervention to reduce losses	Loss reduction		Cost of Inter-vention (USD)	Economic implications	Social implications	Impli-cations for food security	Environmental and climate change implications	Policy impli-cations
	Percentage	Weight (tonne)	USD			Percentage	USD						
Harvesting	10	304 016	63 763 823	Improper harvesting methods	Training	30	19 129 146	27 800 for one district/ year	Additional cost of training, slow returns	Improved price for produce, skill development	Increased awareness of food safety	Judicious use of resources	-
Transportation ▪ Fresh fruit FSC	15	255 374	53 561 611	Improper handling and packaging	Plastic crates on rental basis	20	10 712 322	2 856 304 for one district/ year	▪ Initial cost of capital ▪ Increased tax earnings for the government	Improvement in use of market yards- Better price for produce		Reusable packaging, reduced packaging wastes	
Ripening ▪ Traditional process	19			Unstandardised method	Research into standardising the parameters				Capital requirement for procuring standardized thatching materials, Training cost	Easier to implement with minor modifications, as this is a current practice with the actors	Reduced spoilage of fruit	Decreased fruit wastes leading to reduced disposal. Can be an alternative to energy intensive ripening chambers	

Source: field data

up, especially by women self-help groups (SHG) at the cluster level, to add value to preharvest mangoes that have fallen during wind or storms, or have been slightly damaged or bruised. By training the existing self-help groups and small-scale units to modify the current process, and use the fallen mangoes, will create a viable linkage. This would lead to optimized utility of the lost fruit and improve product quality. In the mango pulp FSC, small-scale jelly manufacturing units in the region could be encouraged to use the fruit that is currently being lost during harvesting and sorting.

Transportation

Plastic crates are currently used on a limited scale because of the lack of effective links that result in the additional cost of returning crates to the source location. Effective links should be developed to rotate crates between locations, for different products or methods of supplying crates on a rental basis.

Market links

Farmers are being exploited by contractors and agents because they are unaware of efficient market links. A tracking mechanism would inform farmers of the price of mangoes across the value chain. This intervention would help farmers negotiate better prices for their produce and, eventually, would improve transparency and reduce the power of the intermediary over the market. Development of market linkages for value-added products from culled or sorted fruit is a determining factor for farmers or women's self-help groups in taking up mango processing or value addition as an enterprise.

Assisting enterprises

Business enterprises or companies that are considered for processing mango waste are typically very small and the members have limited skills, especially in trade networks and business. Incubators at the relevant institutes should assist and nurture individuals who are engaged in these enterprises.

Mostly, local entrepreneurs who are considering starting food processing units are often discouraged by the high capital and equipment costs. To facilitate local initiatives, institutes such as the College of Food Science, ANRGAU or the State Horticultural University should study the feasibility of establishing an 'Incubator' with a pilot plant to assist local entrepreneurs trial and establish their concepts for products. This would also create a bridge between academia and entrepreneurs that would benefit both by creating access to research for the entrepreneurs and subsequent commercialisation of researcher's ideas.

Setting up of a Mango Development Board

As stated by many stakeholders during the study, there should be a body to monitor the supply chain and control all aspects of the mango trade. A Mango Development Board could be developed on similar lines to those for Coconuts and Grapes. The Board should develop the trade in mango and promote research in relevant areas. This will lead to optimisation of pricing, demand, and production, thereby reducing the chances of a glut on the market and subsequent food loss. A similar consideration, currently being studied by the government, should be expedited.

FOLLOW-UP ACTION PLAN – CONCEPT NOTE

The qualitative and quantitative losses in mango are mostly observed during the stages of harvesting, transportation and ripening. Reducing these losses is important as they significantly impact the profitability of farmers and the environment. These losses can be reduced by interventions such as training farmers in harvesting and post-harvest practices and conducting research into improving the traditional ripening method.

Creation of the right content is an important factor in the effectiveness of training. Therefore, the content creation exercise should be carried out by experts from institutes such as the Central Institute of Post-Harvest Engineering and Technology (CIPHET), the State Agricultural and Horticultural Universities, Technology Providers and Processing Companies by considering the local limitations and resource constraints. Training the trainer modules should be developed to train horticulture and extension officers for effective dissemination to farmers. Research institutes such as CIPHET, the Indian Institute of Horticultural Research (IIHR), the Central Food Technological Research Institute (CFRTI) should work on optimising the parameters of traditional ripening methods related to temperature changes, suitable insulating materials, stacking of fruit and ethylene seeding with already ripened fruit, etc. Similar Institutes should develop technology for small-scale units to process by-products using the mango kernel or creating edible or added-value products such as mango kernel fat. This would help create additional value and reduce stress on the environment.

Processing companies such as Jain Irrigation Systems Limited (Farm Fresh) are currently extending their support to promote high density mango plantations. Similar companies can extend support by offering farm services including pesticide sprays, scientific methods of harvesting and post-harvest handling. A public–private partnership model should be developed in consultation with the government and companies to optimize the support and resources under various government schemes and should include contributions from private companies and farmers. This will help reduce unnecessary pesticide use; reduce the impact on the environment; facilitate adoption of integrated pest management and, finally, improve the quality of the final produce. Employment generation and the empowerment of women could be achieved by providing support and assistance to individuals, farmer producer companies and women self-help groups in processing damaged or culled fruit on-farm or during harvesting.

These models and interventions should initially be taken up in one FSC or district. Upon successful implementation, they should be extended throughout the mango producing regions in the state by making the necessary adaptations for different locations.

RECOMMENDATIONS

A one-day stakeholder meeting was conducted with the help of FAO in February 2016 at Vijayawada, Andhra Pradesh, to critically appraise the report and to understand the relevance and adoption of the interventions proposed in the report. The findings of the report were presented to the subsector specific group comprised of experts from the State Horticulture University, post-harvest experts, horticulture officers, mango packing house manager, farmers who work mostly in the policy implementation stage and other stakeholders: the Agriculture Minister of the Andhra Pradesh State Government and principal agriculture secretary, who works on policy formulation.

In the group discussion the findings and interventions were individually assessed for their adaptability and potential to address the food losses in the mango subsectors. Further to the evaluation of interventions, follow up action plans were discussed, which are detailed below.

Importance of harvesting

Harvesting is an important factor in deciding the quantity of losses at all subsequent stages in both fresh fruit and pulp processing supply chains. The panel agreed on the finding that there is increased need for sensitising the actors about the importance of proper time and methods of harvesting and by so doing both quantitative and qualitative food losses in the subsequent stages can be greatly reduced.

On-farm training using ICT tools

It was agreed by the panel that farmers' and farm workers' lack of training is one of the main reasons leading to poor harvesting practices. The need for better harvesting and post-harvest care is to be effectively communicated to farmers to ensure they understand the impact on food loss. The possibility of creating new content and dividing it into modules on: production and preharvest care; harvesting care; and post-harvest care was discussed, so that the training content will be easily taken up by the trainers and effectively delivered. The panel members suggested the possibility of using existing content created by the Horticulture University during the earlier capacity-building programmes. These can be used with the required modifications, as most operations were well captured at that time. Better practices that have been adopted by local progressive farmers and the benefits derived should also be included in the content of the training programmes. The means of delivery to farmers needs to be further explored.

Evaporative cooling chambers

Evaporative cooling chambers are also known as zero energy cooling chambers, are an effective and low cost means of reducing the field heat in produce after harvesting. Currently there is no practice of precooling in both the fresh fruit and pulp processing supply chains to remove field heat after harvesting. The post-harvest experts in the panel indicated that the zero energy cooling chambers are greatly undervalued and there is an immediate need to promote this technology owing to its very low cost and simplicity in design and operation. At the farm level, these cooling chambers can be created using indigenous resources. This can help reduce food losses particularly in the fresh fruit supply chain during long distance transportation.

Packaging designs

All panel members emphasized the need to create improved and low cost designs to package fruit; particularly in the fresh fruit supply chain. It was agreed that best practices in grading and packaging are currently followed in the export supply chain,

which was validated by the packing-house expert on the panel. The panel considered a low-cost option of disposable plastic crates, and it was agreed this would add substantially to the disposal load. The panel agreed that the current corrugated fibre-boards are inferior in design, as they are of improper ply and lack ventilation holes, which leads to buckling of boxes by the time they reach terminal markets. The food losses in the long distance transportation can be reduced greatly if farmers are trained to properly grade and pack. Farmers would complete packaging of the fruit in boxes after proper post-harvest operations including desapping.

Farm and post-harvest service firms

Availability of skilled labour, and subsequently their retention after training, is a major challenge faced by farmers in both food supply chains. This is limiting the availability of training for labourers involved in the farm operations. Models have been tried out in Chittoor by the export packing-house, where harvesting and transportation of fruit was carried out in a scientific manner without the farmers' intervention. The need for starting such an enterprise to offer farm and post-harvest services by local entrepreneurs was well received and examples were discussed of similar entities currently in operation. The local farm workers and unemployed can be absorbed into such entities and trained in a scientific way. Support should be extended to such an enterprise by subsidizing the farm equipment and dedicating transport vehicles for horticultural produce. The possibility of training under the National Skill Development Council programme is to be further explored.

Incubators for promoting entrepreneurs

Currently entrepreneurs in the small-scale sector or self-help groups are facing challenges caused by inadequate access to modern technology and market linkages. This is limiting their potential to produce value-added products from mangoes, which are currently accounted for as a food loss.

Common incubator facilities need to be created in multiple locations to promote the processing of multiple agricultural and horticultural commodities with the help of horticulture or agriculture universities and the state government. The panel emphasized that support to small entrepreneurs should be extended by leasing existing pilot plants in the universities at nominal costs to test proof of concepts, provide technical guidance and regulate support and create market linkages.

In addition to the above points, the panel also stressed there was the need for a detailed study of greenhouse gas emissions from mango cultivation and processing. The following action points were identified for suggested food loss reduction strategies.

- Harvesting is playing a deciding role in the quantity of losses across the subsector. Training the stakeholder such as farmers and farmworkers in better harvesting practices should be taken up as a priority.
- The Department of Horticulture should promote zero energy cooling chambers, especially in the fresh fruit supply chain by raising farmers' and traders' awareness that precooling of fruit leads to reduced losses during transportation.
- A database should be prepared that includes available institutes, pilot plants and technology centres and requirements for any additional equipment or facilities; list of available experts in technology and business to prepare a proposal for the creation of a well-networked incubator.

This last should be initiated at the local university or at state government level to bring all the collaborators on board. A pilot level study should be carried out to understand the viability of farm and post-harvest services enterprises in a district with rich horticultural production, so that the same can be extended to other crops in the off season.

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