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Working paper

*Case studies  
in the small-scale  
agriculture and  
fisheries subsectors*

# **MANGO VALUE CHAIN**

## FOOD LOSS ANALYSIS: CAUSES AND SOLUTIONS

*State of Andhra Pradesh – India*

*Manuscript*

# **Mango value chain**

## **Food loss analysis: causes and solutions**

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Case studies in the small-scale  
agriculture and fisheries subsectors  
*In the State of Andhra Pradesh, India*

*Manuscript*

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Glossary:

AP	Andhra Pradesh
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
FSC	Food Supply Chain
FSSAI	Food Safety and Standards Authority of India
GAP	Good Agricultural Practices
GMP	Good Manufacturing Practices
Ha	Hectares
HACCP	Hazard Analysis and Critical Control Points
INM	Integrated Nutrient Management
IPM	Integrated Pest Management
MIDH	Mission for Integrated Development of Horticulture
MT	Metric Tonnes
MNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
NREGS	National Rural Employment Generation Act
RKVY	Rastriya Krishi Vikas Yojana
USD	United States Dollar
VHT	Vapor Heat Treatment
VZM	Vizianagaram

Executive Summary

The present study is taken up 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 study was carried out by 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 (i.e. by direct observation, direct interaction with chain actors and load tracking exercise) information on food loss, so that the results are comparable. The case study methodology comprises of one-time assessment of the selected supply chains; the situation in next season, another geographical area and in another climatic condition could be greatly different. Therefore, it is highly important to conduct as many as case studies as possible covering different geographical areas and time periods, so that the results are representative and could be extrapolated. The study is executed in phased manner with a “4S” approach consisting of Screening, Survey, Sampling and Synthesis. In this approach the dominant food supply chains of the subsector are identified and studied further to quantify the losses and by thorough observation of the activities across the food supply chain and by interacting with all the stakeholders and experts in the subsector.

India is the leading producer of mango with production around 20 million tonnes in 2015-16, followed by China with production of 5 million tonnes. Mango contributes to major share of horticultural exports from India in both fresh and processed form to major Middle East and European markets. Andhra Pradesh contributes to 6% of global mango production and 15% of the India’s mango production, making it the second largest producer of mangos in the country. The state comprises of two important supply chains in mango subsector i.e. fresh fruit and pulp processing. The district of Vizianagarm was chosen to study fresh fruit FSC while Chittoor district was selected to study pulp processing FSC, as they are dominant FSC 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 the food supply chains were studied in greater detail by interacting with various stakeholders across the value chain ranging from farmers, traders, transport agents, pack house experts, processing companies to horticultural experts. The food losses at individual stages were analyzed for both qualitative and quantitative losses. A load tracking exercise was carried out to validate the losses at each individual stages. Environment, gender and socioeconomic status of the actors were also evaluated in order to determine how these factors are related to root causes of food losses and also the impact of food losses and solutions proposed on these factors

Analysis of the FSCs reveal 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 the transportation in fresh fruit FSC is a major CLP. At ripening stage in pulp processing FSC, losses are high in natural ripening in comparison to ripening chambers. Other important causes for food losses observed include improper packing, non-standard storage and ripening conditions.

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

1. THE SUBSECTOR - Introduction and Background

a. Status and Importance of the 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 usage are recorded in ancient Indian texts and literature. Mango thrives in a tropical climate and is cultivated throughout India as a commercial crop. It is also a common sight in backyards of homes, along field boundaries and roadside avenues. Mango is the most cherished fruit across the country in its fresh fruit form as well as in different products. Mango is utilized at all stages of its development, such as the raw fruits are used in making Pickles, Chutney, mango sauce and Green mango beverages. The ripe fruits are 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/100g. The fruit contains nearly 81% moisture, 0.4% fat, 0.6% proteins and 0.7% fibers. It contains nearly 17% carbohydrates and 0.4% minerals (NIN, 1989). It is also a rich source of vitamin A and C. The mango kernel contains up to 10% good quality fat that is used in 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 to be 2.22 m ha in 2015-16 with production of 19.51 million tonnes and average productivity of 8.8 tonnes per ha. The production and area of cultivation of mango is observed to be in an increasing trend from the past fifteen years with an average annual growth of 5.7% from 2001. Mango contributes to major share of horticultural exports from India in both fresh and processed form to major markets like UAE, Saudi Arabia, Netherlands, Kuwait, and Qatar. The country has exported 36.3 thousand MT of fresh mangoes and 128 thousand MT of mango pulp to the world for the worth of USD 49.5 million and USD 121 million respectively, during the year 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 per the year 2014-15 estimates, Andhra Pradesh ranked first in the country with an area of 315.69 thousand hectares under mango cultivation and ranked second in production with 2.84 million tonnes contributing to 15.27% production with the productivity of 9.0 tonnes/ha. This translates to about 5.6 % of global mango production. The Andhra Pradesh State Horticulture department estimated the value of the produce in 2014-15 as USD 333.30 million with a market price of USD 120 per ton of mango.

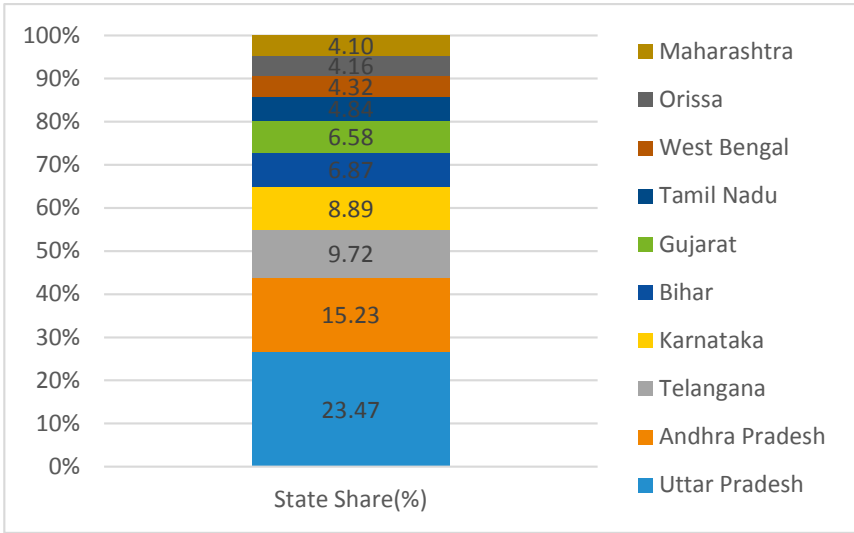


Fig 2: Mango Production (2014-15), Top 10 States

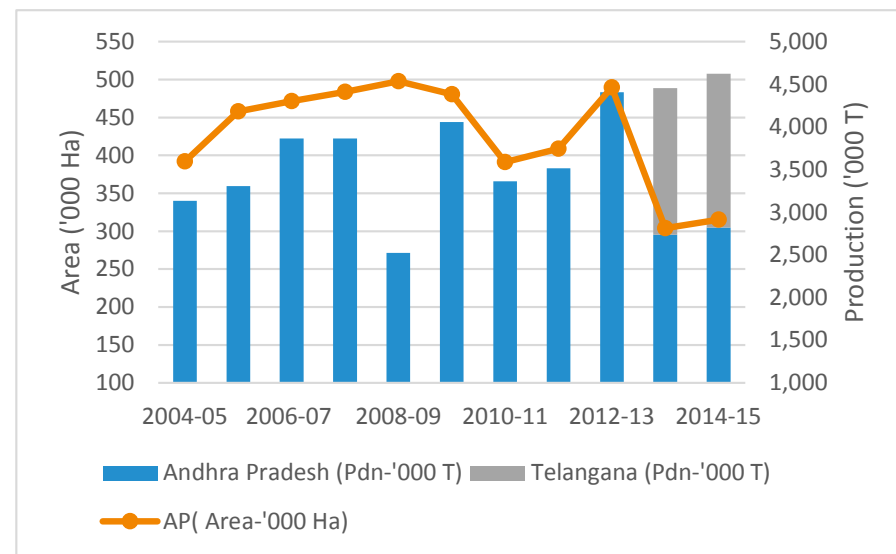
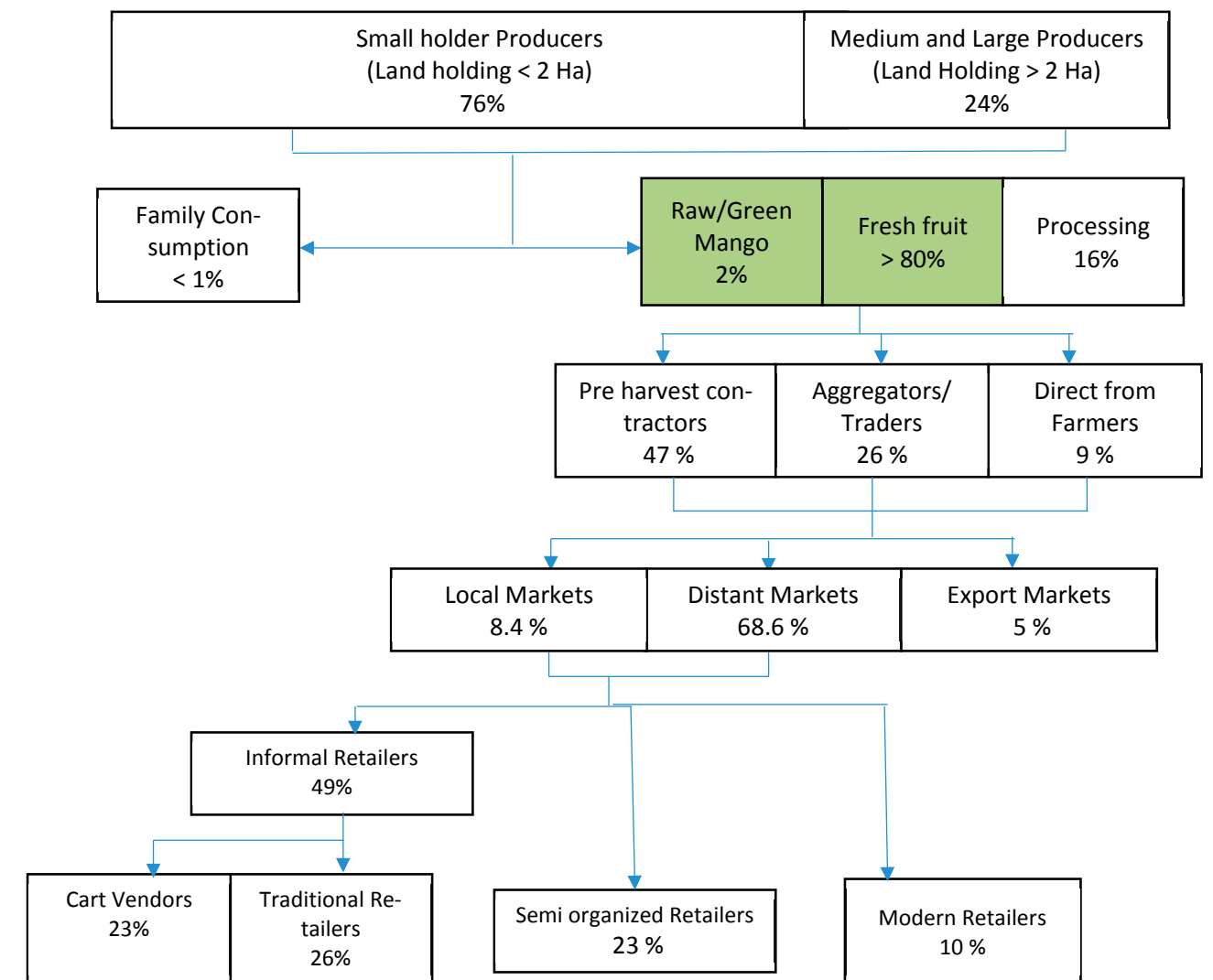


Fig. 3: Mango Production trend in Andhra Pradesh (2004-2015)

Within the state of Andhra Pradesh, Chittoor, Krishna, Vizianagaram, Anantapur, and Kadapa are the predominant mango growing districts. Mango is grown in perennial orchards with the harvesting season from the months of May to July. Nearly 76% of mango farmers are small and marginal with land holdings not more than 2 hectares, while the remaining 24% are medium and large farmers with land holdings of approximately 4 hectares and 10 hectares respectively. The state of Andhra Pradesh in the year 2014 was bifurcated into two separate states of Telangana and Andhra, the land area under mango cultivation from the erstwhile state of Andhra Pradesh to the current one dropped from 4406 ha to 3040 ha. However, the land acreage under mango cultivation in the new state of Andhra Pradesh is constantly growing at an average of 3.5% each year. The main mango varieties produced for consumption as fresh fruit in the region 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 flavor.

#### OUTPUT I-1a: STATE PRODUCTION INFORMATION OF THE FRESH FRUIT SUBSECTOR - Actors and product flow



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

**Producers:** Farmers holding less than 2 hectares of land are classified as smallholder producers and they account nearly 76% of the total farmers and the remaining 24% are classified as large holder producers. Farmers in mango pulp FSC are comparatively more knowledgeable than fresh fruit FSC in terms of post-harvest handling and market information. Most of the farmers in this FSC have direct linkages with processing plants and supply directly to them.

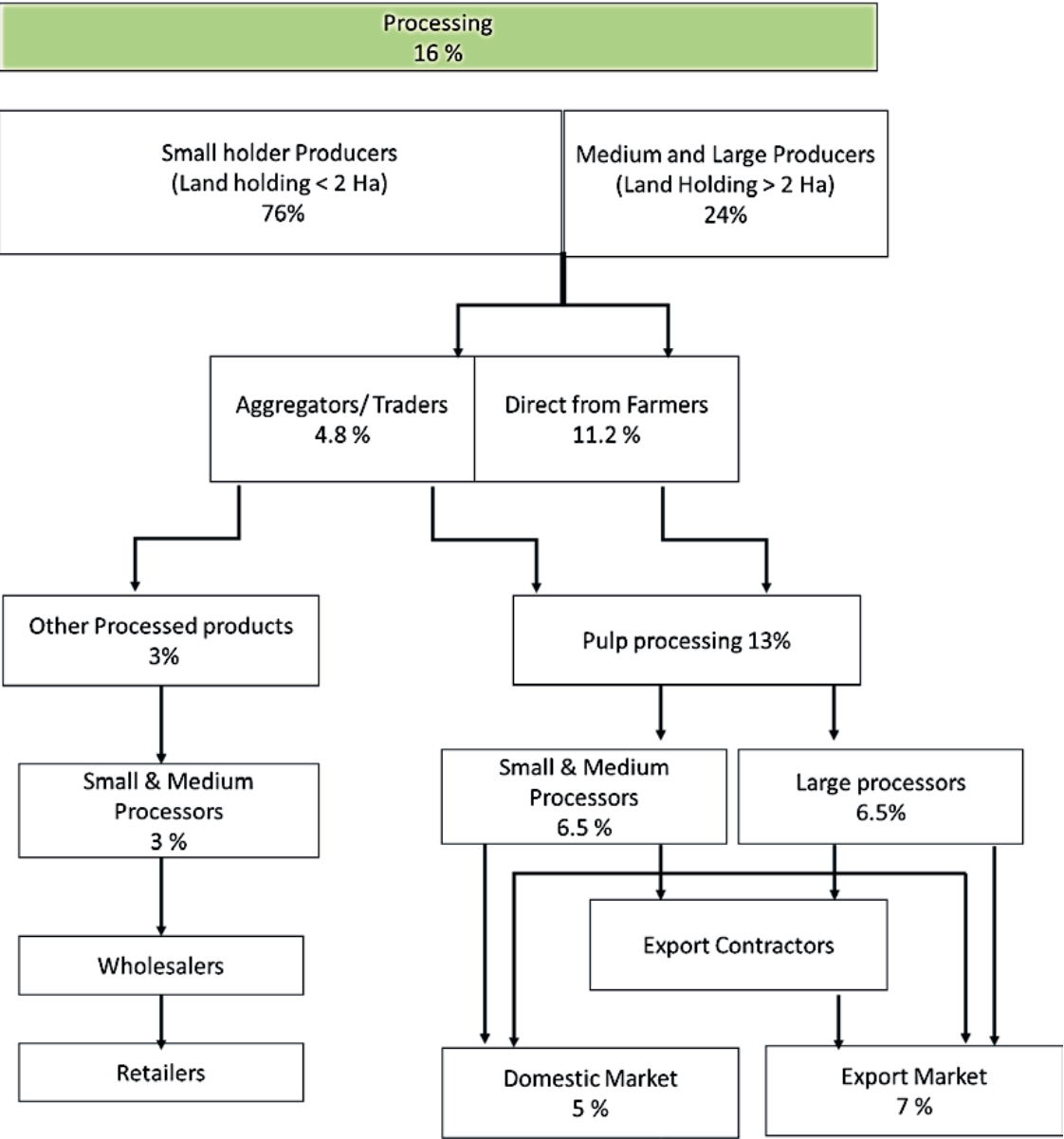
#### Traders and Pre-harvest Contractors:

The traders in the mango pulp FSC, act as commission agents between the producers and the processing plants. They aggregate the produce from small farmers in market yards and supply them to processing plants by charging a commission of 4 % on the sale price. They play an important role in maintaining a continued supply of fruits to the processing plants in the limited production season by procuring fruits from other regions during the beginning and end of the season.

In fresh fruit FSC, traders/aggregators procure fruits from the local producer, aggregate the fruits and ship them to traders in distant markets across the country. The pre-harvest contractors also operate in a similar manner, however, in this case, they contract with the mango producer for the whole produce for one or more seasons and in turn finance the farm operations for that particular season.



**OUTPUT I-1a: STATE PRODUCTION INFORMATION OF THE PROCESSING SUBSECTOR -**  
**Actors and product flow**



**Pulp Processors:**

The major fraction of processors are small and medium scale processors producing up to 100 tonnes of mango pulp per day. About 5% of the total are large producers contributing about 50 % of total production. Aseptic and Canned mango pulp and Pulp concentrate are main products produced in this FSC.

**Processors of Other products:**

Products like mango Jelly and Pickles are manufactured by small/ cottage scale processors with capacities of less than 2 tonnes per day.

**Export Contractors:**

Export Contractors are licensed to export the pulp and have good forward linkages. They procure and supply pulp to export markets, mostly from small processors who lack representation in terminal markets. In some cases, export contractors finance the operations by entering into toll production agreements.

**Wholesalers and Retailers of processed products:**

Wholesalers procure large quantities of processed mango products and distribute them further in the

supply chain. They are usually involved in the trade of multiple commodities. Retailers procure smaller quantities of the products from wholesalers, sometimes on a line of credit, and sell them to the final consumer in the terminal market.

**Wholesalers and Retailers of Fresh fruits:**

The wholesalers for the fresh fruit are usually located in the market yards at distant markets. They procure fruits 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.

**OUTPUT I-1b: STATE PRODUCTION INFORMATION OF THE SUBSECTOR**

	Annual pro- duction (t/yr)	Cultivated area (ha)	Average yield (ton / ha)
2013-14	2,737,008	304,111	9
2014-15	2,822,075	315,415	8.94
2015-16	3,040,168	325,845	9.33
Average annual growth over the last 3 years (%)	31.35	391896	9.07
Average cost of production (USD / ton)	38		
	on-farm consumption	Marketed	
Percentage of production	1 %	99 %	
	volume (ton/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, sex, age of	female	Male	Total
	Total	Total	
Total Producers in the state	3345754	98,23,660	13,169,414 (To- tal Farmers)
Mango Producers	92577	271,822 <sup>1</sup>	364,399
Traders			
Processors			65
Retailers #1			
	Small	Medium	Large
Level of processing operations	76	20	4

<sup>1</sup> Specific data of female and male farmers in mango is not available; numbers are based on the assumption of general land holding pattern for all other crops. 364399 is the total number of landholdings in mango.

On-farm consumption of mango in both the FSC’S is limited to less than 1% and usually accounts for self-consumption by the farmer’s family and farm labor. In most cases, it also involves distribution in the neighborhood as a good will. The major portion of the fresh fruit goes to distant markets due to high demand during the lean season and about 16% of the produce is processed to various value added products. Owing to the perishability and difficulty in storing mangoes, processing plays an important role, not only in improving the product shelf life but also by generating sustainable income to the producer through value addition and by creating better access to markets. In the current season, the production cost incurred by farmers for 1 hectare production is between USD 210 – 300.

**OUTPUT I-1c: FOOD SAFETY MANAGEMENT MECHANISMS**

Food safety practice is critical throughout the mango FSC. However, to a large extent, the importance of food safety is understood and practiced within the mango pulp FSC as well as in the FSC of fresh fruit meant for export markets. The level of implementation of food safety management mechanisms and responsible agencies at different stages of the supply chain are as follows:

**Good Agricultural Practices and Produce Standards:**

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

**Food Safety and Standards:**

Food Safety and Standards Authority of India (FSSAI) issues mandatory rules for registration of manufacturing facility and standards for products, which are stringently followed by processors. It also monitors and controls the usage of ripening agents/ chemicals for fruits. Most of the processing plants are HACCP certified and follow GMP.

**Export Inspection Standards:**

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

**b. Inventory of activities and lessons learnt from past and on-going interventions in subsector losses**

In order to improve mango sub-sector and horticulture as a whole in Andhra Pradesh, the Horticulture Department started providing subsidies to a limited extent using a cluster approach by supporting canopy management, rejuvenation, integrated pest management etc. For improving post-harvest practices, support was extended by providing plastic crates, establishing grading and packing units, processing units etc. at 50% subsidy. These initiatives were supported by both the state government as well as the central government under RKVY, MIDH and other state schemes.

The state government also launched AP Micro Irrigation Project (APMIP) in the year 2003 to conserve the available ground water and also increase the productivity of horticulture crops. This new initiative was taken up by the state government to uplift 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 in mango increases yields by 50 -70% with a minimum of 53% water saving per hectare per season and 53% saving in energy when compared to flood irrigation (AP Socio-economic Survey 2015-16). In the last three years, a total area of 25,765 hectares in Chittoor and 3418 hectares in Vizianagaram have been brought under micro irrigation. Mango farmers, particularly in mango pulp FSC, are progressive to embrace drip irrigation to counter climate change effects such as uneven trends of rainfall and drought conditions for better productivity and reduced fruit loss. Government created Agri Export Zones (AEZ) during 2002 for mango, Grapes, Gherkins and Chillies to promote quality production and exports. However, some Agri Export Zones established for mango, Chillies, and Grapes to promote quality production for export became non-functional later due to lack of demand and proper implementation.

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		
		Doesn't exist		
	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 Lab
		Doesn't exist		
FSC actors - food safety management system	GHP/ GAP/ HACCP/ voluntary standards	GAP, HACCP		Farmers, Processors
	Identification and control of potential hazards <ul style="list-style-type: none"><li>Physical- Foreign matter</li><li>Chemical- Pesticides, Lubricants, Calcium carbide etc.</li><li>Biological Hazards- Insects-fruit flies, Pathogenic microbes</li></ul>		Med	Processors, Food Inspectors, Certifying agencies

Some of the strategies for development of horticulture from past include:

- Convergence of Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) with Horticulture Department for better utilization of labour and empowerment of backward communities
- Improving marketing facilities through rythu bazaars (farmers markets), vegetable markets, and collection centers and refer vans so that the farmers get remunerative prices for their produce.
- Promotion of precision farming through micro irrigation, fertigation, Green House cultivation, mulching for better water conservation and quality of production
- Encouragement of modern farm machinery and tools to save time and labor and for improving the harvest quality
- Promotion of post-harvest management practices through establishment of pack houses, cold storages, ripening chambers and reduce post-harvest losses thereby increasing horticultural exports

**Interventions by FSC Actors:**

Processing companies played a crucial role in awareness building among the mango producers on the importance of post-harvest handling in processing value chain. Currently, fresh fruits are 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 the levels of processors who have upgraded their technology through the scheme provided by APEDA or National Horticultural Board. Construction of concrete



mounted intermediate storage sheds was taken up in places where ripening chambers were absent, in order to ripen fruits in the traditional method. Processing units that started as canning units slowly transformed by adopting aseptic packaging technology. In processing plants, interventions like mechanical washing of fruits, upgrading to pasteurizers from open steam jacketed kettles, improving can-sterilization system, and usage of rotary continuous can filling machines were also taken up. Processing plants also emphasized the importance of quality assurance and implemented quality systems and HACCP standards. These steps have improved the quality, food safety, reduced food losses and environmental impact.

**c. The process of policy making and current policy framework or national strategy on subsector losses (if any), and brief description/ assessment of the level and extent of current implementation**

The Centrally Sponsored Scheme of National Horticulture Mission (NHM) is being implemented in Andhra Pradesh since 2005-06. From April 2014 onwards, NHM has been subsumed under Mission for Integrated Development of Horticulture (MIDH) for holistic growth of the horticulture sector. NHM is being implemented in 11 districts of AP. Major activities being undertaken in the program are production and distribution of quality planting material, area expansion, rejuvenation of senile plantations, creation of community water resources, protected cultivation, IPM/INM, organic farming, development of post-harvest management & marketing infrastructure and human resource development. The mission for MIDH is a Government of India scheme being implemented since 2014 by subsuming six schemes on Horticulture development including NHM. This program is under implementation in nine districts (includes Chittoor but not Vizianagaram).

**Agri Export Zones (AEZ):**

The state government has promoted AEZs to boost the export of horticulture products. The Chittoor AEZ is the most successful in the state as well as in the country. The annual turnover of pulp exports from Chittoor increased from USD 1.22 million before the establishment of AEZ to USD 49.4 million in 2012. Besides the modernization of several units and support for HACCP certification acquisition, the government has exempted sales tax on all inputs and packaging material uses for exports. There are a number of other demands from the processors, but on the whole, the industry is responding well to the policy support.

In post-harvest management, support is also being extended by the following agencies/ schemes.

**Rashtriya Krishi Vikas Yojana (RKVY):** Under this scheme, fruit processors are assisted with soft loans to upgrade technology in the plants.

**APEDA schemes:** Assistance by support in setting up of integrated or individual post-harvest infrastructure like pack houses, pre-cooling units and cold chain units, adoption of QA and food safety systems, assistance in training and skill development of personnel in units meant for export purposes.

**Mega Food Park Scheme:** Ministry of Food Processing Industries (MoFPI), extends financial assistance in establishing mega food parks to link production areas to markets with processing facilities and support infrastructure and to improve value addition, minimizing wastages, increasing farmers' income and creating employment opportunities, particularly in the rural sector. In the mango pulp FSC in mango, two such mega food parks namely Srini Food Park and Sricity Food Park in the region improved the processing facilities and catalyzed the increase in demand for pulp.

**Credit Linked Capital Subsidy Scheme (CLCSS):** Ministry of Micro, Small and Medium Enterprise extends support in promoting small scale industries and technology upgradation by providing a subsidy of up to USD 22000 for plant machinery with a ceiling worth of USD 0.15 Million

**Implementation of Total Quality Management System including ISO 9000, ISO 22000, HACCP, GMP & GHP by MoFPI:** Under this scheme, assistance is extended by reimbursement of expenditure to the extent of 50% of the cost of consultant fee incurred by processing units, fee charged by Certification Agency, plant and machinery, technical civil works and other expenditure towards implementation of Total Quality Management System including ISO 9000, ISO 22000, HACCP, GMP & GHP.

**d. Relevant institutions and their role in terms of policy, organizational structure, mandate and activities in the small and medium subsector industry sector**

**Department of Agriculture, Cooperation, and Farmers Welfare (DAC&FW):**

DAC&FW is responsible for formulating and implementing national policies and programs to achieve rapid agricultural growth through optimum utilization of the state's land, water, soil and plant resources. The focus areas of the Department are agriculture, marketing agricultural produce, horticulture, and sericulture. The objectives of the department are to assess requirements of agriculture inputs and regulate their production and monitor the timely supply of seeds, fertilizers, and pesticides, implements, credit to farmers. The department also performs statutory functions under various acts and regulations (i.e., quality control) to ensure supply of quality inputs i.e., seeds, fertilizers, and pesticides to farmers.

**Department of Horticulture:**

All issues related to the horticulture sector are administered by the Department of Horticulture which coordinates the implementation of schemes from various bodies such as National Horticultural Board. It supports farmers by providing technical advice on the cultivation of horticultural crops, executing various schemes, conducting training and exposure trips for farmers, organizing meetings to advocate new technology, and evaluating the need for assistance after a natural disaster.

**Ministry of Food Processing Industries (MoFPI)**

MoFPI is responsible for overall policy-making in terms infrastructure development and development of food processing sector. MoFPI draws up the overall strategy for promoting food processing and supports through of various schemes for establishing mega food parks, cold chain infrastructure, waste utilization plants and skill development by training various stakeholders.

**Food Safety and Standards Authority of India (FSSAI)**

FSSAI issues and monitors the regulatory standards for intermediate products like aseptically processed mango pulp, canned mango pulp, pulp concentrate and tertiary consumer products like jams, pickles, beverages and candied fruits etc. The companies producing any of these products are obliged to register under FSSAI as Food Business and Operator (FBO) and follow the applicable product, packaging and processing standards.

**Agricultural and Processed Foods Export Development Authority (APEDA):**

The processing companies and export merchants are bound to be registered with APEDA in order to export fresh mangoes and processed products to overseas. APEDA sets standards for products that are to be exported and coordinates with various regulatory agencies and notifies all the stakeholders about changes and developments in standards, trade notifications/ restrictions etc. in the respective geographies. APEDA also works to promote the export of food and agricultural commodities by various interventions like financial assistance, Infrastructure development, markets and quality development. APEDA was instrumental in establishing two Vapor Heat Treatment (VHT) plants each in Krishna district and Chittoor and a common aseptic packaging plant in Chittoor AEZ to promote the export of fresh mangoes and mango pulp respectively.

**Export Inspection Council (EIC):**

EIC ensures the adherence of products to the respective standards for the export market. EIC facilitates testing of samples at labs at Export Inspection Agencies situated at various ports of entry and exit across the country and supports in the issuance of a certificate of origin, phytosanitary certificate, pre-shipment inspection etc.

e. Overview of the most important FSCs in the subsector, selection of FSC

OUTPUT I-2a. FOOD SUPPLY CHAINS IN THE SUBSECTOR.

FSC #	Geographical area of pro-duction	Final prod-uct	Area under mango (ha)*	Volume of mango pro-duction (ton/year)*	Number of smallholder producers/total farmers (%)	Market of final product, location, buy-ers <sup>4</sup>	Project support
1	Chittoor	Pulp, fresh fruit	73,977	665,793	71,000 / 92,000 (77%)	Middle 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, Ja-pan, Middle 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

In 2015-16, mango was cultivated in an area close to 326,000 hectares in Andhra Pradesh with the production of approximately 3,000,000 metric tonnes. Chittoor, Krishna, Ananthapur and Vizianagaram are the leading districts in terms of area under mango cultivation.

For the fresh fruit FSC, Vizianagaram was selected as the district of choice for the study considering the area under cultivation, number of small farmers, the level of infrastructure and the presence of mar-ket value chain for fresh mango fruit. For the mango pulp FSC, Chittoor was selected as the district of choice owing to the variety of mango that is produced which is suitable for processing and also the presence of the entire processing supply chain. Table I-2a identifies and lists the main FSCs in the subsector by the geographical location, final product, and market for the final product.

OUTPUT I-2b. IMPORTANCE OF FOOD SUPPLY CHAINS (from I-2a) AT NATIONAL LEVEL

FSC #	Economic Importance	Genera-tion of foreign exchange	Contribution to national food consumption	Contribution to national nu-trition	Impacts on environ-ment 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

The mango pulp FSC in Chittoor is a major contributor in earning forex for the state of Andhra Pradesh and contributes to a major share of exports. In 2014, about USD 89.8 million worth of pulp is exported from AP. Mango pulp is also traded extensively in the domestic market worth of USD 104.7 million every year.

OUTPUT I-2c. – ECONOMIC IMPORTANCE OF FOOD SUPPLY CHAINS (from I-2a) FOR SMALLHOLDER FARMERS

FSC #	Percentage of produce		Contribution to income generation (% share of total annual income)				
	Smallholders	Other	Farmers	Middlemen	Processors	Wholesalers	Retailers
Mango pulp FSC	76	24	70	50	80	NA	NA
Fresh fruit			40	50	NA	50	25

Mango contributes to nearly 40% of the total income of the small and marginal farmers whose annual net income is in the range of USD 1500 to USD 1750 per annum. In the offseason, their income is supplemented through alternate jobs as farm labor or from cultivating other crops like paddy, sugarcane. In mango pulp FSC, mango being the main crop in the region, most of the work is directed to it and they are also employed in other jobs or business. Processors during off season take up the processing of alternate fruits like Papaya and Guava. The net income from mango processing is about 20% of their net annual income of USD 30000 to USD 75000. Wholesalers and retailers are usually involved in the trade of multiple commodities and the contribution of mango is only partial to their total income.

f. Presumed food losses in the selected FSC

The food losses are observed to be of varying degrees in both the FSC’S. In mango pulp FSC, the perception of losses among the FSC actors is relatively low when compared to that of fresh fruit FSC. In both cases, farmers at all levels agreed that losses during harvesting are about 10%. Losses in trans- portation are high in fresh fruit FSC whereas in mango pulp FSC transportation is minimal, efficient and is a low loss point. In mango pulp FSC critical losses are observed during the traditional ripening process.

OUTPUT 1-3b.PRELIMINARY SCREENING OF FOOD LOSSES IN THE SELECTED FSC

FSC # _1_, <Chittoor>, <Mango Pulp>			
Step in the FSC	Expected Critical Loss Points		Comments/ Remarks
	Quantitative	Qualitative	
Production and Harvesting	5-10 %	5 %	<ul style="list-style-type: none"><li>• Pre-harvest losses due to climatic conditions, diseases, and pests</li><li>• Physical damage of fruits due to improper harvesting</li></ul>
Sorting and grading	10 %	2 %	<ul style="list-style-type: none"><li>• Culled fruits are sometimes lost completely or sold for less value depending on the demand</li></ul>
Ripening–Traditional Process	10-15 %	20 %	<ul style="list-style-type: none"><li>• Due to improper handling and non-standard process</li></ul>
Ripening – Ripening Chambers	3-6 %	10 %	<ul style="list-style-type: none"><li>• Due to internal injuries, fungal infections, over maturity</li></ul>

FSC # _2_, <Vizianagaram>, <Fresh fruit>			
Step in the FSC -VZM	Expected Critical Loss Points		Comments Remarks
	Quantitative	Qualitative	
Harvesting	10-15%	5 %	<ul style="list-style-type: none"> <li>Immature fruits, sap injury, mechanical damage</li> <li>Diseases like stem end rot and pest infestations</li> </ul>
Grading	5%	5 %	<ul style="list-style-type: none"> <li>Physically damaged fruits, blemished and bruised fruits</li> </ul>
Transportation	10-15%	20 %	<ul style="list-style-type: none"> <li>Physical damage to fruits in the boxes</li> <li>5-10% sold for lower value</li> </ul>
Retail- First point of delivery	5%	25 %	<ul style="list-style-type: none"> <li>Storage diseases like anthracnose, Fungal rot etc.</li> <li>Loss of quality due to shriveling, physical injuries</li> </ul>

#### OUTPUT II-3a (INTERMEDIARY) PRODUCTS AND CONVERSION FACTORS IN THE FSC

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

<sup>2</sup> Only applicable for processes that are determined by a length of time independent of the quantity of product and the amount of labour, such as drying, fermenting, ripening, storage, transportation.

## 2. THE FOOD SUPPLY CHAIN - Situation analysis

a. Description of the selected subsector supply chain, its location, an estimate of the quantities of products, and when the case study took place

The present study took place in the month of 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.

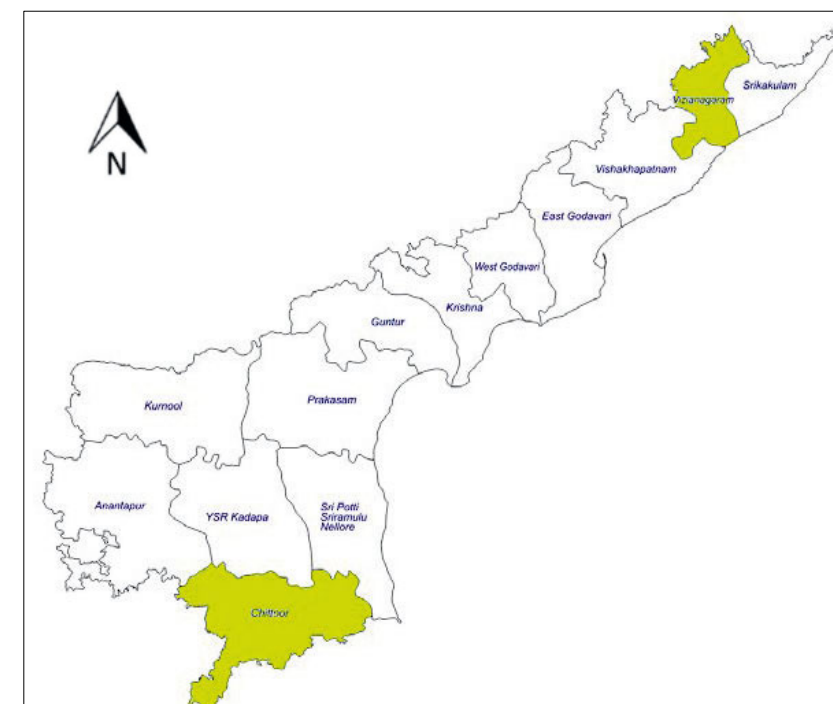


Fig 4: Selected Districts of Chittoor and Vizianagaram for the study

### Vizianagaram:

With Around 47,630 hectares under mango cultivation, Vizianagaram district stands third contributing about 0.43 million MT of production and fresh fruit as main FSC. The area under mango is increasing due to area expansion program implemented by the government and also due to shifting of many upland farmers to mango cultivation due to water scarcity and labor problems. The popular mango varieties cultivated in the region include Banginapalli (extent of 50%), Panukulu (20-25%), Suvarnarekha (15%) and Totapuri (5%) with the rest by other varieties. Panukulu, Suvarnarekha, and Banginapalli are very popular in distant markets like Kolkata. Panukulu is an early season variety in terms of fruit bearing & maturity, followed by Suvarnarekha, Banginapalli, and Totapuri. Many farmers in fresh fruit FSC maintain orchards with a mix of varieties to spread the produce availability and also as a diversification strategy to minimize the risks due to crop losses and climatic factors. More than 90% area under mango cultivation in Vizianagaram district is under rainfed conditions. The district is prone to cyclonic storms and several mango orchards were severely affected by Hud-Hud cyclone in 2014. More than 80% of the mango cultivators are marginal & small farmers.

### Chittoor:

With Around 71,000 hectares under mango cultivation, Chittoor district stands first contributing about 0.68 million MT of production and pulp processing as its main FSC. Increased cost of labor for other crops, less dependency on irrigation, support from government and better market facilities made farmers shift from conventional crops to mango cultivation in this region. About 70% of the total production is accounted for Tothapuri variety, followed by other varieties such as Alphonso, Neelam, Baneshan, Imam Pasand, Pulera and Kalepadu. Most of the farmers have adopted drip irrigation with the support of government or independently. The mango pulp processing sector is called as Chittoor fruit processing cluster and is the largest of its kind in India. There are about 67 registered units of mango pulp industries of which 55 of them were operational this year.



OUTPUT II-3b: DETAILED DESCRIPTION OF THE FOOD SUPPLY CHAIN – BASICS

Mango pulp FSC											
FSC stage <sup>3</sup>	Geographical <sup>4</sup> Location	Months of the year <sup>5</sup>		Main Products <sup>6</sup>	Quantity (ton)	By-prod-ucts	Quantity of By-products (ton)	Duration/ Distance <sup>7</sup>	Services	Food safety and quality controls applied by that part of the chain	
		from	to								
Primary Production	Chittoor	Aug (Previous)	May	Mango	665,793	NA	NA	8 months of production time	Irrigation, fertilizers, farm man-agement	GAP	
Harvest	Chittoor	Jun	Aug	Mango	665,793	NA	NA	1 Day/ Ha	Farm labor, Im-plements	GAP	
Post-harvest handling	Chittoor	Jun	Aug	Mango	599,214	Culled fruits	66579	1 Day/Ha	Farm labor, Crates	GAP, GMP	
Storage		NA	NA	Mango	NA	NA	NA	NA	NA	NA	
Transportation	Chittoor	Jun	Aug	Mango	599,214	NA	NA	50 km	Truck	GMP	
Market sales	Chittoor	Jun	Aug	Mango	432,765	NA	NA	3 months during har-vesting	Sorting and grad-ing, loading and unloading, sales	GMP	
Agro-pro-cessing	Chittoor	Jun	Aug	Mango pulp	466,055	Peel, Stone	116,513- Peel 93,211- Stone	6 T/ hour	Ripening, clean-ing, pulping, thermal pro-cessing and pack-ing	GMP/HACCP, FSSAI	

Mango Fresh Fruit FSC											
FSC stage <sup>8</sup>	Geographical <sup>9</sup> Location	Months of the year <sup>10</sup>		Main Prod-ucts <sup>11</sup>	Quantity (ton)	By-prod-ucts	Quantity of By-products (ton)	Duration/ Dis-tance <sup>12</sup>	Services	Food safety and quality controls ap-plied by that part of the chain	
		from	to								
Primary Production	Vizianagaram	Jul (Previous)	Mar	Fresh fruit	532,836	NA	532,836	8 months	Irrigation, ferti-lizers, farm management	GAP	
Harvest	Vizianagaram	Mar	May	Fresh fruit	532,836	NA	532,836	1-30 days	Farm labor		
Post-harvest handling	Vizianagaram	Mar	May	Fresh fruit	506,194	Culled fruits	26641	1 day	Farm labor	Good hygienic practice / GHP	
Storage		NA	NA	NA	NA	NA	NA	NA	NA	NA	
Transportation	Vizianagaram	Mar	May	Fresh Fruit	362,328	NA	362,328	800 to 1000 km	Loading Pack-aging and trans-portion	GMP	
Market sales	Delhi, Kolkata	Apr	May	Fresh fruit	362,328	NA	NA	4 months	Unloading, re-ripening, re-packing	FSSAI – Control on use of ripening agents	

<sup>8</sup> If one stage in the FSC has two different features, another row should be inserted. E.g. if in the same FSC both crib storage and warehouse storage exist.

<sup>9</sup> Village/town where the FSC stage is located.

<sup>10</sup>Timing of the stage of the FSC.

<sup>11</sup> “Final” product produced by stage of the FSC.

<sup>12</sup> How long does the process in the FSC stage take / what is the distance (and duration) of transportation.

b. Description of the existing marketing systems of the selected subsector supply chain, for small-scale producers (formal and informal).

#### **Mango pulp FSC (Chittoor):**

The major share of the mangoes produced in Chittoor are used for pulp processing and this accounts for about 70% of the total production in the region. The main varieties Tothapuri and Alphonso are processed into aseptic mango pulp or pulp concentrate.

#### **Direct Sale to processors:**

Most of the large and medium farmers owning bigger orchards have collaborations with processing plants to supply harvested fruits directly for processing after sorting and grading at 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 yard and sell it to traders, who in turn will sell them to the processor after sorting and grading. This leads farmers to get slightly lesser about 5% for their produce. The traders also usually finance the small farmers during the off-season and for farm inputs and thus they are bound to sell the produce to the same trader however they are also free to sell the produce to others depending on the rates prevailing that time. There are five market yards governed by Andhra Pradesh Agricultural Marketing Department across Chittoor covering the major mango producing regions. From these market yards majority of the produce goes for processing and a smaller share goes to distant markets as fresh fruit. The market yard in Tirupathi also houses a Vapor heat treatment (VHT) plant to serve export markets as VHT is a prerequisite for many importing countries.



Fig 5: Mango traders in Market yard

Transportation is undertaken by fellow farmers who owns tractors or by transport agents. The overall distance travelled by the produce meant for processing is very less as all the processing plants are distributed across the district. The average distance travelled is around 50 km and duration of transit is 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 neighboring states of Karnataka, Tamil Nadu and other markets of Andhra Pradesh.

#### **Processing Plants:**

Most of the processing plants in the district are small and medium enterprises and a tenth of them are large ones. 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 manufacturing the same by prior contracting. More than half of the pulp produced is exported to countries in the Middle East, Europe, US and rest is consumed in domestic markets.

#### **Fresh Fruit FSC (Vizianagaram):**

More than 90% of the fresh fruit produce from Vizianagaram goes to the distant markets across the country such as Delhi, Raipur, and Kolkata. The remaining quantity (10%) is sold in the local markets of Vishakhapatnam and Vizianagaram districts.

#### **Pre-harvest Contractors (PHC)/ Commission Agents:**

Nearly 80% of the mango farmers in the region sell their produce through pre-harvest contractors (PHC)/ commission agents who pay advance cash to these farmers at the pre-flowering stage and procure the entire produce from these farms and transport the fresh mangoes to traders in distant markets of the nation. The advance money is used by farmers for carrying out farm operations and fulfill the input costs. These agents collect 10% commission charges on the transaction value. Few farmers and traders/aggregators can invest to arrange their own transport and send produce directly to distant markets (accounting for about 20% of total produce in the region). The agent intimates the farmers about the dates on which transportation is being arranged, accordingly, the farmers with the contract harvest, grade and pack the produce for shipment later on the day of harvest.

#### **Local aggregators:**

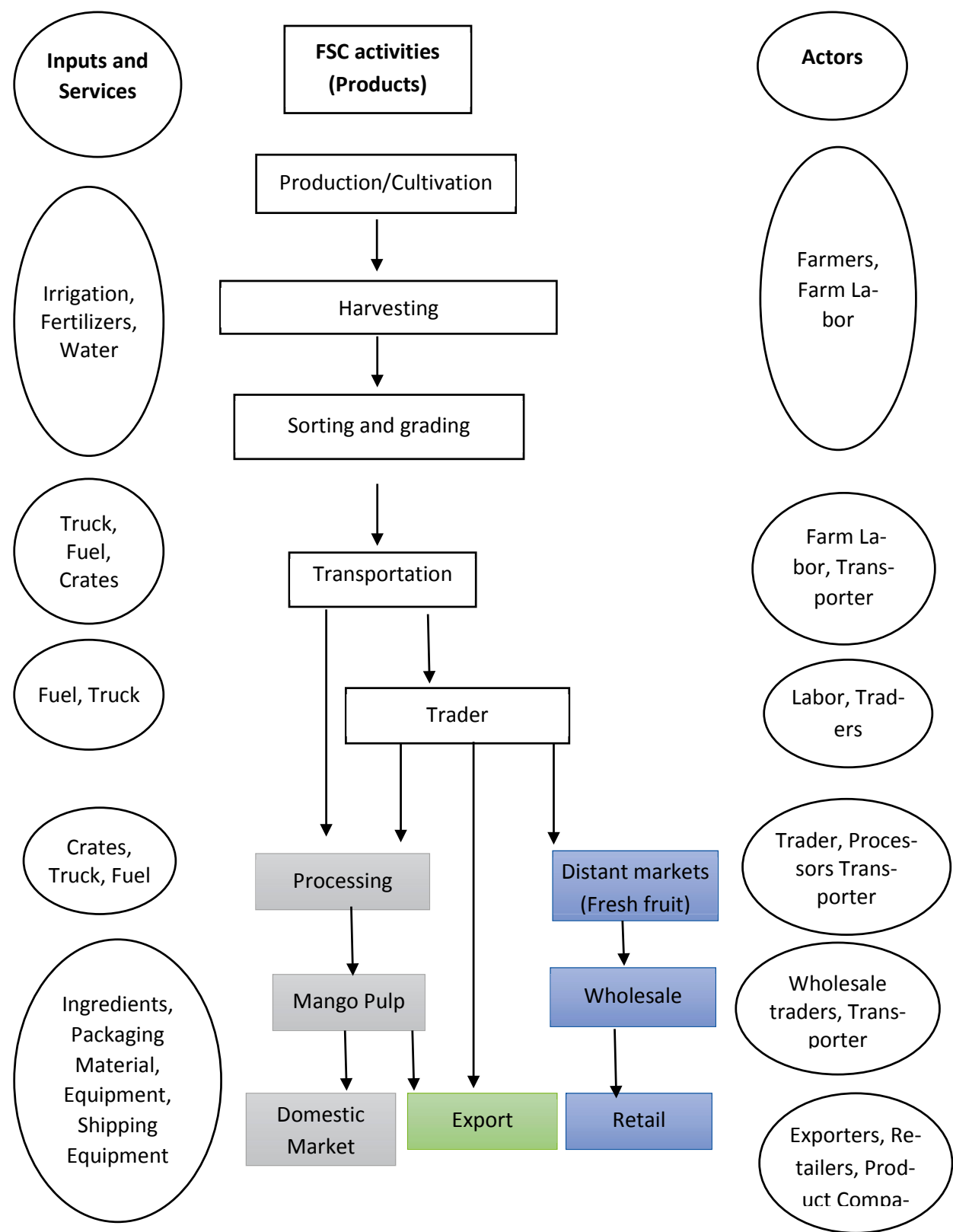
Some small farmers sell the produce to local aggregators who pay the farmers cash immediately. These aggregators do not give an advance for farm operations, but early payment at the time of sale of produce is the incentive in this case.

#### **Farm contractors:**

Some small farmers lease out their farms to agents/traders who acts as farm contractors for 2-3 years and hence are not involved in any farm operations but work as farm labor for the agent. Most of the farmers are not aware of the destination market as agents collect the produce at a fixed price and do not inform them about the destination/ final agent receiving the produce. 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 opine that there should be a mechanism for knowing the sale price of their produce, which currently is not in place as they are paid less compared to the prices that the produce fetch in the market. There are about 14 market yards in the district and some of them mainly deal with horticultural products. The arrival of mango to the market yards is very less this year and most farmers or traders do not prefer to use the market yard facilities to avoid paying tax. A small portion of the produce and culled fruits from sorting and grading operation are sold in the local market to the cottage scale industries involved in manufacturing mango jelly.



OUTPUT I-3a: FLOW DIAGRAM OF THE SELECTED FSC



The different steps involved in the FSC are as follows:

**Production/ 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. However, some farmers do not prefer to cut the branches. For instance, many farmers prefer the higher height of branches so as to allow movement of tractors for mechanical harvesting. However, in case of harvesting of large trees, there is a higher risk of mechanical damage to fruits (5%) due to slipping and falling of fruits on the ground during harvesting. High-density plantations, with smaller trees are easy for harvesting, however, is not yet popular in this region. Farmers plough the fields twice after the season, mainly during June - July, apply fertilizer in August and carry out 3 crop protection sprays during November - December. Over 90% of the area is under rainfed conditions and there is no irrigation provided after the rainy season.

In Chittoor, the canopy of the trees is medium to small owing to the age of plantations, variety and soil conditions. The orchards are better managed and most of them are irrigated through drip irrigation. High-density plantations are slowly gaining importance and support is being provided by the government and the local processing industry. Farm management practices include tilling in the offseason and before rains, pruning before the season to induce reproductive growth. Fertilizer application and crop protection sprays are carried out in a similar manner.

**Harvesting:**

Harvesting is the most important factor governing the post-harvest management of mango. In fresh fruit FSC of Vizianagaram, farmers carry out two to three harvests in a season with a gap of one week in between each harvest. Ideally, the fruits should be harvested at a mature stage when there is some yellow color on the fruits while it is still on the tree. It is a common practice in the region to harvest fruits early in the season (premature stage) to capture the early market. The farmers also harvest fruits 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 best price they can get. Early harvest by small farmers is also to prevent losses from unpredictable weather i.e. storm and winds. Many farmers harvest the fruits with a long pole having a net basket with a blade at the end. If the trees are large, a worker climbs the tree and throws the harvested fruits to another worker standing under the tree. Up to 5% of the fruits usually suffer from mechanical damage in this method of harvesting. The fruits are placed on the ground under the tree, directly exposing the partially damaged fruit is a common source of infection.

In the mango pulp FSC of Chittoor, the harvesting is usually carried out in one stage when 85% of the produce in the orchard is at maturity. Depending on the canopy and height of the trees harvesting is carried out by a pole with nets or by dropping fruits onto the ground. Comparatively, farmers in this FSC understand the value of post-harvest handling and handle them in a better manner. Harvesting commences in the month of June and lasts till July as the main variety grown here, Tothapuri, is a late season variety. During harvesting care should be employed to prevent the spillage of resinous sap on the surface of the fruits to prevent "Sap burn/ Injury". This leads to browning of the skin due to the activity of Polyphenol Oxidase and Laccase enzymes in the fruit skin. Desapping is carried out by harvesting with a lengthy petiole of 5 cm and by inverting the fruit on raised bamboo platforms to remove sap. De-sapping operations are not extensively followed in both the FSC's.

**Sorting and Grading:**

In Vizianagaram for fresh fruits FSC, the fruits are graded variety wise and no standards are followed for grading in this region. The farmers, after removing damaged, spotted and diseased fruits, grade all the produce in two grades, top grade, and second grade; and this grading is indicated on the package. The graded fruits are packed in boxes (weighing approx. 15 kg) and then transported. There are no major exports from this region too and hence standards are not being adopted.



Fig 6: Harvesting in mango; Net apparatus for harvesting

In the mango pulp FSC in Chittoor, no grading is performed, but sorting is carried on the farm itself to remove small, immature, irregular and damaged fruits. If the produce is directly supplied to a processor or this activity is carried out at a market yard if it is sold to a trader. From Chittoor, a considerable quantity of fresh mangoes are exported. In this case, stringent grading is carried out on the basis of weight and size at the export pack house. The fruits rejected during grading from export pack house often confirms to the local market standards and sold by the farmers/ traders in the local market.



Fig 7: Culled fruits from sorting and grading

#### Transportation:

More than 90% of the fresh fruits from the Vizianagaram region goes to the distant markets such as Delhi, Raipur, and Kolkata. Long distance transportation in the region is carried out by trucks and trains, and no refrigeration is used for transporting mangoes. During the transit time of 3-4 days to reach these markets, the fruits touching the sides of the boxes and those on the bottom layer suffer damage (10-15%) during transport. The use of crates can considerably reduce these losses; however, the major problem is bringing back the crates from distant markets which will incur additional costs in transport. The current practice is to use corrugated boxes that are generally provided by the contractor or the aggregator. In Chittoor, the average distance travelled by the fruits from the farm to the processing center is not more than 50 km and the duration is about 3-5 hrs. The sorted fruits are dumped in trucks or tractors and are covered with tarpaulin.



Fig 8: Packaging for transportation in CFB boxes and Plastic Crates



Fig 9: Transportation with plastic crates

#### Ripening:

There is no major requirement for ripening of mangoes in fresh fruit FSC for distant markets as ripening occurs during 3 - 4 days of long distance transport. Ripening of fresh fruits is also carried out by wholesalers in the market and not by the agent or transporters. The local market in the region is very small and due to the ban of Calcium Carbide as a ripening agent, even this market has also shrunk this year. The ban on calcium carbide had no impact on long distance market. In the mango pulp FSC ripening is carried out by processors by means ripening chambers or by using traditional/ natural ripening process in which fruits are carefully heaped and thatched with paddy straw or coconut leaves and left for 6-7 days for ripening. The general perception in this FSC is that the fruits ripened in the natural process are with superior flavor profile. During ripening, in both the methods a weight loss of about 6-8 % is observed due to moisture loss.



Artificial ripening of fruits is very prevalent practice in the wholesale and retail market form a very long time. Most commonly used chemical for this purpose is Calcium Carbide ( $\text{CaC}_2$ ), which upon reaction with water/ humidity releases Acetylene gas. Acetylene, in similarity to ethylene, also triggers ripening mechanism in fruits, although the efficacy is low. Due to the contamination of Arsenic and occurrence of toxic reaction compounds like Phosphorus hydride (Phosphine),  $\text{CaC}_2$  is regarded as harmful for consumer health. Most of the times artificial ripening is misused to ripen immature mangoes where they attain surface color without any development of flavor and also to shorten the actual ripening time so that they can be sold earlier. Recently, FSSAI banned the usage of  $\text{CaC}_2$  as a ripening agent in all fruits including Mango. In the study, the effect of ban on  $\text{CaC}_2$  is enquired with various actors in the FSC.

#### Mango pulp FSC:

In Mango pulp FSC, the ban of  $\text{CaC}_2$  did not affect any of the actors. The process of the ripening is very controlled in ripening chambers where ripening is achieved by using ethylene, a permitted ripening agent under right temperature and humidity conditions. In traditional method, the fruits are carefully heaped and covered with paddy straw or palm leaves and covered with palm leaves. In this case, even the losses are high, the quality of ripened fruit is perceived as superior. The actors are well aware of the importance of ripening and its direct relation to quality of the pulp. Usage of Calcium Carbide is a not a practice in this FSC and hence it did not affect any of the actors.

#### Fresh fruit FSC:

The main objective of the ban is to control the prevalent use of  $\text{CaC}_2$  in fresh fruit FSC. However, the farmers are not directly affected due to the ban but the repercussions like delayed payments from traders are perceived. The ban mainly affected actors in the local fruit markets than in distant markets. In case of Vizianagaram, much of the fruits are transported to distant markets like Delhi, Kolkata which are about 800-1500 km from this location. The transit time is high in this case about 3-5 days and ripening will be attained during that time. However, in local markets to expedite the sale in the market  $\text{CaC}_2$  was used.

The ban affected traders, wholesalers and small scale retailers in this supply chain. In Vizianagaram, the share of produce going for local market is very less, due to lack of nearby markets and hence the effect of ban is relatively low compared to other important fresh fruit FSC'S like Vijayawada where the nearby markets are ample. During the study it was found that the traders are now using unknown chemicals for ripening which are locally being referred as "China Chemical/ Powder or Red powder". This points out to the lack of innovation in addressing the problem and emphasizes on the need for research in developing safer alternatives or infrastructure.

#### Processing:

In Vizianagaram, the quantity of fruits used for processing is very minimal and are used to produce mango jelly within a cottage scale industry. Apart from the good quality fruits, culled fruits are also used in jelly production. Chittoor has a well-developed mango pulp FSC with 70% of small scale industries mainly producing aseptic and canned mango pulp. The fruits after ripening are washed and subjected for pulping and destoning and the derived pulp is thermally processed to make aseptic mango pulp or pulp concentrate. The pulp is then packed either in an aseptic bag in drum systems or cans and are stored at room temperature till shipping is carried out to the terminal markets.



Fig 10: Mango pulp processing

c. FSC actors' involvement and their benefit, including job creation and income generation; economic data of the FSC; environment-related inputs and factors of the FSC

#### Socio-economic aspects and Gender participation at various steps:

##### Production/ Cultivation:

In both the FSC's small and marginal farmers constitute more than 80% of the total mango farm holdings with large farmers constituting remaining 20%. Small farmers involve the family members including women and children in farm operations, whereas this is not a practice followed in the case of farmers with medium to large farm holdings. Culturally the participation of women in farm activities is more prominent 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. Most farms are supervised by men. In old orchards with large trees, men are preferred for harvesting over women. Women are also employed, however, in the Fresh fruit FSC, their role is restricted to collecting and carrying the harvested fruits to the grading place. Grading and packing is done by men in Fresh fruit FSC and by both men and women in mango pulp FSC. In general, male and female labor are hired in 40: 60 ratio. Wages for women are USD 2.25 – 3.75/day and men are paid higher wages as compared to women (USD 4.5/day). Below 14 years, no one is engaged in farm labor but farmer's family members including kids are involved in farm operations.

##### Trading and Processing:

Women are conspicuously absent in the trading functions. Entire trading operations in the market yards are carried out by men and the participation of women here is observed only in the grading, sorting and packaging operations along with men. These people are landless laborers hired from the surrounding places or migrating laborers. They are usually employed for the whole season and they live in the market yards to earn during the season and goes back to their place or to another job. Chittoor fruit processing cluster is creating employment to about 20,000 people directly in processing plants and indirectly in allied services. In processing the plants, women are employed to a lesser extent than men in Operations, Quality assurance, Planning, and Management. An equal number of men and women are observed taking part in processing operations as workers.

In fresh fruit FSC, farmers have a very little choice in decision making regarding harvest time and go by contractor's schedule of transport. They even harvest the produce at immature stages anticipating high prices, fear of weather changes. The small farmers do not have the purchasing/negotiation power to deal with the contractors. Mango contributes to nearly 30-40% income for most of the mango farmers, with other sources of income being upland rice, and pulses. For some farmers with job cards, Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA) - scheme is also an important source of income. The percentage contribution through MNREGA is significant for households with multiple job cards in the household and for the year 2015-16, the average days of employment provided per household is 71 days. Since MNREGA is contributing to the substantial annual income of the household, the wages procured by

women is enabling them to enhance their role in decision making on issues related to their home. Women were able to save money which also helps their families overcome periods of climate shocks. Attempts are also being made to converge the objective of social protection and climate resilience through the MNREGA scheme in Vizianagaram. Under this scheme, work on tanks to increase groundwater has allowed some farmers to dig bores providing a reliable source of year-round water and has enabled farmers to plant crops in both planting seasons. In mango pulp FSC, dealings are fairly transparent due to established linkages and farmers have more control on harvesting and sale their produce. However, they opine that there should be a basis for fixing the price for produce and currently, there is no agency monitoring it.

OUTPUT II-4: DETAILED DESCRIPTION OF THE FSC – SOCIAL STRUCTURES

FSC STEPS	Involvement of Women		Involvement of Men		Who is mainly in- volved:	Organization level of FSC ac- tors <sup>13</sup>	Gender / social patterns Observations and remarks that ex- plain the chosen qualifiers and/or give additional information
	Girls	Adult	Boys	Adult			
	Qualifier <sup>14</sup>						
Primary production		3		3	Men, Women	Individuals	Men are relatively more involved in farming operations than women, however, the difference is very little. The number of female farmers is relatively less.
Harvest		2		3	Men, Women	Individuals	Men and women equally take part in harvesting operations. They are usually employed as farm labour for daily wages or for the entire operation. Women slightly outnumber men in this operation. The wages for women are lesser than men by 20 %. Men are expected to do take up cumbersome work like to climb trees during harvesting
Post-harvest, handling							
Transportation				3	Men	Individuals	Men are exclusively involved in transportation activities. Women are completely absent in this step owing to lack of skills and cultural hold
Market sales				3	Men	Individuals	In market yards, the traders are exclusively men and both men and women are employed as seasonal labour for sorting and grading, packing etc.
Agro-processing		2		3	Women, Men	Individuals	Women and men are employed in processing plants for various support activities like loading, unloading, sorting, culling and packaging operations. Women are usually employed for less laborious activities and disparity in pay is about 20% less.

<sup>13</sup> f.i. Individual/Household level/Cooperative

<sup>14</sup> Qualify the equipment, conditions, access to services and training, 4: excellent, 3: good, 2: moderately good, 1: bad.

OUTPUT II-5: DETAILED DESCRIPTION OF THE FOOD SUPPLY CHAIN – ECONOMICS

FSC stage	Main Products	Cost of operation USD /Ton	Cost USD/Ton final product	Cumulative Cost USD/Ton	Value USD/Ton final product	Value-added / Margins USD/kg	Remarks
Primary Production	Mango	21					<ul style="list-style-type: none"><li>• Cost of ploughing, pesticide spraying, fertilizers, farm management, Labor, Average production of 10 T /Ha</li></ul>
Harvest	Mango	6					<ul style="list-style-type: none"><li>• Manual harvesting by means of labor</li></ul>
Post-harvest handling				27			<ul style="list-style-type: none"><li>• Manual sorting and grading</li></ul>
Storage	NA						
Transportation	Mango	14.3		41.2	210/ ton of Mangoes	168	<ul style="list-style-type: none"><li>• Transportation to a distance of approx. 50 km</li><li>• Valuation is based on current year prices;</li><li>• Price fluctuation is very high from season to season</li><li>• Interest paid by farmer causes a reduction in the actual margin earned by the farmer.</li></ul>
Market sales	Mango	4		45.2	214/ ton of mangoes	168	<ul style="list-style-type: none"><li>• 2 % commission is charged by the trader from either processor or farmer or both depending on the market situation.</li></ul>
Agro-processing	Mango pulp	70		280	400 USD for 550 kg of Mango pulp	120	<ul style="list-style-type: none"><li>• Labor, Equipment, RM, PM, Utilities - Value excluding trade and logistic costs and taxes</li><li>• Approximately 0.55 Tons of mango pulp is obtained from 1 tons of mango</li></ul>
Storage	Mango pulp	10		290	400- 500/ 0.5 ton of mango pulp	110- 120	<ul style="list-style-type: none"><li>• Sale in offseason; Price highly dependent on the demand</li><li>• Margins excluding trade and logistic costs, taxes and overhead expenses. Actual margins are lower than the calculated values.</li></ul>



OUTPUT II-6a: DETAILED DESCRIPTION OF THE FOOD SUPPLY CHAIN – ENVIRONMENT

The inputs required for the production of mangoes in 1 hectare of land are as follows:

PRODUCTION		Quantity	Unit
Tools, Equip-ment, Facilities	Farm implements inclusive of harvesting equipment, trac-	10	No's
	Planting material	60	No's
Materials, Chemicals	Water	1200	mm
	Fertilizers	250	kg
	Pesticides	3-5	litersrs
Energy	Power- Thermal or Hydroelectricity from grid line	18	Kwh
	Diesel	20	liters
Water		1,200	mm
Land		1	Ha
TRANSPORTATION		Quantity	Unit
Tools, Equip-ment, Facilities	Tractor	1	No
	Crates for loading	10	No
Energy	Diesel	20	liters
PROCESSING		Quantity	Unit
Tools, Equip-ment, Facilities	Ripening chambers, Pulp processing line	1	No
Water		5,000	liters



Fig 11:  
Drip irrigation in mango cultivation



Fig 12  
Farm ponds to regenerate groundwater

OUTPUT II-6b: FACTORS FOR THE ENVIRONMENTAL ASSESSMENT

The factors affecting the environment in both the FSC’S are assessed by interaction with experts, local farmers and by literature search are presented in the Table ii-6B.

Factors	Description	Details
Type of production system	Horticulture, Perennial, agroforestry	
Land preparation practices	Tilling, composting	Tilling in the offseason during weeding and fertilizer application. The rotten, infected and fruits with no economic value are dumped into composting pits for organic manure production.
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 water logging/ flooding are major degradation process in Vizianagaram, Pusapatirega, Denkada, Gantyada and Bhogapuram. Slight/ moderate erosion as major degradation process in Kothavalasa. Moderate/ extreme water erosion is degradation problem in Kurupam and Gumma-lakshmipuram. (2015)
Water regime	Low water table. Rainfall dependent, Irrigation through bore wells	Irrigation by furrows at trees. Water scarcity is diverting farmers to adopt micro irrigation. Chittoor is more progressive in terms of shifting towards Drip irrigation. Irrigation by drip and bore wells both 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 the fruit bearing leading to lower fruit yield.
Utilization 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 fruits at processing plants and market yards	Sometimes culled and relatively clean fruits are used for culinary purposes Culled fruits from processing plants are used as cattle feed



3. THE FOOD LOSSES - Study findings and results

a. Description of the FSC: risk factors

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

**Harvesting:** Method of harvesting, age, and canopy of the plants, harvesting equipment, and training and motivation level of the harvesting labor plays an important role in the contribution of losses in this stage. The above factors leads to losses due to falling of fruits, broken fruits, internal damage, improper sorting and grading and cross contamination from broken fruits

**Transportation:** During transportation, factors such as proper packaging material like plastic crates, condition of vehicles, distance of transportation, condition of roads, cold chain plays a key role in the reduction of possible food loss. There is also a possibility of risk of damage to fruits due to improper handling.

**Ripening and Processing:** The losses in ripening are dependent on the factors like the method of ripening, handling of fruits from prior steps, maturity level of the lot, sanitary conditions and availability of plastic crates.

b. Critical Loss Points: type and level of food losses in the selected subsector chains, including both quantitative and qualitative losses.

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

**Production:**

The quality of the fruits produced 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. The mango production in Vizianagaram district this year was severely affected due to delay in flowering, low flowering and low fruit set. Due to reduced difference between day and night temperatures majority of the flowers were unable to withstand heat and led to the premature dropping of mangoes resulting in losses anywhere between 1 to 5%. Lack of irrigation sources also compounded the problem and resulted in crop losses. In Chittoor, although the overall rainfall was low, there was rainfall at an appropriate time during the season which resulted in better quality of fruits. However, the farmers opined that there is 50% reduction in mango production in the current year.

**Harvesting:**

In Chittoor, harvesting for pulp production is carried out in a single instance at optimum maturity level of fruits in the orchard. In this process, there is a quantum loss due to harvesting fruits at immature stage. Also, use of improper mechanism of harvest also causes physical impact to a fraction of fruits. Sorting and grading is carried out at farm level to separate the immature, small, irregular and damaged fruits. Quantitative losses such as left over fruits on the farm and qualitative losses such as fruits with bruises, internal damage were observed in mango pulp FSC in Chittoor. The pattern of these losses is dependent on the demand for culled fruits in the nearby cities and location of the farm. In Vizianagaram, the fruits are harvested in two to three stages and sometimes early harvest by farmers leads to qualitative losses owing to

immature fruits and harvesting at improper stage accounts for the highest post-harvest losses. Other harvesting losses include mechanical damage, sap damage, stem end rot and other diseases resulting in up to 50% reduction in market price or complete salvaging of fruits. These account for nearly 10% of the losses. Farmers with good practices are able to limit these losses to below 5 percent.

OUTPUT II-7: FOOD LOSS RISK FACTORS

Variable	Unit	Parameter- relation to FL	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 leads to food loss like insect incidence	Y
Rainfall during Production	mm	Impact on fruit bearing – optimum rainfall during the growth phase leads to better yield and fruit retention	
Incidence of Pest- Fruit Fly	L/M/H	Impact on quality and quantity with high prevalence of fruit fly and other pests	High
Transport duration	Hrs	Lower duration of transport corresponds to lower losses	2 hr in mango pulp FSC; 3- 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 the harvesting time leads to higher losses	Low
Postharvest technology	L/M/H	By better handling during harvesting and post-harvest operations like 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 fruits	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 utilization of lost fruits	High

Transportation:

During transportation the losses are marginal owing to the sorting and grading in prior step and the average distance travelled being short in the mango pulp FSC of Chittoor. The distance travelled by the produce in fresh fruit FSC is about 800-1,000 km for a duration of 3-5 days. This leads to a quantitative loss of about 10-15% because of damage suffered by side and bottom layered fruits in the transport vehicle.

Ripening:

In mango pulp FSC, ripening is carried out either in ripening chambers or by means of traditional process. The losses during traditional process are higher owing to the uncontrolled conditions and improper keeping conditions. The losses observed are still higher if the prior handling of fruit during harvest is not proper. In ripening chambers, the reported losses are comparatively less, both in terms of quality and quantity. Quantitative losses such as rotten fruits (biological) and qualitative losses like partially rotten fruits, uneven ripening were observed in this step. In fresh fruit FSC, no separate ripening step is carried out as the fruits are left to ripen during the transit, however improper grading at prior steps leads to qualitative losses which results in reduction of market value.

III-8a: QUALITY SCORING OF FOOD PRODUCTS

PRODUCT:	Mango –Totapuri variety	
Quality score	Description of the quality	%age reduction of market value
0	Fully damaged fruits- rot- Biological damage	100
1	Bruised and Broken fruits- Physical Damage	90
2	Irregular, Small, Immature fruits, Blemished, Sap burn- Non-compliance, Physiological Damage	50
3	Sorted uniformly matured, high variance in size	20
4	Sorted, uniformly matured, uniformly sized	0

III-8b: 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 fruits; Improper handling/ harvesting	Culled fruit from harvesting
2	3	Uneven size, fairly good quality	Uniformly graded at ripening chamber
3	4	Uniformly	Uniformly graded at export pack house
REPORT: Average score: 3.25			

Load tracking exercise is carried out at different steps in mango pulp FSC. Different Loads were tracked at individual events as the interval between the events is very large.

Harvesting: During Harvesting the total load for the truck is considered as a sample since weighing the produce on farm was not feasible and is generally not carried out by the farmers or the aggregators. The weight of truck is recorded after the event of harvesting, when it reached to processing plant. The weight of leftover fruits is noted by approximation and averaging.

Transportation- Unloading: The load is from an orchard from nearby village and the produce travelled a distance of 30 km in less than 2 hours. The losses during the transportation are recorded during unloading, before subjecting them to ripening chambers. The entry and exit weight of the truck is recorded on a weigh bridge and fruits on a weighing machine.

Ripening –Traditional Process: The mangoes received at the processing plant are subjected to ripening by traditional method in the processing plant where study is carried out. The ripened lot is opened for production and sorting and grading is carried out to remove spoiled fruits. Four crates of fruits is separated from the lot and segregated for completely and partially spoiled fruits. The weight of the spoiled fruits are recorded on a platform balance in the processing plant. The fruits in the particular lot were not handled properly in the prior events and losses were observed to be higher than the average.

III-9: PRESENTATION OF LOAD TRACKING AND SAMPLING RESULTS

A	Product	Mango			
B	Event	Harvesting and Sorting& Grading			
C	Duration of the event	8 hrs			
D	Location	Sarakallu, Chittoor			
	Before the event	Experimental Unit	Weight of unit	Nr of units	Total weight
E	Load	Tonnes	5 tonnes	1 truck <sup>15</sup>	5 tonnes
F	1 <sup>st</sup> -stage sample				
G	2 <sup>nd</sup> -stage sample				
		Value (score / %)	Observations / Causes		
H	Sample size 2 <sup>nd</sup> -stage				
I	Average quality score (0 – 4)	4	The fruits are being harvested to be sent to a processing plant. Sorting and grading is done on the farm to separate sound, mature and uniform fruits		
J	%age unfit (< 1)				
K	%age 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	1 <sup>st</sup> -stage sample				
N	2 <sup>nd</sup> -stage sample				
		Value (score / %)	Observations / Causes		
O	Sample size 2 <sup>nd</sup> -stage	2kg			
P	Average quality score (0 – 4)	4			
Q	%age unfit (< 1)				
R	%age low quality (2-1)				
	Quantity loss	Value (%)	Observations / Causes		
S	%age lost (E-L)/E	0.6 ton /5 ton= 12%	The study is carried out on a farm from a very interior area. Both unfit and low quality fruit are left on the farm, since transporting them is non lucrative. In other cases usually low quality fruits are sold at much lower value or at least used as cattle feed		
	Quality loss	Value (%)	Observations / Causes		
T	%age lost (Q-J)				
U	%age quality reduction (R-K)				

<sup>15</sup> Truck load- common reference used by the farmers during harvest and transportation; harvesting is initiated after ensuring the availability of the truck.

A	Product	Mango			
B	Event	Transportation-Unloading			
C	Duration of the event	2 hrs			
D	Location	Manjunatha fruit processing industries, Kanipakam, Chittoor			
	Before the event	Experimental Unit	Weight of unit	Nr of units	Total weight
E	Load	Kg	4200	1 truck	4200
F	1 <sup>st</sup> -stage sample				
G	2 <sup>nd</sup> -stage sample				
		Value (score / %)	Observations / Causes		
H	Sample size 2 <sup>nd</sup> -stage				
I	Average quality score (0 – 4)	4	Initial sorting and grading is carried out on the farm to separate low quality, immature and non-uniform fruits. The overall quality of the lot is good.		
J	%age unfit (< 1)				
K	%age low quality (2-1)				
	After the event	Experimental Unit	Weight of unit	Nr of units	Total weight
L	Load	Kg	4180	1 Truck	4180
M	1 <sup>st</sup> -stage sample				
N	2 <sup>nd</sup> -stage sample				
		Value (score / %)	Observations / Causes		
O	Sample size 2 <sup>nd</sup> -stage				
P	Average quality score (0 – 4)				
Q	%age unfit (< 1)				
R	%age low quality (2-1)				
	Quantity loss	Value (%)	Observations / Causes		
S	%age lost (E-L)/E	0.5	The fruits are already graded on the farm and the produce is from a nearby farm, the distance travelled is less than 30 km.		
	Quality loss	Value (%)	Observations / Causes		
T	%age lost (Q-J)				
U	%age 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	1 <sup>st</sup> -stage sample				
G	2 <sup>nd</sup> -stage sample				
		Value (score / %)	Observations / Causes		
H	Sample size 2 <sup>nd</sup> -stage				
I	Average quality score (0 – 4)	3			
J	%age unfit (< 1)				
K	%age low quality (2-1)				
	After the event	Experimental Unit	Weight of unit	Nr of units	Total weight
L	Load	Kg	81.3	4 crates	81.3
M	1 <sup>st</sup> -stage sample				
N	2 <sup>nd</sup> -stage sample				
		Value (score / %)	Observations / Causes		
O	Sample size 2 <sup>nd</sup> -stage				
P	Average quality score (0 – 4)	3			
Q	%age unfit (< 1)	8.4	Fruits are spoiled completely, broken and ready to get spoiled		
R	%age low quality (2-1)				
	Quantity loss	Value (%)	Observations / Causes		
S	%age lost (E-L)/E	19.75	Improper harvesting prior and handling in the prior		
	Quality loss	Value (%)	Observations / Causes		
T	%age lost (Q-J)				
U	%age quality reduction (R-K)				

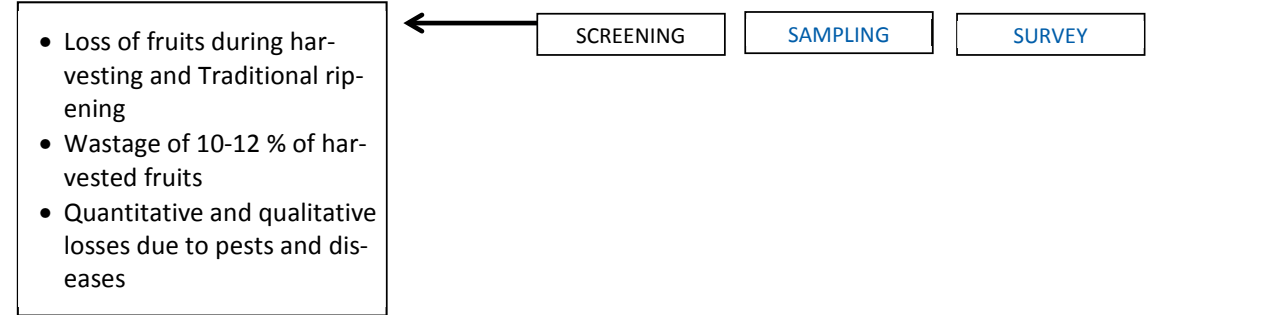
OUTPUT III-10: Summary result matrix of food losses

Mango Pulp FSC

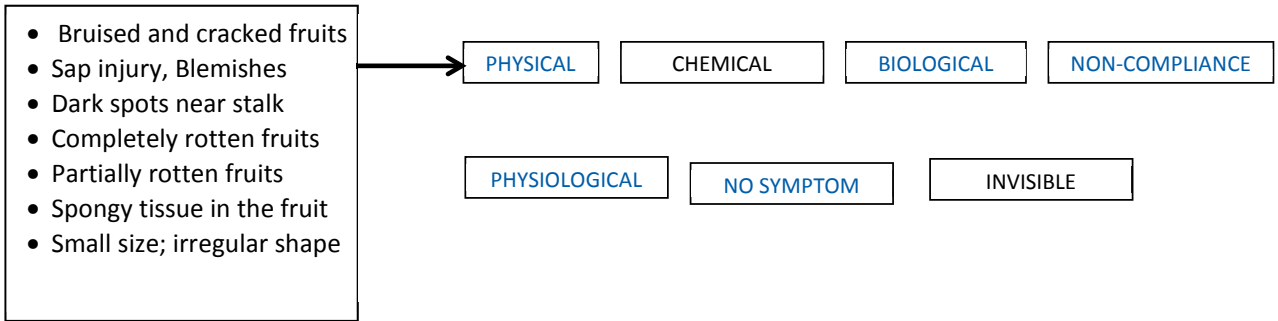
FSC stage/ Process	Type of loss Qn./Ql.	%age lost in this process Quant	%age of the prod- uct that incurred quality loss in this process	%age of product that goes through this stage (#)	%age loss in the FSC (#)	Cause of loss/ Reason for low loss	Reduced market value	CLP / LLP	Destination of food loss	Impacts on the en- vironment/climate change/natural re- sources	Impact/ FSC actors affected (men / women)	Loss perception of FSC actors (men / women)	Suggested solu- tions
Harvesting, Sorting and grading- mango pulp FSC	Qn & Ql	12	5	100	12	Improper har- vest, maturity, Damaged fruits	50%	CLP	Low value/ culled	Environment, Natural re- sources and agri inputs employed in production.	Income of farmers	Not signifi- cant	Small enter- prises for pro- cessing food waste, Training
Transportation – mango pulp FSC	Qn	0.5	NA	100 (88)	0.5	Short distance of transportation, better road infra- structure.	100%	LLP	Discarded	Environment	None	Nil	To be sent to plant ETP
Ripening- Tra- ditional Pro- cess	Qn & Ql	19	20	100 (87.5)		Improper Har- dling	100%	CLP	Discarded	Environment, natural re- sources	Processor- loss of yield and quality	High	Development of standardized methods, Train- ing on Harvest- ing and han- dling
Ripening – Ripening chambers	Qn & Ql	3-6	10	100 (87.5)	3-6 %	Improver har- vesting, Internal bruises of fruits	100 %	CLP	Discarded	Environment, natural re- sources- Power and water used in running Rip- ening chambers;	Poor prod- uct yield to the Proces- sor	Low	Training on Harvesting and handling

OUTPUT IV-1: CAUSE FINDING DIAGRAM

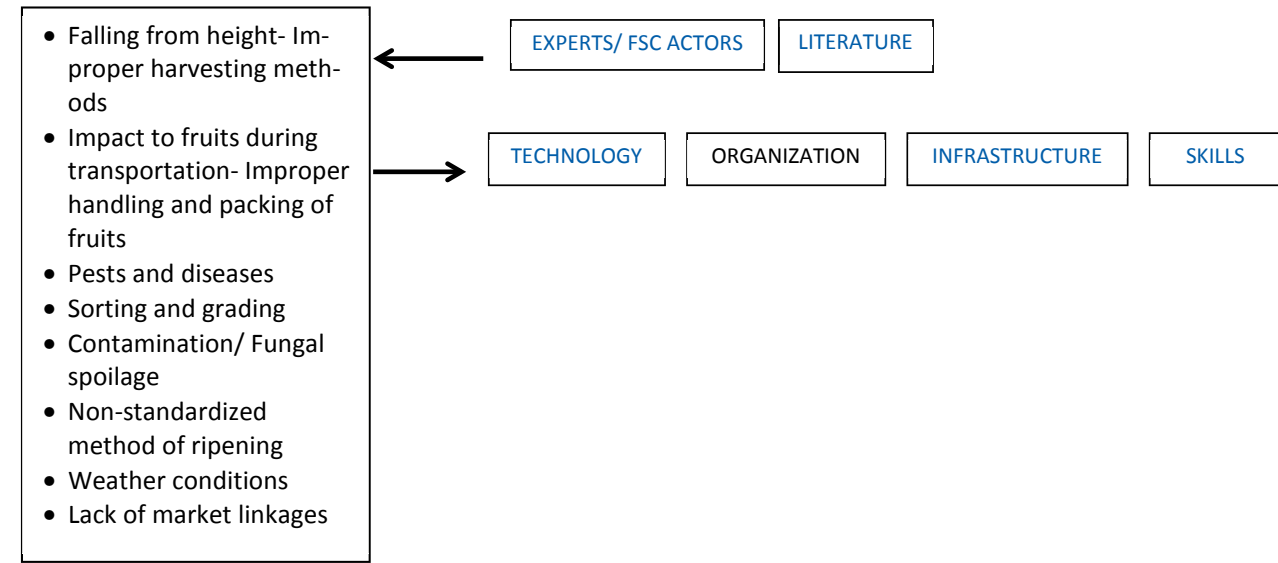
1. Food loss assessment methods have revealed a batch of food products containing *losses or product of low quality*.



2. Identify and describe the *symptoms* that lead to this quantitative/quality loss.



3. Verify the possible *causes* by consultation of experts and literature, and by the on-site investigation.



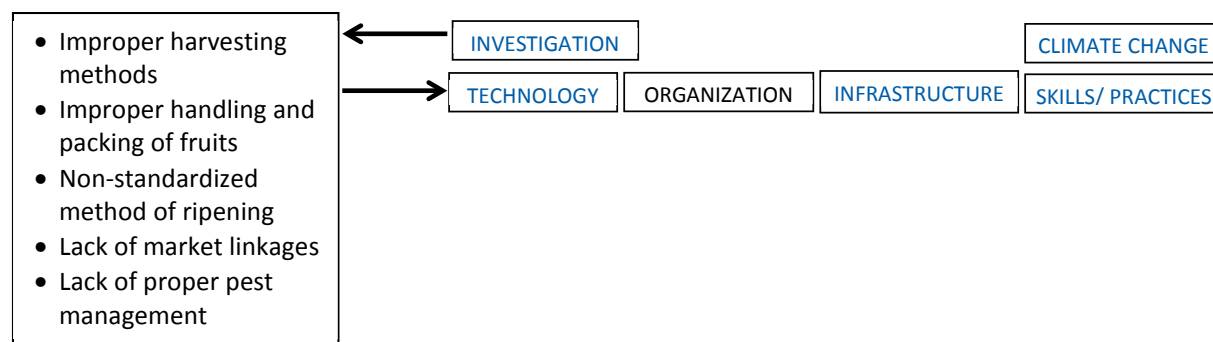
Fresh Fruit FSC

FSC stage/ Process	Type of loss Qn./Ql.	%age lost in this process Quant	%age of the prod- uct that incurred quality loss in this process	%age of product that goes through this stage (#)	%age loss in the FSC (#)	Cause of loss/ Reason for low loss	Reduced market value	CLP / LLP	Destination of food loss	Impacts on the en- vironment/climate change/natural re- sources	Impact/ FSC actors affected (men / women)	Loss perception of FSC actors (men / women)	Suggested solu- tions
Harvesting- Fresh fruit FSC	Qn & Ql	15	5	100	15	Improper har- vesting, Canopy of trees	50 %	CLP	Low value/ culled	Environment, Natural re- sources and agri inputs employed in production.	Income of farmers	Not signifi- cant	Small enter- prises for pro- cessing food waste, Training
Sorting and grading	Qn & Ql	5	5	100 (85)	5	Irregular small fruits, improper desapping	50 %	CLP	Low value/ culled	Agri inputs em- ployed in pro- duction, Envi- ronment	Income of farmers	Not signifi- cant	Training on de- sapping opera- tions
Transporta- tion- 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- Due to ele- vated prices	Moderate	Research on packaging de- signs, Creation of efficient linkages
Retail – Fresh fruit FSC	Qn & Ql	5-10	25	100 (65)	5-10	Long distance of transportation, lack of demand, improper han- dling	100 %	CLP	Often sold for lower value; some- times dis- carded	Environment- disposal prob- lems; manpower and packaging employed	Retailers, consumers	Low	Creation of ef- ficient linkages, training on han- dling and opti- mum storage conditions

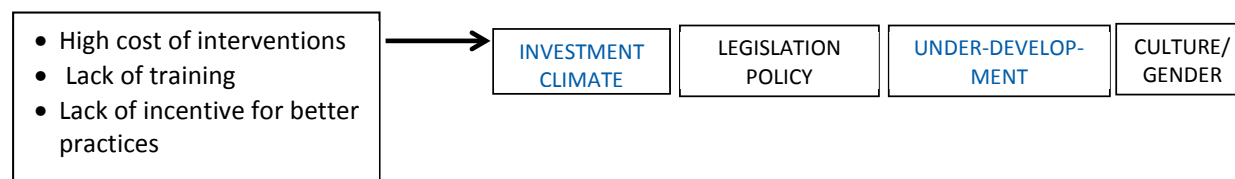
# The figures in the bracket show the percentage of the product after accounting for losses in the previous stages.



4. Identify the *real cause* of the low quality and subsequent food loss.



5. Find the underlying reason for the cause, why the problem hasn't been solved yet.



#### c. The causes of these losses and identified (potential) loss reduction measures

##### Losses during cultivation:

Both qualitative and quantitative losses during the production are caused due to factors like 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:

In mango during harvesting stage quantitative losses like broken and damaged fruits because of improper harvesting by dropping the fruits directly on to the ground, diseased fruits with stem end rot were observed in both the FSC'S. Qualitative losses found are like immature, irregular and bruised fruits due to improper handling. These can be reduced by following proper harvesting methods and post-harvest handling.

##### Losses during Transportation:

In fresh fruit FSC due to lack of nearer markets, the produce travels to almost 800 km leading to a loss of about 10-15 % quantitative losses like damaged fruits and rotten fruits and qualitative losses like irregular ripening, softening and breakage of bottom layer fruits due to load. Plastic crates are currently not used extensively due to lack of effective trade linkages as a result return of crates to the source is an issue. Usage of proper packaging materials and designs and controlled conditions during transportation can reduce the losses in this stage.

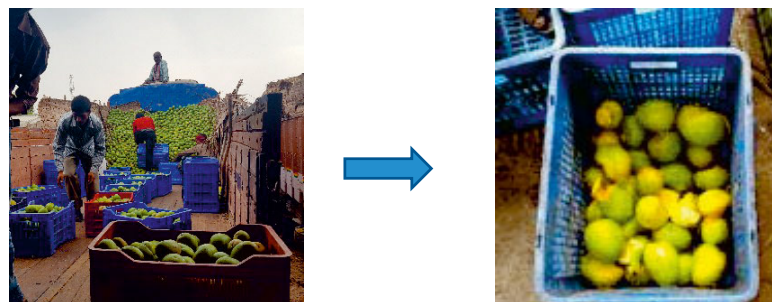


Fig 13: Low losses during transportation in mango pulp FSC (from a load of 12 Tonnes)

##### Losses during Ripening:

Fruits in mango pulp FSC when subjected to ripening in traditional method higher quantitative losses like rotten fruits and qualitative losses like partially rotten fruits, irregular ripening were observed due to fungal rot, improper handling, uncontrolled and unstandardized conditions. Development of standardized conditions and better handling of fruits in prior steps can reduce the losses in the traditional ripening process.



Fig 14: Mango spoilage due to post-harvest diseases and improper handling during ripening

#### d. Low Loss Points, and good practices leading to low food losses.

- Transportation in mango pulp FSC is very well managed and is considered as low loss point. The produce is transported immediately after harvesting and the distance travelled by the produce is very less. The observed losses were at a lower level of 0.5%.
- Ripening of mangoes in ripening chambers leading to considerably lower losses than the traditional method due to better handling and controlled conditions. However, proper handling of fruits during and after harvesting might help in further reducing the losses.
- The importance of GAP is understood and followed well by the farmers in mango pulp FSC, consequently leading to lower losses.
- Mango pulp FSC is an ideal example for promoting horticultural production where the losses across the stages are considerably less due to the availability of market and processing facilities.
- Usage of crates in handling the fruits is more prevalent in Chittoor leading to lower losses and better quality of fruit.
- Intensive training the farmers in both the FSC's are gradually making them aware of the importance of quality and food safety aspects and their relation to the returns.
- Policy support for adoption of micro irrigation systems is helping in increasing the productivity of the orchards as well as in conserving the water.
- Ultra-High Density and High Density plantations are characterized by trees with smaller canopies leading to reduced difficulty in harvesting, better handling of fruits and increased productivity.

## 4. THE FOOD LOSS REDUCTION STRATEGY - Conclusions and Recommendations

### a. Impact of food losses in the selected FSC

The impact of food losses on different actors and stages of FSC:

**Farmers:** Small and marginal farmers constitute a major share of mango growers in both the FSC's. The loss of produce is directly impacting the income of the farmers as mango contributes to 30- 40% of annual income. Usually a nominal quantity of losses during harvesting and other operations are factored into consideration in price negotiations, however, when these losses are coupled with conditions like untimely rains, hailstorms, low yield and high pest incidences leads to significant income loss and adds a stress on repayment and raising a loan for future crops. In such conditions, it leads to extended affliction on the alternate income means to cope for loan repayment. The diverse nature of losses in terms of both quality and quantity in every season is leaving them with no viable solution to process or utilize the on farm wastage that is currently occurring.

**Traders:** The income of traders in both fresh fruits and mango pulp FSC depends on the volume of fruits traded by them. The on-farm wastage and production losses can be accounted as lost opportunity of sales in the market yards and indirectly the tax earned by the government. The overall quality of the fruits in the season determines the price and there by the commission they earn. The impact on commissions earned by the traders also gets reflected in the loan dispersal to small farmers who are dependent on collateral free loans form informal financial modes.

**Processors:** The qualitative and quantitative losses in the mango production seriously affects the profitability of the pulp processing business. Qualitative losses in the produce lead to a product with lower quality, low yield due to trimming losses. The nonlinear relationship between the raw material costs and price of the pulp in the international market outlines the importance of quantitative losses of produce, which otherwise should enter mango pulp FSC.

**Retailers:** Quantitative loss of mango is impacting the direct sales income of the retailers of all stages and qualitative loss is negatively impacting the ability to prolong the sale period, premium price fetched by the fruits and cross contamination to other fruits. The major share of mango in fresh fruit FSC is still traded by small retailers like cart vendors. Quantitative and qualitative loss greatly affects the selling price and thereby the volume of sales. This partially affects by causing loss or change of livelihood.

Additionally, it is also leading to problems during the disposal of spoiled fruits. Indirect losses like packaging material and manpower incurred are also factored to a loss at retail stage.

**Environment:** About 1,600 kg of CO<sub>2</sub> is generated in mango FSC per hectare, from production to processing both from direct and indirect emissions. The quantity of fruits wasted at all the stages represents the proportional wastage of resources and impact on the environment. In both the FSC'S usage of fertilizers and pesticides is mostly in line with the general guidelines and they contribute about 286 kg of CO<sub>2</sub> from one hectare of mango production. Additionally, there is a chance excess runoff of pesticides into the environment apart from that of produce. Irrigation during the fruit bearing and off season play an important role in determining the quality of the crop. In both the FSC's mango is taken up as a rain fed crop, assisted with other forms of irrigation like micro irrigation or flooding, in place of other crops like paddy and sugarcane due to erratic rainfall and water intensive nature of other crops.

In mango pulp FSC, huge quantities of kernel/stone which is obtained as by product is currently being used as boiler fuel after drying or discarded in open areas which lead to bad odor in the vicinity and proliferation of pests.

b. Required inputs and cost-benefit analysis of the food loss reduction measures (for 10 year implementation) identified at the critical loss points; social implications

In mango pulp FSC, the perception of losses is not significant among the actors and many believe the losses are currently low and a part of inherent process variance. During the interaction with stake holders in fresh fruit FSC, the farmers and traders are comparatively aware of the losses and opined that lack of proper technology, availability, and retention of skilled labour is an important factor leading to food loss.

Another important cause that was observed to cause losses is lack of effective training particularly in the area of post-harvest handling of the fruits by farmers and farm workers.

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

**Cultivation practices:** High density plantations characterizes shorter trees with smaller canopy and more number of plants approximately about 600 per hectare in place of 50 trees per acre in conventional harvesting system. This results in better harvesting and handling of fruits and increase in productivity.

**Irrigation:** Irrigation plays an important role not only in maintaining productivity but also in determining qualitative factors of the fruit and fruit loss during the bearing time. Mango cultivation in both the FSC's is dependent on the Rainfall for irrigation. Implantation of micro irrigation methods like drip irrigation are already initiated only to cover a minor portion currently. Extensive promotion should be carried out to bring more area under drip irrigation.

**Harvesting:** Harvesting is an important factor in determining the losses in subsequent stages as well apart from the losses during harvesting. Harvesting should be promoted to be carried out by "Net Basket (Dapoli)" Harvester. Care should be employed to reduce the impact received to the fruits during the operation. Fruits should be heaped on a plastic sheet during harvesting, rather than leaving them on the soil. This could reduce the chances of bacterial and fungal infections which leads to post harvest losses. Desapping operation should be carried out immediately, especially for fresh fruit FSC, in order to reduce losses due to sap injury and fungal infections at later stages.

**Transportation:** Usage of crates during transportation should be extensively promoted particularly in the fresh fruit FSC. In current practice, the crates are mostly used for carrying fruits during harvesting. Usage of better packaging structures and controlled storage conditions of temperature and humidity should be explored.

**Ripening:** High losses are observed during the traditional ripening process, mainly due to a non-standardized method and un-controlled conditions. Development of standard method with optimized conditions and corrective actions for deviations will help in reducing the losses. Hot water treatment plants can be explored to address the pest infestation issues, particularly like fruit fly. This leads to a reduction in quantitative and qualitative losses caused by the larvae. Due to lack of external symptoms, most of the time pest infestation is neglected in the domestic market. However, this also might be effective in addressing the bacterial and fungal infections, but control of re-contamination in the subsequent is a challenge.

The following propositions are evaluated in order to achieve the reduction in losses:

### **Farm and post-harvest services by Private entities:**

Lack of proper training to farmers and unavailability of skilled labour to carry out the farm operations and post-harvest operations is hindering the better handling of produce in both the FSC'S. The proposed intervention comprises of establishing private enterprises or service providers for scientific delivery of activities like pesticide and fungicide application, pruning, rejuvenation of senile plantations, harvesting, desapping and postharvest handling. These enterprises can be collaborated to deliver the support programs extended by the government agencies.

This will lead to:

- Addresses the problem of unavailability of skilled labor
- Training of local manpower and absorbing them into the enterprise thereby creating employment
- Efficient delivery of the support programs.
- Lowered financial burden on framer for mechanization as the equipment is procured by the service provider and will be used in multiple orchards.
- All round improvement in pre-harvest and post-harvest activities as they are carried out in a scientific way.

**Training on the Farm:**

Currently, the training is provided to framers at a centralized location, with limited audio visual support. Farmers opined that it was difficult to relate the solutions and implement them. The proposed intervention suggest training on the farm with effective use of audio visual support like potable projector kits. This also involves the creation of new content in the local language and delivering it at right before the start of the operations, with demonstrations in the farm. Training should also cover the linkages between the better practices and returns to the framer in the short term and long term as 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 by multiple means like mobile phones or central kiosks/desktops at village or block level.

This will lead to:

- Increased participation in training as the training is happening in the village itself
- Higher chances of implementing the training as it is delivered right before the start of the operations
- Better tracking and improving the training content by evaluating the level of implementation at the village level
- Modulating the content of training as per the prevailing specific crop conditions (e.g.: post-harvest diseases)
- Increased interaction among the farmers through peer based learning.

OUTPUT IV-2a: Budget calculation for food loss reduction

Items		Value	Unit	Calculation
a	Product quantity	532,836	ton/year	Production of Vizianagaram
b	Product value	210	\$/ton	
c	Loss rate	10.00	%	Quantitative and qualitative
d	Anticipated loss reduction	30	%	
e	Cost of intervention	39,000.00	\$	Audiovisual kits, Content crea- tion
f	Depreciation	5	Years	Average life span of kits
g	Yearly costs of investment	7,800	\$/year	e / f
h	Yearly costs of operation	20,000	\$/year	Travel and other costs during the training
i	Total yearly costs of solution	27,800	\$/year	g + h
j	Client costs per ton product	0.0522	\$/ton	i / a
k	Food loss	53,283.6	ton/year	c * a
l	Economic loss	11,189,556	\$/year	k * b
m	Loss reduction	15,985.08	ton/year	k * d
n	Loss reduction savings	3,356,866.8	\$/year	m * b
o	Total Client costs	27,800	\$/year	a * j = i
p	Profitability of solution	3,329,066.8	\$/year	n - o

**Plastic crates on a rental basis:**

Usage of plastic crates is currently limited to fresh fruits 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 fruits, accounting for almost 10% during transportation.

To address this, the proposed intervention consist of renting of crates by market yards to transport the fruits to the distant markets. Plastic crates will be procured by the government or market yards or private agencies in the mango producing region. The traders/ farmers intending to transport fruits will procure the crates from source market yard by paying an advance amount which will be repaid on returning the crates at the terminal market. These crates in the off season will be used in another region for other horticultural pro-  
duce.

This leads to the following improvements:

- Better handling of fruits and reduced qualitative and quantitative losses
- Improved participation in market yards leading to the formation of effective and well integrated supply chains which can be extended to other horticultural crops
- Realistic data capturing for production, trade volumes and food loss

Reduced load on environment due to reusable packaging material.



OUTPUT IV-2a-1: BUDGET CALCULATION FOR FOOD LOSS REDUCTION

	Items	Value	Unit	Calculation
a	Product quantity	1,83,828.4	ton/year	50 % of produce going to distant markets from Vizianagarm
b	Product value	210	\$/ton	
c	Loss rate	15.00%	%	Quantitative and qualitative
d	Anticipated loss reduction	20%	%	
e	Cost of intervention	13,756,524	\$	50 % of the cost of crates, considering they are used for other fruits and vegetables in off season
f	Depreciation	5	years	Average life span of crates
g	Yearly costs of investment	2,751,305	\$/year	e / f
h	Yearly costs of operation	105,000	\$/year	Cost of transportation of crates in the beginning of season and washing
i	Total yearly costs of solution	2,856,305	\$/year	g + h
j	Client costs per ton product	5.3606	\$/ton	i / a
k	Food loss	79,925.4	ton/year	c * a
l	Economic loss	16,784,334	\$/year	k * b
m	Loss reduction	15,985.08	ton/year	k * d
n	Loss reduction savings	3,356,867	\$/year	m * b
o	Total Client costs	2,856,305	\$/year	a * j = i
p	Profitability of solution	500,562	\$/year	n – o

OUTPUT IV-2b: Assessing 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
<b>Farm and post-harvest services by Public private partnership</b>			
1. ...impact the employment situation of FSC actors?	Improve the employment situation in the FSC. Creates employment to the local agricultural graduates to start enterprises or 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 essential step to catalyse the participation and women farm workers in the program	
2. ... increase or reduce the workload of FSC actors?	Decrease the workload on the farmers by partially taking the ownership of the activities. The work load among the farm workers will be optimised by employing them in multiple activities during the crop season	Will affect both the 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 get fair income	Controls should be laid in place to ensure that benefits are transferred to all the stakeholders
5. ...impact dynamics of power in the FSC? (WHO has ownership of solutions?)	Will not alter the dynamics of FSC, but it gives a chance for farmers to negotiate a better price and farm workers better wages for improved services	Will affect both the genders equally	
6....take into consideration mobility restrictions of FSC actors?	This will not affect the mobility factors of farmers. For farm workers, this will reduce the migration as they will be employed in multiple activities and crops.	Will affect both the 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	

(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
8. ...cause for some actors' exclusion from the FSC activities?	This will lead to a gradual reduction of the middlemen and input suppliers on 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 middlemen into other activities
9. ....impact the environment adversely?	Reduces the negative effect on environment due to controlled use of farm inputs like irrigation and pesticides	Will affect both the genders equally	
<b>Training on the farm:</b>			
1. ...impact the employment situation of FSC actors?	The training will improve the knowledge of fruit handling, which will lead to marginal increase in farm labour requirement	Employment opportunities will equally increase 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 the genders equally in terms of increase/ decrease in workload. Female extension officers should be included in the sessions to ensure participation of women	The increased work load in marginal and is a necessary intervention to reduce food loss. The price incentive for better produce should justify this
3. ...raise or increase the need for training to apply solutions?	Training will be required to extension officers on usage of AV units and new content	Female extension officers should be trained for ensuring woman participation and tailoring the information	
4. ...distribute benefits to the FSC actors? (income access and control)	Price incentive earned should be distributed among the actors to ensure the viability of the solution	Females will be paid equally for the similar operations they carry out along with men	Due to lack of transparency, traders may not transfer the benefits to farmers. A mechanism to know or estimate 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 bargain for his produce for improved quality, will not alter the dynamics in larger sense	Training women empower them and create a level playing field	
6....take into consideration mobility restrictions of FSC actors?	Increased travel for extension officers, the travel of farmers and farm labour will be reduced	Increased Travel is a point of concern for Female extension officers	The travel will be limited to mandal /block level which is currently allocated to them. The number of trips might increase as the training will 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	Women participation can be low	To ensure participation of women, female extension officers should be a part of training contingent

(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
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 due to increased awareness among the actors		
<b>Plastic crates on rental basis</b>			
1. ...impact the employment situation of FSC actors?	Will not change the employment situations of exiting actors in the FSC. May create additional jobs in the area of crates handling	Will not affect women specifically	
2. ... increase or reduce the workload of FSC actors?	Marginally might increase the workload on all the actors initially to streamline all the activities. Automation at later stages to lift the crates at market yard will decrease the work load	Will not affect women specifically	
3. ...raise or increase the need for training to apply solutions?	Marginal increase in training needs to 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 fruits available for sale. The intervention will only sustain 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 to observe the benefit transfer to farmer should be identified
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 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 affect women specifically	
8. ...cause for some actors' exclusion from the FSC activities?	Might cause loss of business to companies supplying packaging materials currently	Will not affect women specifically	
9. ....impact the environment adversely?	Reduce the usage of disposable packaging material.	Will not affect women specifically	



### c. Food loss reduction plan and strategy, investment requirements

Mango cultivation in the state of Andhra Pradesh comprises of two major FSC's i.e. Fresh Fruit and mango Pulp FSC. Other minor but important FSC's like mango jelly and pickle industry also holds local importance. Though these food supply chains are not considered due to their smaller size, the proposed strategy also helps in addressing the food loss reduction of all the food supply chains as most of the practices are similar and prevalent in them as well. The causes for food loss are observed to be complex ranging from technical, skill gap/ lack of awareness, economical and at the policy level. To address this apart from the proposed solutions in the earlier section, an overarching strategy comprising of following aspects is proposed.

#### Extension training through ICT/ Videos:

Training and capacity building is observed to be a serious gap in both the FSC's. The farmers in mango pulp FSC are slightly well aware of the importance of post-harvest care. However, due to lack of incentive for any amount of additional care, there is general laxity in the handling of the produce. There is a need for capacity building in the following areas:

- Training on harvesting & produce handling practices, desapping, grading for farmers as well as farm labor, focus on showing the impact of good practices in the videos and success stories of the farmers who adapted good practices
- Training on disease control to address pre-harvest diseases by following IPM and eradication measures at cluster level and at individual level to address post-diseases like anthracnose, stem-end rot etc.

#### Value added products for reducing food losses:

The pre harvest fruit drop at marble stage (around 10 - 20 %) can be converted to an additional source of income. These wasted mangoes can be used in making Amchur (dried & powdered raw mango), brined mango slices and pickles etc. The main problems for processing of such produce are lack of machinery, labour availability. To process raw mangoes to Amchur steps like removal of stones, chopping & drying, dehydration and milling are required. Several farmers can adopt the processing with the availability of machinery and labour. Small scale pickling units can be encouraged, especially as women self-help groups (SHG) at the cluster level, to create value addition to pre harvest dropped mangoes during winds/storms, slightly damaged and bruised fruits. By training the existing SHG's and small scale units to modify the current process in order to utilize the dropped mangoes, a viable linkage can be created. This leads to optimized utility of the lost fruits and product quality. In mango pulp FSC, small scale jelly manufacturing units should be encouraged in the region to create utilization of fruits that are currently being lost during harvesting and sorting.

#### Transportation:

Plastic crates are currently used on a limited scale due to lack of effective linkages which results in an additional cost of returning crates to the source location. Effective linkages to rotate crates across locations and for different products or mode of supplying crates on rental basis should be developed.

#### Market Linkages:

Due to lack of awareness and efficient market linkages, farmers are being exploited by contractors/ agents. A tracking mechanism to know the price across the value chain will help farmers in negotiating a better price for his produce and eventually will improve the transparency and reduce the hold of middle men. Development of market linkages for value added products from culled fruits/ sorted fruits is a determining factor for farmers or Women's SHG in taking up mango processing/ value addition as an enterprise.

OUTPUT IV-3: SUMMARY TABLE 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 intervention (USD)	Economic implications	Social implications	Food security implications	Environmental and climate change implications	Policy implications
	%	Weight (MT)	USD			%	USD						
Harvesting	10	304,016	63,763,823	Improper harvesting methods	Training	30	191,291,46	27800 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	10712322	2856304 for one district/ year	Initial cost of capital, Increased tax earnings to government	Improvement in usage of market yards, better price to produce		Reusable packaging, reduced packaging wastes	
Ripening- Traditional Process	19			Unstandardized method	Research on standardizing 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 fruits	Decreased fruit wastes leading to reduced disposal. Can be an alternative to energy intensive Ripening chambers	

### **Handholding of Enterprises:**

The enterprises or companies considered for processing mango wastes are typically very small and the members are with a limited skillset, especially in trade networks and business skills. Incubators in relevant institutes should look to hand-hold and nurture the business of such enterprises.

Most of the times, the local entrepreneurs considering to start food processing units are often discouraged by the high cost of capital on the equipment. To facilitate such people institutes like College of Food Science, ANRGAU or State Horticultural University should look into the feasibility of establishing an Incubator with a pilot plant to help local entrepreneurs in establishing proof of concept for their product ideas. This will also create a bridge between the academia and entrepreneurs benefiting both by creating access to research and subsequent commercialization.

### **Setting up of Mango Development Board:**

As opined by many stakeholders during the study, there should be a body to monitor the supply chain and control the aspects of mango trade. A Mango Development Board on similar lines to that of Coconut and Grapes should be installed to develop mango trade and promote research in relevant areas. This will lead to optimization of pricing, demand, and production, thereby reducing the chances of a glut in the market and subsequent food loss. A similar consideration, currently in the perusal of government should be expedited.

### **Follow-up action plan/ Concept.**

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

Creation of right content is an important factor for the effectiveness of the training. Therefore the content creation exercise should be carried out by experts from institutes like Central Institute of Post-Harvest Engineering and Technology (CIPHET), State Agricultural and Horticultural Universities, Technology Providers and Processing Companies by considering the local limitations and resource constraints. “Training the trainer” module should be developed to train horticulture and extension officers for effective dissemination of the training to the farmers. Research institutes like CIPHET, Indian Institute of Horticultural Research (IIHR), Central Food Technological Research Institute (CFRTI) should work on optimization of parameters for traditional ripening methods like temperature changes, suitable insulating material, stacking of fruits and ethylene seeding with already ripened fruits etc. Similar Institutes should also develop technology for small scale units to process by products like mango kernel to edible/valuable products like mango kernel fat. This helps in creating additional value and reduced stress on the environment.

Processing companies like Jain Irrigation Systems Limited (Farm fresh) are currently extending their support to promote High Density Plantations in mango. Similar Companies can extend support by offering farm services like pesticide sprays, scientific methods of harvesting and post-harvest handling. A public private partnership model should be developed in consultation with government and such companies to optimize the support and resources under various government schemes and along with contribution by private companies and farmers. This will help in reduction of unnecessary pesticide usage, reduced environmental impact, adopting integrated pest management and finally in improving the quality of the final produce. Employment generation and women empowerment can be achieved by giving proper support and hand holding to Individuals, Farmer Producer Companies and Women Self-Help Groups in processing the Damaged/ Culled fruits on farm or during harvesting.

These models and interventions should be taken up in one FSC / District initially and upon successful implementation, should be extended to the all the mango producing regions in the state by doing necessary changes and localization.

### **Follow up- action plan:**

A stakeholder meeting was conducted with the help of FAO on 1<sup>st</sup> February at Vijayawada, Andhra Pradesh, in-order to critically appraise the report and to understand the relevancy and adoption of the interventions proposed in the report. The findings of the report were presented to the subsector specific group comprising of experts from the State Horticulture University, post-harvest experts, horticulture officers, mango pack house manager, framers who work mostly in the policy implementation stage and other stakeholders like, Agriculture Minister of the Andhra Pradesh state government and principal secretary-agriculture, who work at policy formulation stage.

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 are discussed which are detailed in the below section.

**Importance of Harvesting:** Harvesting is an important factor in deciding the quantum of losses at all subsequent stages in both fresh fruit and pulp processing supply chains. The panel agreed to the finding that there is increased need for sensitizing the actors about the importance of proper time and methods of harvesting and by doing so, both quantitative and qualitative food losses in the subsequent stages can be reduced to a great extent.

**Training on the farm with ICT tools:** It was agreed by the panel that lack of training to the farmers and farm workers is one of the main reason leading to poor harvesting practices. The need for better harvesting and postharvest care is to be effectively communicated to the farmers in order to make them understand the effect on food loss. The possibility of creating new content and dividing it in the modules of Production & pre-harvest care, Harvesting care and Post-harvest care was discussed, so that the training content will be easily taken up by the trainers and delivered effectively. The panel members suggested the possibility of using existing content created by Horticulture University during the earlier capacity building programs. These can be used with required modifications, as most of the operations were well captured at that time. Better practices followed by the local progressive farmers and benefits derived by them should also be captured in the content for the training programs. The means of delivery to the farmers needs to be further explored.

**Evaporative Cooling Chambers:** Evaporative cooling chambers, which are also known as Zero energy cooling chambers are an effective and low cost means to reduce the field heat from the produce after harvesting. Currently there is no practice of pre- cooling in both fresh fruit and pulp processing supply chains to remove field heat after harvesting. It was rightly pointed by the post-harvest experts in the panel 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 farm level, these cooling chambers can be created with indigenous resources. This can help in reducing the food loss particularly during long distance transportation in fresh fruit supply chain.

**Packaging designs:** The need for improved and low cost design for packaging fruits particularly in fresh fruit supply chain was emphasized by all the panel members. It was agreed by the panel that best practices in grading and packaging are currently followed in export supply chain and the same was validated by the pack house expert in the panel. A low cost option of disposable plastic crate was considered by the panel and agreed on to the point that it adds a substantial disposal load. The panel agreed that the current corrugated fiber 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 to greater extent if the farmers are trained on proper grading and packaging, to an

extent where they themselves can complete the packaging of fruits in boxes after proper postharvest operations like desapping.

**Farm and post-harvest services firms:** Availability of skilled labor and subsequently their retention after training is a major challenge that is being faced by farmers in both the food supply chains. This is limiting the availability of training to the manpower involved in farm operations. Similar models were tried in Chittoor by the export pack house, where in harvesting and transportation of fruits was carried out in scientific manner without farmers' intervention. The need for starting such an enterprise to offer farm and post-harvest services by local entrepreneurs was well received and examples of similar entities currently in operation were discussed. The local farm workers and unemployed people can be absorbed into such entities and can be trained in a scientific way. Support should be extended to such an enterprise by subsidizing the farm equipment and dedicated transport vehicles for horticultural produce. The possibility of imparting training under National Skill Development Council program is to be further explored.

**Incubators for promoting entrepreneurs:** Currently the entrepreneurs in the small scale sector or self-help groups are facing challenges due to limited access to modern technology and limited market linkages. This is limiting their potential to produce value added products from mangoes that are going as food loss.

Common Incubator facilities need to be created at multiple locations for promoting the processing of multiple agricultural and horticultural commodities with the help of horticulture/ agriculture universities and state government. It was emphasized by the panel that support to small entrepreneurs should be extended by leasing existing pilot plants in the universities at nominal costs for testing proof of concepts, providing technical guidance and regulatory support and creation of market linkages.

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

- Harvesting is playing a deciding role in the quantum of losses across the sub sector. Training the stakeholder viz. farmers and farm workers on better harvesting practices should be taken up on priority.
- Promotion of zero energy cool chambers by department of horticulture, especially in fresh fruit supply chain by creating awareness in farmers and in traders that pre cooling of fruits leads to reduced transportation losses.
- Preparing a database of available Institutes, pilot plants and technology centers and requirements for any additional equipment or facilities; List of available experts in technology and business fronts for preparing a proposal for creation of well networked incubator.

This should be initiated at the local university or at state government level to bring all the collaborators on board. A pilot level study 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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Post-Harvest Profile Of Mango		Directorate Of Marketing & Inspection, GoI, 2013.
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Carbon emission from farm operations	R. Lal	Environment International 30 (2004) 981– 990



Experts Consulted	Title/ position	Institution
Mr. AM Subhani	Assistant Director	Department of Horticulture, Chittoor, Andhra Pradesh
Mr. Koteswara Rao	Horticulture Officer	
Dr. S Rama Mohan	Assistant Director	Department of Horticulture, Viziana-garam, Andhra Pradesh
Mr. A. Rajashekaram,	Horticulture Officer	
Dr. Shiva Prasad	Professor	Sri Konda Lakshman Telangana State Horticulture University, Hyderabad.
Mr. B.Narasimha Varma,	Chairman	Agriculture Market Committee, Gajapathinagaram, Vizianagaram Dis-trict
Mr. Y. V. Ramana	Factory Manager	Hayath Foods Private Limited, Chittoor.
Ms. A. Aruna	Quality Assurance Manager	Sun Gold Tropic Fruit Products Private Limited, Chittoor.
Mr. K. Govardhana Bobby	Managing Director	Suvera Processing Foods Private Lim-ited, Chittoor.
Mr. Amith Khuslani	Managing Director	Sri Manjunatha Fruit Canning Industries, Chittoor.

Study Itinerary:

Date	Place	Activity
22-Apr- 2016 to 23- Apr-2016	Vizianagaram	<ul style="list-style-type: none"><li>• Interaction with the Assistant director- horticulture, horticulture officer.</li><li>• Interaction with farmers, traders- Kothavalasa Mandal</li><li>• Visit to pack house, local jelly processing units</li></ul>
26-Apr-2016	Vijayawada	<ul style="list-style-type: none"><li>• Visit to mango market yard, Nunna</li><li>• Visit to Export pack house, VHT plant</li></ul>
16-May-2016 to 21-May-2016	Chittoor	<ul style="list-style-type: none"><li>• Interaction with Assistant Director –Horticulture.</li><li>• Interaction with Horticulture officer.</li><li>• Visit to UHDP mango plantation, interaction with the farmer.</li><li>• Visit to Galla foods Pvt Ltd.</li><li>• Interaction with President, Chittoor Mango Processors Association</li><li>• Visit to Sun gold Fruit processing Industries, Interaction with QA manager</li><li>• Visit to Hayat Foods Pvt Ltd</li><li>• Visit to Suvera Foods Pvt Ltd.</li><li>• Visit to Bangarupalyam Chittoor mango market yards- Interaction with traders</li><li>• Interaction with Farmers- Bangarupalyam, Chittoor, Mapakshi</li><li>• Visit to VHT plant tirupathi, mango market yard tirupathi</li><li>• Interaction with quarantine inspector, VHT plant supervisor, traders, transporters.</li></ul>
16-May-2016 to 18-May-2016	Vizianagaram	<ul style="list-style-type: none"><li>• Load tracking study- Sarakallu village; Manjunatha fruit canning industries pri-vate limited, Suvera foods private limited, Chittoor market yard.</li><li>• Interaction with Farmers, Traders, Transporters, Farm workers, processors.</li></ul>
15- Jun-2016 to 17- Jun-2016	Chittoor	<ul style="list-style-type: none"><li>• Interaction with MPEO, Bheemali</li><li>• Visit and Interaction with Jelly Processors</li><li>• Interaction with Farmers, Traders – Bheemali and L. Kota\</li><li>• Interaction with farmers- Merakamudidam mandal</li><li>• Visit to Agriculture Market Committee, Gajapathinagaram</li><li>• Visit to Nellimarla Industrial; mango processing units.</li></ul>
16- Jul-2016 to 17- Jul- 2016	Delhi	<ul style="list-style-type: none"><li>• Visit to Azadpur fruit market</li><li>• Interaction with traders, market workers</li><li>• Interaction with small retailers, modern retailers</li></ul>



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