CHAPTER 3

PROBLEM DESCRIPTION

This chapter provides the information about the aim of the research work, objectives of research work, case description of a banana supply chain in India and bamboo shoot supply chain in Thailand and the framework used in this research.

3.1 RESEARCH GAP

The design of an agro-industrial supply chain is a challenging task because the quality of product is influenced intentionally and unintentionally in each and every link in the supply chain. Quality issues for instance, food safety, freshness, shelf life and uncertainties play a crucial role in success or failure of agro-industrial supply chains. In practice, agro-industrial supply chain management issues deals with vague, ambiguous, and imperfect information throughout different enablers in the supply chain. Moreover, the range of influencing factors includes: the vagaries of weather, the unpredictable nature of biological processes, pronounced seasonality of production and market cycles, geographical separation of production and end users and the unique and uncertain domestic and international political economy of food and agriculture sectors. The decision made by the one enabler for one activity at a particular stage in the chain may leads to risk for other enablers in the chain.

Extensive research work was carried out in the area of the agro-industrial supply chain which focuses on optimization in transportation, scheduling, inventory management, effective preservation processes and agro-industry process technologies. Most of the works are restricted to limited stages in the agro-industrial supply chain. Furthermore, most of the cases paid attention is paid to a well-organized supply chain operated by one company.

In Asian countries, in Thailand, and India for instance, fruits and vegetables from farm pass through trader, wholesalers, manufacturers, retailers and customers. These are operated and handled by various firms. Fruit and vegetable supply chains are not well organized. Risk and uncertainty are ubiquitous and varied within agriculture and agro-industrial supply chains. Frequently attention focuses on addressing one type of risk faced by particular stake holders. For instance, there are: weather risk faced by farmers, price risk faced by traders, lack of raw material risk faced by manufacturers and quality loss risk facing retailers. Supply chain enablers are typically inter-dependent and need to manage different types of risks. System-wide assessment of risk is needed. The assessments would collect and compare risk factors and response opportunities involving the broad range of supply chain participants, including the private and public sector, support service providers, and the broader enabling environment e.g., macroeconomic, trade and regulatory policies.

As reported by Commodity Risk Management Group, Agriculture and Rural Development Department World Bank (Jaffee et al 2008), the application of such agricultural supply chain risk assessments should be valuable in multiple contexts, including: (i) as part of subsector or value chain competitiveness and strategy development processes; (ii) an input into the identification and formulation of investment or capacity building projects related to agricultural commercialization, rural finance and export promotion,

and (iii) as an input into sectoral policy and regulatory reform processes. A combination of quantitative data and qualitative information would be sourced and analyzed. However, little attention has been paid to integrate risk and quality issues across all the stages involved in the design of the agro-industrial supply chain. This can be useful to all enablers in the chain and also they can simultaneously consider for sustainable development issues.

Any decision and action made by any enablers at a particular node of the chain should not increase risk level to another enablers in the chain. Suitable decision models should allow the decision makers to understand the resulting successes and failures of the sustainable supply chain. This research deals with the integration of these main issues across all the stages in design of agro-industrial supply chains. Case studies of the Banana supply chain in India and Bamboo shoot supply chain in Thailand are considered.

3.2   AIMS OF THE RESESRCH WORK

The primary aim of this research is to identify and understand agro-industry supply chain context in Asian countries in order to propose an appropriate approach for supply chain risk management. There are several risk factors that cause agro-industrial supply chain failures. Supply chain partners are forced to make decisions with insufficient information, while reliable information is hard to access. This research attempts to find out appropriate methods for making decisions in agro-industrial supply chain under an uncertainty environment within cost and time reasonably.

3.3   OBJECTIVES OF RESEARCH WORK

Agro-Industrial Supply Chain Risk Management (AISCRM) generally provides separate supply chain risk strategy, which is designed by a

combination of top down design and bottom-up emerging. The complex network of possible causes and effects and the relationship of the risks to one another were not adequately addressed in the risk management process. This work attempts to convert uncertainties related to risk in modelling and also to avoid failure of the supply chain due to various sources of uncertainty. One can evaluate and redesign appropriately to achieve the highest possible supply chain profitability. The objectives of this research work are:

(i)   To identify risk from various sources of uncertainty that play crucial roles in failure or success of the agro-industrial supply chain.

(ii)   To develop a risk profile by an appropriate approach to estimate reasonable control parameter values in order to limit or reduce risk in the supply chain.

(iii)   To find suitable methodology for integrating risk in agro-industrial supply chain redesign and analysis.

(iv)   To develop an appropriate decision making model to identify the alternate route at a specified quality level with reasonable profit within the agro-industrial supply chain environment.

3.4   FRAMEWORK OF THE RESEARCH

This research was conducted based on two supply chain case studies: Bananas in India and Bamboo shoots in Thailand. The major part of study deals with uncertainties and imperfect information to meet the

appropriate strategies and achieve supply chain profit in sustainable supply chain. The thesis framework is shown in Figure 3.1.
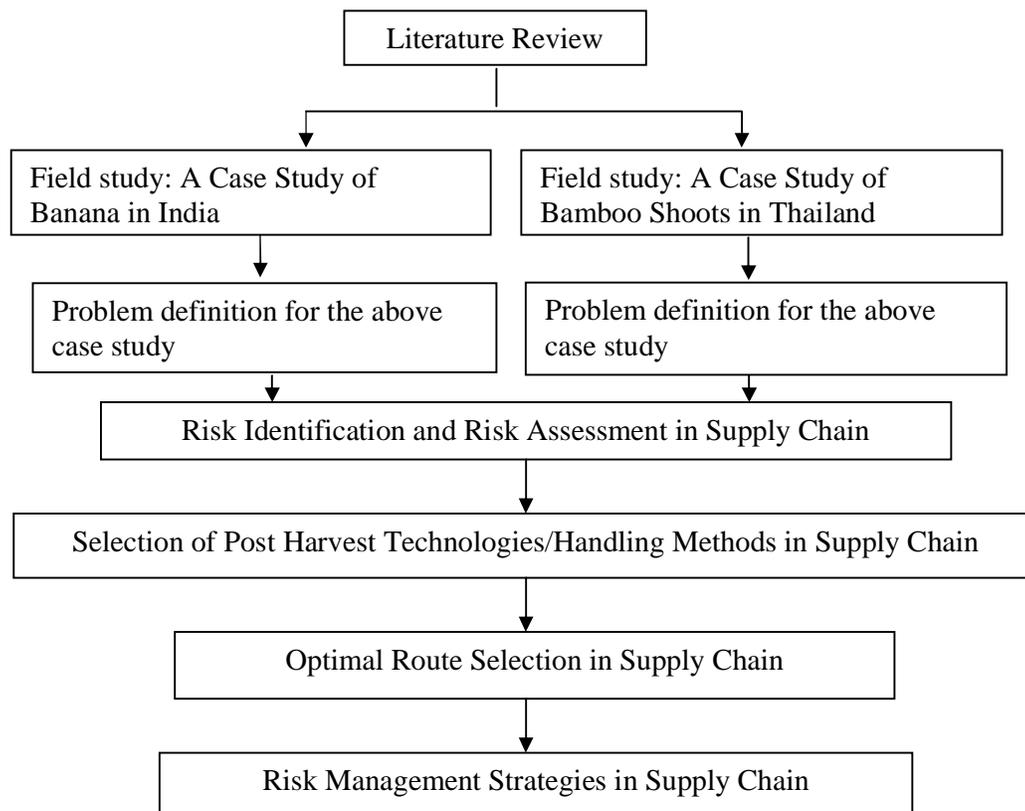
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                    │  Literature Review  │
                    └─────────────────────┘
          ┌───────────────────┴───────────────────┐
          ▼                                         ▼
┌─────────────────────────┐          ┌─────────────────────────┐
│ Field study: A Case Study│          │ Field study: A Case Study│
│ of Banana in India       │          │ of Bamboo Shoots in      │
│                          │          │ Thailand                 │
└─────────────────────────┘          └─────────────────────────┘
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┌─────────────────────────┐          ┌─────────────────────────┐
│ Problem definition for   │          │ Problem definition for   │
│ the above case study     │          │ the above case study     │
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          ▼                                         ▼
    ┌───────────────────────────────────────────────┐
    │ Risk Identification and Risk Assessment in      │
    │ Supply Chain                                    │
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                          ▼
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│ Selection of Post Harvest Technologies/Handling     │
│ Methods in Supply Chain                             │
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    │ Optimal Route Selection in Supply Chain         │
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    │ Risk Management Strategies in Supply Chain      │
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Figure 3.1 Framework of the research

3.4.1   Banana Supply Chain in India

This work started with interviews and discussions with Banana growers, traders, commission agents, wholesalers, and faculty members and researchers involved in the banana supply chain. Risk issues and risk factors were obtained through interviews and discussions. Causal Loop Diagram (CLD) as a tool from systems dynamics (SD) is developed after interview and discussion. Fuzzy Delphi Method (FDM) is used to obtain the value of the elementary risk factor. Analytic Hierarchy Process (AHP) is applied for

selection the of most appropriate post-harvest technology alternative. Dynamic Programming (DP) is used to take quality attributes into account and to find the optimal of route in the supply chain. The Multistage Fuzzy Goal Programming (MFGP) approach is employed to deal with uncertainty in price, quality attributes, and operation cost of post harvest technological action in order achieve maximum profit and the most reasonable risk in profit/loss. The framework of research use in this case is shown in Figure 3.2.

3.4.2   Bamboo Shoot Supply Chain in Thailand

The initial stage of this study started with interviews and discussions. FDM is used to obtain values from elementary risk factors (operation cost, delivery time, price, carrying cost, etc.). Risk with respect to different players in short term in the chain can result in different values. Fuzzy Inference System (FIS) is applied to quantify the sustainable risk value that contributes risk to every party in the entire supply chain in the long term. System Dynamics (SD) approach is used to construct the bamboo shoot supply chain and to propose higher profitability for bamboo shoot growers. Analytic Hierarchy Process is applied to find the most appropriate post-harvest treatment. The framework used is shown in the Figure 3.3.
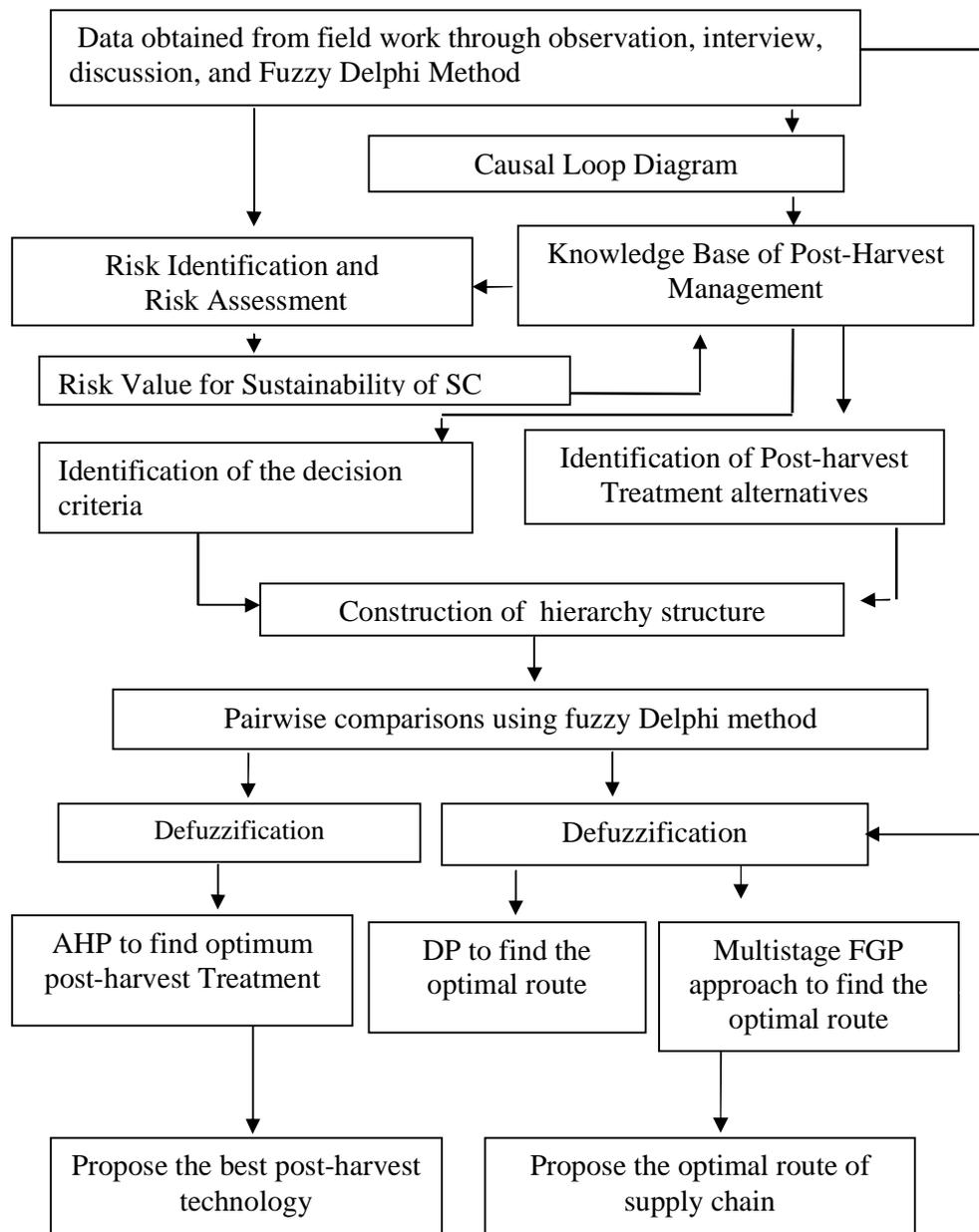
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┌─────────────────────────────────────────────────────────────┐
│ Data obtained from field work through observation, interview,│
│ discussion, and Fuzzy Delphi Method                          │
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                    ┌──────────────────────────┐
                    │   Causal Loop Diagram     │
                    └──────────────────────────┘

┌──────────────────────┐         ┌──────────────────────────┐
│ Risk Identification and│        │ Knowledge Base of Post-Harvest│
│   Risk Assessment    │         │     Management            │
└──────────────────────┘         └──────────────────────────┘

┌──────────────────────────────┐
│ Risk Value for Sustainability of SC │
└──────────────────────────────┘

┌──────────────────────┐         ┌──────────────────────────┐
│ Identification of the decision│   │ Identification of Post-harvest│
│   criteria           │         │   Treatment alternatives  │
└──────────────────────┘         └──────────────────────────┘

          ┌──────────────────────────────────┐
          │ Construction of hierarchy structure│
          └──────────────────────────────────┘

     ┌──────────────────────────────────────────┐
     │ Pairwise comparisons using fuzzy Delphi method│
     └──────────────────────────────────────────┘

     ┌──────────────┐              ┌──────────────┐
     │ Defuzzification│             │ Defuzzification│
     └──────────────┘              └──────────────┘

┌──────────────────┐   ┌──────────────┐   ┌──────────────────┐
│ AHP to find optimum│  │ DP to find the│   │ Multistage FGP    │
│ post-harvest Treatment│ │ optimal route│   │ approach to find the│
└──────────────────┘   └──────────────┘   │   optimal route   │
                                          └──────────────────┘

┌──────────────────────┐              ┌──────────────────────┐
│ Propose the best post-harvest│        │ Propose the optimal route of│
│   technology         │              │   supply chain        │
└──────────────────────┘              └──────────────────────┘
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Figure 3.2   Framework of research used in Banana supply chain case study in India

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┌─────────────────────────────────────────────┐
│ Data obtained from field work through        │
│ observations, interviews, and discussions    │
└─────────────────────────────────────────────┘
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                    ▼
         ┌──────────────────────────┐
         │ System Dynamic Approach  │
         └──────────────────────────┘
                    │
                    ▼
┌───────────────────────────┐   ┌──────────────────────────┐
│ Fuzzy Inference System     │◄──│ Knowledge Base of Post-   │
│ (FIS)                      │   │ Harvest Management for     │
└───────────────────────────┘   │ Fresh Bamboo Shoot         │
                    │            └──────────────────────────┘
                    ▼
┌───────────────────────────┐
│ Risk Value for             │
│ Sustainability of SC       │
└───────────────────────────┘

┌───────────────────────────┐   ┌──────────────────────────┐
│ Identification of          │   │ Identification of         │
│ the decision criteria      │   │ Post-harvest Treatment    │
└───────────────────────────┘   │ alternatives              │
                                 └──────────────────────────┘

┌─────────────────────────────────────────────┐
│ Construction of  hierarchy structure          │
└─────────────────────────────────────────────┘
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                    ▼
┌─────────────────────────────────────────────┐
│ Pairwise comparisons using                    │
│ Fuzzy Delphi method                           │
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         ┌──────────────────────────┐
         │ Defuzzification          │
         └──────────────────────────┘
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│ AHP to find optimum post-harvest Treatment    │
└─────────────────────────────────────────────┘
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│ Implementation of the selected method         │
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Figure 3.3   Framework of research used in Bamboo shoot supply chain case study in Thailand

3.5   A CASE STUDY OF BANANAS IN INDIA

The Banana is a very popular fruit due to its low price and high nutritive value. It is consumed in fresh or cooked form both as ripe and raw fruit. The banana is rich in carbohydrates and vitamins, particularly vitamin B. It is also a good source of potassium, phosphorus, calcium and magnesium. The fruit is easy to digest and is free from fat and cholesterol. Banana powder is the most common baby food in Asian culture. It helps lower the risk of heart disease when used regularly and is recommended for patients suffering from high blood pressure, arthritis, ulcer, gastroenteritis and kidney disorders. Processed products, such as chips, banana puree, jam, jelly, juice, and wine can be made from the fruit. The tender stem, which bears the inflorescence is extracted by removing the leaf sheaths of the harvested pseudostem and used as a vegetable. Plantains or cooking bananas are rich in starch and have a chemical composition similar to that of potato. Banana fiber is used to make items like bags, pots and wall hangers. Rope and good quality paper can be prepared from banana waste. Banana leaves are used as healthy and hygienic plates for eating.

3.5.1   Banana Production in India

The Banana crop is one of the most important crops in the world, and is a major fruit crop grown in India. With respect to area it ranks second after mango in the country. India is the largest producer and consumer of banana in the world with estimated production of 23.2 million tons of bananas annually. India's domestic production alone exceeds the rest of the world's banana trade. Figure 3.4 shows banana production shares around 36.5% of major fruits in India. From 1991 -2008, banana production trends increased every year as shown Figure 3.4. The state of Tamil Nadu is the leading

producer as shown in Table 3.1. This fruit contributes more than 2.8 percent of the GDP of agriculture in India.
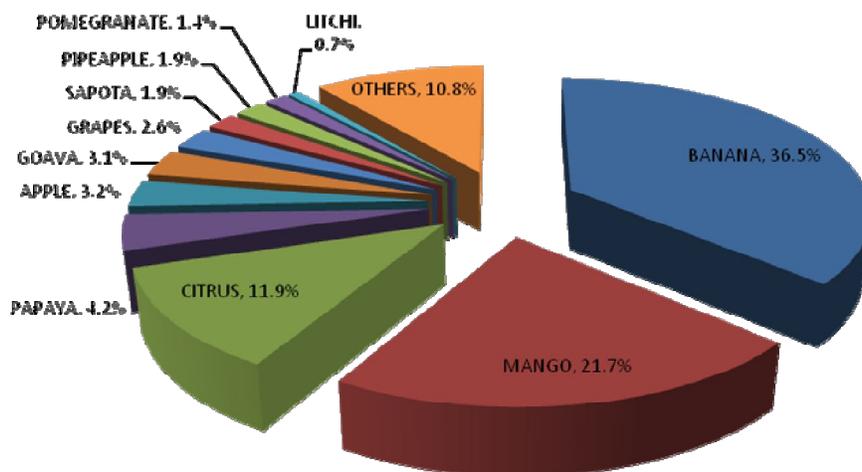
Figure 3.4 Production Share of Major Fruits in India (2007-08)

Source: National Horticultural Board, Government of India (2009)
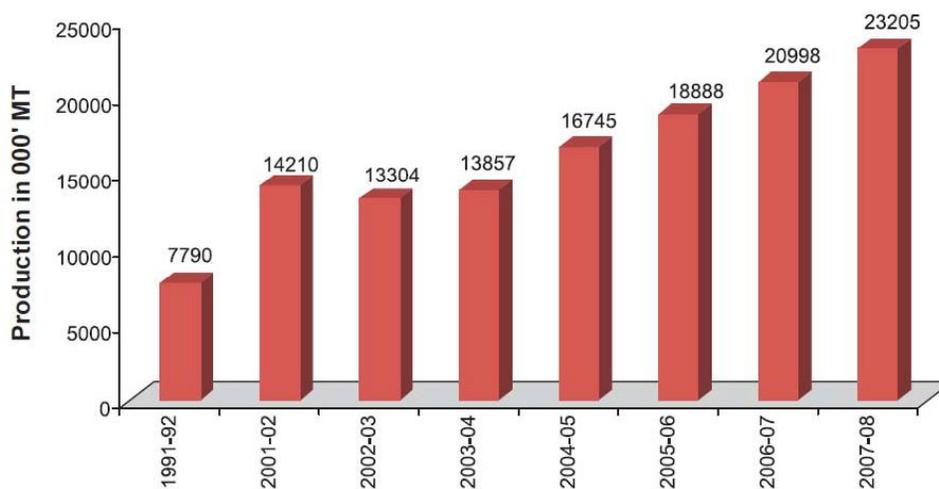
Figure 3.5 Production Trend of Banana

Source: National Horticultural Board, Government of India (2009)

Table 3.1   State wise Cultivation Area and Production of Quantity of Banana

No	State	Area in x 1000 HA			Production in 1000 MT		
		2005-6	2006-7	2007-8	2005-6	2006-7	2007-8
1	Tamil Nadu	94.6	102.2	114.1	4,647.6	5,019.4	6,116.5
2	Maharashtra	73.2	73.4	80.0	4,608.5	4,621.9	4,962.9
3	Gujarat	49.2	53.4	57.7	2,498.8	2,912.6	3,157.7
4	Andra Pradesh	65.0	72.4	75.1	1,628.1	2,173.3	2,254.3
5	Karnataka	56.4	60.8	59.9	1,423.8	1,558.5	1,513.3
6	Bihar	28.0	29.0	30.5	959.3	1,125.1	1,329.4
7	West Bengal	27.8	31.7	37.4	544.9	802.1	892.2
8	Madhya Pradesh	15.0	14.9	15.2	730.0	773.0	788.2
9	Assam	42.0	43.3	44.1	577.7	598.9	610.9
10	Kerala	61.4	59.1	61.5	491.8	463.6	493.9
11	Others	56.8	63.9	71.4	818.5	949.3	1,085.4
	Total	569.5	604.9	646.9	18,927.0	20,997.8	23,204.8

Source: Nation Horticultural Board, Government of India (2009)

3.5.2   Banana Supply Chain in Tamil Nadu

Tamil Nadu is responsible for about 26.4% of the total banana production in India. Bananas are cultivated in 114,100 hectares with a production of 6.1 million tons. The banana cluster in Tamil Nadu is located mainly in the districts of Theni, Trichy, Erode, Dindigul, and Tirunelveli (NHB, 2009). The peak harvest period of bananas in the state of Tamil Nadu is February to May and June to November. Most of the produce which is grown in Tamil Nadu is consumed within state and distributed to Bangalore market. The major wholesale markets are Chennai and Bangalore. Banana trade takes place mostly on a consignment basis. According to the Kanataka

Horticulture Marketing Federation report, about 70% of bananas in the wholesale market in Bangalore are from Tamil Nadu (KHF 2009). Various intermediaries involved in marketing of the bananas brokers, are wholesalers and commission agents. Private traders carry out nearly 95% of the trade and even provide credit to farmers for cultivation, but at high rate of interest.

Table 3.2   **Monthly Arrival Quantity (in Metric Tons) of Bananas from January to December (2007-2008)**

Month	2007		2008	
	Chennai	**Bangalore**	**Chennai**	**Bangalore**
January	810	2,150	14,900	7,110
February	940	2,060	9,990	6,277
March	930	3,020	9,800	7,695
April	1,310	2,800	10,380	7,800
May	1,210	1,225	10,960	6,885
June	1,140	1,185	10,760	7,605
July	1,150	1,660	12,380	8,415
August	1,230	1,020	11,390	7,245
September	1,060	1,665	9,790	4,140
October	1,170	2,130	9,830	6,210
November	940	1,200	10,790	5,013
December	950	1,560	11,400	6,390
Total	12,840	21,675	132,370	80,785

Source: National Horticultural Board, Government of India (2009)

Banana trade is largely dominated by the local traders. They purchase the produce at the farm itself and dispatch to distant markets at their risk and cost. When the banana is matured, local pre-harvest contractors negotiate with the farmer and fix the price. Traders will make advance payments before harvesting. Goods are dispatched to the commission agent for the sales where the price/rate is not confirmed. The commission agent will sell the goods and deduct all expenses, 5% to 6% transportation charges borne by the buyer for instance. In this type, the buyer's representative is present at the time of harvesting and loading to confirm the quality and for better handling. Chennai wholesale market receives most of the produce from Tamil Nadu Cavendish, Nendran, and Elakki are the major varieties traded in this market. In the Bangalore wholesale market, every day over 225,000 tons of bananas arrive from surrounding districts of Bangalore and also from other states: Tamil Nadu and Andhra Pradesh. Arrival of banana at Chennai and Bangalore wholesale market in 2007 and 2008 is shown in Figures 3.6 and 3.7, respectively.
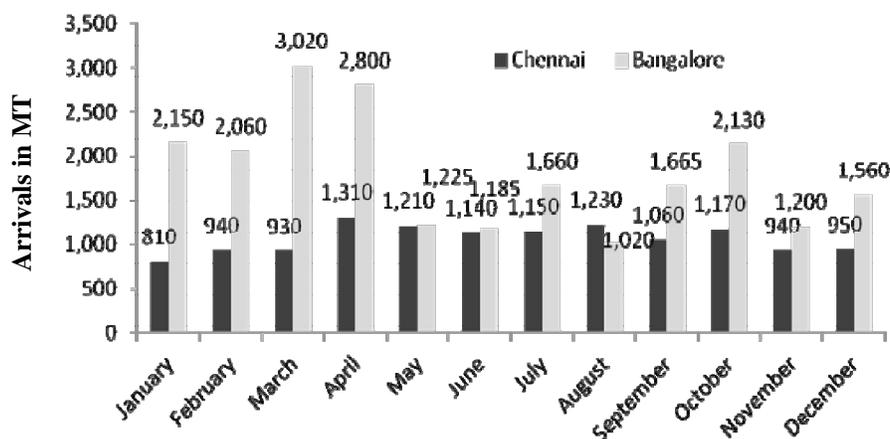
Figure 3.6   Monthly Arrival Quantity of Banana in Chennai and Bangalore (2007)

Source: National Horticultural Board, Government of India (2009)
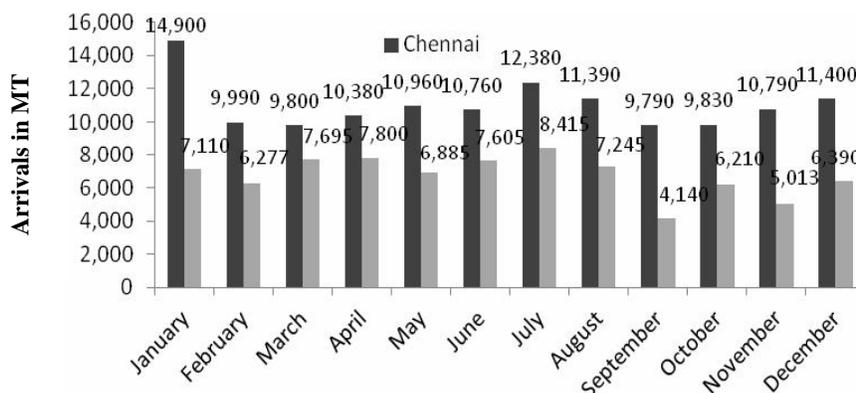
Figure 3.7   Monthly Arrival Quantity of Bananas in Chennai and Bangalore (2008)

Source: National Horticultural Board, Government of India (2009)

Although Tamil Nadu is the leading banana producer in India (NHB, 2009), export of banana from the state is very limited. Growers cannot decide appropriate treatment to satisfy various markets with different levels of quality expectation. Uncertainty in demand and quality depends on various factors including, technologies, climate and socioeconomics. Since the farmers are worried by various uncertainty factors, the local traders still play a vital role in the banana chain. Based on information from demand forecasting, the local traders have pre-harvest contracts with big farm holders. For each orchard, based on quantity and quality, the local traders will decide the market to deliver and the pre-harvest and post-harvest treatment to be done before dispatching the banana to distant markets. Banana chain networks in Trichy district and Theni district of Tamil Nadu state is shown in Figure 3.8.
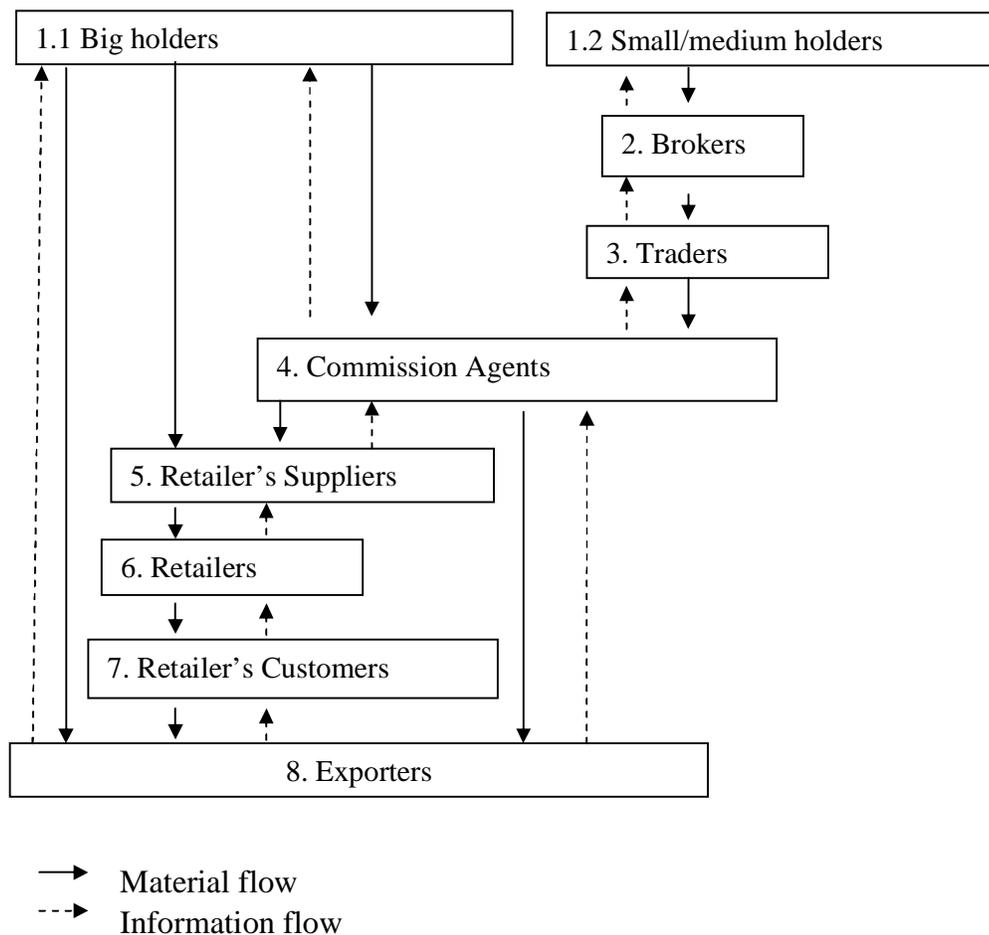
Figure 3.8 Banana Chain Network in Trichy and Theni, Tamil Nadu

3.5.3 Quality and Uncertainty Issues in Banana Supply Chains

Harvested Banana is ripened artificially. Dwarf bananas, a commercial variety, is ready for harvest within 11-14 months after planting while tall cultivars take about 14-16 months to harvest. A bunch usually takes 90-120 days to mature after shooting depending on the climate and cultural practices. The maturity of banana is indicated by drying of top leaves, change in colour of fruits from dark green to light green and tendency of the floral end of the fruit to fall by the slight hand touch. The mature fruit becomes plump and all the angles are filled in completely. When tapped the fruit gives

a metallic sound. The method of harvesting depends on the height of the plant. Low growing varieties are harvested by cutting through the bunch stalk about 30-35 cm above the top hand. With taller varieties, the stem of the plant will be partly cut through in order to bring the bunch down within the harvester's reach. Grading is mainly based on size, color and maturity of the fruits. While grading, smaller fruits are separated from the larger ones in order to achieve uniform ripening. Immature, overripe, damaged and diseased fruits are discarded in the process of grading.

During banana handling from farm to market, both quantitative and qualitative losses occur. Loss of harvested banana can occur in various nodes in the chains. In order to minimize these losses, players must understand the biological and environmental factors involved in postharvest deterioration, and then use the appropriate post-harvest technology procedures that will slow down deterioration and maintain quality of the commodities. Pre-harvest treatment and post-harvest technologies can be applied as required by the expected customers such as exporters or customers. Farmers, traders, and commission agents are the main players in post-harvest treatment. Although the biological and environmental factors that contribute to post harvest losses are well understood and many technologies have been developed to reduce these losses, those technologies have not been implemented. Players in the banana chain are not willing to adopt these technologies since they are worried about the loss of money invested in post-harvest treatment. Both possibility of loss in the post-harvest supply chain and loss in the economics of post-harvest practices can be considered as risks in the supply chain. Solving the post-harvest technology problems necessitates cooperation and effective communication among research and extension personnel. Post-harvest horticulturists therefore need to coordinate their efforts with production horticulturists, agricultural marketing economists, food technologists and others who may be involved in various aspects of the

marketing systems. Solutions to existing problems in the post-harvest handling system requires the use of existing information rather than new technology research (FAO, 2004). The technology used elsewhere is not necessarily the best for use under conditions of a given problem. Many of the recent developments in post-harvest technology in developed countries have come in response to economize the labor, materials, and energy use and to protect the environment. Current practices used in Tamil Nadu should be studied then technologies for local conditions should be adopted. Without proper management, expensive high-end equipment and facilities cannot improve the quality. Furthermore, the investment in handling facilities can result in economic losses if customers are unable to absorb these added costs.

3.6   A CASE STUDY OF BAMBOO SHOOTS IN THAILAND

Bamboo shoots are commercial produce being transformed into various forms of processed products in Thailand. Bamboo shoots are important constituents of stir-fry cuisine and specialized recipes. They are produced and consumed in great quantities in China, Taiwan, Thailand, Japan and Korea. Taste and presentation vary widely from country to country. Bamboo shoots or bamboo sprouts, a member of the grass family, are the edible shoot of new bamboo culms that come out of the ground. Bamboo shoots are harvested for food before they are two weeks old or one-foot tall. Bamboo shoots are crisp and tender, comparable to asparagus, with a flavor similar to corn. They are used frequently in Asian cuisine. Commercially canned bamboo shoots are common for agro-industrial processing, but fresh, locally grown bamboo has far better flavor and texture. Fresh bamboo shoots can be stored in the refrigerator for up to two weeks. A bitter taste develops if it is kept longer than two weeks. In Thailand, they are sold in various processed shapes, and available in fresh, dried, and canned versions. In India, bamboo shoots are a significant consumption item in the home. However,

they are not significant in commercial terms when compared to the volume of bamboo shoot business and derivatives in South East Asia.

3.6.1 Bamboo Shoot Production

Bamboo shoot production and distribution in Prachinburi Province, the East of Thailand, was taken as a case study. Four provinces in the east of Thailand comprise the major region for growing and processing bamboo shoots. The provinces are: Prachinburi, Nakon Nayok, Sakaew and Chacherngsoa. Prachinburi is known as the province of sweet bamboo shoot and bamboo shoot orchard area covers 19,769 acres. Average production is 80,808 tons per year (2005-2008), while produce was supplied to the wholesale market, retailers, and factories. Apart from agricultural production input, production yield and price dependent on season also influence of interacting factors. Fresh bamboo shoot is a commercial produce being transformed into various forms of processed products, and canned product is the most common in the export market. Fresh bamboo is common in the domestic market. Moreover, there are many small business enterprises established by members of farmers in the community as co-operatives. These co-operatives in rural communities also applied sterilization technology for processing bamboo shoot in their regions. Most often, small bamboo shoot processing units in rural communities will supply their product to factories.

The harvesting season for bamboo shoot is during March to September with its peak from July to September. Bamboo shoot price is highly fluctuated throughout the season starting from US 1 $ /Kg in the beginning of season (March) and US 0.14 $ /kg during July to September. Quantity, price, revenue, accumulation yield and accumulation revenue during 2005-2008 are shown in Figure 3.9.
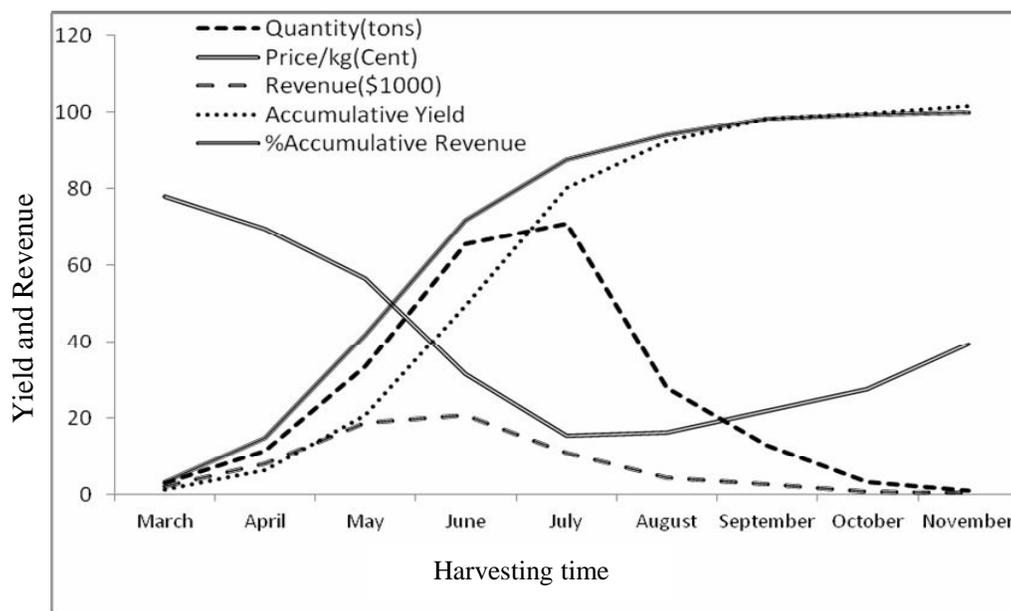
Figure 3.9   Quantity, price, revenue, yield and accumulation yield (2005-2008)

As shown in the Figure 3.9, price is always changing over the period of harvest. Decision makers who are looking for pre-harvest and post-harvest treatment also have to consider whether capital invested in the treatment method can be absorbed by the price of products.

3.6.2   Bamboo Shoot Supply Chain

Bamboo shoots are rich in Vitamins, Cellulose and amino acids. Most bamboo species produce edible shoots. Fresh bamboo shoot is commercial produce being transformed into various forms of processed products. Canned product is the most common in the export market, while peeled fresh bamboo shoot is the most common in the domestic market. In Bamboo shoot supply chain, production volume, quality attributes and price are dependent on each other.

Bamboo shoot supply environment in the East of Thailand is shown in the Figure 3.10.
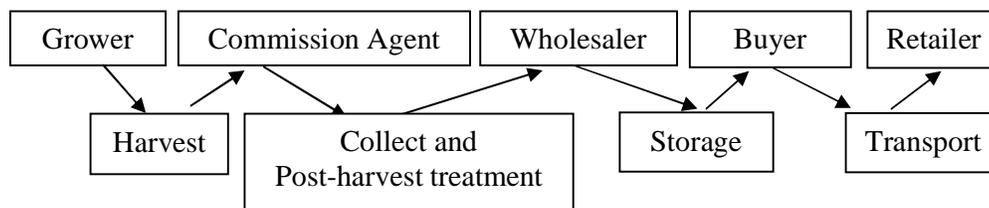
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┌─────────┐  ┌──────────────────┐  ┌────────────┐  ┌─────────┐  ┌──────────┐
│ Grower  │  │ Commission Agent │  │ Wholesaler │  │  Buyer  │  │ Retailer │
└─────────┘  └──────────────────┘  └────────────┘  └─────────┘  └──────────┘
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Figure 3.10 Partners of bamboo shoot supply chains in Eastern Thailand

As shown in Figure 3.10, parties in the bamboo shoot supply chain consist of growers (harvesting), commission agents (collection and post-harvest treatment), wholesalers (storage), buyer (transportation) and retailers (storage). A commission agent or a trader is a major decision maker involved in the chain. Frequently, both commission agent and wholesaler can be the same enabler who plays a vital role in different activities. Such activities include selecting post-harvest treatment and avoiding post-harvest technology if there is significant risk of financial loss. Application of improper post-harvest technology will lead to loss in profit due to the influence of quality and price uncertainty.

3.6.3   Quality and Uncertainty Issues in the Bamboo Shoot Chain

The edible vegetable portions of bamboo are the young emerging shoots that are harvested before significant fiber development. The shoots are progressively formed from latent buds on rhizomes. There are diverse views on the harvesting of bamboo shoot for edible purposes. Shoots of clumping bamboo grow vigorously beneath the soil surface, finally breaking through into the light. At this stage, they often pause in their growth. The reason for this is not known. However, exposure to sunlight causes the production of

chemicals that are bitter and hastens shoot elongation by stimulating the development of a very woody base. Freshly harvested bamboo shoot, in particular, requires precooking preparation. This is primarily to remove the toxic and bitter components from the bamboo shoot.

3.7   PROBLEM DEFINITION

In the case studies of bananas in India and bamboo shoots in Thailand, production and distribution of agro-products are often handled by several operators and through several regions. Major criteria for responsiveness in the agro-industrial supply chain are quality attribute, price, and operation cost in which these criteria are affected by influencing factors. These are: weather conditions, fertilizing investment, pre-harvest treatment options and post-harvest treatment methods. To improve and maintain quality attributes, post-harvest technologies are required. Proper handling operation is needed but these operations will escalate the costs. Increasing post-harvest technological investment and handling operation will mark up the selling price. Then increasing cost in handling and implementation of technology to improve quality may cause additional operation cost. There are several players in the agro-industrial supply chain. Each one make decision to maximize their own profit at one link in the chain but this action may decrease profit of the player another and finally, in the long term, this leads to the loss for all parties in the chain. In order to redesign the agro-industrial supply chain effectively, reliable data should be obtained from all practitioners but data from this environment is commonly imperfect, imprecise and linguistic. Most enablers in the supply chain made decisions for achieving profit based on their experience. Uncertain events in the supply chain can affect cost, quality and price. Dealing uncertainty is hard to measure and control. Risk is also related to uncertainty and can show likelihood of event. From this point of view, if risk issues and risk factors in the

agro-industrial supply chain can be identified, then the risk factors can be controlled and uncertainty events that interrupt the supply chain should be reduced. It make agro-industrial supply chain to achieve higher levels of sustainable profit, which contributes to all parties in the supply chain. In this thesis, an attempt is made to address the above said issues in two case studies (Banana supply chain in India and Bamboo shoot supply chain in Thailand).