School of Marketing

Sustainable Supply Chain Risk Management in Dairy Industry: An Empirical Study in Bangladesh

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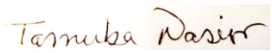
DECLARATION

To the best of my knowledge and belief, this thesis contains no material previously published by any other person except where due acknowledgement has been made. This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.



Tasnuba Nasir

Date: 13 October 2016

DEDICATION

To My Loving Family

My Mom, Dad, Sisters and Brother

My Mother-in-Law and her family

My Husband: Professor Dr. Mohammad Shamsuddoha (Doha)

My Kids:
Mohammad Saifuddoha Fawaaz
Mohammad Samiuddoha Faizaan and
Mohammad Sadiddoha Farzeen

"THANKS TO ALL THOSE WHO KEEP ME IN THEIR CONSTANT PRAYERS"

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ABSTRACT

The practice of supply chain risk management is essential for modern businesses facing the immense challenges of competition and managing economic, social and environmental sustainability. Contemporary literature reveals that, to date, the dairy livestock sub-sector has not received sufficient consideration from academics. In particular, supply chain risks and their possible mitigation strategies at different processing levels of the dairy industry have received little consideration. In fact this specific industry suffers from various kinds of supply chain risk associated with cattle rearing, storing, processing, distribution and forward and backward supply chain activities. A few research studies have explored existing supply chain risks in the dairy industry based on different geographic locations. They have identified various supply chain or general risks but appropriate mitigation strategies have not been considered. Identifying supply chain risks and finding their appropriate mitigation strategies are major challenges for this particular industry. Efficient and effective dairy supply chain risk management is necessary to achieve higher and more sustainable production outcomes. So far, a few unstructured research initiatives have been undertaken to close the research gap. To ensure a sustainable supply chain risk management process in the dairy industry, research on this particular industry is essential. Thus, the current study is an attempt to depict existing supply chain risks embedded in the storage, processing and distribution levels of the dairy industry and suggest ways to manage them appropriately in order to gain the maximum benefits in terms of their social, economic and environmental aspects.

The research was conducted using a "mixed methods" research design (a combination of qualitative as well as quantitative methods) under a positivist paradigm. The methodology was developed in the light of contingency theory and sustainability theory and incorporated the Quality Function Deployment (QFD) technique. Initially, a qualitative method was deployed to identify various risks from the case dairy operation. Then the variables were matched with those in the existing literature. Once the risks were identified through qualitative interviews and literature, Quality Function Deployment (QFD) technique was used to analyse the quantitative data obtained from the questionnaire.

The findings of this study reveal appropriate supply chain risk management comprising proper risk identification and the effective application of risk mitigation strategies in accordance with the research objectives. Some of the high impact and high probable risks are found to be high rate of interest, absence of insurance coverage, Illiterate and inefficient worker and Hartal and strike. On the other hand, the most preferred mitigation strategies are adequate credit support with low interest rate, purchase insurance against production loss, hiring skilled staff, appropriate training facilities and initiative to remove political uncertainty. Such mitigation strategies ultimately bring economic, social and environmental outcomes for the concern industry. The profit maximisation, cost minimisation, increase in personal income, increase in production, product quality improvement, scientific farming and diversified products belong to economic sustainability. Whereas goodwill enhancement, quality food supply, nutritional development, improved living standard and employment creation are considered as social sustainability. Finally environmental sustainability relied on sound working environment, proper waste management and animal genetic development.

This research has both theoretical and practical implications. In terms of its theoretical implications, the research expands the fields of contingency theory and sustainability theory to include dairy supply chain risk management. This research focused on three aspects of contingency theory: contingency, response and performance. These aspects are concerned with situational characteristics, managerial actions and the effectiveness of existing supply chain risks and mitigation strategies. On the other hand, sustainability theory deals with the social, economic and environmental aspects of dairy supply chain risk management.

In terms of its practical implications, the findings of this research will help to identify dairy supply chain risks in time to develop appropriate mitigation strategies for sustainable outcomes. The outcomes can be categorised in terms of three aspects of sustainability: social, economic and environmental. The findings of this research will benefit dairy farmers, supply chain members, policy makers, concerned livestock ministries and officials.

PUBLICATIONS FROM THIS DISSERTATION

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CHAPTER 1: INTRODUCTION

1.1 OVERVIEW

Bangladesh is a South-East Asian country with more than 160 million people and a plethora of problems. Despite this the country is progressing steadily. They are managing food and other basics in a modest way. In recent decades, Bangladesh has attained phenomenal growth in agro-based industries. Dairy, poultry and fisheries are the main livestock sub-sectors in the economy of Bangladesh. These sub-sectors have a reputation for providing cheap sources of protein, creating employment opportunities, and serving as direct and indirect income sources for millions of people (Das et al. 2008). Livestock is not only a source of protein but also of cash income through the sale of a range of products such as meat, eggs, milk, skin, draught animal power, manure, feathers and horns. The sale of livestock and livestock products enables poor families, particularly insolvent women, to increase income for the family without detracting from household activities. The dairy industry is one of the most important sub-sectors in Bangladesh, contributing in immense ways to the country's economy and society. It is one of the sectors best suited to alleviating poverty in the rural economy of Bangladesh. It generates employment by providing jobs to the whole family, i.e., children, men and women alike. However, unlike other sectors,the dairy industry has not shown significant growth. This is due to the various risks associated with the sector. The dairy farming industry in Bangladesh is beset with different risks in its different sectors. Its input sector faces risks like feed scarcity, treatment inadequacy, credit unavailability, low productivity of breeds and so on. Due to the poor functioning of the input sector, the production sector, i.e. Farming operation, is also handicapped (Raha and Talukder 2004). The distribution sector is also affected due to limited access to markets, too many middlemen, poor transport facilities and improper infrastructural facilities.

The concepts of risk and risk management have been associated with various field of knowledge. Supply chain risk management (SCRM) is rapidly developing into a favoured research area for academicians as well as practitioners, especially in the modern business era (Manuj and Mentzer 2008b). As risk pervades every dimension of our lives, both personal and professional, so we need to encounter and manage risk in every aspect of our daily routine. In this sense, the Bangladesh dairy is no exception.

The Bangladesh dairy industry is major sub-sector serving to alleviate poverty and create employment. It is an important livestock sub-sector for generating income and employment for rural poor people (Saadullah 2011). It contributes to the economic and social development of the country. Dairy consumption has doubled in the past three years, though the rise is moderately low per capita (TheDairySite 2013). This industry has immense prospects in terms of production and consumption, as consumption per capita is still significantly below the standard level. But theindustry is associated with a number of risks which hinder its development and growth(Nasir, Quaddus and Shamsuddoha 2014).

The dairy industry is still unstructured in terms of managing and mitigating current and possible risks. Therefore the purpose of this research is to develop a framework to identify potential risks to supply chain processes and to suggest potential mitigation strategies that can be implemented to mitigate these risks. A mixed methods approach has been developed in the light of contingency theory (Zeithaml, Varadarajan and Zeithaml 1988a) and **s**ustainability theory (Carter and Rogers 2008b) by which different risks to the dairy supply chain are categorised. Risk mitigation strategies are developed through the Quality Function Deployment (QFD) tool (Park and Kim 1998) and the outcomes are analysed through network QFD (Kahraman, Ertay and Büyüközkan 2006). Qualitative and quantitative data are combined with literature support to build a QFD model.

After starting with an overview, the thesis presents an extensive literature review of the Bangladesh dairy industry, supply chain risks, supply chain risk management strategiesand other relevant studies. Then research questions and methodologies are described in detail, followed by a description and analysis of qualitative data identifing risk factors,mitigation strategies and probable sustainable outcomes specific to Bangladesh dairy industry production and its supply chain.

Quantitative data collected from the respondents of two case dairies through survey questionnaires via in-depth interviews is analysed. Results, interpretations and discussion of the data are provided and the thesis closes with a summary of the research and a description of its contribution to the literature and agribusiness. Finally, the limitations of the study are acknowledged and directions for future research are proposed.

1.2 BACKGROUND OF THE RESEARCH AREA

A supply chain is not just a single relationship of business to business but a network of multiple businesses and relationships among the supply chain actors (Lambert and Cooper 2000; Lambert, Stock and Ellram 1998).It is a complex chain which is connected through multiple relationships among the supply chain actors. The goal of supply chain risk management (SCRM) is to manage supply chain risks through coordination and collaboration among the supply chain partners in order to ensure profitability and continuity (Brindley 2004). Supply chain risk management (SCRM) is still a relatively new concept in developing countries like Bangladesh, and many companies have not even begun to consider the formal management of their supply chains. In Bangladesh, economic, social and environmental issues are equally significant due to huge population pressures, the high level of poverty, limited land resources, food shortages and drastic climatic changes (Shamsuddoha 2012; Shamsuddoha, Quaddus and Klass 2011; Shamsuddoha, Klass and Quaddus 2011). Companies are struggling to operate their dairy businesses to achieve profitability with minimum environmental hazards.

Moreover, in the dairy business, the nature of raw milk (input), processed product (output), frequency of transactions, present market structure and environmental hazards have added more risks(Mishra and Shekhar 2011).Support for implementing supply chain risk management and sustainability programmes at the industry level is intensifying.There is a noteworthy gap in existing knowledge about the implementation of proper supply chainsin this particular industry. Risk and risk management strategies for dairy industries have received little attention in agricultural research. Therefore, an exploratory study has been carried out to provide empirical insights into Bangladeshi dairy farmers' risk perceptions and risk management responses. This research seeks to identify the major risks facing the dairy supply chain in the context of sustainability, rank them in terms of their potential impact and frequency, and offer a framework for improving risk management practices. It also suggests possible sustainable outcomes as a result of implementation of proper mitigation strategies.

1.3 PROBLEM STATEMENT

In recent years, supply chain risk management has become an important research area as supply chains face a multitude of risks (Rao and Goldsby 2009). The flow of a supply chain is often interrupted by disruptions such as protests, outbreaks of disease,

accidents at plants, the loss of a critical supplier, terrorist attacks, natural disasters, and economic downturns (Sheffi 2005; Christopher and Peck 2004; Kleindorfer and Saad 2005; Jüttner, Peck and Christopher 2003; Thun and Hoenig 2011). Disruption of the supply chain can negatively affect the ability of corporations to continue the normal flow of supply chain operations (Jüttner, Peck and Christopher 2003). The rapid escalation of supply chain disruptions highlights the need for more attention to be given to supply chain risk management to enable businesses to remain sustainable and competitive (Christopher and Lee 2004).

Recently the widespread disruptions caused by terrorist attacks in the USA, by foot and mouth disease in the UK, and by the SARS outbreak in China, Hong Kong and Canada, have drawn attention to the issue of safety across supply chains, and have highlighted their susceptibility (Jüttner, Peck and Christopher 2003).In the global market place, floods caused by Hurricane Floyd disrupted the business of DaimlerChrysler in Greenville, North Carolina, where seven different plants of the company across North America had to be shut down for several days (McGillivray 2000). In a similar way, Toyota was forced to close down for six weeks following a fire at its brake-fluid proportioning valve supplier. This disruption cost the company an estimated $40 million per day (Nelson, Moody and Mayo 1998). More recently, in the USA, 29 ports were shut down for ten days, which cost $1 billion per day to the US economy (Jüttner, Peck and Christopher 2003). These are examples of events that have paralysed the flow of supply chains. From these examples, it is clear that modern supply chains are a very complex bonding of several entities where a disruption affecting a single entity within the supply chain can have a direct effect on the ability of a corporation to continue to operate the supply chain smoothly. The discontinuity of supply chain operations can negatively affect both cost and revenue of the whole chain (Ponomarov and Holcomb 2009).

Supply chain risk management helps a supply chain to prepare for unpredicted disruptions and to recover from unexpected losses (Christopher and Peck 2004). Though awareness is increasing among practitioners, the concepts of supply chain risk and supply chain risk management (SCRM) are still in their infancy (Jüttner 2005). Additionally, a number of contributions regarding risk and risk management from a logistics perspective have emerged in academia (Miller 1991; Svensson 2000; Zsidisin, Panelli and Upton 2000). However, there is still a lack of research on issues of supply chain risk management from a practical perspective (Jüttner 2005). Therefore

empirical work is needed in the field of supply chain risk management for proper identification of supply chain risks and effective management of those risks (Thun and Hoenig 2011).

The Bangladesh dairy industry is an important livestock sub-sector for generating income and employment for rural poor people in Bangladesh. This industry is still unstructured in terms of managing and mitigating current and possible risks. A huge number of risks hinder the development of this industry. Supply chain risk management is still a relatively new concept in the dairy sector of Bangladesh. Many companies have not even begun to consider formal management of their supply chains. Very limited research has been conducted in the field of dairy supply chain risk management, especially in the Bangladesh context. Thus, this research attempts to identify the multidimensional dairy supply chain risks in Bangladesh and considers their likelihood and their potential impact on the supply chain, in order to develop appropriate mitigation strategies.

1.4 RESEARCH QUESTION AND OBJECTIVES

The purpose of this study is to identifythe various riskslikely to arise at the storage, processing and distribution levels of the dairy industry and to explorethe various strategies developed to mitigate those risks, along with possible sustainable outcomes. Supply chain risks and the outcomes after implementing risk mitigation strategies are considered from economic, social and environmental perspectives. The variables are evaluated with the help of a QFD model with respect to three research questions and four research objectives.

This research addresses the following research questions (RQs):

RQ1: How can sustainability theory be used to categorise the risks associated with the dairy supply chain in Bangladesh?

RQ2: What are the optimal strategies to mitigate the highly probable, high impact risks associated with the dairy supply chain in Bangladesh?

RQ3: What are the probable outcomes of implementing the mitigation strategies at the organisation level?

The above research questions give rise to the following research objectives (ROs):

RO1: To identify the risks associated with the dairy sector in Bangladesh using sustainability theory.

RO2: To identify the highly probable high impact risks associated with the dairy supply chain.

RO3: To develop risk mitigation strategies through a QFD (Quality Function Deployment) approach.

RO4: To identify the possible sustainable outcomes resulting from implementing mitigation strategies at the dairy farm level.

1.5 FOCUS AND SCOPE OF THE RESEARCH

Despite the importance of SCRM in today's business practices, there are noteworthy gaps in the existing literature. Therefore, the focus of this research is on identification of risks and investigation of risk management strategies, along with probable sustainable outcomes. More specifically, the research identifies risk factors and explores risk mitigation strategies associated with the dairy suppy chain. Subsequently possible sustainable outcomes after implementing suggested risk mitigation strategies are also presented in. Two dairies in Bangladesh have been selected as case studies and theresearch assesses their risks at various supply chain levels and examines their mitigation strategies. Consequently the variables are used to develop a QFD model for the dairy industry. The model can be replicated in individual dairy companies if the variables are replaced.

1.6 DEFINITION OF TERMS

Risk: Risk is the likelihood of the occurrence of a particular event or outcome (Ritchie and Brindley 2007).

Supply Chain Risk Management (SCRM): SCRM can be defined as the management of SC risks through co-ordination or collaboration among the SC partners so as to ensure profitability and continuity (Tang and Musa 2011).

Sustainability: Sustainability is the balance between economic development, environmental stewardship and social equity (Sikdar 2003).

Sustainable Supply Chain Management (SSCM): SSCM is the strategic, transparent integration and achievement of an organisation's economic, social and environmental goals in the systemic coordination of key inter-organisational business processes for improving the long-term economic performance of an individual company and its supply chains (Carter and Rogers 2008b).

1.7 SIGNIFICANCE OF THE RESEARCH

This research has both theoretical and practical implications for the Bangladesh dairy industry This study combines sustainability theory and contingency theory to develop a QFD model which is used to construct a true representation of dairy supply chain risk management by analysing risk issues and risk mitigation strategies. Practically, dairy industrialists and policy makers will benefit from this research in their decision-making processes. The research has following theoritical and practical significance.

Theoretical significance: This study uses a research framework based on contingency and sustainability theory to categorise risks in the dairy supply chain and to identifypossible risk mitigation strategies. Effective risk mitigation strategies are developed through Quality Function Deployment (QFD) techniques and the outcomes are analysed using a network QFD process (Kahraman, Ertay and Büyüközkan 2006). Thus this research adds to existing knowledge and contributes significantly to theories of dairy supply chain risk management.

Practical significance: This research contributes to the dairy supply chain management process by identifying the existing risks and appropriate risk mitigation strategies associated with the dairy sector in Bangladesh. The proposed model will deal with the issues of the different categories of dairy supply chain risk and identify the high probable and high impact risks associated with dairy supply chain in Bangladesh along with the risk mitigation strategies. It is thus expected that the practical application of the study will contribute significantly to the dairy sector of Bangladesh in terms of mitigating existing risks. Outcomes of the research will benefit dairy stakeholders, supply chain members, concerned livestock ministries and officials. As a consequence, this study makes a significant practical contribution to the Bangladesh dairy industry.

1.8 ORGANISATION OF THE THESIS

This thesis is organised and presented in sevenchapters as shown in Figure 1.1. A brief outline ofeach chapter is as follows:

Chapter 1: Introduction

This current chapterpresents the the research background and draws attention to the importance of the research and the gap in existing literature. It describes the focus of the research, the research questions and the research objectives.The theoretical and

practical contributions of the research are also presented in this chapter, followed by an overview of the whole thesis structure.

Chapter 2: Bangladesh dairy industry and research case description

Chapter 2 discusses the basics of the dairy industry including its structure, scope, present status, contribution, supply chain process, associated supply chain risks and adopted risk mitigation strategies in Bangladesh. This chapter also includes some statistical information regarding the Bangladesh dairy industry. A description of case dairiesis also included in this chapter.

Structure	***Description***	***Output***
Chapter 1	Introduction to the thesis ● Establish the research problem	Determines the research questions and objectives
Chapter 2	Bangladesh Dairy Industry ●Structure ● Present status of dairy industry ●Dairy Supply chain process ● Dairy risks and risk mitigation strategies	Provides the research subject and rationale of the study
Chapter 3	Literature Review ●The theoretical background ● Discussion about the existing gap ● Theoretical framework	Discusses the relevant literatures and theoretical framework
Chapter 4	Methodology ● Descriptions of research method	Presents the methodology adopted for this research
Chapter 5	Results ● Numerical results of qualitative and quantitative data ● Analysis of the study	Presents the numerical results of analysis
Chapter 6	Discussion ● Discussion of the analyses	Delivers the interpretations of the research findings
Chapter 7	Conclusion and Recommendation ● Overview of the research and future direction	Wrapping up the dissertation and proposes the future

Figure 1.1: Structure of the Thesis

Chapter 3: Literature review and conceptual model

In Chapter 3, an extensive literature review focusing on dairy supply chain, dairy risk, supply chain risk and risk mitigation strategy mostly associated with the dairy industry,is presented. The literature review relates the current study to the relevant concepts of sustainability and the supply chain. At the same time, attention is also drawn to the existing gap in knowledge.

Chapter 4: Research methodology

The methodological underpinning of this research is presented in Chapter 4. It involves a mixed methodology that combines quantitative and qualitative approaches. The rationale and justification for the methodologyare also discussed.

This chapter describes the process and outcome of a qualitative field studythat was conducted using semi-structured interviews with ten interviewees including executives and employees from two large scale commercial dairy industries with long experience in the Bangladesh dairy sector. Content analysis was used to analyse the responses. Details of the development of the questionnaire for the research survey is also provided in this chapter.

The quantitative approach used in this study is also discussed in this chapter. A survey questionnaire was distributed to twenty two key persons including employees, executives and supply chain members of two large commercial dairy farms in Bangladesh. Quality Function Deployment (QFD) was used to analyse the survey data.

Chapter 5: Results of data analysis

The findings are presented in Chapter 5, where problems encountered during data collection are also recorded. This chapter presents the factors and variables associated with dairy supply chain risk, risk mitigation strategies, relative costs incurred in strategy implementation and the correlation between strategies when two are implemented simultenously. The QFD results including various equations are also described in this chapter, as well as the optimisation results of QFD analysis.

Chapter 6: Discussion

Chapter 6presents a discussion of the research findings based on the research questions and research objectives. Contrasts and comparisonsare made between the two case dairiesin terms of practical implementation.

Chapter 7:Conclusion and future research directions

Chapter 7, the final chapter, presents a summary of the research and the significanceof its contribution to theory and practice. The limitations of this current research study are acknowledged and recommendations of possible directionsfor future research are proposed.

1.9 SUMMARY

This chapter has provided the background and scope of the current research study. Ithas provided an overview of the existing literature, identified the gap in knowledge, and described how the gap has been addressed by this research. It has also discussed the theoretical framework by reference to the concepts of sustainability and supply chain concepts and the use of the Quality Function Deployment (QFD) research process. Furthermore, the research objectives, research questions and key definitions have been outlined in order to point oute the direction of the current research. This chapter concluded with a brief outline of the organisation of the thesis. The following chapter discusses the Bangladesh dairy operation and the detail of the case industries in the light of the current study.

CHAPTER 2: BANGLADESH DAIRY INDUSTRY AND RESEARCH CASE DESCRIPTION

2.1 INTRODUCTION

This chapter provides an account of the basics of the dairy industry and its contribution to the livestock industryin Bangladesh. It also discusses the development of dairy industries, dairy breeds, feeding systems, structures, processs, supply chain networks, factors affecting dairy production, dairy risks and risk management strategies. By showing the scope and future demands of the dairy industryin Bangladesh, this chapter highlights the significance of the industry for the future of the country. In the final section, twocase dairiesare described in terms of their existing operations and procedures for maintaining farming in the Bangladesh environment.

2.2 BANGLADESH DAIRY INDUSTRY

Bangladesh is an agro-based country with a land area of 130,000 square kilometres of which 69.4% is classified as agricultural land. Only 6.6% of the agricultural area is permanent pasture (FAOSTAT, 2005). Agriculture, dairy, poultry and fisheries are the main occupations of the rural people (Shahnaz, Shimazaki and Kato 2004). Dairy is an important livestock sub-sector in the economy of Bangladesh. It provides food in the form of milk, milk products and meat; energy in the form of draft and traction power; fuel for cooking; raw materials in the form of wool, hair, skins, hides, bones, hoof and horns; manure for crops and cow dung for fuel (Raha and Talukder 2004). The dairy industry is a major sub-sector which serves to alleviate poverty and create employment and thus contributes to the economic and social development in the country. In Bangladesh, dairy is not only a popular livestock sub-sector in the rural economy but also a powerful avenue for additional income generation which is passed on to the next generation through inheritance. Thus dairy is increasingly proving to be a worthwhile livelihood option for a large number of households engaged in milk production and trade. But this sector features small scale, unorganised animal holdings, low productivity, inappropriate animal feeding and health care, inadequate infrastructure for procurement, scanty transportation facilities, low processing and marketing facilities for milk and an absence of professional management (Raha and Talukder 2004).

The Bangladesh dairy industry is an integral part of the livestock business, enriched with deep-rooted history, from time immemorial. Dairy farming has been conducted both commercially and at subsistence level since British reign. Milk cow rearing has been practiced by millions of rural households for centuries (Raha and Talukder 2004). According to Hemme and Khan (2004), an estimated 3% of the milk is produced through formal channels (commercial structured supply chain channels) of production in Bangladesh and the remaining 97%is traded by informal distributers (Hemme and Khan 2004). The majority of dairy farms in Bangladesh are privately owned. New entrepreneurs are becoming involved in small scale dairy farming in urban and peri-urban areas (Saadullah 2011). At present, there are fourteen structured companies operating dairy business in Bangladesh. Of these, Milk Vita, BRAC and PRAN hold the largest share of the market (see Table-2.1). The Bangladesh Milk Producers Cooperative Union Limited (BMPCUL) was first established in 1973 under the brand name of Milk Vita. Table 2.1 shows the market share of different dairy enterprises.

Table 2.1: Volume of Sales of Processed Liquid Milk by Different Dairy Enterprises Milk Processing Capacity, 2007 (Haque 2009)

Sl. No.	Dairy (Establishment Year)	Average milk Collection (litres/day)	Small-holder Milk Suppliers	Percentage of Market Share
1	Milk Vita (1973)	200,000	150,000	52%
2	Amomilk (1996)	10,000	5,000	2.6%
3	Tulip Dairy (1998)	3,000	2,000	0.78%
4	Arong-BRAC dairy (1998)	80,000	70,000	21%
5	Bikrampur Dairy (1998)	10,000	6,000	2.6%
6	Shelaida Dairy (1998)	10,000	4,000	2.6%
7	Aftab (1998)	8,000	4,000	2.08%
8	PRAN (2001)	40,000	30,000	10.42%
9	Grameen- CLDDP (1999)	7,000	6,000	1.82%
10	Rangpur Dairy (2007)	8,000	7,000	2.08%
11	Akij Group (2007)	4,000	500	1.04%
12	GrameenDanone (2007)	1,000	From CLDDP	0.26%
13	Savar Dairy (1974)	3,000	From own farm	0.78%
14	Army	Self-consumption	From own farm	
Total		384,000	284,500	

2.2.1 Structure of dairy farms in Bangladesh

In Bangladesh, 90% of dairy farms have an average farm size of 1–3 cows; 96% have an average of 110 cows. The remaining 4% of the farms have more than 10 cows (Hemme and Uddin 2009). The majority of dairy farms in the country are privately owned. These can be categorised into five different groups on the basis of their primary use of cows and farm size (Saadullah 2011):

a) Dairying for home consumption: This group comprises farmers with large and medium size farms, who normally keep 1–3 cows to meet primarily their household demand for milk products, the surplus being sold in the local market

b) Dairying for dual purposes (cultivation and milking): Farms in this group take the form of a rural household with 2–6 animals, including both bulls and dairy cows. They often have to use their dairy cows for cultivating. During the off season when cows are free from agricultural farm use, they produce milk which is sold to markets.

c) Small-scale dairy farming: This group comprises farms with small- and medium-size livestock holdings, having 2–5 cows and aided by financial and technical support from the government, NGOs and cooperatives. 90% of the milk is sold to a nearby milk market.

d) Medium size commercial dairy farming: This group is made up of medium size households keeping 6–25 cows and also receiving mostly government incentives or cooperative support to establish rural dairy farms. All the milk and milk products are sold to the market.

e) Private large commercial dairy farms: These are modern dairy farms, which are privately owned, usually keeping 26+ cows. 98%of the milk is sold to a milk processing company with a nearby collection point (Hemme and Khan 2004).

Small dairy farms are part and parcel of almost every family home in the rural areas. Interestingly, large private farms produce the maximum proportion of milk compared to millions of small-scale farms, but it is the small scale farms that fulfil the nutritional demands of the local community. Dairy cooperatives were established to collect milk from rural communities to supply the city areas where consumption is higher than the rural communities. The next section discusses the genesis of cooperative societies in Bangladesh.

2.2.2 Genesis of Cooperative Union in the Bangladesh dairy industry

Before the partition of India, in 1946, an organisation named 'National Nutrients Co. Ltd.' made a plan to set up a dairy plant with a capacity of 2,000 litres of milk per day at Lahiri Mohanpur, Pabna (presently Serajganj district). However, the plan was not fully executed due to the partition of India and Pakistan in 1947 (Raha and Talukder 2004). In 1952, Eastern Milk Products Limited, a private company, purchased this dairy plant from the original owner, Mr Mokhlesur Rahman of Calcutta, and adopted the brand name Milk Vita. In 1965, a cooperative system was introduced into the management

and operation of the plant and the first milk producers' cooperative society was formed, with government patronisation (Haque 2009).

In 1967 it was handed over to the Cooperative Marketing Society. In 1973, soon after the liberation, the Government of the People' Republic of Bangladesh initiated a development project titled Cooperative Dairy Complex, based on recommendations from the United Nations Development Program, the Danish Agency for Development Assistance (DANIDA) and the Food and Agriculture Organization of the United Nations (Jahan and Rahman 2003). Both dairies were amalgamated into the new project named, Eastern Milk Producers' Cooperative Union Ltd., was maintained until 1977. Subsequently, it was changed to the Bangladesh Milk Producers' Cooperative Union Ltd. There were about 335 primary milk producers' cooperatives with a membership of over 28,000 small and landless farmers around this plant area (Haque 2009). Milk Vita owns the largest processing plant in the country and collects milk from 565 primary associations of milk producers, each comprising 60 to 80 members (Knips 2006).

In 1983, BRAC initiated a new livestock programme in Manikgonj. BRAC also offered a package of services including credit, skill training, artificial insemination (AI) and veterinary services to reduce the rate of animal mortality, improve the breed and increase productivity (Halder and Barua 2003). Later BRAC initiated a dairy food project under the brand name of Arong with the establishment of seven chilling centres in the Sahajadpur, Pabna and Manikgonj districts with a total handling capacity of 27,000 litres per day (Halder and Barua 2003).

The project expanded to another five districts and 13 new chilling centres were established in different districts of Bangladesh. Moreover, PRAN Dairy Limited, a sister concern of the PRAN group, began to place more emphasis on its dairy sectors. In 2001, PRAN established nine chilling centres (PRAN 2005). Table 2.2 provides a summary of different plants established by BMPCUL based on year, capacity and distance from the capital city of Dhaka. Table 2.3 shows the BRAC chilling facilities in different places at different times. The next section discusses the scope of the dairy sector in Bangladesh.

Table2.2: Plants of the BMPCUL (Raha and Talukder 2004)

Location	Distance from Dhaka (km)	Nature of plant	Capacity/ Day (Litre)	Date of installation
Mirpur	10	Processing	110,000	May 1976
Tangail	100	Chilling	10,000	June1975
Manikganj	90	Chilling	10,000	September 1975
Takerhat	190	Pasteurisation	25,000	December 1977
Baghabari	125	Processing	162,000	October 1993
Rangpur	300	Chilling	10,000	December 1995
Bhangura	155	Chilling	5,000	October 1999
Lahirimohanpur	155	Chilling	10,000	November 2000
Bhairab	75	Chilling	5,000	April 2001
Raipur	208	Chilling	10,000	February 2002
Natore	265	Chilling	5,000	January 2003
Islampur	211	Chilling	5,000	May 2003
Gabtali	185	Chilling	5,000	June 2004

Table 2.3: The BRAC Chilling Facilities (Halder and Barua 2003)

SL No.	Name of Chilling Centre (CC)	Year of Establishment	Handling Capacity ('000 Litre/day)
1	Shahjadpur CC, Serajgonj	1998	6
2	Bera C & B CC, Pabna	1999	10
3	Bera CC, Pabna	1998	2
4	Sujanogor CC, Pabna	1998	2
5	Ataikula CC, Pabna	1998	3
6	Vhangura CC, Pabna	1998	8
7	Foridpur CC, Pabna	2000	10
8	Demra CC, Pabna	1999	6
9	Betila CC, Manikgonj	1998	2
10	Kawalipara CC, Manikgonj	1998	2
11	Birampur CC, Dinajpur	2001	2
12	Thakurgaon CC	2002	2
13	Amtala CC, Barguna	2003	2

2.2.3 Scope of the dairy sector

Dairy provides nutritional security by producing milk which is only one of many direct products those farmers receive from dairy cattle rearing. Milk is used for child feeding and in the preparation of dessert items, and meat is a source of protein (Halder and Barua 2003). Dairy animals comprising cows and buffaloes are the major source of drafting power. This reduces production costs in agriculture and can be considered as indirect income (Saadullah 2011). Apart from their role in milk production, cattle contribute as an important source of organic fertiliser by providing manure for crops. They also contribute to the industrial sector by providing hide, skin, and bone as industrial raw materials (Shamsuddoha and Edwards 2000). In addition, if attention is paid to proper waste management, bio-gas can be produced (PRAN-RFL 2007).

The scope of dairy is very promising as 5.67 million tons of milk produced in the 2012–13 fiscal years which is 46.32% more than 2011–12 fiscal year (DLS 2014). Importantly, such milk production covers 91.03 mL/day or 32 litres/year/person (ChartsBin 2015). This consumption is remarkably lower than the world average consumption of 108 litres/year/person (ChartsBin 2015). The countries with the highest milk consumption are Finland, Sweden, Netherlands and Switzerland where people consume 361.19 litres, 355.86 litres, 320.15 litres, and 315.78 litres/year/person respectively (ChartsBin 2015). The following section discusses the present status of the Bangladesh dairy industry.

2.3 PRESENT STATUS OF BANGLADESH DAIRY INDUSTRY

The following shows the present status of the Bangladesh dairy industry.

2.3.1 Bangladesh dairy at a glance

According to DLS (2005), the numbers of livestock in Bangladesh are estimated to be 22.6 million cattle, 1.06 million buffalo, 18.4 million goats, 2.38 million sheep, 164.1 million fowls, and 13.5 million ducks (cited in Bari,2008). Milk production was 2.27 million tonnes in 2006 (Haque 2009). Half of the milk is produced in the north of the country (Hemme and Khan 2004). The four major milk sheds in Bangladesh are in Tangail, Manikgonj, Baghabari (Sirajganj) and Takerhat (Madaripur). Hemme and Khan (2004) estimate that 3% of the milk produced through formal channels（commercial structured supply chain channels) of production and the remaining 97% are traded by informal distributers. New entrepreneurs are becoming involved in small scale dairy farming in urban and peri-urban areas (Saadullah 2011). Low productivity, small scale and unorganised firms, inappropriate animal feeding, inadequate infrastructure and the absence of professional management are the main characteristics of this industry (Raha and Talukder 2004). Figure 2.1 shows milk production and change from 1996 to 2010.

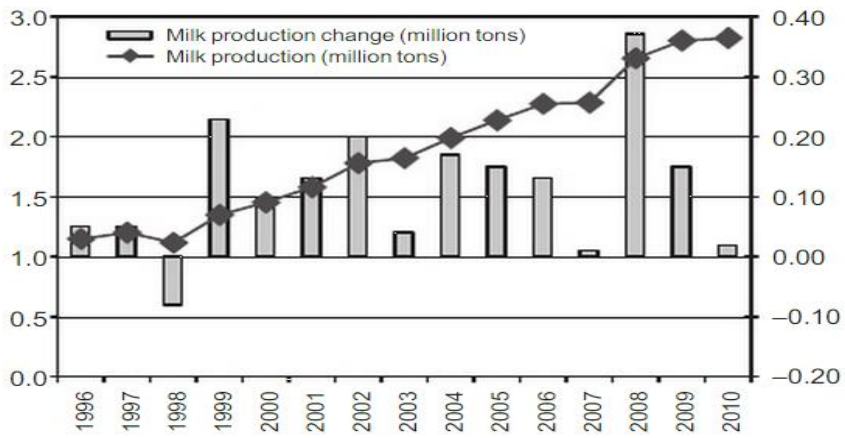


Figure 2.1: Milk Production and Change in Bangladesh (million tons) (DLS 2012; Hemme 2010)

2.3.2 The development of the dairy industry in Bangladesh

The development of the dairy industry in Bangladesh has been inconsistent due to natural, political and methodological issues, a failure to protect cattle from outbreaks of disease and improper implementation problems (Rahman 2015). In Bangladesh, 10 million dairy cattle, including 4 million cross-breeds, produce 2.82 million tons of milk. This is much lower than Pakistan, where only 5.5 million dairy cattle produce 25 million tons of milk (Raja 2001; DLS 2010; Hemme 2010). Bangladesh has doubled its milk production in the past decade but the growth rate has fluctuated considerably due to natural disasters, regular flooding and the severity of the monsoons (Uddin et al. 2011). The long-standing floods in 1998 and 2004 and the *sidor* (like a tsunami) in 2007 affected milk production drastically. Crucially, the nationwide prevalence of anthrax during the last quarter of 2010 dramatically decreased milk production from 5.4% in 2009 to 0.7% in 2010 (Hemme 2010).

2.3.3 Dairy products and production in Bangladesh

The Bangladesh Milk Producers Cooperative Union Limited (brand name Milk Vita) products include fresh milk, flavoured milk, butter, ghee, ice-cream and sweet curd. The products of Arong (a concern of BRAC) include low fat fresh milk, flavoured milk, butter, ghee, yogurt, UHT fresh milk and UHT flavoured milk. Basically dairy products in Bangladesh can be categorised into two types:

a) **Traditional dairy products:** Traditionally milk is consumed in liquid form in Bangladesh. Before consumption, milk is boiled to prevent spoilage and micro-organisms (Jabbar 2010). Milk is also consumed in the form of curd and sweets and

clarified butter. Basically local sweet shops produce and sell the traditional dairy products. The traditional dairy products of Bangladesh are shown in Figure 2.2.

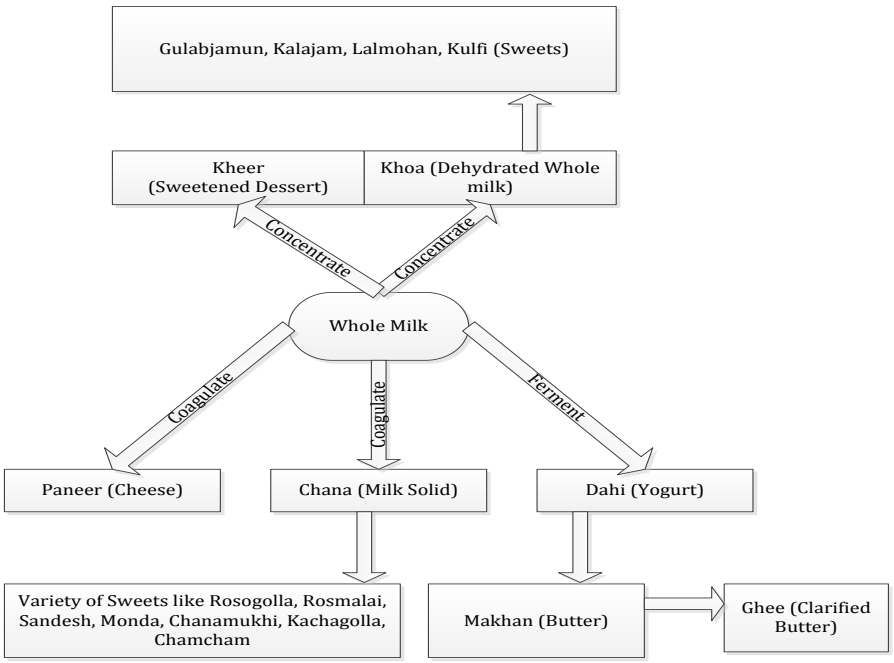


Figure 2.2: Chart of Traditional Dairy Products of Bangladesh (Shahnaz, Shimazaki and Kato 2004)

a) **Non-traditional dairy products:** Among the non-traditional dairy products, processed liquid milk, skimmed milk, milk powder, condensed milk, ice-cream, full cream milk, flavoured milk and butter are the most common in Bangladesh. The non-traditional dairy products are depicted in Figure 2.3.

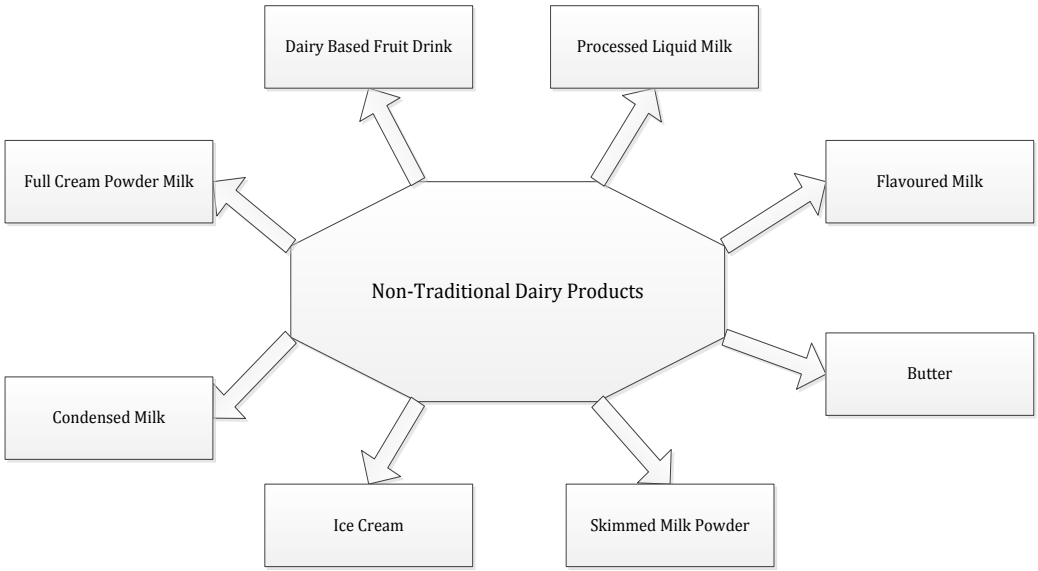


Figure 2.3 Chart of Non-traditional dairy products of Bangladesh (Shahnaz, Shimazaki and Kato 2004)

2.3.4 Factors influencing dairy sector growth

The growth of the dairy sector is influenced by many factors including technology implementation and policy intervention. Technologies relating to feed, veterinary services, and policy relating to investment in infrastructural development, technology delivery and regulation of input and output markets, can alter the market situation (Jabbar 2010). With respect to the dairy sector, Jabbar found that dairy farming is affected by many factors. These include: i) Feed scarcity or poor quality of feed, ii) Poor quality breed of cattle, iii) Frequent occurrence of diseases, iv) Shortage of technical skills and limited knowledge, v) Lack of credit support and insurance coverage, vi) Limited milk collection and processing facilities, and vii) Absence of proper market information. Scarcity of cattle feed and poor quality of cattle feed results in low productivity of cattle. Most of the farmers in Bangladesh are used to feeding their cattle with crop residues and cereal by-products. A few dairy farmers produce Napier grass and supplement it with broken rice, oilseed meals and other by-products. However, in most cases this feed management is done in an unscientific manner and does not improve productivity.

Milk collection and processing facilities are very limited in Bangladesh and milk producers have very limited access to the market (Raha and Talukder 2004). An assured market and a reasonable price for the dairy producers can significantly contribute to stabilising the milk production and dairy sector development. Diseases and parasites are a major concern for the dairy industry and can impede dairy sector growth, but vaccination and veterinary services are poor and limited because of budgetary constraints (Shamsuddoha and Edwards 2000). The animal health services need to be developed and upgraded at every level by means of quality training programmes. The development of sectoral growth depends on efficient and successful marketing activities. The objective of any marketing programme is to physically distribute products to consumers in an orderly manner so as to satisfy the customers and ensure profit to producers and processors. Efficient milk collection and processing facilities are needed for perishable nature of milk. Such facilities are rare in Bangladesh to maintain high quality supply.

2.3.5 Cattle feed and feed management

Normally cattle are fed with agricultural by-products, mainly rice straw which constitutes more than 90% of total cattle feed energy intake. As cattle fodder, shrubs,

tree leaves, tender shoots and twigs are also traditionally used in the village (Saadullah 2011). Everyday each head of cattle needs 8 kg of green grass and 2 kg of rice straw but there is a deficit of more than 57.44 million tons of green grass and 0.17 million tons of rice straw in Bangladesh (Jahan and Rahman 2003). During the dry season, Bangladesh experiences a shortage of feed and especially quality feed. In the rainy season, plenty of green grass grows on the river sides, roadsides and embankments, but surplus green grass cannot be preserved due to a shortage of knowledge, technology and infrastructure. Thus the cattle do not receive adequate feed as per their requirement most of the year. Dairy farmers are recommended to feed 1 kg concentrate for 2-3 kg of milk yield (Khan, Peters and Uddin 2009). The concentrate feed contain rice polish, wheat bran and oil cakes, which are expensive. So small scale farmers cannot afford to buy the required amount of concentrate. Some farmers of medium and large farms feed concentrate regularly to their animals. Due to a shortage of knowledge, some rich farmers feed their cattle concentrate adlibitum basis, which results in a lower conception rate (Khan, Peters and Uddin 2009).

2.3.6 Cattle breed and breed management

Over 90% of the cattle in the country are of the indigenous *zebu* type and the remaining 10% are either pure breeds of Sahiwal**,** Sindhi, Holstein Friesian and Jersey or their crosses with indigenous cattle (Khan, Peters and Uddin 2009). Indigenous cows are usually characterised by low production of milk, short lactation and prolonged calving intervals (Halder and Barua 2003). However indigenous cows also have some favourable characteristics, including affordable maintenance cost, strong resistance to local diseases and high adaptation to the local environment (Ghosh and Maharjan 2001). But these types of cows are not suitable for commercial farming because of their low production rate. The Department of Livestock Services (DLS) has an extensive artificial insemination (AI) network consisting of 22 District Artificial Insemination or AI centres, 433 Upazilla AI sub-centres and 641 Union AI points using liquid and frozen semen (Ghani and Rahman 2004).

2.4 CONTRIBUTION TO RURAL AND NATIONAL ECONOMY

In Bangladesh, dairy is a popular livestock sub-sector of the rural economy and a powerful avenue for additional income. Thus dairy is an important and growing sector of Bangladesh's economy, and is increasingly proving to be a worthwhile livelihood option for a large number of households engaged in milk production and trade. The contribution of the livestock sub-sector and the agriculture sector as a whole to Gross

Domestic Product (GDP) is currently 3.2% and 19% respectively (BBS 2010). Table 2.4 shows that the livestock sub-sector contribution in 2012-13 was 2.45% of GDP while the annual growth rate was 13.91% which was slightly down from the year 2008-09. Furthermore, dairy generates more job opportunities in production, processing and sales and marketing, particularly for the rural poor, many of whom regard livestock as their only livelihood option (Bari 2008; Saadullah 2011). The small scale dairy also contributes to the creation of employment opportunities for family members of the entrepreneur which helps to reduce unemployment in the country. Likewise the dairy sector contributes largely by offering sustained employment opportunities, particularly for rural poor through income and employment generation.

Table 2.4: Contribution of the Livestock Sector to GDP (Raihan and Mahmud 2008; BBS 2008)

	Year			
	2000-2001	**2005-06**	**2008-09**	**2012-13**
GDP (%)	2.95	2.92	2.73	2.45
Annual Growth Rate	2.81	6.15	15.83	13.91

This sector also serves as a concrete tool in the development of the village level micro-economy of Bangladesh by improving rural livelihoods and alleviating rural poverty (Shamsuddin et al. 1987; Shamsuddin, Alam, Hossein, Goodger, Bari, Ahmed and Hossain 2007). Between 1996 and 2006, the livestock sector accounted for 2.45% of GDP and 15% of employment (Jabbar 2010). Small scale livestock farming provided self-employment to approximately 3 million poor women during the years 1993–2002 (Karim et al. 2010). The livestock sub-sector contributed 3% of GDP in 2006, but this amount doubles (i.e. 6%) when the indirect benefit of draught power, manure for fuel and fertiliser is added to the direct economic output of meat, milk and hides (Haque 2009). Moreover, the dairy sector makes a considerable contribution to the agricultural sector and also serves as a source of food (milk and meat) and industrial raw materials (horn, hair and hide). The value of milk in the early protein nutrition of young children cannot be underestimated as it provides good nutrition and resistance against disease, and also supports the development of the child's cognitive abilities.

The contributions of the dairy sector can be categorised in terms of three factors: economic, social and environmental, as shown in Table 2.5. In summary, the economic contribution of the dairy industry is high GDP, better export earnings and sources of secondary income; the social contribution is poverty alleviation, protein needs,

employment generation and national health and nutrition; and the environmental contribution is energy producing bio-fuel, biogas and the creation of biodiversity.

Table 2.5: Sustainable Contribution of the Dairy Sector

Economic	Social/ Organisational	Environmental
Higher GDP Higher export earnings Source of secondary income	Poverty alleviation Improvement of living standard Contribution in fulfilling our daily protein needs Employment generation Contribution to national health and nutrition by providing fresh milk and milk products	Optimisation of available resources: energy for drafting, raw material in the form of wool, skins, bones, etc. Optimisation of unused resources: cow dung for fuel and manure purpose, biogas Biodiversity creation

Source: (Raha and Talukder 2004; Bari 2008; Halder and Barua 2003; Shamsuddoha and Edwards 2000; Shamsuddoha 2009)

2.5 DAIRY SUPPLY CHAIN PROCESS

The dairy supply chain in Bangladesh is exclusively dominated by the informal private sector. Only 3% of total production is processed and marketed through formal channels. The remaining 97% is marketed by informal agents in raw form in the supply chain (Hemme and Khan 2004). The dairy supply chain consists of various groups, each performing a dedicated role at a relevant point in the chain. A chain of dairy producers, collectors, middlemen, processors, traders/wholesalers/retailers, and consumers is involved in transferring milk and milk products from producers to consumers (Saadullah 2011). The party involved at each point is briefly mentioned in Table 2.6.

Table 2.6: Parties involved in Bangladesh Dairy Supply Chain

Type	Description
Dairy producers	Rural home consumption farmers, rural dual purpose farmers, commercial dairy farmers, & city and peri-urban milk producers
Dairy collectors	Goala, Paikers (wholesalers) milk collection centres and dairy cooperatives
Milk processors & producers of milk products	Gosh (who use milk for preparing sweet, curd and ghee) khoya makers, confectioners, pasteurising plants, UHT milk plants, chilling plants
Milk retailers	Sweet shop, tea shop, restaurant, local hotel, urban hotel, grocery shop, super market, departmental store
Consumers	Consumers of fresh milk, consumer of milk products, local consumers and urban consumers.

Feed, veterinary and animal health services, financial and artificial insemination services play a vital role as links in this chain. There is an organised supply chain network for the formal and large scale dairy industries in Bangladesh. The BMPCUL and BRAC are the two leading dairy ventures in the country and they provide feeds, vaccines, and AI services to the dairy farmers. The chain of milk marketing from producer to consumer which is developed by the large scale dairy industries and the cooperative societies is shown in Figure 2.4.

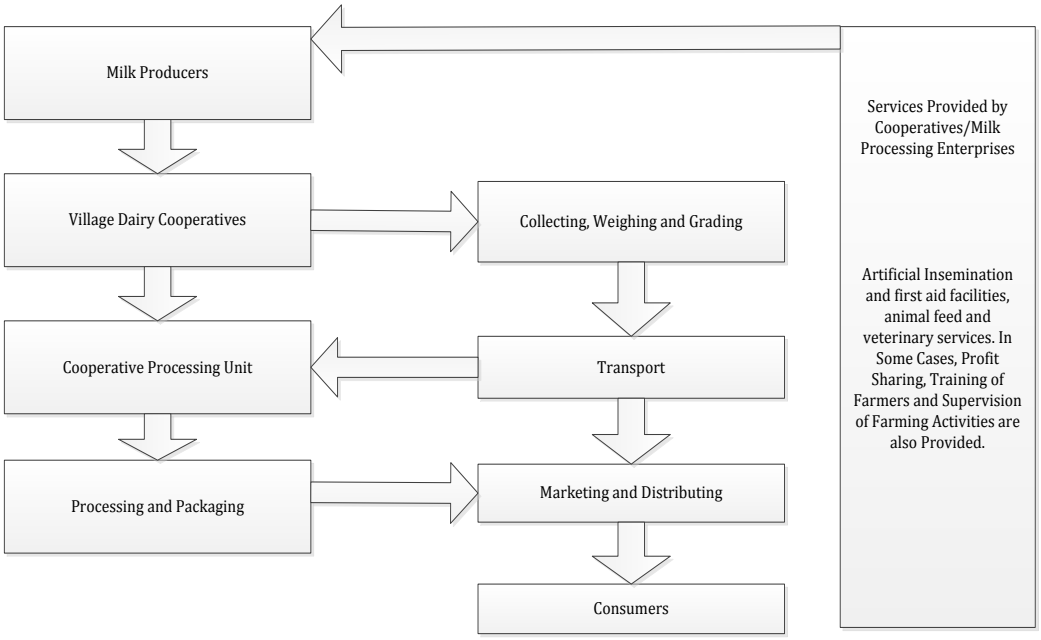


Figure 2.4: Milk Marketing Chain (Saadullah 2011)

There are formal and informal sectors for processing and marketing dairy products in Bangladesh. The processing and marketing systems differ between formal and informal sectors. The formal sectors consist of public and private sector companies/dairy cooperative such as Milk Vita, Arong, PRAN dairy, Rangpur dairy, etc. In the informal sectors, there are different groups who are engaged in the trade of milk. Goala (milkman) is the active player of this sector. Goala is the local term for milkmen who collect milk from the farmers' houses and sell it through door-to-door visits and to the local market. There is also a group of people named Paikars (wholesalers) who buy and sell milk in larger quantities on a regular basis by maintaining regular contact with the large scale commercial dairy farms. Another group, who are called Ghosh, are also associated with this sector. Normally Ghosh (retail milk seller) are engaged in preparing milk products and sweets from milk. They buy bulk amounts of milk from the Paikers. After collecting milk from the producers or local market, the Paikers

sometimes supply it to different chilling centres but this is limited only to selected areas (Halder and Barua 2003).

In case of the formal sector of the dairy industry, there are organised collection, processing and marketing procedures. Bangladesh Milk Producers Co-operative Union Ltd (Milk Vita), BRAC (Arong), PRAN dairy, Rangpur dairy and some other private dairy industries in Bangladesh have their own contact farmers in urban and peri urban areas for processing, packaging and marketing activities (Saadullah 2011). Figure 2.5 shows the dairy processing and marketing system in Bangladesh as described by Halder and Barua in 2003.

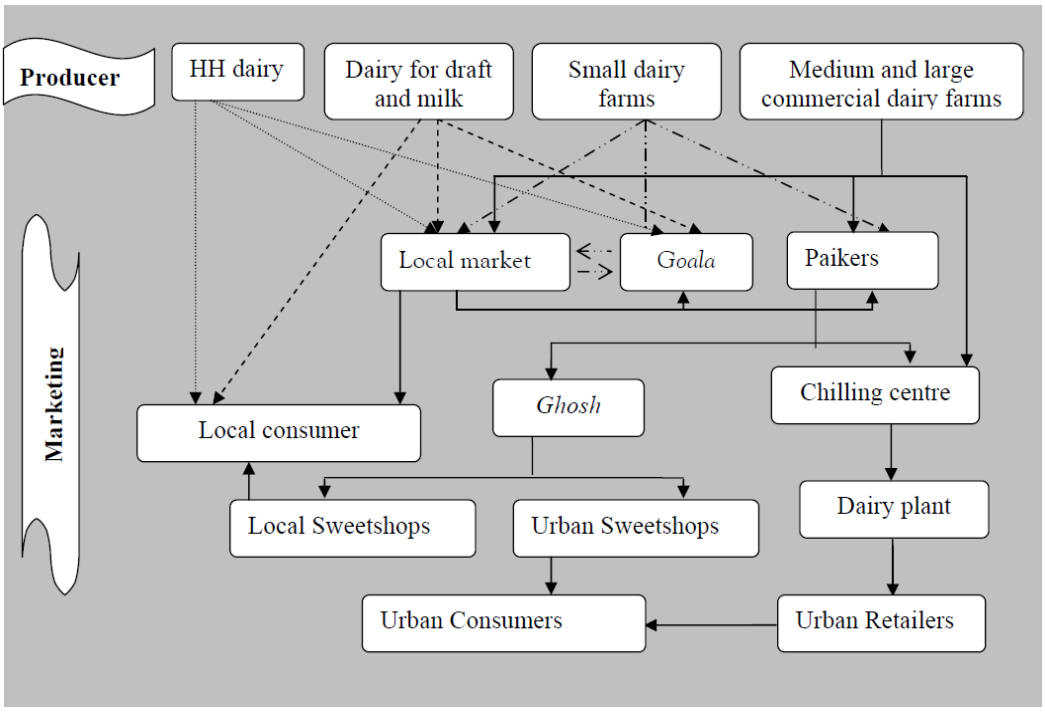


Figure 2.5: Dairy Processing and Marketing System in Bangladesh (Halder and Barua 2003)

2.6 RISKS IN THE DAIRY SECTOR OF BANGLADESH

Bangladesh dairy industries, especially small and medium scale industries, face difficulties relating to insufficient supplies, poor technological adoption and low yield at harvest. Small and scattered animal holdings, scarcity of feed and pastureland, and limited availability of quality feed are major constraining factors, which generate risks in commercial growth of the dairy sector. Frequent occurrences of diseases resulting in high losses are also a risk factor. The country's climate, along with the poor nutritional status of cattle and limited coverage of veterinary services, are responsible for the

frequent occurrence of diseases. There are also limited credit and insurance services support which is most important but unavailable for the dairy business.

Milk collection and processing facilities are also inadequate, along with an erratic power supply which brings significant difficulties to the dairy supply chain and generates huge financial losses, largely as a result of milk spoilage when milk cannot be effectively chilled. Storage is another problem during peak seasons because the majority of rural farmers do not have refrigerators. The absence of adequate and appropriate transport to move milk from rural areas to urban markets is also a major distribution risk to the Bangladesh dairy industry. This sector does not attract adequate attention from researchers (Shamsuddoha and Edwards 2000). Although dairy farming is an ancient occupation of the people of Bangladesh, this sector is not free from risks. Different types of problems associated with this industry create different risks in its different sectors. Problems which may create risks for the dairy supply chain fall into three sustainability categories. These are shown in table 2.7.

Table 2.7: Risks to the Dairy Sector from Sustainable Perspectives

Economic	Social/ Organisational	Environmental
• Inadequate credit facilities • Lack of organised market • Scarcity of land • Scarcity of quality feed • High cost of feed • Inadequate transport facilities. • Scanty adaptation with modern technology. • Inadequate treatment facilities AI facilities	• Shortage of professional staff • Inadequate public and private investment • Poor infrastructure facilities • Poor training facilities. • Absence of proper market information • Heavy dependence on imported products. • Mismanagement of staff • Absence of research centre • Lack of fixed government policy • Involvement of middlemen	• Climatic change • Repetitive occurrence of diseases • Natural disasters: flood, heavy rainfall, storm, earthquake etc. • Pollution

Source: (Shamsuddoha and Edwards 2000; Bari 2008; Raha and Talukder 2004; Halder and Barua 2003; Curtis 2011)

2.7 RISK MANAGEMENT STRATEGIES FOR DAIRY INDUSTRIES IN BANGLADESH

In Bangladesh livestock services are provided to farmers by different public sector organisations, including the Directorate of Livestock Services (DLS), the Bangladesh

Livestock Research Institute (BLRI), a number of Non-Governmental Organisations (NGOs) and cooperative societies such as Milk Vita. Different services are provided to the farmers in order to mitigate or minimise the different risks associated with the dairy industry. Table 2.7 categorises some of the risks in terms of three sustainability aspects.

a) Breed management

Dairy farming in Bangladesh has been enhanced by improving local breeds of dairy animals through artificial insemination services. Artificial insemination services are provided by a number of organisations, including DLS, Milk Vita and BRAC. The BLRI is also engaged in developing appropriate breeds to suit the local environment. Additionally, they are involved in researching diseases and epidemiology of the bovine population (PRAN-RFL 2007). Moreover, to foster rapid development in the dairy sector, the government recently allowed the commercial import and distribution of exotic breeds of cattle with subsidised credit (Islam et al. 2001).

b) Feed management

To improve dairy productivity, researchers and government officials need to give special and immediate attention to issues of feeding and nutrition. Many commercial farms in Bangladesh have their own feeding standards for dairy animals. These standards vary among farms due to differences in breed, available feed resources, financial ability and possible level of technology.

c) Financial services

Access to finance to enable farmers to expand their dairy production is complex. In Bangladesh, some NGOs provide micro-credit which is highly valued by farmers. Under this programme, farmers receive training to become eligible to obtain this credit for rearing poultry, fattening cattle, milk cows, and goats (Jahan and Rahman 2003). So beneficiaries are able to expand their business with the help of both credit and training.

d) Education and training programme

Farmers need training in animal care, housing management, hygiene practices, and prevention of diseases, vaccination, de-worming, and resource utilisation for improved productivity of safe milk. Particular breeds, especially highly productive breeds, need very precise management for optimum output. In this regard, a joint effort of public-private organisation is needed to educate and train farmers. The DLS (Directorate of

Livestock Services) has five training institutes which are primarily used to provide basic knowledge about dairying. So far the DLS has trained 10,000 voluntary rural workers in different types of package rearing (Islam et al. 2002).

e) Dairy Development Board

Considering the great potential for increased production of livestock products to meet current market demand, the Bangladesh government has commenced various measures, including the provision of institutional loans through the public sector, extension services for breeding and raising cattle, and fostering commercial farms (Shamsuddoha and Edwards 2000). The government has also developed a National Milk Grid which identifies the surplus and deficit milk production zones and seasons so as to improve milk quality and reduce seasonal variations in milk production and consumption (PRAN-RFL 2007).

f) Technology adoption

BLRI has the authority to generate low-cost technologies to advance livestock production, but since its establishment in 1985, it has failed to adopt suitable technologies for the rural poor due to poor staffing and low motivation and commitment of staff (Jahan and Rahman 2003). In contrast, DLS has introduced fodder extension technologies by means of fodder nurseries at dairy farms and different veterinary hospital compounds (DLS 1998). Through these nurseries, small dairy entrepreneurs acquire most of the fodder genetic materials at a very low price to established milk processing plant to balance the market demand and supply.

g) Improvement of extension services

The lack of effective livestock extension services is a well-recognised limitation to the expansion of Bangladesh livestock production. Good extension workers try to utilise every single opportunity to spread their messages using all the advances in communications science that are available to them. These may include group talks, farm demonstrations, posters and cartoons, leaflets and comic strips (Shamsuddoha and Edwards 2000). In the private sector, most companies offer extension services to their suppliers, but the government is still far behind the private companies when it comes to offering extension services to encourage dairy development. The major extension services provided by the DLS include entrepreneur development, feed production, arrangement of training programme and technology development (Saadullah 2000). The extension services of BMPCUL (Milk Vita) include Artificial

Insemination and veterinary services with a focus on improving the quality and quantity of milk (PRAN-RFL 2007).

h) Animal health services and veterinary services

The most voluminous component of the DLS's service is animal health protection and veterinary services. These services are provided through a network of 464 Upazila Veterinary Hospitals (UVH), nine regional diagnostic laboratories, seventeen district diagnostic laboratories and one Veterinary Vaccine Production Laboratory (VVPL) (Jahan and Rahman 2003). The VVPL produces the necessary vaccines to protect cattle from contagious diseases like foot and mouth disease, Black Quarter, Anthrax, Haemorrhagic Septicaemia and so on. The different veterinary services used by the dairy producers include vaccination, clinical assessment, internal parasite control, bull services and so on. DLS and BMPCUL provide various veterinary services (Islam et al. 2002). The Upazilla Veterinary Hospitals (UVH), each of which is staffed with 3 to 5 Veterinary Field Assistants (VFA), one Upazilla livestock officer, one veterinary surgeon and one compounder, works as the nucleus of DLS activities at grass roots level. Besides these, 20 national and 150 local NGOs are engaged in delivering services related to disease protection, as well as some output services (Jahan and Rahman 2003). Moreover, there are about 25 pharmaceutical companies engaged in the manufacture or import of livestock drugs, vaccines, sera, premix and vitamins (Jahan and Rahman 2003).

The above sections of the thesis provided an account of the Bangladesh dairy industry and its status in terms of present conditions, scope and risks associated with the industry. The following section presents details of the case dairies used in this research.

2.8 THE CASE DAIRY DESCRIPTION

This section introduces two well-known Bangladesh dairy farms which are used as case studies in this research, and presents details of their history, market share, vision, production, supply chains, products and the technologies used in their operation.

2.8.1 THE CASE DAIRY FARMS

The two dairies, Nahar Dairy and Paharika Dairy, were selected on the basis of their production capacity, usage of modern technology and scientific dairy management. They are briefly described below.

2.8.2 NAHAR DAIRY

Nahar Dairy is a sister concern of the reputed 'Nahar Agro Group'. They also have one of the largest and best organised poultry parent stock (PS) farms in Bangladesh. At the same time, they own one of the biggest dairy units in Bangladesh. Many sources confirm that Nahar Dairy is the largest milk producing farm in Bangladesh. Neither farm produces more than 2,500 (maximum 3000) litres milk in a day (Rahman 2015). Figures 2.6 and 2.7 show the physical locations of both farms using Google Earth. The map shows their location close to the Dhaka–Chittagong highway but isolated from the populated areas. Such a place is ideal for the dairy farming. They have chosen isolated and grassy areas to protect against possible disease outbreaks. All of the dairy sheds are environmentally controlled so that no wild species can enter and carry diseases. All farm employees live on the farm and a strict no-visitors' policy is enforced.

The Nahar Dairy farm was founded in the beginning of 1990s. It was initially a family-owned farm, having a cluster of 35 cattle. They have invested one million Bangladeshi Taka[1], which is equivalent to AUD $14,500 (approximately). For around ten years they had a maximum of 55 cattle, worth AUD $30,000, and produced 250 litres of milk per day. In 1999, Nahar Dairy restructured their farm with the introduction of bigger lands, capital and logistics. At present, they have 560 cattle of all kinds with 2,600 to 3,000 litres of milk production a day. Their vision for 2020 is to improve their milk production capacity to around 8,000 litres per day. At the same time, they have incorporated an additional 50 acres of grass land to supply their cattle with healthy and organic feed. They also added chiller facilities holding 3,000 litres to preserve their milk for 8-12 hours. They have expanded their farm to three different locations to rear cattle scientifically and have developed their supply chain network to maintain proper supply.

[1] Taka= Name of Bangladesh Currency

Figure 2.6: Satellite Image of Nahar Dairy (Unit 1), Source: www.maps.google.com

Figure 2.7: Satellite Image of Paharika Dairy, Source: www.maps.google.com

2.8.2.1 Historical background of Nahar Dairy

Nahar Agro Group Limited is an agro-based company. It started its operations in 1986 with a small-scale dairy and poultry rearing. It is now a group of companies that

consists of almost every type of agro-based and livestock business. Poultry, dairy, fisheries, livestock wastage by-products and commercial fruits and vegetables are their main businesses. Of these, poultry has been their highest investment project since 1995. Nahar Agro Group is ranked first in individual milk production and is in the top seven in the production of poultry day-old chicks in Bangladesh (Rahman 2015).

Nahar Agro Group Limited is a family-owned company that started operations in 1986 with 35 laying hens and 15 dairy cows. The initial investment was around AUD $3,000. The present business worth is around AUD $15 million dollars, excluding other associated businesses. The main initiator of this small business operation was the late Tipu Sultan Mahbubur Rahman, who had been an ex-officer of Bangladesh Railway since 1963. After his death in 1994, his wife, Shamsun Nahar, and two of his sons followed him, inspired and motivated by his example of conducting livestock and agro-based business, not only for the sake of their own profit but also for the benefit of the country. His eldest son, Mohammad Rakibur Rahman Tutul, was the most motivated. He became an outstanding entrepreneur. His younger brother, Dr. Mohammad Shamsuddoha (Doha) (Professor of Marketing, University of Chittagong), always backed them with knowledge, time and hard-working attitudes. They started adding new concepts (technology, dynamic ideas, and risk measurement) to their farming procedures, along with high technology from the USA, France, China, Thailand, India, and Canada. At the same time, they managed to get bank finance to develop their new projects and that helped their business to flourish.

2.8.2.2 Vision

The vision statement of Nahar Dairy states that they want to be a market leader through achieving sustainability and introducing hi-tech concepts into their existing operations. Initially, they just started their business and did not think too much about the impact of hi-tech, analysis of the supply chain or sustainability. Now, they are trying hard to incorporate such knowledge into their farming operations so that they can achieve sustainability and stability, gain a larger share of the market, and become a market leader.

2.8.2.3 Market share

Table 2.8 shows the average milk production of the two case dairies from 2010 to 2015. It shows that Paharika Dairy produced more milk in 2010 than Nahar, but

recently, Nahar Dairy has more than doubled Paharika's production, using appropriate management.

2.8.3 PAHARIKA DAIRY

Paharika Dairy was founded at the beginning of 1996 as a private limited commercial farm. They started with around 200 cattle and produced 700 litres of milk per day. They have invested six million Bangladeshi Taka[2] (approximately) which is equivalent to approximate AUD $103,000. This money is to maintain milking machines, chiller machines, transport and science sheds and management. They have slowly expanded their farm. At present, they have 352 cattle of all kinds producing a maximum of 1,300 to 1,500 litres of milk per day.

Nowadays, it has dropped down to 1,000 litres, but they expect to restore their production within a year. Unfortunately, they lost momentum when they failed to expand their farm like Nahar Dairy. Although they have amalgamated 30 acres of grassland to supply their cattle with healthy and organic feed input and also added chiller facilities for 1,000 litres to preserve their milk for hours at a time in the summer, they still confined their farm within the same place to maintain their modest scientific farm. Paharika Dairy has also developed their supply chain network.

2.8.4 COMPARISON BETWEEN THE TWO DAIRY FARMS

Nahar started their farm six years earlier than Paharika but it was on a small scale under family supervision. Although Paharika initiated their farm later than Nahar, they began with a more structured approach. Interestingly Nahar re-launched their farm in 1999 with a huge investment, better management and greater capacity. They have set their visionary targets for expansion and are meeting their targets. Unfortunately, Paharika is getting little sluggish due to its awkward location, poor management and less investment. Nevertheless, both are maintaining their farms in more scientific and hygienic ways than the other farms in Bangladesh. Table 2.8 shows the average milk production for both dairies from 2010 to 2014. It is observed that Nahar Dairy is well ahead of Paharika Dairy in terms of milk production per day.

[2] 1 Australian Dollar (A$) = 57.79 Bangladeshi Taka, July 12, 2015, http://www.oanda.com/currency/converter/

Table 2.8: Average Milk Production of Case Dairies

Year	Nahar Production litre (average)	Paharika Production litre
2010	670	720
2011	877	770
2012	1522	1184
2013	1928	1232
2014	2630	1355

Table 2.9 shows the distinctive features of the two case dairies in order to highlight the differences between them. Some distinguishing features include milk production, competitive advantages, locations, suppliers, number of livestock, number of employees and number of milk sheds. Both farms help each other if required. They have a strategic relationship in light of profit and service maximisation for quality output. It is apparent that Nahar Dairy is much further ahead than Paharika Dairy in terms of their average milk production.

Table 2.9: Distinguishing Features of Nahar and Paharika Dairy Farms

Subject	**Nahar**	**Paharika**
Size (No. of employees)	55	32
Time period	1990-till date	1996-till date
Number of livestock	560	352
Production	2600L-3000 L/day	1300L-1500L/day
Supply	Feni based (Urban area) - Madhumela - Bonoful - MilkVita	Chittagong based (Rural area) - Bonoful - Local consumer
Vision	8000 litre within 2020	-----
Competitive advantage	Strategic location (near highway) 75%-80% breed upgradation More grass/land availability 2 veterinarian Bio-security- high 70-90% mechanised milking but 100% capacity	Country side location/ rural area 50%-60% breed upgradation Less grass/ land availability 1 veterinarian Bio-security- low 50-60% mechanised milking but 70% capacity
Chiller capacity	2500-3000 litre	1000-1350 litre
Milk shed	3 (Olinagar, Chakoria, Mirarsharai)	1 (Fatikchari)

2.8.5 SOURCES OF CATTLE BREED

Initially, Nahar Dairy imported their breeds from different countries including France, USA, Canada, and Australia. Currently, they are close to self-sufficient in terms of breed management for future cattle. On the other hand, Paharika Dairy is also trying to be self-sufficient in breed management, but they are also receiving help from government AI centres and strategic alliances/partners like Nahar Dairy. Table 2.10 presents a list of ten breeds and milk producing companies in Bangladesh. Among them, Nahar Dairy is positioned at the top while Paharika Dairy is in third position on the list. Table 2.10 also provides information about the breeds which are being reared by the different companies in Bangladesh. Most of the companies are relying highly on the Holstein-Friesian and Sahiwal cross breed. They all try to improve their genetics although creating alliances between scientific farms, government livestock and artificial insemination centres.

2.8.6 FARMING UNDER DIFFERENT CALAMITIES

Bangladesh dairies face a huge number of calamities in their operations, including natural and man-made/controlled calamities. Dairy diseases and natural disasters may be categorised as natural calamities whereas over/under production, market demand, government policy and competitors' actions are man-made calamities. Bangladesh is a densely populated country having small area of land for living and cultivation and this disadvantage hinders the growth of the dairy industry in Bangladesh. Moreover, there are no specific industrial policies to isolate dairy zones from the community.

2.8.6.1 Dairy disease

The direct and indirect socio-cultural and economic impacts of disease outbreaks influence policy measures and disturb markets, causing the loss of assets. There are strong negative impacts on the livelihoods of rural communities for all producer groups including small holders. Risk assessment at different points along the supply chain and guidance on measures for safe dairy production are therefore of great importance. Specific consideration should be given to strategies and measures that ensure a sustainable approach to support the poor. Dairy diseases can contaminate the community or market place through ignorant behaviour associated with waste management and improper vaccination. The Bangladesh dairy industry is losing millions of dollars every year due to various kinds of common disease. There is also a fear of mad-cow disease, although there is no evidence of mad-cow disease in Bangladesh.

Table 2.10: Breeds and Milk Collection of Bangladesh (Chowan 2015; Shamsuddoha 2015)

SL No.	Name of Milk Collection Organisation	District	Type of Organisation	Tentative Milk Collection Per Day (Litre)			No. of Milking Cow (App.)	Avg. (Litre)	Total Cow	Name of Dairy Breed
1	Nahar Dairy	Chittagong	Private	2550	To	2850	205	12.56	538	Holstein-Friesian cross and very few number of Sahiwal cross.
2	GUK (Gram UnnonKormochuci)	Bogra	NGO	1025	To	1060	81	12.9	152	Holstein-Friesian cross and Jersey cross
3	Paharika Farms	Chittagong	Private	900	To	1050	105	12.3	352	Holstein-Friesian cross and Jersey cross
4	Molla Dairy	Chittagong	Private	950	To	970	70	13.7	180	Holstein-Friesian cross and Sahiwal cross.
5	Saver Dairy	Shaver, Dhaka	Government	710	To	750	150	4.87	1400	Holstein-Friesian cross and Sahiwal cross, Jersey cross and also meat type Bramaha
6	HosanSoudagor	Chittagong	Private	280	To	290	30	9.5	60	Holstein-Friesian cross and Sahiwal cross
7	Akiz Dairy	Chittagong	Private	260	To	280	61	4.4	250	Holstein-Friesian cross and Sahiwal cross
8	Reduan Dairy	Chittagong	Private	250	To	260	21	12.1	48	Holstein-Friesian cross and Sahiwal cross
9	M/S ShaAmanot	Chittagong	Private	240	To	250	21	11.7	42	Holstein-Friesian cross and Sahiwal cross
10	Khamer Dairy	Chittagong	Private	190	To	210	18	11.1	50	Holstein-Friesian cross and Sahiwal cross
Total				6455		6670	657	10.0	2720	

2.8.6.2 Natural disasters

Bangladesh is a low-lying, riverine country located in South Asia with a largely marshy jungle coastline of 710 km (441 miles) on the northern littoral of the Bay of Bengal. Formed by a delta plain at the confluence of the Ganges (Padma), Brahmaputra (Jamuna), and Meghna Rivers and their tributaries, Bangladesh's alluvial soil is highly fertile, but vulnerable to flood and drought. In a report entitled "A Global Report: Reducing Disaster Risk: A Challenge for Development", the UN Development Programme (UNDP) identified Bangladesh as the country most vulnerable to tropical cyclones and the sixth most vulnerable to floods (UNDP 2009).

According to data from the government's Centre for Environmental and Geographic Information Systems (CEGIS), two-thirds of the country is only five metres above sea level, rendering it particularly vulnerable to sea level rises and tidal waves (www.cegisbd.com). Experts opine that melting Himalayan glaciers and an encroaching Bay of Bengal in the south further increase the risk of flooding (IRIN 2013). Natural disasters hamper various kinds of businesses every year in Bangladesh and the dairy industry is no exception. Market demands and supplies are completely susceptible to natural disaster. If a massive flood occurs, huge numbers of dairy farms have to cease production due to their farm areas and grasslands being under floodwater. Farmers who have no insurance cover lose their capital forever. Thousands of farmers are never able to farm again due to inadequate further sources of finance to recommence their farming. Others somehow manage to obtain funds from financiers, friends, or personal loans with high interest. In this way, some have success and some do not. Nevertheless, most of those who carry on their business despite the vicissitudes of calamities, ultimately achieve success in terms of profitability.

2.8.6.3 Underproduction

Under production is one of the main problems for the dairy industry of Bangladesh. Dairy production is a business which is always controlled by the natural cycle of cows giving birth to calves. The natural cycle determines the milk production cycle and it cannot be manipulated. When a farm forecasts future production, they make plans to ensure that forecasted production will become a reality in the near future. Once milking starts, it must be carried on, as no one can stop its production. This is the reason behind under production based on market volatility. Market volatility is influenced by trends in the consumption of milk and milk related products. Consumption is, in turn, linked to seasons, festivals, and the frequency of social

activities like marriages, birthdays, and post-marriage parties. Dairy disease also influences market volatility, as disease break outs make people panic, resulting in drastic falls in milk related product consumption.

2.8.6.4 Government policy

Recently, the government failed to take proper initiatives to control existing market supply and demand and that created an imbalance in the market. The most suicidal decision taken by the government has been to invite foreign companies to do business in the local market. This kind of decision hampers the ability of local entrepreneurs to do profitable business. Local companies are now really struggling to compete with foreign companies in terms of capital, technology, and market coverage.

2.8.6.5 Market demand

The dairy industry in Bangladesh is not expanding sufficiently to meet the increasing demand for milk and dairy products. Between 2001 and 2011, Bangladeshi milk consumption doubled to 44 millilitres per capita per day (TheDairySite 2013). The production situation has improved slightly but not enough to meet expected target. Therefore, demand is not a major concern. Rather, the concern is to concentrate on production increase and the conversion of milk into milk related products like butter, yogurt and so on.

2.8.7 TECHNOLOGIES USED IN DEVELOPED COUNTRY AND CASE FARMS

There are many types of dairy equipment necessary for successful dairy farming. Entrepreneurs are interested in becoming involved with this business as there are huge opportunities for profit. The demand for dairy and dairy related products is increasing day by day. It is always necessary to have modern equipment and technologies to carry out effective and efficient farming and to achieve maximum output in order to serve the community and the country. Scientific management of housing, grass areas, feeding habits and others are briefly described below:

2.8.7.1 Housing

Appropriate dairy housing is necessary for healthy cattle and high standard milk production. The different kinds of dairy house may include a concrete house, a sealed house with controlled temperature, a roofed shed with no walls, a roofed shed with minimum height walls, and a completely open field with no roof and no walls. The roofed shed with minimum height walls is a popular variation in Bangladesh. They

maintain a moderate temperature by using curtains in the vacuum space in winter and electric fans in summer. Although the standard space required for a cow is around eight or nine square metres, many farms can only provide four or five square metres. Some farms do not have any grassland; they just bring grass in from outside and serve it in the confined housing space. A few more modern farms have separate spaces for resting and grassing their cattle. Interestingly, the findings revealed no evidence of cattle being reared only in grassland. The important things to consider before preparing cattle sheds are sufficient air, light, optimum temperature, adequate feed with grass and enough water to drink all the time.

2.8.7.2 Milking machine/milk parlour

Filipovic and Kokaj (2009), in a study conducted in Croatia, compared the effects of two different milking methods (hand vs. machine milking) on milking time, milk yield, milk composition, somatic-cell-count (quality of milk) and micro-organisms (bacteria and archaea test) in milk. They found that the average milk yield per milking was significantly higher (5.06 vs. 3.69 L, $P<0.05$) and milking time was significantly shorter (4.42 vs. 6.05 min, $P<0.05$) with machine rather than hand milking. Differences in milk composition (fat, protein and lactose contents) using different milking methods were not significant (Filipovic and Kokaj 2009). The average value of somatic-cell-count (SCC) was much higher (65%) in milk from hand milked rather than machine milked cows, but the difference was insignificant due to the excessive discrepancy of the values. The average value of micro-organisms was considerably higher ($P<0.05$) in milk from hand milked cows (Filipovic and Kokaj 2009). Therefore, for these reasons, experts do not recommend hand milking. The case dairies use a mix of hand and machine milking due to inadequate finance and lack of knowledge. But the case dairies determine to raise enough finance to cover 100% automatic milking within a few years.

2.8.7.3 Chiller

A chiller is a reservoir for holding milk for a particular time to prevent it from perishing. Both the case dairies have chiller but not sufficient to their needs. Nahar Dairy has a chiller of 2,000 litre capacity whereas Paharika Dairy has only a 1,200 litre capacity chiller. Both farms have plan to increase their capacity as their existing chiller capacity is not enough to save their milk from different uncertainties like political unrest or natural disasters.

2.8.7.4 Nutrition analyser

In the case of dairy farming systems, it is essential to maintain a nutrition analyser to measure the required nutrition intake for the cows. Herds of different ages need appropriate nutritional intake to deliver the best results in providing milk and meat. Both case dairies use conventional way of analysing nutrition rather than investing more money to adopt the latest analyser.

2.8.7.5 Flooring

Neat, clean and dry floor keeps the cattle herd healthy. So farmers are always trying to keep their floors appropriately hygienic. Indoor farming methods use scratchy brick or concrete floors with a soft artificial bed.

2.8.7.6 Others

The case dairies try to combine local and imported semen so that the next generation can be grown as higher breeds, along with better productivity and less disease.

2.9 SUMMARY

This chapter discussed two different aspects of Bangladesh dairy operations and provided descriptions of the research case studies. The first seven sections of the chapter described the existing status, trends, scope, and contributions of the Bangladesh dairy industry. It revealed the importance of the dairy sub-sector for the Bangladesh economy and its people. The second part of the chapter presented the research case dairies in light of their mission, vision, market share, products, current production, and technologies for maintaining sustainable farming. The discussion also included reference to the various calamities and factors which need to be addressed for successful farming. The next chapter presents a review of the literature on this topic.

CHAPTER 3: LITERATURE REVIEW

3.1 INTRODUCTION

This chapter reviews the literature related to the research topic. It focuses on literature explaining sustainability, dairy supply chain, supply chain risk issues and supply chain risk management. Different sections of this chapter reveal the gaps in the extant literature. This not only informs the current research but also reveals differences between previous research and the current study and confirms the significance of the study. The chapter shows that there has been a dearth of research conducted on dairy supply chain risk management based on sustainability issues. The chapter also describes contingency theory and sustainability theory, both of which are used as theoretical bases to explicate various concepts in the study. This chapter concludes with the construction of a dairy supply chain risk management model.

3.2 WORLD DAIRY INDUSTRY

The dairy industry is an important and dynamic part of the global agricultural economy. Due to the rapidly increasing demand for dairy products, the global dairy industry has flourished in recent decades. But the rapid growth and development of this industry has been beset by a series of problems associated with milk production, processing, distribution and profit allocation (Cross 2006). The worldwide demand for milk and milk products has increased in response to the rapidly increasing population. Recently the private sector has made a large scale investment in dairy production and processing (Godfray et al. 2010). In spite of having different policies to attract private investment into the dairy sector, many hindrances significantly influence the dairy sector in negative ways. The basic concern is that, in most countries, the dairy sector is still unstructured and underutilised. As noted by Vivien Knips (2005), dairy industries all over the world are facing different types of challenges and these are forcing them to reconsider and adopt different strategies. The challenges are related to the growing demand for dairy products, an increasing number of customer requirements, limited market opportunities and the like. The literature also reveals that dairy companies are handling a growing number of consumer necessities, in combination with growing customer power, in a market where the food processing and food service industries are key customers for dairy products.

In India, in response to competitive forces, the dairy cooperatives of different states have started to work in an integrated way by practising supply chain management (SCM). This practice includes inventory management, procurement of milk supplies, logistics and distribution management. Organisations are struggling to overcome the different risks that arise from the immense competition for existing customers (Mishra and Shekhar 2011). The industry is engaged with several stake holders' including milk producers, transport authorities, processors and consumers from rural to urban areas involved in processes like storage, transportation and pasteurisation. With the involvement of so many stakeholders, the system is at risk of being disrupted at various times over the course of its operation. The dairy industry is also confronted by some common constraints like low productivity of cattle, limited processing facilities, limited coverage of veterinary services, improper milk cooling infrastructure, poor road infrastructure, poor quality of milk and seasonal and price variability of milk (Choudhary et al. 2011).

Figure 3.1 shows the world's major cow milk producers in 2013. The United States ranked first having a milk production (cow) quantity of about 91.27 million metric tons (Statistica 2014). The following is a description of each of the world's leading milk producing countries.

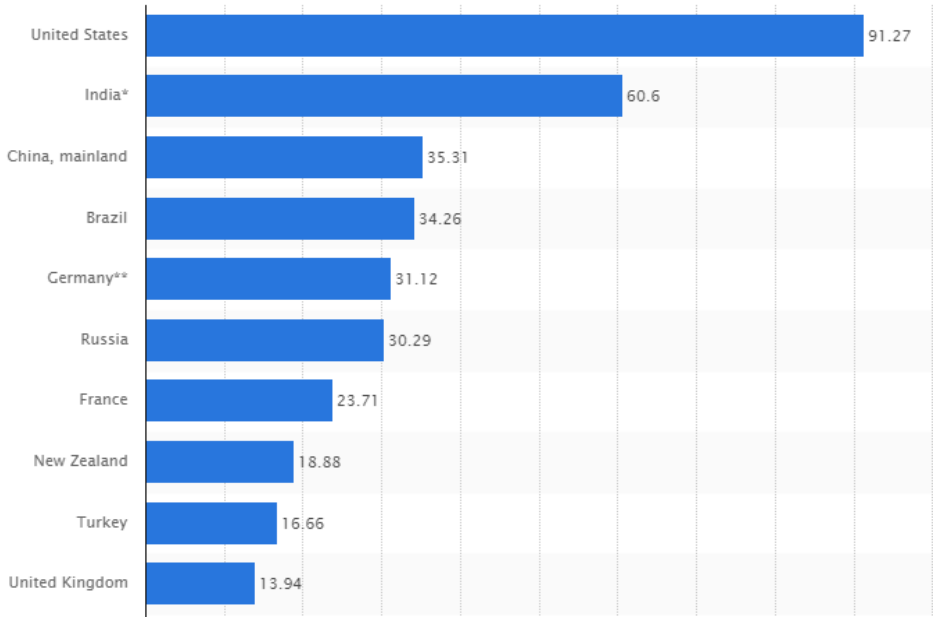


Figure 3.1: Major Producers of Cow Milk Worldwide in 2013, by country (in million metric tons) (Statistica 2014)

3.2.1 USA dairy

The US dairy industry produces10% of the world's milk, with noteworthy structural modification over the past eight years (IUF 2013b).The USA produces around 90 million tons of milk per year. This is generated from 78,000 dairy farms with average dairy herds of 115 cows producing approximately 23 litres per cow (Statistica 2014)(www.thecattlesite.com). Since 1975,the USA has achieved a steady growth of 1.1% per annum, determined by revenue growths of 1.5% and a 0.3% reduction in the number of dairy cows (8,400 litres per cow/year) (www.thecattlesite.com). It is observed that Southeast Asia, Mexico and Canada remained the major destinations for US dairy products, whereas Canada, New Zealand and Italy are the top three countries retailing dairy products to the USA with the support of its dairy policy (Kress, Miller and Koehler 2010). The US dairy policy has five main components: Dairy Product Price Support Program; Federal Milk Marketing Orders; the Dairy Export Incentive Program; direct payments under the Milk Income Loss Contract (MILC) Program; and tariff-rate quotas on dairy imports (IUF 2013b). Dairy cooperatives also play a major role in the US dairy industry (IUF 2013b). Although the volume of milk production per capita is high, the USA does not always receive a high ranking due to the fact that it has a smaller population than India, Mexico and whole EU union. After that, the USA and Canada are the leading milk producing countries with sophisticated technology and methods for rearing and producing diversified dairy related products (Thornton 2010).

3.2.2 India dairy

India is one of the world's largest milk and dairy products producing countries by volume, although it consumes almost all of its own milk production. Prior to 2000, India failed to export any of its dairy items although it also did not import such items from other countries (IUF 2013a). However, since 2001, India has become a net exporter following the implementation of its Operation Flood Programme (IUF 2013a). In India, 65% of milk comes from buffaloes with 113 million head of cattle/buffaloes and 75 million dairy farming households each having an average of 1.5 adult female cows or buffaloes per farm (www.thecattlesite.com). Although India is a promising country in terms of dairy production, it suffers from various problems associated with environmental impacts, waste management, proper technology, effective methods of producing dairy products and improper guidance for exports (Patankar, Patwardhan and Verbong 2010).

3.2.3 China dairy

The people of China drink more milk and consume more dairy products today than ever before (Wang, Parsons and Zhang 2010). Figure 3.1 shows that China produced 35.31 million metric tonnes which makes it the third highest producer in the world, after having secured fifth place in 2005. China is probably going to secure second position next year (Simpson 2006). Most of its milk goes to formal processing centres to be reprocessed into dairy products. Chinese dairy farms can be categorised into two groups: small farms with 1 to 40 cows and large farms with more than 200 cows having local collection point (www.thecattlesite.com). China is also a huge importer of dairy products as it can only fulfil 86% of its own milk requirements (Du et al. 2002). At the same time, the Chinese dairy industry is also suffering from various difficulties related to productivity, structural problems and efficiency in Chinese dairy farms (Wang and Yu 2012).

3.2.4 New Zealand dairy

New Zealand is one of the world's largest exporters of dairy products, representing one-third of the international dairy trade each year (Dobson 1990). Its farmers do not receive any subsidies but have low-cost, high productivity farming systems (Dobson 1990). Recently, New Zealand produced 18.8 million tons of milk which is equivalent to 20% of USA milk production. This was produced by 12,300 dairy farmers with average dairy herds of 315 cows yielding 3,526 kg/day (or11.2 kg/cow) (www.thecattlesite.com). It exports about 95% of its milk production and, with 15 million tons export volume. New Zealand is the world's largest exporter of the commodity. Simultaneously, New Zealand dairy is facing challenges associated with cattle health, environment, water contamination and others (Chesterton et al. 1989).

3.2.5 Australia dairy

According to Collard and McElhone (2014), 6,700 Australian dairy farmers produce 9.2 billion litres of milk a year, having a value of AUD $4 billion with the investment of AUD $13 billion. Australia is one of the countries that export dairy products around the world. It is a country with diversified farms, as well as manufacturing and export industries. Importantly, the Australian dairy industry directly creates employment for Australians on farms and also employs more than 100,000 Australians in associated factories and service industries (Collard and McElhone 2014). Conversely, the Australian dairy industry is also suffering from lack of appropriate research, progress

and extension, market access, health, nutrition, and efficient people, as well as supply chain and policy issues (Collard and McElhone 2014).

3.2.6 Bangladesh dairy

Bangladesh Dairy production systems are similar to systems in Pakistan and India. However, milk production and yields (2.8 million tons ECM from cows and buffaloes, and 711 kg of ECM per cow/per day, respectively) are significantly lower than those of other sub-continental countries like India and Pakistan (www.thecattlesite.com). The major proportion of the milk is consumed by farming households or sold on to the informal market, and less than 20% is delivered to formal milk processors (Hemme and Khan 2004). At the same time, per capita milk consumption is around 32 kg/year. It is observed that Bangladesh is 85% self-sufficient in milk and imports 0.4 million tons per annum from other dairy developed countries. Bangladesh, like other dairy producing countries, is facing the multi-faceted challenges associated with this industry.

3.2.7 Other dairy countries

In Uganda, dairy is a vital and rising sector of the economy. It is gradually proving to be a productive livelihood option for a number of people dealing in milk production and trade. Choudhary et al. (2011) describe the Ugandan dairy industry as comprising both subsistence and commercial farming systems. More than 90% of farmers practise subsistence farming whereas less than 10% practise commercial farming. Their report also reveals that the future prospects of the Ugandan dairy industry are bright, with stakeholders investing enough interest and effort to make the dairy business profitable for all. But for this effort to be successful, it is necessary to identify and mitigate risks and most of the farmers in the different regions are already doing this. Coudhary et al. (2011) also highlight the different risks associated with the Ugandan dairy supply chain and describe some of the coping mechanisms used to mitigate the identified risks.

Livestock is an important component of the rural economy of Bangladesh which is basically based on agriculture. The livestock sector has an important place, not only in the economy of Bangladesh, but in the economies of most South Asian countries. The dairy sector of such countries as India, Bangladesh, Nepal, Sri Lanka and Pakistan is characterised by small scale, unorganised animal holders; inadequate basic infrastructure and transport facilities; low productivity; and shortage of skilled

management (Singh and Pandir 2001). Dairy farming is a popular and ancient occupation in the rural areas of Bangladesh, but its development is subject to a number of risks (Nasir, Shamsuddoha and Quaddus; Nasir, Quaddus and Shamsuddoha 2014). At the same time, the Bangladesh dairy industry suffers from a lack of relevant information, modern breeding systems, feeding, management, diseases and marketing. To address the industry's current problems effectively, it is necessary to assess the role of market failures and of government policies and their contribution to rural poverty (Shamsuddoha and Edwards 2000). Appropriate research and policies can contribute to solving these problems.

3.2.8 Comparative study on dairy production worldwide

Table 3.1 compares the top ten countries for cow, sheep and goat milk in a year. It is evident that the USA ranks first in cow milk production whereas China and India have the same position in sheep and goat milk respectively. Interestingly, Bangladesh secured second position in goat milk production, which means they have great prospects in this sub-sector. Highest production does not mean highest availability and consumption, as it depends on a country's population, consumption habits and milk affordability. The above discussions have clearly shown that most dairy developed countries have some problems and challenges to deal with, and Bangladesh is no exception. This research seeks to identify the related problems and risks and to identify ways to mitigate them appropriately. The next section deals with supply chain, supply chain risks and supply chain risk management.

Table 3.1: Production Worldwide (FAOSTAT 2014)

Top ten cow milk producers (Metric Tonnes)			Top ten sheep milk producers (Metric Tonnes)			Top ten goat milk producers (Metric Tonnes)		
Rank	Country	Production	Rank	Country	Production	Rank	Country	Production
1	United States	90,865,000	1	China	1,580,000	1	India	4,850,000
2	India	54,000,000	2	Turkey	1,010,007	2	Bangladesh	2,608,000
3	China	37,419,500	3	Syria	703,008	3	Pakistan	779,000
4	Brazil	32,304,421	4	Greece	699,500	4	Mali	715,000
5	Russia	31,576,047	5	Romania	650,912	5	France	624,016
6	Germany	30,506,929	6	Somalia	615,000	6	Somalia	500,000
7	France	23,983,196	7	Spain	552,517	7	Spain	443,625
8	New Zealand	20,053,000	8	Iran	465,000	8	Greece	407,000
9	Turkey	15,977,837	9	Italy	406,177	9	Turkey	369,429
10	United Kingdom	13,884,000	10	Algeria	336,000	10	Niger	288,974

3.3 SUPPLY CHAIN RISK AND SUPPLY CHAIN RISK MANAGEMENT (SCRM)

This section discusses the concepts of supply chain, supply chain risk and supply chain risk management (SCRM).

3.3.1 Supply chain

Supply chain is a popular term in business and academia due to its relevance for the processes of forward and reverse logistics to accomplish the tasks required to make substantial profits(Lambert and Cooper 2000; Mentzer et al. 2002; Wisner, Tan and Leong 2015). A number of clarifications and delineations of the term are available in various academic writings. The most simple definition is: the supply chain is a process that starts from managing raw materials, and continues through the relevant suppliers, retailers, and other parties who provide services to the customer (Cox, Blackstone and Spencer 1995) and different points of consumption (Svensson 2007), culminating with the final consumer. Essentially, the supply chain is an amalgamation of numerous parties and processes that include raw material collection (backward), production, and forward progressions within a business firm to accomplish its daily chores (Shamsuddoha 2014). A supply chain comprises every step involved in producing and distributing the ultimate product, on or after the supplier's supplier to the customer's customer (Cooper, Lambert and Pagh 1997; Council 1999; Ellram and Cooper 1993; Lummus and Vokurka 1999; Lummus and Alber 1997). A number of models designed based on various practical problems. Similarly Mentzer, et. al. (2002) highlights this concept as a traditional business model for systemic, strategic and tactical harmonisation with other functions. Croom, Romano and Giannakis (2002) cite a number of other definitions (See Table 3.2).

Table 3.2: Different Definitions of Supply Chain Management (Croom, Romano and Giannakis 2000)

Authors	Definition
Tan, Handfield and Krause(1998)	"Supply chain management encompasses materials/supply management from the supply of basic raw materials to final product (and possible recycling and re-use). Supply chain management focuses on how firms utilise their suppliers' processes, technology and capability to enhance competitive advantage. It is a management philosophy that extends traditional intra-enterprise activities by bringing trading partners together with the common goal of optimisation and efficiency".
Berry, Towill and Wadsley(1994)	"Supply chain management aims at building trust, exchanging information on market needs, developing new products, and reducing the supplier base to a particular OEM (original equipment manufacturer) so as to release management resources

	for developing meaningful, long term relationship".
Jones and Riley (1985)	"An integrative approach to dealing with the planning and control of the materials flow from suppliers to end-users".
Saunders (1995)	"External Chain is the total chain of exchange from original source of raw material, through the various firms involved in extracting and processing raw materials, manufacturing, assembling, distributing and retailing to ultimate end customers".
Ellram(1991)	"A network of firms interacting to deliver product or service to the end customer, linking flows from raw material supply to final delivery".
Christopher (1992)	"Network of organisations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer".
Lee and Billington(1992)	"Networks of manufacturing and distribution sites that procure raw materials, transform them into intermediate and finished products, and distribute the finished products to customers".
Kopczak(1997)	"The set of entities, including suppliers, logistics services providers, manufacturers, distributors and resellers, through which materials, products and information flow".
Lee and Ng (1997)	"A network of entities that starts with the suppliers' supplier and ends with the customers' custom the production and delivery of goods and services".

Therefore, the supply chain manages and incorporates all of these activities into a unified process (Tan 2002; Ponomarov and Holcomb 2009). Aitken (1998) describes the supply chain as "a network of connected and interdependent organisations, mutually and co-operatively working together to control, manage and improve the flow of material and information from suppliers to end users" (Aitken 1998). In the implementation of this process, supply chain stakeholders face some risks in their own operations which they need to mitigate. The next section discusses risks to the supply chain.

3.3.2 Supply chain risks

Supply chain risks and the associated financial and operational risks are burning issues for all firms in the present competitive market (Roth et al. 2008). Trkman and McCormack (2009) observe that the need to solve supply chain management problems is emerging as an important issue (Trkman and McCormack 2009).They argue that the ability to identify suppliers with greatest risk potential is a critical step in the management of risk within the supply chain. Briefly, supply chain risks are disruptions that occur to the flow of products, information and finance from producer to consumer within the supply chain. They are unplanned and unanticipated events which disrupt the normal flow along the supply chain (Svensson 2000; Hendricks and Singhal 2003).

Various organisations approach the risks that arise across the supply chain in a number of different ways. A few industries accept the risks and take appropriate measures to mitigate them; otherorganisations avoid the risks (Thun and Hoenig 2011). Whatever their approach, they must assess the impact of risks throughout the supply chain process. Thun and Hoenig (2011) conducted a survey of 67 German automotive industries to identify and examine the key drivers of supply chain risk. They identified some of the key drivers for disrupting the supply chain as: outsourcing; cultural risk; transportation risk, exchange rate risk and catastrophes such as terrorist attacks, bankruptcy, and financial loss. They identified the risks and predicted the likelihood of their occurrence and their potential impact on the supply chain by means of a probability impact matrix, which is also one of the research objectives for this study.

Raoand Goldsby (2009) identifies some sources of risk (Figure 3.2) in terms of organisational, environmental and social factors. Political instability, shifts in government policy, social uncertainties and natural uncertainties are the primary variables associated with environmental risk (Miller 1991). Saha (2007) reveals that political instability in Bangladesh is one of the major causes why many large firms have begun to find it unfeasible to conduct business there. Therefore, political instability could also be a source of supply chain risk. Social uncertainties, which may include terrorism and theft, also represent a threat to the supply chain (Sheffi 2005), as do organisational uncertainties (at the firm level) such as labour strikes, scarcity of raw materials, and technological change (Ritchi and Marshall 1993)

Tang and Musa (2011) identify the supply chain risks associated with the flow of different elements, namely, material (single sourcing, outsourcing, product quality, operational disruption), information (information disruption and accuracy) and cash (financial strengths of supply chain partners, cost and price risks). Actually, supply chain risks can have different sources internal and external to a supply chain network. Consequently the impact of risks also varies according to the risk sources. For instance, natural disaster is an environmental risk destroying production capacity with high impact. Different scholars have constructed different typologies and/or taxonomies of supply chain risks e.g., Svensson 2000; Christopher and Peck 2004; Jüttner, Peck and Christopher 2003; Ritchie and Marshall 1993. For instance, Jüttner (2005) posits three categories: supply, demand and environmental. Svensson (2000) proposes two categories: qualitative and quantitative. Ritchie and Marshall (1993) distinguish five categories: environmental, industrial, problem specific, organisational and decision

related. After examining these definitions it can be concluded that supply chain risk is related to the chance of damage, danger, loss, injury or any other unexpected consequence (Harland, Brenchley and Walker 2003). Figure 3.2 depicts the classification of supply chain risk sources identified by Ritchie and Marshall (1993) but also confirmed by Rao and Goldsby (2009).

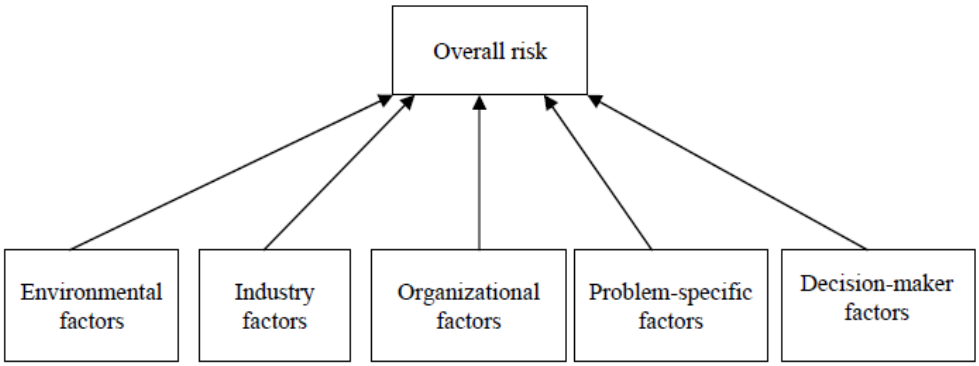


Figure 3.2: Supply Chain Risk Factors (Rao and Goldsby 2009)

Supply chain risk factors are discussed below:

Environmental factors

Environmental risk variables are considered in the overall business context across industries (Ritchie and Marshall 1993). Akcaoz, Kizilay and Ozcatalbas(2009) consider the same variables for analysing risk management strategies in Turkish dairy farming. Variables representing environmental risks are political (Shubik and Herring 1986), policy related (Ting 1988), micro-economic (Oxelheim and Wihlborg 1987), social (Dunn and Herring 1983) natural (Miller 1991) and those associated with uncertainty (Rao and Goldsby 2009).

Industrial factors

Industry risk variables refer to a particular segment of an industry rather than to the whole sector (Ritchie and Marshall 1993). Three different types of industrial risk are identified in the literature: input market, product market and competitive uncertainty (Rao and Goldsby 2009).

Organisational factors

Ritchie and Marshall (1993) draw attention to the organisational uncertainty associated with the first level of the farm supply chain. They posit four different sub-

variables: operational, liability, credit, and agency uncertainties (Miller, 1991; Wu et al., 2006).

Problem-specific factors

This particular risk is associated with the potential negative effects of a risk reduction process (Bettis 1982). For instance, outsourcing is a risk reduction strategy which also gives rise to vulnerability as control over a particular element in the supply chain may be lost. Moreover, problem-specific risks are influenced by the structure of the overall risk and their interrelationship (Ritchie and Marshall, 1993), objectives and constraints associated with the resolution of the problem (Bettisand Hall, 1982) and overall decision making complexity (Cohen and Levesque 1990).

Decision-maker factors

Decision-maker related risks could be related to an individual or to a decision making group within an organisation (Rao and Goldsby 2009). This factor is influenced by the decision maker's detailed knowledge (Ritchie and Marshall, 1993), information seeking behaviour and institutional rules and procedures for taking decisions (Wilson 1982), and bounded rationality (Simon 1987).

Tang and Tomlin (2008) also refer to supply risks, process risks, demand risks, intellectual property risks, behavioural risks, and political/social risks. Figure 3.3 shows the supply, process and demand risks and their relationships with upstream and downstream partners. Here process risks are linked with the manufacturing processes of both the partners. There are two ways to measures such risks: the likelihood of the occurrence of an undesirable event, and the negative implications of the event (Bogataj and Bogataj 2007). Two options to diminish the occurrence of certain undesirable events are risk avoidance and the application of TQM principles. A "Triple-A" model can also eliminate the negative implications of some undesirable occurrences associated with supply, process, and demand. The "Triple-A" model was first presented by Lee (2004). Its principles are alignment, adaptability and agility.

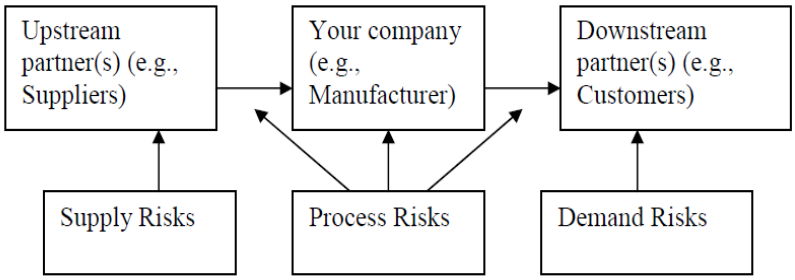


Figure 3.3: Supply Risks, Process Risks, and Demand Risks (Tang and Tomlin 2008)

Literature on sustainable dairy sector supply chain risk management is limited and fails to address three particular aspects of sustainability-economic, social and environmental-within the supply chain operation. There is also a dearth of studies addressing the adoption of mitigation strategies and efficient supply chain risk management for sustainable outcomes. But this literature review suggests that there could be varieties of risk sources in the supply chain process. This research attempts to fill the gap by identifying dairy supply chain risks and specifically distinguishing high probability and high impact risks.

3.3.3 Supply chain risk management (SCRM)

Supply chain risk management (SCRM) is a rapidly growing area of research for academics as well as practitioners (Manuj and Mentzer 2008a). It is emerging as a most important contribution to the field of management decision making (Giannakis, Croom, and Slack (2004)). Supply chain risk management is the management of supply chain risk through coordination or collaboration among the supply chain partners so as to ensure profitability and continuity (Tang 2006b). According to Zsidisin, Panelli and Upton (2000), risk management is a continuous process in which supply chain partners engage in communication and information gathering and evaluation to facilitate appropriate decision making. Giunipero and Eltantawy (2004) suggest that supply chain experts need to escalate information flow, communication, and relationship coordination within the supply chain in order to mitigate risk and develop competitive advantage. However, as Giunipero and Pearcy (2000) observe, the negotiation skills, team work and interpersonal communications skills required for supply chain integration are not easy to apply successfully in the modern competitive arena. For this reason, the authors recommend hiring and developing staff to manage supply chain risks.

The risk management procedure starts with identification of the risk and ends with mitigation of the risk through strategies of risk avoidance and risk transference (Mishra and Shekhar 2011), cooperation and control (Jüttner, Peck and Christopher 2003). Jüttner, Peck and Christopher (2003), (shown in Figure 3.4) draw attention to four elements of supply chain risk management:

a) Measuring the risk sources for the supply chain;
b) Recognising the risk concept of the supply chain by defining the most relevant risk consequences;
c) Tracking the risk drivers in the supply chain strategy; and
d) Mitigating risks in the supply chain.

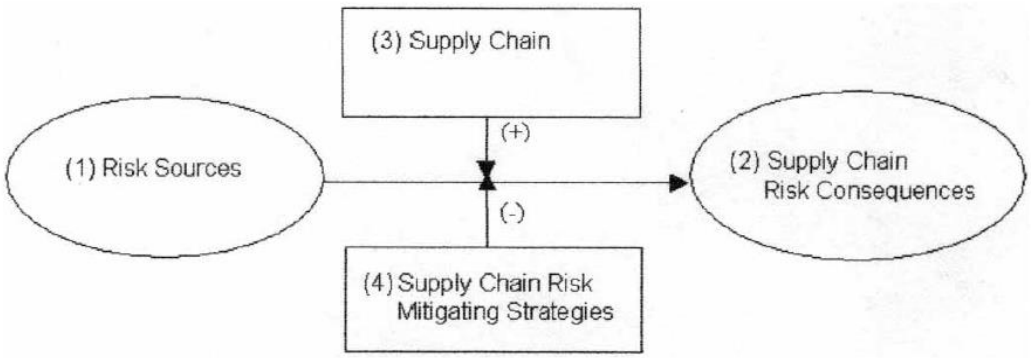


Figure 3.4: Supply Chain Risk Management-The Basic Constructs (Jüttner, Peck and Christopher 2003)

Conversely, Thun and Hoenig (2011) identify two approaches to supply chain risk management, namely, preventive and reactive. In a comparative study they found that the group using reactive supply chain risk management had higher average values in terms of disruption resilience or the reduction of the 'bull whip effect', whereas the group using preventive supply chain risk management had better values in relation to flexibility or safety stock. Tang and Musa (2011) identify some risks associated with flow (material flow, information flow and cash flow) along with some quantitative and qualitative solutions for those risks. Quantitative solutions include multiple sourcing, single sourcing, resilience supply chain, supply chain design, operation hedging, and so on. Qualitative solutions include simulation-based decision support system (DSS) model, optimisation model, multivariate analysis, postponement model and others.

Blos et al. (2009) conducted an empirical study of 46 industries (automotive and electronic) in Brazil. They developed a supply chain vulnerability map with four quadrants (financial, strategic, hazard and operations) of supply chain risk. To mitigate supply chain risk, they recommend improved supply chain communication: supply chain and business continuity risk management training programmes; and the creation of a chief risk officer. Miller (1991) posits five generic strategies to mitigate risk in a single organisation. Four of these are adapted to the supply chain context by Jüttner, Peck and Christopher (2003). These four strategies are summarised in Table 3.3 and then discussed in greater detail:

Table 3.3: Supply Chain Risk Mitigation Strategies (Jüttner, Peck and Christopher 2003)

Avoidance	Dropping specific products/geographical markets/supplier and/or customer organisations
Control	Vertical integration Increased stockpiling and the use of buffer inventory Maintaining excess capacity in productions, storage, handling and/or transport Imposing contractual obligations on suppliers
Co-operation	Joint efforts to improve supply chain visibility and understanding Joint efforts to share risk-related information Joint efforts to prepare supply chain continuity plans
Flexibility	Postponement Multiple sourcing Localised sourcing

a) Avoidance

Risk associated with operations or geographical areas are unacceptable. One strategy to mitigate such risks is avoidance. A company could avoid risk by dropping particular products, markets or supplier if they become unreliable.

b) Control

Control strategies are the most well-known strategies (Jüttner, Peck and Christopher 2003). Companies can control various risk sources within which they must operate, rather than consider these risks as constraints (Miller 1991). Vertical integration, use of buffer inventory or managing excess capacity in production, storage and distribution are some common examples of control in supply chains.

c) Cooperation

To reduce risk, cooperative responses may take the form of joint agreements (Miller 1991). Joint agreements among organisations, information sharing and preparation of joint business continuity plans are instances of cooperation in a supply chain.

d) Flexibility

The strategy of flexibility increases responsiveness while the strategy of control attempts to increase the predictability of contingencies arising from different risk sources. An example of flexibility is postponement (delay in decision making). This decreases dependency on forecasts and increases responsiveness to variability or disruptions. Multiple sourcing (managing risk through spreading risk) and localised sourcing (sourcing with short lead times and quick response potentialities) are other examples of flexibility in supply chain risk mitigation.

Jüttner, Peck and Christopher (2003) propose three sources of risk to the supply chain. These are: environmental risk sources, network-related risk sources and organisational risk sources. One example of an environmental risk source is the occurrence of fire in an organisation. Network-related risk sources include socio-political actions, such as fuel protests or terrorist attacks, and acts of God, such as extreme weather or earthquakes. Organisational risk sources include various types of labour disturbance such as strikes, production uncertainties such as machine failure, and IT-system uncertainties.

Tang (2006a) suggests a risk assessment programme based on the following four tasks:

a) Identify different types of risks;

b) Estimate the likelihood of each type of major disruption occurring;

c) Assess potential loss due to a major disruption; and

d) Identify strategies to reduce risk.

This risk assessment programme can be effective if administration is able to successfully sort out the risk types and identify appropriate strategies for their mitigation.

The following recommendations are compiled from studies conducted by Rice and Caniato(2003) and Zsidisin, Panelli and Upton (2000):

a) To assess the risks, industries should undertake risk assessment programmes and deploy different formal quantitative models to develop informal qualitative plans.

b) They should develop their own contingency plans to meet legal requirements

c) They should have alternative suppliers for strategic parts of the supply chain. This is the most common approach for reducing supply chain risks.

d) They should develop data points to efficiently estimate the probability of the incidence of any particular disruption and to measure correct impact for each disaster that may difficult to predict.

The literature reveals that an assessment of risk should be made prior to the adoption of particular mitigation strategies for sustainable outcomes in a particular dairy industry. Accordingly, industries should have their own contingency plan to protect against sudden hazards. Although the previous studies addressed supply chain risk management, they did not highlight the dairy industry. A few studies have been conducted on dairy disease management, but they have not identified the industry's operational risks. This research is an attempt to fill this research gap.

3.3.4 Supply chain risk management in the dairy industry

The literature on supply chain risk management suggests various policies including risk insurance, information sharing, relationship development, agreed performance standards, partnership structures, joint training and development programmes, joint pro-active assessment, regular joint reviews, planning exercises, developing risk management awareness and skills, joint strategies and relationship marketing initiatives (Ritchie and Brindley 2007). There is some evidence of successful risk management through insurance and co-operative responses like sharing strategic information (Kleindorfer and Saad 2005). The management of supply chain risks vary according to the type of organisations/industry. Sometimes researchers trial strategies and policies from different industries and analyse their impacts.

One of the objectives of this research is to determine the supply chain risks in the Bangladesh dairy industry and to deploy appropriate mitigation strategies for highly probable and high impact risks. So far the existing literature has revealed a variety of risks related to certification and traceability (Meuwissen et al. 2003), food supply chains (for example, Melamine in infant formula and powdered milk sourced from China) (Narasimhan and Talluri 2009), botulinum toxin in milk (Wein and Liu 2005),

environmental impact (Sonesson and Berlin 2003), restructuring existing vertical supply chains(Dries et al. 2009), emerging foodborne pathogens (Altekruse et al. 1999), vulnerability and political regulation (Deimel, Frentrup and Theuvsen 2008), dairy products retailing (Hendrickson et al. 2001), the effects of the metabolism of propylene glycol (Nielsen and Ingvartsen 2004), quality control (Faye and Loiseau 2002b), and cooperative models (Chaddad and Cook 2004).

From the literature, it is apparent that dairy milk producing countries suffer from a number of risks and problems, and Bangladesh is no exception. Jabber (2010) identifies some of the risks experienced by the Bangladesh dairy industry as follows:

(i) Inadequate knowledge and technical skills of dairy farmers
(ii) Feed scarcity and poor quality
(iii) Diseases
(iv) Inadequate veterinary service coverage and diagnostic facilities
(v) Lack of credit support
(vi) Milk collection constraints due to distance and quantity
(vii) Low price, breed management and problem associated with regulatory body

Jabbar (2010) also suggests the following strategies to overcome the situation:

(i) Cooperative dairy development
(ii) Community-based contact farming schemes
(iii) Smallholder dairy farming, integrated with crop and fish culture
(iv) Supply chain based production, processing and marketing of milk and milk products
(v) The establishment of an active dairy regulatory body to promote dairy development
(vi) The establishment of a 'National Dairy Research Institute' to carry out dairy research

The literature on dairy supply chain risk management, particularly in the Bangladesh context, is limited. This research attempts to redress this limitation by identifying dairy supply chain risks, especially those associated with sustainability, and subsequently analysing the risks in terms of high probability and high impact, with the understanding that such problems can be solved through identifying suitable strategies to solve particular risks (Han et al. 2001). This research identifies relevant

and appropriate strategies to mitigate risks to the dairy supply chain through a QFD approach (Park and Kim 1998).

3.4 SUPPLY CHAIN RISK MANAGEMENT FOR SUSTAINABILITY

Another aim of this research is to identify ways to ensure that risk mitigation strategies have appropriate sustainable outcomes in terms of a triple bottom line of economic, social and environmental development. Other business disciplines, such as operations and management, are likewise concerned with sustainability. No matter what the nature of operation is, nowadays almost every organisation, institution and industryis concerned withachieving sustainability.

3.4.1 Sustainability: An examination of the literature

Sustainability has three aspects: economic output, social welfare and the natural environment. These aspects are reflected in the concept of the triple bottom line (TBL) (figure 3.5) developed by Elkington (1998, 2004) in the mid-1990s to measure performance in corporates. The TBL refers not only to economic profits and returns on investment, but also to shareholder values associated with social and environmental issues. The TBL also represents the three keywords of profit, people and planet as the three pillars of sustainability (Bader 2008). Thus the concept of triple bottom line is based on the idea that there are activities that organisations can be involved in at the intersection of economic performance, social welfare and environmental benefit which not only positively affect society and the natural environment, but are also able to generate long term economic benefit and competitive advantage for the organisation (Carter and Rogers 2008a). So the interrelated elements of profit, people and planet-the triple bottom line-can be an important device for measuring sustainability in a livestock business. Sustainability is a vital indicator of smart management (Savitz and Weber 2006). Other aspects of sustainability include risk management, strategy, transparency, and culture (Gladwin, Kennelly and Krause 1995; Hart 1995; Elkington 1998; Henriques and Richardson 2004; Jennings and Zandbergen 1995; Sarkis 2001; Savitz and Weber 2006; Shrivastava 1995; Starik and Rands 1995). Hence, consideration of the risks associated with the dairy industry needs to include consideration of their impact on sustainability, so that the industry can effectively serve the people of Bangladesh.

The most widely adopted and most often cited definition of sustainable developmentcomes from the "Brundtland Report" of the World Commission on

Environment and Development (WCED 1987), which defines it as "development that meet the needs of the present without compromising the ability of future generations to meet their own needs". According to the United States Environmental Protection Agency, sustainability represents the preservation or recovery of certain social conditions and ecological capabilities (Sikdar 2003; Elkington 1994; Jennings and Zandbergen 1995). Scarcity of resources (Davis 1990; Wakeford 2012; Daily and Ehrlich 1992), polluted natural resources (Tilman et al. 2002), acceleration in non-renewable resource consumption (Goodland and Daly 1996), huge population (Davis 1990; Daily and Ehrlich 1992), radical change of global climate (Belisle 2011), chaotic industrialisation (Barrera-Roldán and Saldıvar-Valdés 2002) and problematic biodiversity and ecosystems (Tilman, Wedin and Knops 1996) are the main reasons for the increased attention being given to sustainability.

Sustainability issues like the impact of economic activity on the ecology (Erlich and Erlich 1991); fulfilment of fundamental human needs (Savitz and Weber 2006); preservation of non-renewable resources (Whiteman and Cooper 2000) and ensuring food security (Lal et al. 2002) are all issues requiring action. Diesendorf (2000) distinguishes three principles of sustainability: economic growth, societal equity and environmental protection. These principles reflect the "triple bottom line: economic, social and environmental or profit, people, and planet" (Elkington 2004; Norman and MacDonald 2004; Peacocka and Shermanb 2010; Elkington 1994). Shrivastava (1995) adds that sustainability requires the reduction of long term risks associated with resource depletion, energy cost fluctuations, pollution and waste management.

In recent years, the application of the principles of sustainability has improved productivity in many domains including management, operations, supply chain and engineering, although the terminology differs in different domains. In the management literature, sustainability refers more to the natural environment with only an implied recognition of economic and social responsibilities (Starik and Rands 1995; Jennings and Zandbergen 1995). The operations literature considers sustainability from the three common viewpoints of economy, society and ecology (Sarkis 2001; Hill 2001; Daily and Huang 2001). Sustainability is explicitly incorporated into the engineering field as well, where it is defined as "a wise balance between economic development, social equity and environmental stewardship" (Sikdar 2003; Go´ncz et al. 2007).

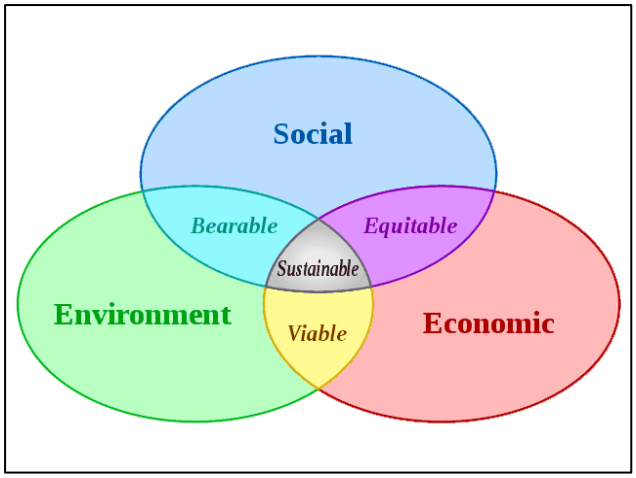


Figure 3.5: Sustainability: The Triple Bottom Line (Carter and Rogers 2008a)

Solaiman and Belal(1999) identifies some of the major challenges (figure 3.6) for sustainable development based on Hart's (1997) earlier findings. These challenges are environmental pollution, natural resource depletion and extreme poverty. They also posit some strategies for achieving sustainable development, including indigenous technology development, skill development of poor people, development of village based entrepreneurship, strong legal enforcement, and so on.

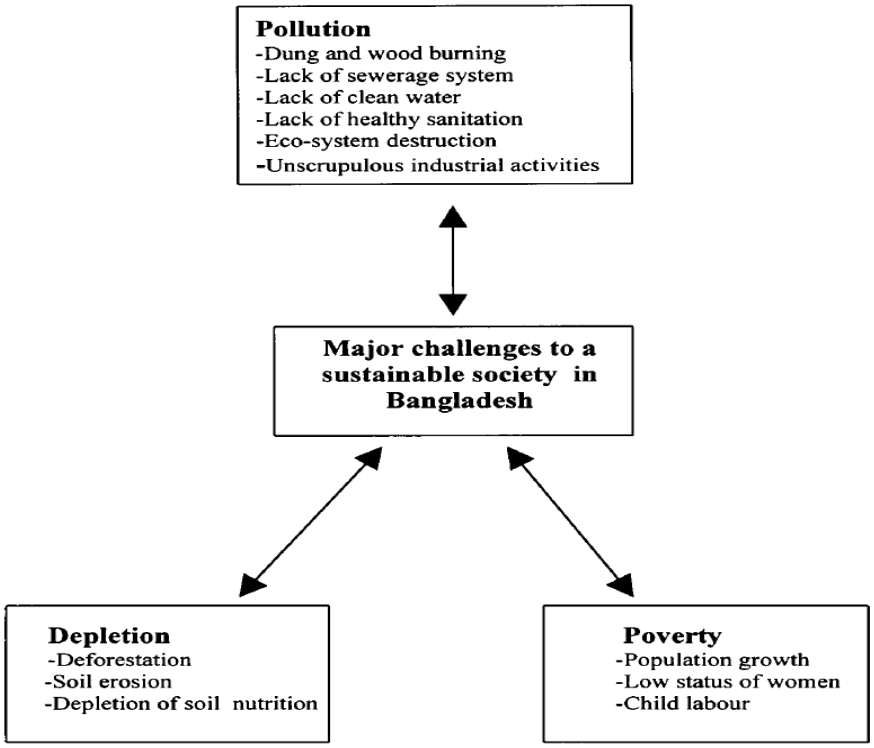


Figure 3.6: Major Challenges to Sustainable Development (Hart 1997)

Moreover, eco-friendly packaging, recycling, and adequate waste disposal have also assumed importance as contributors to environmental sustainability (Faisal 2010). Although the concept of sustainability is considered in different academic disciplines, it is not widely understood by the general public (Komiyama et al. 2011). The concept of sustainable development has yet to be adopted by many developing countries (Ravindranath and Hall 1995; Ahern, Cilliers and Niemelä 2014; Cohen 2006). Thus this study attempts to mitigate supply chain risks in a sustainable way.

3.4.2 Sustainable dairy production

Sustainable dairy production needs to be practiced and the principles of sustainability need to be incorporated into the production process (Darnhofer et al. 2011). Sustainable health security and comfort can also be achieved through maintaining eco-friendly goods and services for human wellbeing (McMichael, Butler, and Folke 2003). On the environmental side, human lives are under threat due to depletion of soil fertility and natural resources, scarcity of fresh water and biosecurity degradation (Raven 2002; McMichael, Butler and Folke 2003). Coordination among the natural sciences, social sciences, humanities and engineering would help societies to attain sustainability (Ostrom 2002; McMichael, Butler and Folke 2003).

Dairy industries face environmental challenges arising from air and water pollution. The degradation of air and water quality impedes the development of the dairy industry by spreading diseases and hindering the upkeep of optimum health of dairy cattle. Sustainability in the dairy industry can be attained by developing cattle breeds that can survive the rough weather with minimum and inexpensive inputs and that are resistant to exotic and local disease (Khanna 2004). It is also necessary to identify the problem areas responsible for social and environmental damage. Severe environmental pollution is caused by dumping livestock farming waste into rivers, vacant lands and crop lands in the natural environment (Rasul and Thapa 2004; Payraudeau and van der Werf 2005). To reduce the short- and medium-term negative environmental effects of this, science and technology can be used (Boyazoglu 2002). Moreover, to maintain sustainable production and prevent natural and social degradation, technological advances in scientific production, processing, preservation and promotion are rapidly changing throughout the world.

Sustainable dairy farming involves principles and practices across the whole farm system including its economic, social and environmental aspects (SAI 2009). In this

report, economic sustainability refers to financial stability, diversification, safety, quality and transparency. Social sustainability refers to working conditions, rights and obligations of workers, and training facilities. Environmental sustainability refers to the minimisation of adverse impacts on global environment through waste management, proper handling of recycling, and biodiversity enhancement. Consequently, attention needs to be given not only to livestock production but also to the enclosing environment. Productivity needs to be sustainable so that the environment is not degraded, and management gains increased societal acceptance and economic advantages for future generations (de Jong 2013).Thus farms must be careful to improve their socio-economic conditions; otherwise humans and livestock will suffer from the socio-economic hazards (Boyazoglu 2002). Kliebenstein (1998) suggests that industries can avoid natural disasters through their collective efforts by upgrading their positive environmental impact by means of improved process technologies. At the same time, innovative management practices can reduce the air pollution caused by the livestock industry (Colletti et al. 2006). Suppliers need to modify their existing production methods, invest in skill development and improve infrastructure in order to transform a supply chain into a sustainable supply chain (Faisal 2010).

The literature discussed suggests that sustainable production depends on meeting certain criteria for improving infrastructure, environmental hazards, skills, collective efforts and the like. Very few research recommendations have been implemented in practice to test the match between theory and reality. Thus this research examines existing dairy operations and their outcomes in terms of the three aspects of sustainability.

3.5 THE DAIRY SUPPLY CHAIN

The word dairy is related to the production of milk-based products and processes, like dairy farm, dairy cow, dairy goat and so on (ACF 2012). Basically, the extraction and processing of animal milk (cows, buffalo or goats) for human consumption are facilitated by dairies. Usually, a dairy farm produces milk and a dairy factory processes the produced milk and converting it into different dairy products. So dairy can be identified as a department of agribusiness that deals with milk production and milk conversion into different consumable products like fluid milk, skim milk, cheese, yogurt, butter, powdered milk, ice cream and different types of sweets (Raha and

Talukder 2004; Shahnaz, Shimazaki and Kato 2004). Additionally meat, leather goods and organic fertilisers are also end products of the dairy industry.

On the other hand, the supply chain is the process that links suppliers and users within and outside a company, starting with the raw materials and ending with the finished product (Maxwell and Vorst 2003; Croom, Romano and Giannakis 2000). In supply chain management, the entire process appears as one system (Lummus and Vokurka 1999). The supply chain also includes inside and outside partners, transporters, information providers and third-party companies. Moreover, recycling, disposal, remanufacturing of rejected or used products are additional elements of the supply chain (Kocabasoglu, Prahinski and Klassen 2007). Other elements of the supply may include production of by-products, design of by-products, product life expansion, and retrieval and recovery of products and processes at end-of-life (Linton, Klassen and Jayaraman 2007).

The dairy supply chain begins with dairy farms producing raw milk. The raw milk is supplied to a processing centre where the raw milk is processed and converted into consumable milk or other dairy products. Once processing is completed, the milk is transported to wholesale distributors. From the wholesale distributors, the milk goes to the retailers where it is purchased by consumers. This is the general flow of a formal dairy supply chain. In the case of an informal dairy supply chain, after the raw milk is produced, it is supplied to milk traders (Ghosh, Goala, and wholesalers), retailers (sweetshops, tea stalls, local hotels, etc.) and local consumers. In a World Bank report based on a field study in Uganda, Choudhary et al. (2011) evaluate and assess risk in different types of dairy supply chain. Four types of milk distribution channels are identified. These channels include raw warm milk, raw chilled milk, boiling centres and pasteurized milk. They also identify the major stakeholders in the dairy supply chain. These include national dairy traders' association, dairy cooperatives, veterinary services and pharmaceutical industry.

Mishra (2011) conducted survey of Indian dairies and found that the supply chain is entangled with many stakeholders. They report that it is a complex bonding of several stakeholders, and that distortion of one of the components distorts the entire chain in varying degrees. Raw milk has a tendency to spoil quickly, as it has very short life. So after collecting milk from the collection point, most dairy companies add ice to the milk to preserve it and save it from perishing (Javed 2004). Javed identifies the different

parties involved in a dairy supply chain. These include contractors of milk, suppliers of milk, gawalas (middlemen), milk collection centres in villages and those involved in direct collection from small scale dairy farmers, transport authorities and so on. After being collected, the milk should be transported to a chiller within 5-6 hours of milking. Then the temperature of the milk should be brought down to 2-4 degree Celsius. After that, the milk should be transported to the processing centre for processing. A very common milk collection and transport system is shown in Figure 3.7.

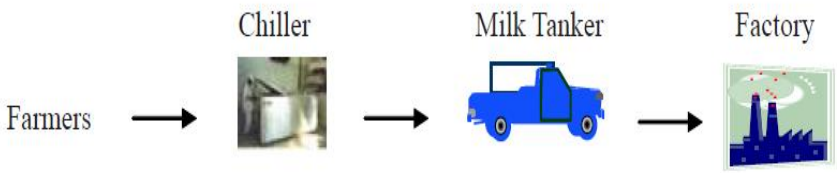


Figure 3.7: Milk Collection and Transport System (Javed 2004)

The whole dairy supply chain consists of different parties, each of which has a separate role within the chain. Producers, collectors, processors, middlemen, traders and consumers are the different parties engaged in the dairy supply chain (ZIA 2006). Qiang et al. (2010) present the findings of a study on the quality control mechanism of a dairy supply chain for a single moral hazard. They presented two coordination models: "External Lose Sharing Model" and "Internal Punishment model". Okano et al. (2010) measured dairy chain productivity usingdifferent indicators of best practices to improve productivity. After analysing a unique data set on dairy supply chain characteristics, Fałkowski (2012) identifies factors associated with households not participating in the market. The study also found that modernisation of the supply chain is not significant if commercial farms are compared to subsistence farms in supplying the traditional marketing channel. As noted by IFC (Hemme 2010; Hemme and Uddin 2009), the starting point of a dairy supply chain is the dairy farmer and the end point is consumers, including different authorities like agents, collection centres, processing centres, dealers and retailers. Figure 3.8 shows the dairy supply chain developed by PRAN Dairy in Bangladesh. Nevertheless, a report from Oakhurst Dairy found that the dairy supply chain begins with feed management, i.e. producing feed for the animals. The report also distinguishes different supply chain parties including farmers, processing units, packaging and transport authorities, distributors, retailers and consumers (shown in Figure 3.9).

Figure 3.8: PRAN's Dairy Supply Chain (Kumar and Iversen 2012)

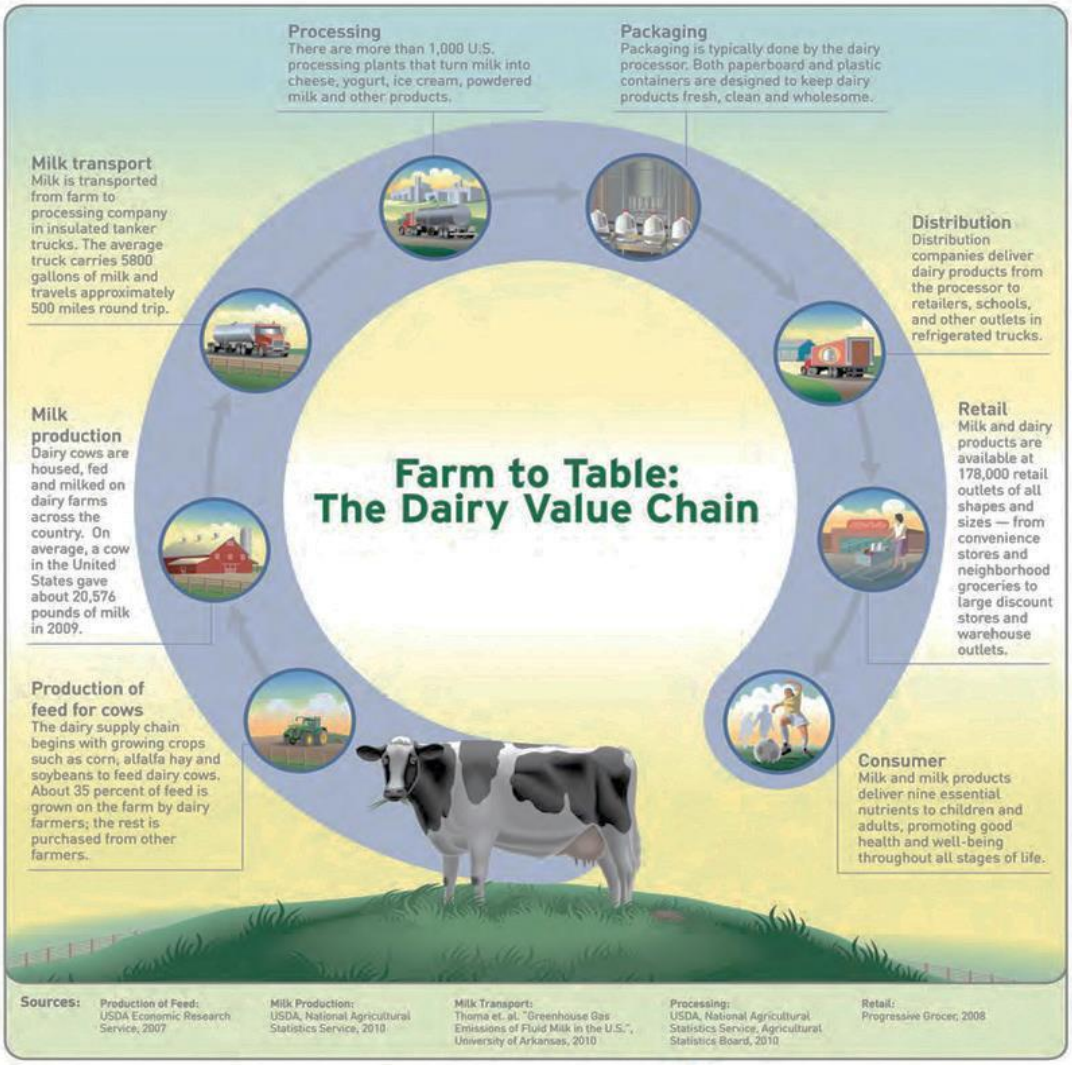


Figure 3.9: The Oakhurst Dairy Supply Chain (Schmitz 2012)

Studies on the dairy supply chain have given little attention to the associated risk factors (Venkatesh 2006; Zokaei and Hines 2007). Moreover, there has been only limited work done on dairy supply chain risk management. This research categorises the risks to the dairy supply chain from a sustainability perspective and simultaneously develops mitigation strategies and discusses probable outcomes. Thus this research fills the existing gaps in knowledge concerning the dairy supply chain.

3.6 DAIRY SUPPLY CHAIN RISK

Risk can be broadly defined as the likelihood of the occurrence of a particular event or outcome (Ritchie and Marshall 1993) or as the probability of variation surrounding an anticipated outcome (Carter and Rogers 2008a). Risk has been observed via behavioural decision theory in economics and management (Wiseman and Gomez-Mejia 1998; Kahneman and Tversky 1979) and finance in terms of insurance and portfolio analysis (Stulz 1996). Supply chain risk can be defined as the possible occurrence of an inbound supply event which may lead to the incapability of fulfilling customer demand (Zsidisin, Panelli and Upton 2000). Supply chain risks may arise from legal obligations (Giunipero and Eltantawy 2004), natural adversities (Atkinson, Mourato and Szymanski 2006), price fluctuations for main raw materials (Barry, 2004), poor demand forecasting (Christopher and Lee 2004), poor environmental and social activities of a firm and its supplier that may result in costly legal actions (Carter and Jennings 2004), and logistic failure and higher transportation costs (Schoenherr, Rao Tummala and Harrison 2008).

Agro business is comparatively riskier than any other type of business. Financial risk, low productivity, land scarcity, technological disruptions, shortage of logistic support, poor quality feed, diseases and natural uncertainties are the most frequently cited risks in the dairy sector. Low productivity in dairy originates from food shortage, diseases and inefficient management (Ghani and Rahman 2004). As a dairy supply chain engages with its various stakeholders, it faces various risks to its operation. Moreover, the only raw material, with which this dairy industry deals, milk, is perishable in nature. This perishable nature of milk increases the probability of risk occurrence in the daily operation of the supply chain. Mishra and Shekhar (2011) identified some dairy risks after conducting in-depth personal interviews with different corporate authorities. They found that the major risks were: logistic risk, hazard risk, high cost of food, low risks, product shortage, delivery risk and lack of skilled staff. Choudhary et al. (2011) identified cattle diseases, drought, abrupt regulation, erratic power supply,

flood, drought and milk spoilage as major risks to the dairy supply chain (Choudhary et al. 2011). The same report considered limited extension and veterinary services, limited availability of pastures and water, limited milk-cooling infrastructure, poor milk-handling practices, improper road infrastructure and perishability of milk to also be supply chain constraints.

Vulnerabilities in terms of risks and uncertainties are multiplied by the perishable nature of the raw material (milk) in the dairy industry. The absence of a proper cold chain and the distribution of milk in plastic containers contribute to the spoilage of milk, especially in hot weather. Mishra and Shekhar (2012) classified three types of dairy risk: procurement, processing and distribution. They identify illiterate farmers, high cost of feed, inadequate infrastructure and milk testing equipment and improper transport facilities as procurement related risks. As processing related risks, they identify out dated technology, shortage of skilled staff, competition, hazard risk (fire and sabotage) and inadequate transport facilities. In this context, the high cost of fuel adds to the present transport problems. Last of all, they identify transportation problems, inferior quality of product and the absence of demand forecasting skills as distribution related risk. Farmers in rural areas rely on middlemen to sell their product, but the middlemen deprive them by taking the maximum share (Ghani and Rahman 2004). After production there is a need to preserve the raw milk in the chilling centre. Disruption in the supply of power at the chilling centre and processing plant, shortage in treated water and flawed machinery may disrupt operational activities and this may, in turn, affect the quality of the product and profitability (Food 2011a).

There is inefficient cold chain management in most developing countries, including Bangladesh (Huq 2007). Central chilling centres are setup at strategic locations so that different dairy processors can chill their milk for the convenience of transporting it over greater distances. In this context, most small scale dairy farmers, who do not have the convenience of chilling facilities, sell their product to local consumers where demand is very limited. Seasonal fluctuations in milk production and consumption which are at relative odds with each other may create further risk for the dairy industry (Zia 2007). Zia (2007) reports that milk production is at its maximum between January and April because of the availability of green fodder, but production is low from May to August. In contrast, during winter, the consumption of milk is low, but it is high during summer because of the higher intake of consumer items such as ice

cream, yogurt and lassi (milk made drinks). So production is lower in the season of high consumption and higher in the season of low consumption.

Akcaoz, Kizilay, and Ozcatalbas (2009) point out some agricultural risks which are also relevant to dairy farming. These are associated with production, marketing, financial, human resource management and the environment. Patrick et al. (1985) and Boggess, Anaman, and Hanson (1985) found that livestock farms were perceived to have a high risk of animal diseases and personal safety health risks. But Wilson, Luginsland, and Armstrong (1988) and Patrick and Musser (1997) found that risks related to yields and input-output prices were perceived to be the most important risks for livestock farms. The US dairy farmers were concerned about production risk, commodity price risk and changes in government laws and regulations (Harwood et al. 1999), whereas Indian dairy farmers are more concerned about animal diseases and see the lack of institutional support as a major risk source (Bardhan et al. 2006).

In Norway, institutional risk was perceived as the most important risk for dairying (Flaten et al. 2005) but in New Zealand, rainfall variation and price risk were found to be the highest risk sources for dairy farming (Martin 1996) Moreover, climatic conditions (hot weather, too much humidity) may also create risks for dairy if the cold chain cannot be maintained properly (Faye and Loiseau 2002a). Drought, flood, and diseases are the biggest risk factors because they cause unpredictability in milk production which, in turn, leads to financial losses in the dairy industry (Choudhary et al. 2011). Table 3.4 shows risks identified in the existing literature based on different levels of supply chain and sustainability respectively. Various dairy risks have been identified by different authors (Table 3.4) but there has been little research on identification of the risks on the basis of sustainability, which is covered by this research in the context of Bangladesh.

Table 3.4: Risks identified in the Literature

Level	Aspects	Risks	References
STORAGE	Economical	Technology Disruption	(PRAN-RFL 2007; Chowdhury 2007; Akcaoz, Kizilay and Ozcatalbas 2009)
		Erratic Power Failure	(Blos et al. 2009; Choudhary et al. 2011; Chowdhury 2007)
		Logistic Failure	(Mishra and Shekhar 2011; Schoenherr, Rao Tummala and Harrison 2008)
		Perishability of product	(Choudhary et al. 2011)
	Social	Employee Strike/ Labour dispute.	(Mishra and Shekhar 2011; Rao and Goldsby 2009; Jüttner, Peck and Christopher 2003)
		Political risks (Strike, lock- out etc.)	(Mishra and Shekhar 2011; Peck 2005; Blos et al. 2009; Wagner and Bode 2006)
		Mismanagement of staff (Theft, Spoilage, Corruption etc.)	(Choudhary et al. 2011; Akcaoz, Kizilay and Ozcatalbas 2009; Blos et al. 2009; Finch 2004)
	Environmental	Pollution and unhygienic environment.	(Akcaoz, Kizilay and Ozcatalbas 2009; Blos et al. 2009)
		Contamination(Improper temperature control)	(Faye and Loiseau 2002a)
		Hazard Risks (Fire, Accident etc.)	(Mishra and Shekhar 2011; Finch 2004; Jüttner, Peck and Christopher 2003; Akcaoz, Kizilay and Ozcatalbas 2009)
PROCESSING	Economical	Land Scarcity	(Mishra and Shekhar 2011)
		High cost of food	(Mishra and Shekhar 2011; Akcaoz, Kizilay and Ozcatalbas 2009; Shamsuddoha and Edwards 2000)
		Poor quality of feed	(Schoenherr, Rao Tummala and Harrison 2008; Bari 2008; Mishra and Shekhar 2011)
		Financial problem / Inadequate loan facilities	(Akcaoz, Kizilay and Ozcatalbas 2009; Chowdhury 2007; Bari 2008; Ghosh and Maharjan 2001)
		Logistic failure	(Mishra and Shekhar 2011; Akcaoz, Kizilay and Ozcatalbas 2009; Schoenherr, Rao Tummala and Harrison 2008; PRAN-RFL 2007; Food 2011b)
		Supply Disruption (Damage or Delay)	(Schoenherr, Rao Tummala and Harrison 2008)
		Absence of modern technology	(Ghani and Rahman 2004; Jüttner, Peck and Christopher 2003; PRAN-RFL 2007; Raha and Talukder 2004; Shamsuddoha and Edwards 2000)

		Lack of Training	(Ghani and Rahman 2004; Shamsuddoha and Edwards 2000; Akcaoz, Kizilay and Ozcatalbas 2009; Bari 2008)
		Inadequacy of AI Facilities	(Akcaoz, Kizilay and Ozcatalbas 2009; Shamsuddoha and Edwards 2000; Raha and Talukder 2004)
		Bankruptcy.	(Thun and Hoenig 2011; Manuj and Mentzer 2008a)
	Social	Political Unrest and interference	(Choudhary et al. 2011; Chowdhury 2007; Rao and Goldsby 2009)
		Poor quality product	(Blos et al. 2009; Curtis 2011; Wagner and Bode 2006)
		Mistrust worthy Employees	(Ahsan 2011)
		Adulteration and contamination	(Faye and Loiseau 2002a)
		Policy barrier/ Changes in Government Policy	(Choudhary et al. 2011; Akcaoz, Kizilay and Ozcatalbas 2009; Rao and Goldsby 2009; PRAN-RFL 2007; Manuj and Mentzer 2008a)
		Labour uncertainty	(Rao and Goldsby 2009; Jüttner, Peck and Christopher 2003; Sheffi and Rice 2005)
		Competition	(Manuj and Mentzer 2008a)
	Environmental	Cattle diseases	(Choudhary et al. 2011; Akcaoz, Kizilay and Ozcatalbas 2009; Peck 2005; Bari 2008)
		Natural disaster (flood, heavy rain, drought etc.)	(Choudhary et al. 2011; Jüttner, Peck and Christopher 2003; Finch 2004; Schoenherr, Rao Tummala and Harrison 2008)
		Abrupt regulation	(Choudhary et al. 2011; PRAN-RFL 2007; Kang et al. 2012)
		Contamination by environmental germs	(Faye and Loiseau 2002a)
		Fresh water scarcity	(Choudhary et al. 2011; Carter and Rogers 2008b)
DISTRIBUTION	Economical	Too long chain	(Peck 2005; Thun and Hoenig 2011)
		Too many middlemen/ Deprived by the middlemen.	(Ali and Kapoor 2008; Ahsan 2011; Ghani and Rahman 2004)
		Transport disruption (damage or delay)	(Chowdhury 2007; Jüttner, Peck and Christopher 2003; Schoenherr, Rao Tummala and Harrison 2008; Giunipero and Eltantawy 2004)
		Inadequate infrastructure (roads and highway)	(Ali and Kapoor 2008)
		Milk price variation	(Akcaoz, Kizilay and Ozcatalbas 2009; Mishra and Shekhar 2011; Ghani and Rahman 2004)
		Demand unpredictability	(Giunipero and Eltantawy 2004)

		Risk of perishability	(Mishra and Shekhar 2011; Ghani and Rahman 2004)
	Social	Exploitation from middlemen	(Ali and Kapoor 2008; Ahsan 2011; Ghani and Rahman 2004)
		Adulteration	(Giunipero and Eltantawy 2004)
		Political Unrest	(Choudhary et al. 2011; Chowdhury 2007; Rao and Goldsby 2009)
		Heavy dependence on import products.	(Giunipero and Eltantawy 2004; Qian et al. 2011; Curtis 2011)
		Human diseases	(Faye and Loiseau 2002a)
		Distorted information	(Qian et al. 2011; Carter and Rogers 2008b)
	Environmental	Natural uncertainties	(Mishra and Shekhar 2011; Finch 2004)
		Hazard risks (accidents, fire, delay, damage, strikes etc.)	(Finch 2004; Chowdhury 2007; Mishra and Shekhar 2011; Jüttner, Peck and Christopher 2003)

3.7 DAIRY SUPPLY CHAIN RISK MITIGATION

Risk mitigation is the action taken to prevent possible risk to people or property. Arrangements made to reduce the severity of losses such as disease management, crop diversification, etc., are termed risk mitigation (Choudhary et al. 2011). The process of risk management begins with risk identification and finishes with the mitigation of risks through the development of risk responses. Different responses for dealing with risk in an organisation are risk avoidance, risk mitigation, risk sharing, risk transference and risk retention (Mishra and Shekhar 2011). Jüttner; Peck and Christopher (2003) suggest four generic strategies which can be used as risk mitigation strategies. These are: avoidance, control, cooperation and flexibility. Table 3.5 presents the mitigation strategies. These strategies can be categorised under the four generic strategies prescribed by Jüttner, Peck and Christopher (2003). For instance, the elimination of middlemen comes under avoidance, while disease management comes under control. Similarly, business practices and breeds management come under cooperation, whereas disaster resilience comes under flexibility.

Table 3.5: Dairy Mitigation Strategies

Strategy	Description	References
Feed Management	Focus on certified supplier of feed in order to get high quality of feed.	(Ahsan 2011; PRAN-RFL 2007)
Breed Management	Attempts to create various cross breeds to increase productivity by adopting AI services.	(Ghani and Rahman 2004; Shamsuddoha and Edwards 2000; Ahsan 2011; Khanna 2004; PRAN-RFL 2007)
Herd Management	Cattle management by arranging proper housing with water in quantity and quality and disinfecting in milk operation.	(Ha and Kim 2004)
Training Management	Staff training and development programmes.	(Ritchie and Brnidley 2007a; Chowdhury 2007; Bari 2008; Raha and Talukder 2004; PRAN-RFL 2007)
Diseases Management	Prevention of diseases by providing vaccination services and veterinary facilities.	(Choudhary et al. 2011; Shamsuddoha and Edwards 2000; Ghani and Rahman 2004; Bari 2008)
Disasters Resilience	The capacity of hazard-affected bodies to resist loss during disaster in a specific area in a given period by proper food and water supply and managing early warning system.	(Habiba, Shaw and Takeuchi 2011; Tang and Musa 2011; Choudhary et al. 2011)
Eliminate Middlemen	Removal of the unnecessary influence of middlemen from the chain.	(Peck 2005; Sheffi and Rice 2005; Jüttner, Peck and Christopher 2003; Ahsan 2011)
Insurance Management	Buying insurance against production loss.	(Akcaoz, Kizilay and Ozcatalbas 2009; Choudhary et al. 2011; Bari 2008)
Technology Development	Adoption of improved technology and hiring technical know-how.	(Akcaoz, Kizilay and Ozcatalbas 2009; Choudhary et al. 2011; Okano, Vendrametto and Santos 2010)
Multiple Sourcing	Undertaking multiple source of feed to ensure the delivery of feed in case of the delivery or quality problem.	(Ahsan 2011; Jüttner, Peck and Christopher 2003; Tang and Musa 2011)
Sound business Practice	Promote sound business practices by cooperation, better coordination and information sharing.	(Choudhary et al. 2011; Jüttner, Peck and Christopher 2003; Carter and Rogers 2008b; Shamsuddoha and Edwards 2000)
Diversification	Focus on product diversification and value addition.	(Choudhary et al. 2011; Karim et al. 2010)
Incentive Programme	Undertake motivational and incentives programmes for staffs.	(Rao and Goldsby 2009; Ritchie and Brnidley 2007a; Okano, Vendrametto and Santos 2010; Abdullah 2004)

Financial Management	Assurance of adequate institutional credit support.	(Shamsuddoha and Edwards 2000; Raha and Talukder 2004; Ahsan 2011)
Monitoring team	Maintenance of monitoring team.	(Peck 2005; PRAN-RFL 2007; Sheffi and Rice 2005; RD_Food 2011)
Government support	Create a national dairy development policy and improve transparency and accountability at all levels.	(Choudhary et al. 2011; PRAN-RFL 2007; Food 2011b; Raha and Talukder 2004)
Business policy	Reduction of risks through merger, acquisition and integration.	(Rao and Goldsby 2009; Peck 2005; Manuj and Mentzer 2008a; Jüttner, Peck and Christopher 2003; Carter and Rogers 2008b)
Backup capacity	Managing adequate power backup (own powerful generator).	(Food 2011b; Choudhary et al. 2011; Sheffi and Rice 2005)
Direct Marketing	Arrange direct marketing by reducing extra involvement of middlemen.	(Akcaoz, Kizilay and Ozcatalbas 2009; Ahsan 2011)
Transport Management	Arrangement of adequate refrigerated transport services for perishable milk and milk products to ensure timely distribution.	(Choudhary et al. 2011; Food 2011b; Barabas 1995)
Total Quality Management (TQM)	Following the improvement of total quality throughout the whole chain.	(Khanna 2004)
Liquidity Management	Managing adequate amount of cash and personal savings for the business.	(Akcaoz, Kizilay and Ozcatalbas 2009; Ahsan 2011)
Off-farm income and Investment	Introducing off- farm activities.	(Ahsan 2011; Akcaoz, Kizilay and Ozcatalbas 2009)
Liaison with the Political Party	Maintaining a good relationship with leading political group.	Field observation

Risk management strategies may be preventive or reactive. Thun and Hoenig (2011) state that the preventive approach involves cause related measurements that attempt to reduce the probability of risk happenings whereas the reactive approach involves effect related measurements that attempt to absorb the damage after risk occurrences. Akcaoz, Kizilay, and Ozcatalbas (2009) conducted a survey on risk and risk management strategies associated with dairy in the Antalya province of Turkey. The survey categorised farms as small, medium and large. According to the findings for small farms, the most important risk management strategies were decreasing livestock disease, implementing strict hygiene rules and keeping good liquidity. For medium farms, the most effective strategy was keeping debt low. For large farms, producing at lowest possible cost was found to be the most important risk mitigation strategy. Dairy

is a high risk business because of the raw material that the industry deals with (Mishra and Shekhar 2012). Due to the perishable nature of milk (the main product of dairy), dairy industries need to adopt strategies to either prevent or reduce the risks. Milk has to be kept cold and maintained at a certain temperature throughout its progress along the marketing chain. Hence the distribution of milk should be done in an insulated vehicle in order to reduce the risk of perishability by avoiding excessive temperature increases (Abdullah 2004).

In order to mitigate risk, the elimination of both economic and technical constraints is important (Shamsuddoha, 2000). Economic constraints can be overcome by providing adequate loan facilities. Technical constraints can be overcome by improving breeds, feed and production methods. At the Asian Productivity Organization (APO) conference, Khanna (2004) suggested the Total Quality Management (TQM) approach as a risk mitigation policy, where improvement of quality has to follow the entire chain from the producer's doorstep to the arrival of products to the consumer. This approach includes good hygiene practices, good housekeeping, and good manufacturing practices. Training programmes for employees could be another strategy for mitigating risk. To increase the lifetime productivity of dairy animals, farmers need to be properly trained in management practices (Khanna 2004). According to Hall, Alam and Raha (2012), technical training in feeding management, breed management and milk preservation could also help to mitigate risk. They also suggest regular and consistent delivery of health services including veterinary and marketing services and development.

Although different strategies to mitigate dairy risks have been put forward, risk cannot be avoided completely in this sector. Therefore, this research explores a further mechanism for developing mitigation strategies by taking a Quality Function Deployment (QFD) approach (Han et al. 2001). In response to the lack of formal approaches to dairy risk mitigation, this research develops a new framework that categorises risks to the supply chain in terms of sustainability, and identifies possible outcomes of appropriate mitigation strategies. This is a significant contribution to the theoretical aspects of dairy supply chain risk management. It is important to know the impact of mitigation strategies for various risks based on performance outcome. This research uses performance analysis to find the perfect match between supply chain risks and mitigation strategies selected from available options. The next section discusses performance outcomes based on the implementation of mitigation strategies.

3.8 PERFORMANCE OUTCOME

Performance outcome is the result of effective and efficient management responses. Outcomes in terms of efficiency and effectiveness are linked to risk management responses which help to measure existing risks in supply chain (Ritchie and Brnidley 2007b). Ritchie and Brindley (2007) explain that risk management responses include risk insurance, information sharing, joint training, regular joint reviews and developing risk management awareness and skills.Several research models have been developed to identify the performance outcomes that can able to measure the risks. Bettis (1982) developed a model in which performance outcomes are linked to industry characteristics, strategic decisions and risk. Carter & Rogers (2008) propose a sustainable supply chain model, which features sustainable outcomes like warehouse safety, worker safety, lower labour costs due to the motivation of supply chain personnel, better quality product and reputation enhancement.

The dairy industry, which plays a crucial role in the agro-based economy of a country, provides enough scope for the rural and sub-urban people to earn extra money in their leisure time (Mishra and Shekhar 2012; Mishra and Shekhar 2011). Livestock are well integrated into the mixed farming system in Bangladesh, where 25% of the population are directly involved in livestock production and another 60% are indirectly involved (BBS 2010). Livestock are reared, not only to be eaten on occasion, but also to earn cash income through a range of other products such as meat, milk, eggs, draught power, manure, skin, feather and horns. Sale of livestock and livestock products enables poor families-in particular destitute women-to attain increased stability in income for the family without disrupting household activities. Small-scale livestock production does not compete with crop production. Instead crop and livestock production supplement each other. The livestock production therefore provides opportunities for rural people to improve their livelihood without disrupting the balance of the integrated farming system (Jahan and Rahman 2003).

Dairying is a good source of income for small and marginal farmers. The feeds required for milk production can be met from their limited land resources, as most of the milch animals are ruminants and the majority of their food can be derived from forage, coarse roughage and by-products not utilised by human beings, without incurring much additional cost. Dairy animals, comprising cows and buffaloes, are the major livestock and hold a very important place in the national economy of Bangladesh. Apart from their role in milk production, they contribute a huge quantity of organic manure,

which is one of the major inputs to Bangladesh agriculture. Dairying is a subsidiary occupation of almost all farmers in Bangladesh. More than 60% of the families involved in dairying consist of small and marginal farmers and even agricultural labourers. Diseases and parasites are a major problem for the dairy industry in Bangladesh. Diseases like rinderpest, contagious bovine pleuro-pneumonia, and foot and mouth disease cause high mortality and severe economic loss (Shamsuddoha and Edwards 2000; Edwards and Daniel 1992).

Table 3.6 shows sustainable outcomes described by various authors based on the concept of triple bottom line. For instance, profit maximisation, cost minimisation, income and production increments are categorised as economic outcomes. Goodwill, food quality, nutrition development, increased living standards and employment creation are categorised as social outcomes. Waste management and hygiene practice are categorised as environmental outcomes. If a farm can implement appropriate strategies to achieve these sustainable outcomes, then it can be called a sustainable business.

Table 3.6: Sustainable Outcomes from Literature

Sustainable aspects	**Outcomes**	**References**
Economic	Profit maximisation through increasing sales	(Fawcett, Magnan and McCarter 2008), Wagner and Neshat 2010) (Shamsuddin, Alam, Hossein, Goodger, Bari, Ahmed, Hossain, et al. 2007)
	Cost minimisation through reducing utility cost	(Carter and Rogers 2008, Bennett 2004, Wagner and Neshat 2010, Fawcett, Magnan, and McCarter 2008)
	Increasing income through higher production	(Bari 2008Abdullah 2004, Ghani and Rahman 2004, Jabbar 2010, Shamsuddoha 2009, Kabir and Huo 2011)
	Increase in production by proper cattle management	(Abdullah 2004)
	Product quality improvement by TQM approach	(Abdullah 2004, Raha and Talukder 2004, Fawcett, Magnan, and McCarter 2008)
	Expansion of farming system	(Shamsuddoha and Edwards 2000, Bari 2008)
	Production of value added product and diversified product	(Ghani and Rahman 2004)

Social	Goodwill enhancement	(Carter and Rogers 2008b)
	Supply of quality food to the consumer	(Raha and Talukder 2004)
	Nutritional development	(Okano, Vendrametto, and Santos 2010, Bari 2008, Haque 2009, Ghani and Rahman 2004, Halder and Barua 2003)
	Improvement of living standard	(Bari 2008; Curtis 2011; Khan, Peters and Uddin 2009)
	Creation of employment opportunity	(Ritchie and Brnidley 2007, Bari 2008, Jabbar 2010)
Environmental	Creation of sound working environment	(Carter and Rogers 2008 , Group 2009)
	Waste management	(Al Mamun, Nasrat, and Debi 2012, Loehr 1974)
	Environmental development(increase in hygiene practice)	(Khanna 2004 , Group 2009)

Despite numerous research studies into supply chain risk management, little attention has been given to dairy supply chain risk management and the probable outcomes of risk mitigation strategies in terms of sustainability. This research attempts to meet this gap by identifying the possible sustainability outcomes of risk mitigation strategies implemented at the dairy farm level in Bangladesh.

3.9 THEORETICAL FRAMEWORK: CONTINGENCY THEORY AND SUSTAINABILITY THEORY FOR SCRM

This research is built on two theoretical underpinnings: Sustainability and Contingency theories (Carter and Rogers 2008a; Faisal 2010). As described earlier, sustainability incorporates environmental, social and economic components that allow an organisation to achieve long term viability (Carter and Rogers 2008a). According to the World Commission on Environment and Development (WCED1987, p.8), sustainable development is 'development that meets the needs of the present without compromising the ability of future generations to meet their needs'.

On the other hand, potential initiatives for reducing long term risks related to resource depletion, fluctuation in energy costs, pollution and waste management can also be described as sustainability (Shrivastava 1995). The Sustainable Agriculture Initiative (SAI) Platform 2005 reports that good management of a farming system refers to economic, environmental and social sustainability. The report adds that overall sustainability is the outcome of sustainable farming systems (breed management, feed

management, milking hygiene), economic sustainability (food quality, production quality and production profitability), social sustainability (proper training and fair treatment to employees) and environmental sustainability (bio-diversity, energy, waste management, water).

Bagheri and Hjorth (2007) consider that sustainability is not a fixed ideal but an evolutionary process which can improve management systems by improving knowledge and understanding. In recent years, improved understanding has required that strong attention be given to the sustainability of supply chains. However, as Faisal (2010) observes, very limited research has been conducted into the impact of sustainable supply chains focusing on the protection of green, global and social capital associated with an organisation's overall economic welfare. In addition, research has ignored the area of competitive advantage development arising from sustainable supply chains (Markley and Davis 2007) and future competitive advantage through sustainable supply chains. Thus it is apparent that, in order to develop a sustainable global economy, it is necessary to implement sustainable supply chain strategies and evaluate their impact.

The dairy sector of Bangladesh is rural based and experiences various risk factors concerned with breeding, feeding, management, diseases and marketing (Shamsuddoha and Edwards 2000). The risks can be eliminated using proper strategies. At the same time, the Bangladesh dairy industry could achieve sustainable outcomes through the appropriate implementation of strategies. The term sustainability has been used in different research domains but little research has been conducted on the dairy sector and its supply chain management. In an effort to explore sustainability theory in a supply chain context, this research will categorise the supply chain risks in terms of their sustainability aspects. This categorisation will be useful for developing risk mitigation strategies which will ultimately lead to sustainable outcomes for the dairy sector.

Contingency theory assumes that the effectiveness of an organisation in coping with the demand of its environment is contingent upon the elements of its various sub-systems (Thomas 1986) and situation favourableness (Fiedler 1971). Tosi and Selcom (1984) argue that contingency theory must include both environmental sectors (users of output, input sources and external regulators) and attributes of specific sectors (customers, raw product supplies, capital sources, technology). Contingency theory is a

framework for organising knowledge in a given area, acknowledging that certain variables may affect the outcome of a process (Tait and Vessey 1988). Zeithaml, Varadarajan and Zeithaml 1988b) distinguish three types of variables: contingency variables, response variables and performance variables (Zeithaml, Varadarajan and Zeithaml 1988b).

Contingency variables are situational characteristics, response variables are managerial actions and performance variables are dependent measures which evaluate the effectiveness of contingency variables and response variables (Thomas 1986; Zeithaml, Varadarajan and Zeithaml 1988b). In this research, contingency theory is used to develop a framework based on these three variables, where contingency variables represent the risk categories in terms of sustainability, response variables represent risk mitigation strategies, and performance variables represent possible outcomes. The adoption of principles of sustainability in supply chain management is challenging because there are pressures from surrounding stakeholders to integrate sustainable components into the supply chain. Dairy supply chain risks are situational, and contingent upon environmental uncertainty, technology and organisational size. Moreover, this industry directly or indirectly involves the livelihood of a significant number of people. This research will thus resolve the existing problems relating to achieving sustainability in the context of current dairy supply chain risks.

3.10 SUMMARY OF RESEARCH GAPS

This section articulates the research gaps found in sections 3.3 to 3.9**.** Initially, the literature studies found limited research on Bangladesh dairy supply chain risk management. The research limitation is based on identifying dairy supply chain risks, especially those associated with sustainability, and subsequently analysing the risks in terms of high probability and high impact. Such problems can be solved through identifying suitable strategies to solve particular risks. The literature review also failed to explore appropriate recommendations for real-life practices on improving infrastructure, environmental hazards, operational skills, accumulated efforts and the like. Hence this research investigates existing dairy operations and their outcomes in terms of the triple bottom line aspects of sustainability.

This research also attempts to categorise the risks associated with the dairy supply chain from a sustainability perspective and simultaneously develops mitigation strategies and discusses probable outcomes. In existing studies, there has been little

research on identification of the risks on the basis of sustainability. Thus this research fills the existing gaps in knowledge concerning the dairy supply chain. It is important to know the impact of mitigation strategies for various risks based on performance outcome. In response to the lack of formal approaches to dairy risk mitigation, a new framework is developed to categorise risks to the supply chain in terms of sustainability, and identifies possible outcomes of appropriate mitigation strategies. This is a significant contribution to the theoretical aspects of dairy supply chain risk management. This research also uses performance analysis to find the perfect match between supply chain risks and mitigation strategies selected from available options.

In this research, contingency theory is used to develop a framework based on three variables, where contingency variables represent the risk categories in terms of sustainability, response variables represent risk mitigation strategies, and performance variables represent possible outcomes. The adoption of principles of sustainability in supply chain management is challenging because there are pressures from surrounding stakeholders to integrate sustainable components into the supply chain. Dairy supply chain risks are situational, and contingent upon environmental uncertainty, technology and organisational size. Moreover, this industry directly or indirectly involves the livelihood of a significant number of people. This research will thus resolve the existing problems relating to achieving sustainability in the context of current dairy supply chain risks.

Overall this study has filled the research gaps for Bangladesh dairy and its supply chain risk management issues to achieve sustainability. First this research has taken initiative to explore the risks associated with the dairy industry in Bangladesh. Then , risks are categorised based on probability of occurrence and severity of impact. The current research has then identified appropriate mitigation strategies for specific risks found in the dairy operations in Bangladesh. Lastly probable outcomes are identified for sustainable dairy production and process. Dairy supply chain risk management is very contemporary. Yet there is no adequate comprehensive approach to identify dairy risks and their sustainable mitigation strategies. Hence this study contributes to fill the research gap prevailing in dairy supply chain risk management in Bangladesh.

3.11 PROPOSED RESEARCH MODEL

Drawing on the relevant literature, a risk mitigation model was developed (Figure 3.10). In this model, supply chain risks are identified based on different level of storage, process and distribution. Identified risks are then categorised in terms of the three

aspects of sustainability. Similarly, mitigation strategies are identified and classified in terms of the three aspects of sustainability. Finally mitigation strategies are implemented in order to achieve a sustainable outcome.

Supply chain risk variables were collected from the primary sources through qualitative interviews. Interview responses were transcribed and key variables were identified. A number of variables were rejected due to insufficient responses and limited importance. Respondents were asked about particular mitigation strategies associated with various supply chain risks. The findings show that sustainable outcomes can be achieved once appropriate mitigation strategies are deployed for particular supply chain risks. A sustainable outcome is a combined result of the economic, social and environmental aspects of mitigation strategies over the risks arising at the storage, process and distribution levels.

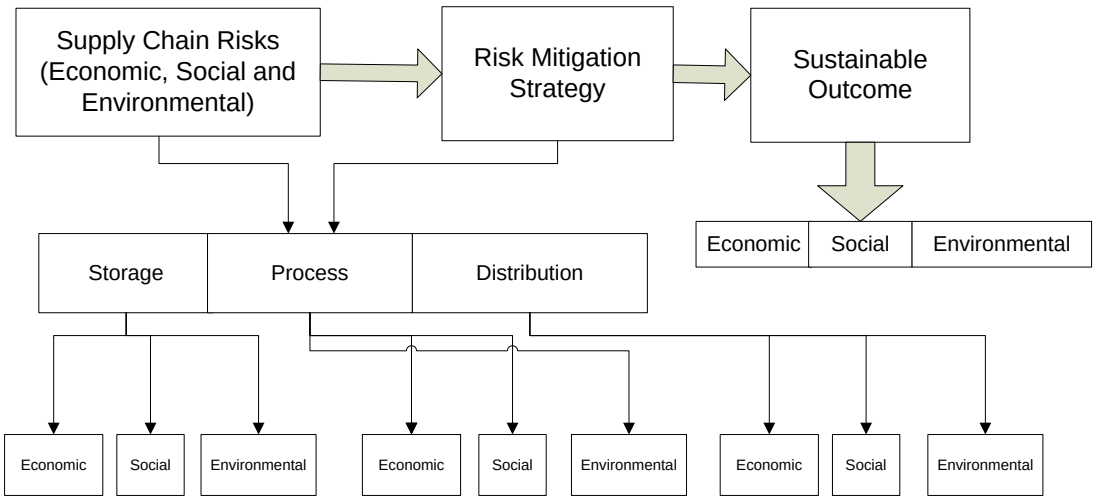


Figure 3.10: Dairy Supply Chain Risk Mitigation Strategy Model

3.12 SUMMARY

This chapter reviewed the literature relevant to this current research. The theoretical concepts of sustainability, triple bottom line, sustainable supply chain, dairy supply chain, supply chain risks, supply chain risk management, dairy supply chain risk and dairy supply chain risk management were defined and reviewed. The review revealed the gaps in knowledge and highlighted the significance of this research. This chapter also presented an initial research model based on sustainability and contingency theories. The next chapter discusses the research methodology and research design, along with the operationalisation of the major phases of the research.

CHAPTER 4: RESEARCH METHODOLOGY

4.1 INTRODUCTION

This chapter details the research methodology used to conduct the current research. It describes the research method, process and tools used in the study. Different authors have defined research methodology variously as the systematic exploration of facts and principles or the collection and analysis of information to address specific research objectives and questions (Tress, Tress and Fry 2006; Ritchie and Lewis 2003; Bernard 2012; Denzin and Lincoln 2011; Wilkes and Krebs 1995). In this chapter, the research questions and objectives that were presented in Chapter 1 provide the basis for the action of this study. The 'mixed methods' approach, that is, the combination of both qualitative and quantitative approaches, is used (Teddlie and Tashakkori 2003; Tashakkori and Teddlie 2003). A step-by-step method for conducting the three basic stages of this research-the interview, questionnaire survey and case studies-is described in this chapter. The chapter also explains the adopted methods in terms of a positivist paradigm and includes the rationale and justification for using this method to conduct the research.

4.2 RESEARCH PARADIGM

A research paradigm is a conceptual framework that guides the research activities, including the research design, data collection method, presentation and interpretation of findings. The research paradigm can be regarded as a set of basic principles which allows researchers to recognise their role in the research process (Lincoln and Guba 1994). According to Gephart (1999), there are three philosophical paradigms: positivism, interpretivism, and critical science.

The positivist research paradigm attempts to apply the methods and principles of the natural sciences model to explain the behaviour or phenomena in terms of a causal relationship. In positivist research, researchers assume that reality is independent from the knower and the research is objective-oriented (Johnson 2004; Smith 1983). In this view, data collection and analysis are value-free rather than based on subjective interpretation (Krauss 2005). The positivist paradigm features specific research questions and hypotheses testing connected with quantitative research (Johnson 2004; Johnson and Onwuegbuzie 2004; Creswell 2008; Creswell 2002). Furthermore, positivist researchers do not reach conclusions based on their own cognition or

rationality; rather they usually maintain a distance from the participant(s) and what is being researched, and see reality as 'being' rather than 'becoming' (Dwivedi 2007).

The second research paradigm is the interpretivist paradigm. This paradigm features qualitative methods. Interpretivism attempts to interpret the inter-subjective meanings, where a phenomenon is subject to multiple explanations or realities rather than one causal relationship or one theory (Schwandt 1994; Neuman 1997; Creswell 2002, 2013). In contrast with the positivist researcher, the interpretivist researcher believes that the researcher should interact with and affect the issues being researched and see all things as 'becoming' (Creswell 2013). The positivist paradigm informs quantitative research by seeing information as flowing from a logical and mathematical scientific process (Fairclough 2003; Larraâin 1979), whereas the interpretivist approach aims to develop a natural science through social interpretation (Neuman 2005) which is normally used in qualitative research (Creswell 2013).

The third paradigm, critical science, is a combination of critical theory and postmodernism. It seeks to provide historical understandings through the re-examination of important events to reveal unacknowledged forms of exploitation and domination (Swanson and Holton 2009). This paradigm usually focuses upon opposites, conflicts, and contradictions (Myers 1997) and takes a qualitative approach, although the quantitative approach is becoming increasingly prominent.

The use of these underlying paradigms varies. Orlikowski and Baroudi (1991) state that 96.8% of studies they examined took a positivism approach, only 3.2% took an interpretivism approach and none employed critical epistemology. Mingers (2003) states that 75% of the research studies were examined using positivist approach, 17% took an interpretivist approach and only 5% took a critical theory approach.

When considering the research paradigm and methodology of the present study, it is necessary to reflect on the objectives, nature, and context of the research. This research on dairy supply chain risk management attempts to identify risk sources, measure the risks and develop risk mitigation strategies with probable outcomes. Initially qualitative methods were used to identify risks and possible mitigation strategies; later quantitative methods were used to examine the effectiveness of the risk mitigation strategies and the probable outcomes. Most studies take either a mono-method approach (such as a positivist (quantitative) or an interpretivist (qualitative) approach) or a mixed methods approach (Venkatesh, Brown and Bala 2013). However, the nature of the current study

places both quantitative and qualitative research methods under a positivist paradigm. There was a long debate on mixed methods and the positivist paradigm in the 1970s and 1980s, and some researchers favoured using mixed methods under positivist paradigm (Hall 2012). The current study is conducted within a positivist paradigm.

This study takes a mixed methods approach as both qualitative (designed to collect words) and quantitative (designed to collect numbers) (Greene, Caracelli and Graham 1989a; Marshall and Rossman 2014) data were collected. Within the positivist paradigm, the mixed method design adopted in this research was concerned with the collection of both qualitative (identification of risk sources and risk mitigation strategies) and quantitative (measurement of the effectiveness of the risk mitigations strategies and probable outcomes) data. The reason for quantifying the risks was to identify the most highly probable and high impact risks. The effectiveness of mitigation strategies was examined in terms of optimisation. Therefore, the acceptable risks and mitigation strategies needed to be confirmed by a group of dairy farm representatives. The likelihood of new risk sources and possible mitigation strategies was also explored. For these purposes, a qualitative study was conducted. This was followed by a quantitative study conducted to measure high probable and high impact risks, objectively evaluate the effectiveness of mitigation strategies, and determine probable outcomes.

The combination of qualitative and quantitative methods within one study is common in behavioural studies (Bailey 2008; McEachern and Warnaby 2005; Beedell and Rehman 1999). Most studies of supply chain risk management (SCRM) are guided by either a positivist (quantitative) or an interpretivist (qualitative) paradigm. However, for the above-mentioned reasons, a mixed methods approach has been approved for this study. This approach combines the virtues of qualitative methods to answer exploratory questions and quantitative methods to answer confirmatory questions (Tashakkori and Teddlie 2003) posed by the study.

4.3 RESEARCH METHOD

4.3.1 Mixed methods

The combination of both qualitative and quantitative methods usually termed 'mixed methods' (Tashakkori and Teddlie 1998) is used in this research. This mixed methods approach implies a third paradigm (Tashakkori and Teddlie 1998). In the mixed paradigm, a blend of qualitative and quantitative approaches is taken to diverse segments within the whole research process. According to Greene et al. (1989b), mixed

methods refers to "studies that contain at least one qualitative method (to collect words) and one quantitative method (designed to collect numbers), where none of the methods is integrally linked to any particular inquiry paradigm". Referring to Tashakkori and Teddlie (1998), the mixed methods approach refers to studies that use qualitative and quantitative data collection and data analysis either equally or sequentially. Creswell (2003) identifies four major types of mixed methods research design (shown in Figure 4.1): triangulation design (collect and compare the data collected using both qualitative and quantitative methods to validate or expand quantitative results with qualitative data); the embedded design (the collection of both qualitative and quantitative data, but one of the data types takes a supplementary role within the overall design)the explanatory design (the collection and analysis of quantitative data addressing the study's questions, followed by subsequent qualitative data collection and analysis); and the exploratory design (to explore a phenomenon, begins with qualitative data and then moves to a second quantitative phase).

The current research is an exploratory study that builds on the initial qualitative findings and progresses to generalizable results in the quantitative phase (Creswell 2008). The qualitative part of this research is limited to a small number of interviews as few respondents were available. As discussed in Chapter 1, the main objective of this research was to explore the risk issues and mitigation strategies of dairy supply chains, along with sustainable outcomes resulting from strategy implementation. Thus a qualitative field study employing semi-structured interviews was conducted to identify risks associated with the dairy sector in Bangladesh and potential strategies to mitigate those risks. Finally, a quantitative study taking the form of a survey was carried out.

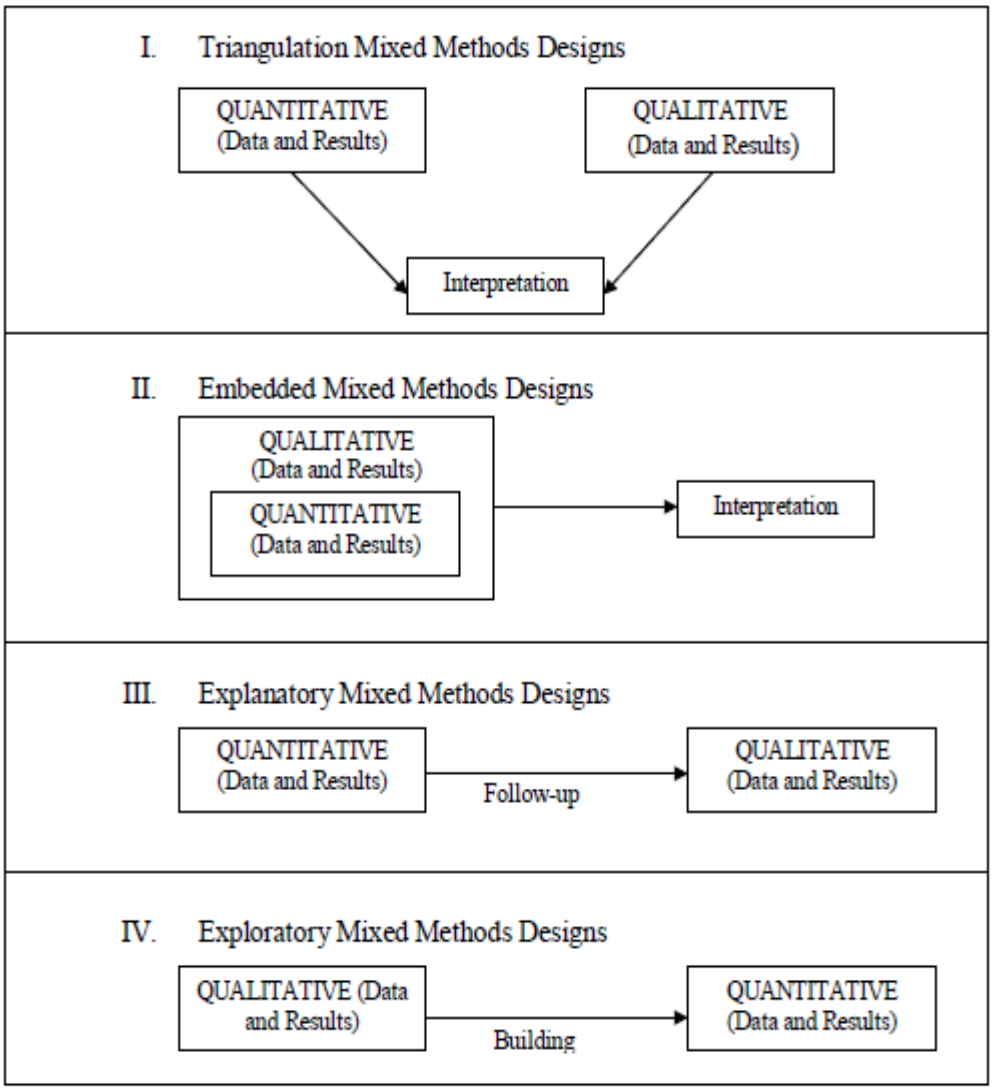


Figure 4.1: Four Types of Mixed Method Design (Creswell 2002)

4.3.2 Case studies

Case studies refer to a particular form of qualitative research consisting of in-depth studies of cases over time, using multiple sources of information obtained through observation, documents, questionnaires and interviews (Seawright and Gerring 2008). A single case study involves an in-depth, longitudinal study of a single event with a limited number of variables, rather than using large samples and following a rigid protocol. Yin (2003) defines a case study as an empirical/practical investigation that inspects a current phenomenon within its real-life context. Case studies can focus on understanding or investigating relationships in either one or many organisations (single or multiple cases). They provide a systematic way of examining events. Therefore, they can be used for many purposes, including providing descriptions, testing theories and generating theories (Yin 2009, 1994; Yin 2011; Yin 2003). An

extensive review of the research literature reveals that case studies could be most appropriate for this research study because they principally address those research problems that ask 'how' and 'why' type questions (Eisenhardt and Graebner 2007; Yin 2003). Thus, in this research, case studies of two large scale commercial dairy farms were conducted using combined methods of data collection including observation, interviews and questionnaires. It is noted here that both case industries have granted permission to reveal their names. A dairy farm operating with more than 3.0 hectares of land and eighty to one hundred cows can be classified as a large scale dairy farm (Uddin 2003; Saadullah 2011; Islam et al. 2002). In this sense both of the cases are large scale dairy farms. Miles and Huberman (1994b) and Eisenhardt and Graebner (2007) suggest that case studies have the advantage of collecting a range of data from experienced people. The two cases are briefly described below.

4.3.2.1 Nahar Agro Farms Limited

Nahar Dairy was founded at the beginning of the 1990s. It was a family-owned farm initially having a cluster of 35 cattle. They invested one million Bangladeshi Taka which is equivalent to AUD $14,500. They continued with that small dairy farm for around ten years with a maximum of 55 cattle, AUD $30,000 and 250 litres of milk production. In 1999, Nahar Dairy restructured their farm with the scope of bigger lands, capital and logistics. At present, they have 560 cattle of all kinds with 2,600 to 3,000 litres of milk production per day. Nahar Dairy also developed its supply chain network to maintain proper supply. Table 4.1 shows the distinctive features of the two case farms to highlight their differences.

4.3.2.2 Paharika Farms Limited

Paharika Dairy was founded at the beginning of 1996 as a private limited commercial farm. They started with around 200 cattle with 700 litres of milk production per day. They invested three millions Bangladeshi currencies (Taka) which is equivalent to approximately AUD $43,000 to maintain milking machines, a chiller machine, transport and scientific sheds and management. They have slowly expanded their farm. At present, they have 352 cattle of all kinds with 1,300 to 1,500 litres of milk production per day. They also added chiller facilities of 1,000 litres to preserve their milk for over time in the summer. They still keep their modest, scientific farm confined within the same place. Table 4.2 shows the comparison analysis for two case farms to highlight the differences.

Table 4.1: Nahar and Paharika at a glance

Subject	Nahar	Paharika
Size (No. of employees)	55	32
Production (L/day)	2600–3000	1300–1500
Chiller capacity (Litre)	3000	1000
Milk shed	3	1

Table 4.2: Average Milk Production of Case Industries

Year	Nahar Production	Paharika Production
2010	670	720
2011	877	770
2012	1522	1184
2013	1928	1232
2014	2630	1355

4.4 RESEARCH PROCESS

The research process was carried out in sequential steps. It commenced with an extensive review of the literature related to theories of supply chain risk management. From the literature review, the initial risks, mitigation strategies and sustainable outcomes (after implementing mitigation strategies) for dairy industries were identified. The next step was the conduct of the qualitative field study using interviews and content analysis of the interview responses. The field study findings were then used to refine the risks, mitigation strategies and sustainable outcomes identified from the literature. The next phase involved the development and design of a questionnaire-based survey using the literature review and field study findings. Data for QFD analysis were collected from the two case industries. These data were collected through a three-part questionnaire-based survey of employees, executives and supply chain members. The gathered quantitative data was then analysed. The Quality Function Deployment (QFD) tool was used to test the effectiveness of the results, which were then interpreted and discussed. The whole process of this study is diagrammatically presented in Figure 4.2.

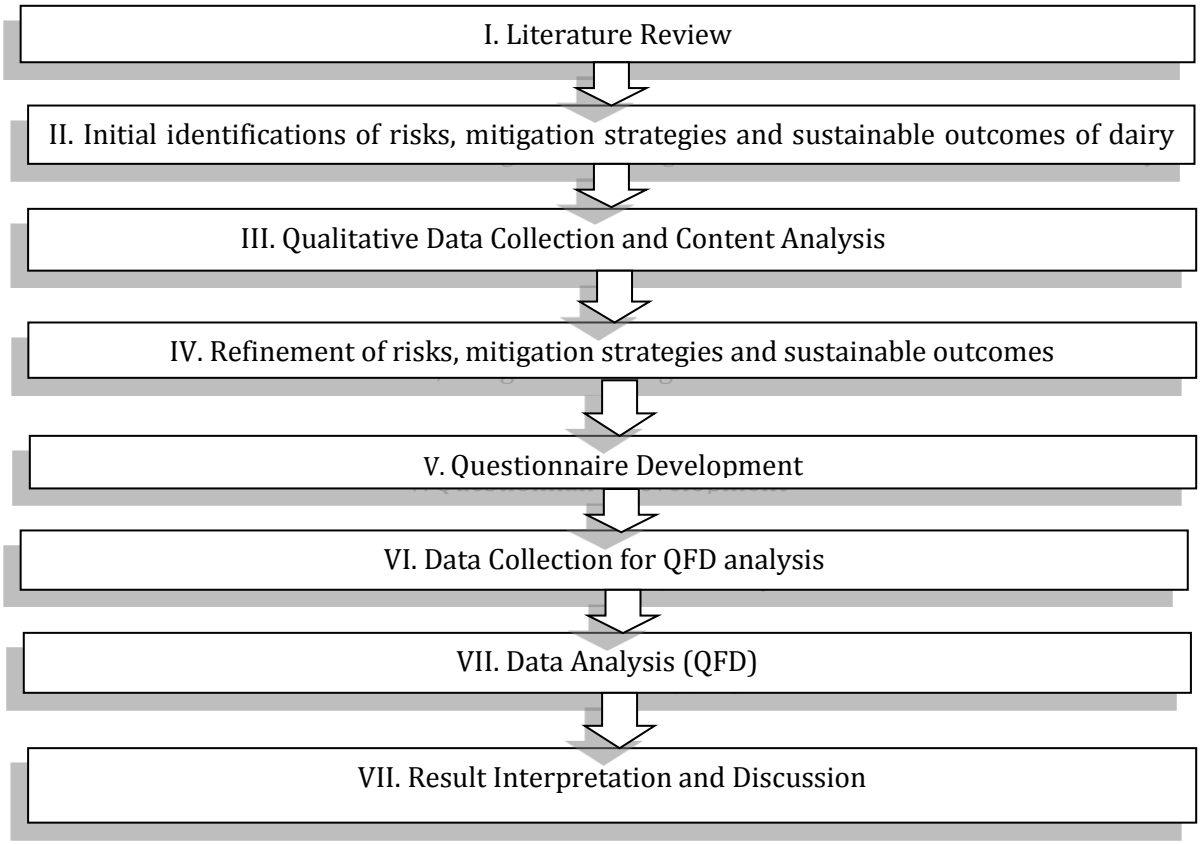


Figure 4.2: The Sequential Presentation of the Research Process.

Step I: Literature review

This step involved a thorough review of the literature to identify gaps in knowledge and produce research objectives and construct a model. This is done by reviewing literature in journals, books, seminar proceedings, working papers and the other sources. Following the literature review, the research questions and corresponding research objectives were outlined. Several research questions and objectives were developed. These were sketched in Chapter 1.

Step II: Initial identification of risks, mitigation strategies and sustainable outcomes in the dairy industry

The review of the literature revealed a range of risks, mitigation strategies associated with the dairy industry, and different sustainable outcomes that may be attained through implementing mitigation strategies.

Step III: Qualitative data collection and content analysis

Interviews were conducted with 10 respondents (farm managers/owners) from two large scale commercial dairy farms in Bangladesh. Both farms are rapidly growing and

facing different risks to their existing operations. Different risks at the storage, process and distribution levels of the dairy supply chain were identified. Possible risk mitigation strategies were also identified through interviews with stakeholders in the case industries and the probable sustainable outcomes were also identified. The interviews were conducted using semi-structured questions and subsequently transcribed by the researcher. Then the transcribed data were analysed using the content analysis method recommended by Miles and Huberman (1994b) and Marshall and Rossman (2010). The findings revealed the risks, mitigation strategies and sustainable outcomes (after implementation of different risk mitigation strategies) for the two dairy farms.

Step IV: Refinement of risks, mitigation strategies and sustainable outcomes

The dairy supply chain risks, possible mitigation strategies and sustainable outcomes were identified. Decisions concerning the inclusion of important variables and the exclusion of similar variables were made in this stage.

Step V: Questionnaire-based survey development

In this step, a three-part questionnaire-based survey was designed based on the findings of the in-depth interviews. The first part of the questionnaire was structured to collect data about the probability and impact of risks in the dairy farms. Participants were asked to rank the probability of the occurrence of risk and its impact on the dairy supply chain. The second part of the survey was developed to gather data regarding the relationship between risks and mitigation strategies. The strength of this relationship was scored (strong, medium, weak) by the participants. Once this was done, the third part of the survey was designed to collect data about the relative costs of implementation of each mitigation strategy.

Step VI: Data collection for QFD analysis

In this step, the data required for QFD analysis were collected via the survey. Data were collected from two large scale commercial dairy farms. The researcher has access and considerable contacts with these farms and their support enabled the collection of detailed and accurate data. Data for the case studies were collected from employees, executives and supply chain members. It should be noted that data were collected at the farm level, as farms produce, store and distribute milk and milk products through the supply chain.

Step VII: Data analysis (QFD)

Data gathered through the survey were analysed using the Quality Function Deployment (QFD) technique. The QFD analysis produced a descriptive analysis which helped to identify the highly probable and high impact risks and appropriate risk mitigation strategies for each dairy farm. The QFD method is discussed in Section 4.5(Research Framework Based on QFD).

Step VIII: Results interpretation and discussion

The final step in the process was the interpretation and discussion of the results obtained from the QFD analysis. The detailed results for each group (employees, executives and supply chain members) of both case industries were included. .

4.5 RESEARCH FRAMEWORK BASED ON QFD

In this section, the meaning of QFD is explained and its applications, along with its advantages and disadvantages, are described.

4.5.1 Quality Function Deployment (QFD)

Quality Function Deployment (QFD) was first developed in 1972 by Professor Yoji Akao at the Tamagawa University in Tokyo. It has since been introduced into numerous industrial and service applications throughout the world (Fowler 1991; Al-Mashari, Zairi and Ginn 2005). Quality Function Deployment (QFD) is defined differently by different authors. In a general sense, QFD is an organised process of a set of interlinked engineering and management plans with a visual language that uses various management tools. It involves establishing customer value by using the voice of the customer and converting that value to design, manufacturing and production process characteristics. The QFD process is often referred to as "listening to the voice of the customer"(Sower, Savoie and Renick 1999). Ronald G. Day (1993) defines QFD as a planning process, not a tool. Akao (1997) defines Quality Function Deployment as "converting the consumers' requirements into design requirements and developing a design quality for the finished product by systematically deploying the relationships between the demands and the characteristics, starting with the quality of each functional component and extending the deployment to the quality of each part and process. Overall quality of the product formed through this network of relationships (Akao 1997, 1994). So Quality Function Deployment assigns responsibility for producing a quality item to all parts of a corporation. American Supplier Institute (Bottani and Rizzi 2006) defines QFD as "a system for translating consumer requirements into appropriate company requirements at each stage from research and

product development to engineering and manufacturing to marketing/sales and distribution''.

QFD is also referred to in terms of the "house of quality" (HOQ) model because when the matrices in QFD fit together, they form a house-shaped diagram (Kutucuoglu et al. 2001; Bicheno 1994). This is a method of providing structure to the development cycle by linking it to the framework of a house. The foundation of the house represents customer requirements and the frame represents different types of planning matrices including importance ratings, relationship ratings, scale-up factors and so on. The second floor of the house represents design requirements and the roof represents the correlation of design requirements. The walls represent the relationship matrix between customer requirements and design requirements.

Generally in QFD modelling, "customer requirements" are referred to as WHATs and "design requirements" are referred to as HOWs. Different users use QFD models in different ways, each involving different components, but the most simple and widely used QFD model contains at least the customer requirements (WHATs) and their relative importance, technical measures or design requirements (HOWs), the importance ratings of the HOWs and their relationships with the WHATs. In a basic QFD model, the following input information is required:

I. WHATs: The required benefits of a product or service in the customer's own words – also called customer requirements.
II. HOWs: Design attributes or technical descriptors of the product –also called design requirements.
III. WHYs (Importance): Relative importance of the customer requirements as perceived by the customers
IV. WHATsvs. HOWs (Relationship matrix): Relationship between WHATs and HOWs (strong, medium or weak) prepared through the judgement of which WHATs impact which HOWs and to what degree.
V. HOWs vs. HOWs (Correlation matrix): The interrelationships among the design requirements (HOWs) – also known as ''the roof matrix''.
VI. Action plan: The weights of the HOWs.

4.5.2 Applications of QFD

QFD originally belonged to the domain of quality management (Bevilacqua, Ciarapica and Giacchetta 2006; Chan and Wu 2002). The techniques of QFD later expanded to wider fields including engineering, management, teamwork, planning and decision making (Chan and Wu 2002). Overall, QFD is a planning technique to improve quality, reduce development cost and pre-production costs, increase organisational capabilities and, above all, make an industry more competitive. Although there have been different applications of QFD reported in the literature, most focused on product development; only a few focused on strategic planning (Wang and Hong 2007). This research makes use of the QFD technique to assess the level of dairy supply chain risk mitigation and to determine the optimum set of risk mitigation strategies so that the objectives of these strategies can be achieved.

QFD Advantages

QFD has many advantages, primarily in management. There are many reports of its successful application, including: Hsieh, C.-H. and Y.-C. Wu (2016), Yoji Akao (1997), Robert King (1989), author of 'Better Designs in Half the Time', Bossert (1991), author of Quality Function Deployment (QFD) for practitioner approach, Fortuna (1988) of quality upstream, and Kenny (1988) for new paradigm for quality assurance and the like. These authors list the advantages of QFD as follows:

- QFD results in major savings in development time and costs, shorter design cycles and changes (Gunasekaran 1998; Howell 2000).
- QFD helps companies use competitive information effectively and prioritises the results (Bossert 1991, 6).
- QFD promotes teamwork by improving multifunctional communication and participation (Bouchereau and Rowlands 2000b; Bouchereau and Rowlands 1999; Carnevalli and Miguel 2008).
- Using QFD makes the quality and output of a service more precise through a continual improvement process, so that a company can reach world class (Howell 2000; Fortuna 1988).
- QFD simplifies customer priorities for competitive advantage (Shahin 2005; Stocker 1991).
- QFD brings together large amounts of verbal data, organises data in a logical way, and generates better data for filtering the design of future products and services (Ermer and Kniper 1998).

QFD Disadvantages

Despite the numerous advantages listed above, QFD is not a panacea for planning and manufacturing processes. It is a flexible tool that can be applied incorrectly or inconsistently, like any new process. If applied incorrectly, QFD may increase the workload and create problems in production development (Akao 2004, 3; Akao 1990). A few common disadvantages of QFD are outlined below:

- QFD is not always simple to implement, particularly in large, complex systems; companies have faced problems using QFD (Harding et al. 2001).
- QFD is a time consuming process (Prasad 1993).
- In QFD, it is difficult to categorize the answers given by customers as demands, due to ambiguity in the voice of the customer (Dahlgaard 1994).

4.6 FRAMEWORK OF HOUSE OF QUALITY FOR QFD MODEL

In this research, the QFD method is contextualised for the dairy industry, with different connotations attached to the WHATs, HOWs, HOW MUCHs, etc. Figure 4.3 shows the QFD model developed for this research. The below figure 4.3 portraits the House of Quality (HoQ) based on QFD model.

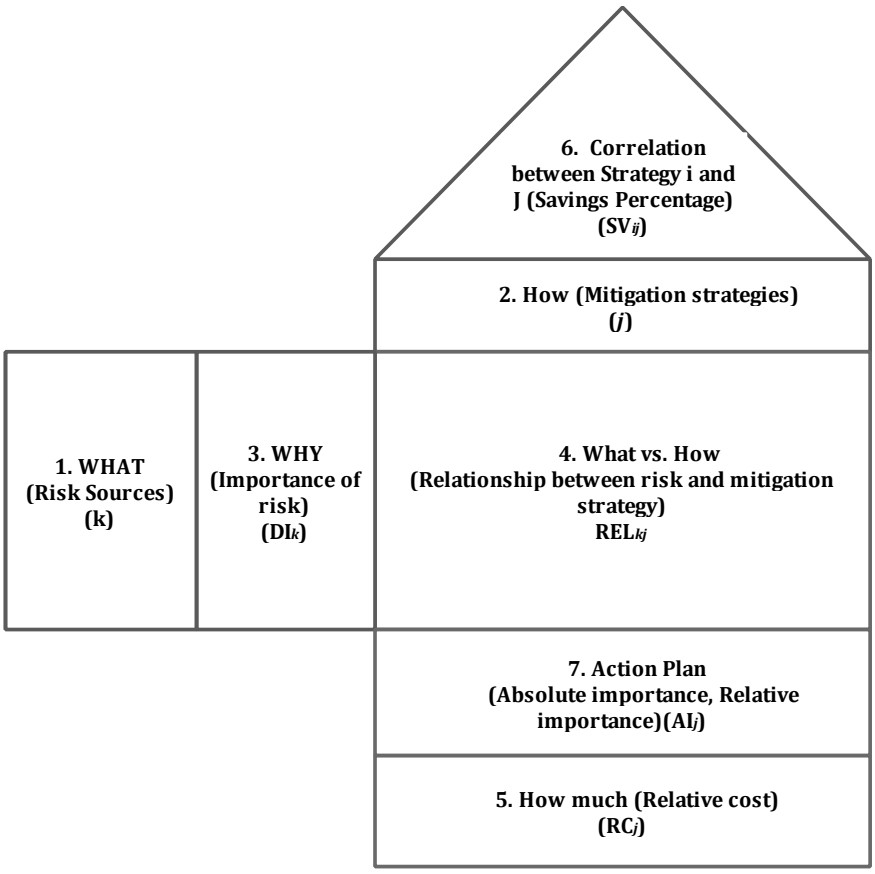


Figure 4.3: House of Quality (HoQ) for QFD Model

Note: Risk=k, Mitigation strategy=j, Correlation matrix=SV_{ij}, Degree of importance of risk=DI_k, Relationship matrix (degree to which k is met by j)=REL_{kj}, Absolute importance=AI_j, Relative cost=RC_j.

In this model:

I. WHATs are the risks associated with the dairy supply chain.
II. HOWs are the mitigation strategies that an organisation can adopt to control the risks.
III. WHYs (Importance) refer to the degrees of importance of risks; this is determined by prioritising the risk sources.
IV. WHATS vs. HOWs (Relationship matrix) refers to the relationships between risks (WHATs) and mitigation strategies (HOWs); this is determined by judging which risks need which strategies and to what degree.
V. HOW MUCHs are the relative costs to implement each strategy.
VI. HOWs vs. HOWs (Correlation matrix) refers to the interrelationships among the mitigation strategies (HOWs) and the cost savings associated with implementing strategies simultaneously.
VII. Action plans are the weights of the mitigation strategies (HOWs).

4.6.1 The QFD Process

Quality Function Deployment (QFD) is a useful tool that uses a series of structured management processes (Chen and Ko 2010). Chen and Ko (2010) applied a four phase QFD to mitigate risk in new product development processes. Ertay et al. (2005) used it as a cross-functional planning tool for product planning and design. This research applied a networked QFD process over two phases, as described by (Kahraman, Ertay and Büyüközkan 2006). Phase1 involved constructing a HoQ showing the relationship between risks and mitigation strategies, while Phase2 involved constructing a HoQ showing the relationship between mitigation strategies and sustainable outcomes. Figure 4.4 shows the two phase QFD process (Kahraman, Ertay and Büyüközkan 2006).

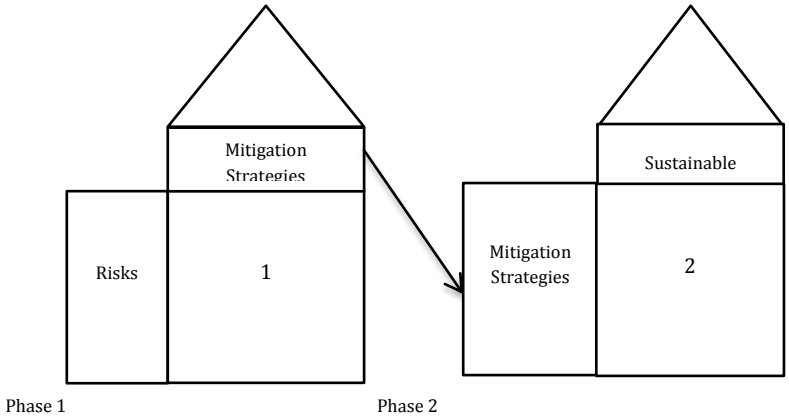


Figure 4.4: Networked QFD Process (Kahraman, Ertay and Büyüközkan 2006)

Phase1 of the QFD process is completed by following the approaches suggested by Brown (1991), Griffin (1992), Griffin and Hauser (1993, 1992), Park and Kim (1998) and Bevilacqua et. al. (2006). The whole process of Phase 1 has two parts: Part I and Part II.

Part I:

According to step IV and VI of section 4.4 (Research Process), Part I of Phase 1 of the process involves preparing data for QFD analysis and calculating the relationship matrix, Absolute Importance (AI) and Relative Importance (RI). Part II of Phase 1 of the process consists of optimisation of dairy supply chain risk mitigation problems through the use of an appropriate mathematical programming model. The problems are solved using linear and integer programming, considering the organisational resource constraints.

The stepwise procedures for **Part I** of Phase 1 are as follows:

Step 1: Identify the WHATs: The risks associated with the dairy supply chain.

Step 2: Identify the HOWs: Possible strategies to mitigate risks associated with the dairy supply chain.

Step3: Calculation of WHY: Calculate the degree of importance of the WHATs (risks) by prioritising them.

Step 4: Preparation of the relationship matrix: The relationship between risks and mitigation strategies (WHATs vs. HOWs), where the relationships are rated as weak, medium and strong, with a corresponding value of 1, 5, and 9.

Step 5: Identify the HOW MUCHs: The relative costs of implementing each strategy.

Step6: Elaboration of the correlation matrix: A correlation matrix of mitigation strategies (HOWs), also known as a 'roof matrix' (How vs. How) was constructed to depict the cost savings of implementing strategies simultaneously.

Step 7: Action plan: The weights of the mitigation strategies (HOWs) were calculated which are also termed as absolute importance. These weights are one of the main outputs of the QFD analysis. Relative importance (RI) of mitigation strategies was also calculated at this step.

The approach has taken involved the translation of QFD principles from dairy supply chain risk identification to dairy supply chain risk mitigation. While the traditional HoQ correlates customer requirements (WHATs) with design requirements (HOWs), in this research risks (WHATs) are correlated with possible mitigation strategies (HOWs) that could be undertaken by the dairy industry stakeholders to improve the condition of dairy supply chain risk management.

Part II:

Part II of Phase 1 of the QFD process was carried out to optimise the level of risk mitigation. The data were taken from Part I of Phase 1 of the QFD analysis process. Two steps were involved:

Step 1: Optimisation of dairy supply chain risk mitigation through Linear Programming: The optimum level of risk mitigation was identified using a linear programming model. This model does not consider cost savings of the organisations.

Step 2: Optimisation of dairy supply chain risk mitigation through Quadratic Integer Programming: The optimum level of risk mitigation was identified using a quadratic programming model. This model does consider cost savings of the organisations.

Phase 2 of the QFD process (see Figure 4.4) was executed as follows:

Step1: To develop a QFD matrix, optimum mitigation strategies from Step 2, Part II, and Phase 1 of the QFD process were presented in rows (WHATs) and sustainable outcomes from the qualitative interviews were presented in columns (HOWs).

Step 2: The relationship matrix was based on the extent to which sustainable outcomes were realised through strategy implementation. The scales used were 0=not realised, 1=little realised, 5= moderately realised, and 9= highly realised.

Step3: The Degree of Importance (DI) is taken from Relative Importance (RI) data. These RI data are obtained in steps 7 of QFD part I from Phase 1.

4.7 DATA COLLECTION: PHASE 1

4.7.1Qualitative data collection

a) In-depth interviews

In-depth interviews were used to collect data for QFD Part I (Steps 1 and 2 of the QFD process described in Section 4.6.1). In accordance with the recommendations of Yin (2003), a semi-structured interview guide was developed based on the literature review. Risks at the storage, processing and distribution levels of the dairy supply chain were identified and possible mitigation strategies were suggested. Probable sustainable outcomes were also identified. Each question was given an identification number. This phase of the data collection employed open-ended questions designed to ascertain the respondents' views on risks. Simultaneously this phase also ascertained the respondents' opinions regarding adopted or suggested mitigation strategies. Overall 14 questions were designed to cover the three main topics (risks, mitigation strategies and sustainable outcomes) of this study. A sample questionnaire is provided later in Chapter 5 and appendix.

Curtin University Ethics Committee approved the data collection instruments before the interviews took place. According to the conditions of this committee, participants must be provided with a short statement of information about the research objectives and advised that their personal details will remain confidential. Participants were also assured that they had full freedom to quit the interview at any time without any prejudice. Before each interview, the participants were given a clear explanation of the research purpose. The interviews were recorded with the consent of the participants and short notes were taken instantly throughout the interview. The time duration of each interview was around one hour. The interviewer inserted the questions into conversation and prompted whenever needed. The interview was recorded on a digital voice recorder and then transferred to the researcher's computer for subsequent transcribing. Each recorded interview was transcribed immediately and reviewed thoroughly by the researcher while the interview was still fresh in the researcher's mind.

b) Sample selection

The sample of this study was based on accessibility and availability of subjects who were close at hand (Zikmund 2000). The main criteria for selecting the subjects were their experience and their position in the organisation. So, for this research, purposive sampling was employed (Corbin and Strauss 2008). Ten interviewees, including

executives (or employers) and employees from two dairies with long experience in the dairy sector, were invited via telephone to participate in the interviews. In the two case industries (Nahar Dairy and Paharika Dairy), five people from each dairy were interviewed. The sample of 10 consisted of three executives and two employees of Nahar Dairy and two executives and three employees of Paharika Dairy. Each and every participant took part in this research voluntarily.

c) Data analysis

In qualitative research, data analysis is one of the challenging jobs. Several data analyses techniques are available (Miles and Huberman 1994a). Researchers must select the technique(s) based on the objective of the research (Quaddus and Xu 2005). As this research was exploratory in nature, a content analysis technique was chosen to analyse the data collected from the interviews (Berg 2004). There were more than one hundred pages of interview transcripts to analyse from ten interviews. Using content analysis, different factors and variables regarding risk issues and mitigation strategies were explored. A number of possible sustainable outcomes after implementing the mitigation strategies were also through interview. All content analyses were conducted manually and both inductive and deductive approaches were employed to identify and categorise the factors and variables from the raw data to fulfil the objectives of this study (Berg 2004).

In the inductive phase, by reviewing the transcript line by line, factors and their corresponding variables were identified and labels for these factors and variables were created. A number of free nodes were established and each section of data was given a label. Later, tree nodes were developed from sets of relevant free nodes. For example, when respondents were asked about dairy supply chain risks, 49 variables (free nodes) were identified. After combining the variables with similarities, 45 variables emerged as distinct variables.

In the deductive phase, the factors and variables found in the qualitative interviews were matched with those from the literature. A number of factors and variables regarding risks and possible mitigation strategies were identified through extensive content analysis and different sustainable outcomes resulting from the implementation of strategies were also identified. Later these factors and variables were labelled, where possible in line with the literature (Finch 2004);(Jüttner, Peck and Christopher 2003);(Mishra and Shekhar 2011);(Rao and Goldsby 2009; Choudhary et al.

2011);(Akcaoz, Kizilay and Ozcatalbas 2009);(Carter and Rogers 2008b);(Raha and Talukder 2004);(Blos et al. 2009); and (Manuj and Mentzer 2008a).

The necessary qualitative data for Steps 1 and 2 of QFD Part I (risks and strategies) were collected through interviews and analysed using content analysis. For QFD matrix development, risks were listed as WHATs and risk mitigation strategies were listed as HOWs.

4.7.2 Quantitative data collection: Phase 1

A three-part questionnaire-based survey was conducted with a view to collecting data for Steps 3 to 5 of QFD process Part I of Phase 1 (see Section 4.6.1). The survey was conducted among three different groups (employees, executives and supply chain members) of both case industries (Nahar Dairy and Paharika Dairy) to explicate probability and impact ratings of risks. The same investigation explored relationships between risks and mitigation strategies and the relative costs of implementing each strategy. Data were collected in the following ways.

a) Step 3 (WHY) rated the probability of occurrence and likely impact of a dairy risk (section 4.6.1).

b) Step 4 (WHATs vs. HOWs) scored the relationship between risks and mitigation strategies from which the relationship matrix was formed.

c) Step 5 (HOW MUCHs) identified the relative cost of implementing each risk mitigation strategy

The different parts of this survey are as follows:

a) Questionnaire development

The Likert Linguistic scale was used to measure different dimensions of respondents' opinions. The Likert scale has been applied to various research studies (Malhotra 2008), using odd and even numbers in selecting scale categories (Hair, Money and Samouel 2007). Park and Kim (1998) observe that there are various rating scales, including the 1–3–9, 1–3–5, 1–5–9, 1–2–4, and 1–6–9 scales. There is disagreement as to which scale is most suitable for research studies. Cohen and Cohen (1995) consider that there is no scientific basis for any of the choices. Hair et al. (2007) favour the use of a midpoint as a 'neutral' point, but Mattel and Jacoby (1972) argue that a neutral point should not be used when the scale consists of many points (Matell and Jacoby 1972). Thus this study used a four point scale with no neutral point.

This study included a threefold questionnaire with the expectation of collecting data regarding probability ratings and impact ratings of risks (45 risks), relationship ratings of risks and mitigation strategies and probable cost incurred to implement mitigation strategies. The first part of the questionnaire aimed to determine the probability and impact of risks, while the second part of the questionnaire measured the relationships between risks and mitigation strategies. The last part of questionnaire was intended to identify the relative cost of implementing each mitigation strategy. The probability and impact of risk responses were rated using a scale of 0 to 9. Probability of risk responses were rated from 0=cannot occur to 9= certain to occur, and impact responses were rated from 0= low to 9= high (Ward 1999). The relationships between risks and strategies were rated using measures 0, 1, 5, 9 (no, weak, medium and strong) (Park and Kim 1998).Finally, the relative costs were rated from 10=minimum to 100= maximum. A sample of the questionnaire is attached in Appendix 4A.

b) Sampling

The sample was taken from the stakeholders of two different dairy farms (Nahar and Paharika). This study used convenient sampling procedure to collect data (Berg 2004). The selection was based on the long experience of respondents in the relevant field. The stakeholders included farm employees, executives and supply chain members. The sample size was 22 and comprised six employees, three executives and two supply chain members from each farm. The background information of sample is provided later in Chapter 5.

c) Data collection

A self-administered printed questionnaire was used to collect required data for the development of QFD matrices (Step VI of Section 4.4). The necessary matrices for Steps 3, 4, 5 and 6 of the QFD process described in Section 4.6 were produced from this quantitative data. The questionnaire was distributed to the respondents based on their experience in the related field. The respondents were given two weeks to complete the survey. A reminder was given after a week. A sample of the completed survey, guidelines about the completion procedure and the contact number of the researcher were also added to the survey. This was to avoid or minimise any disruption or confusion in completing the survey. Twenty four responses were received within the given time. Of these, 22 were accepted because two were incomplete and therefore not usable.

Data regarding the cost savings made by implementing two strategies simultaneously were collected by telephone. This data was collected to form the correlation matrix between mitigation strategies for QFD Part I (in Step 6 of the QFD process). These data were collected from only the executives of the case industries, as only the executives would have a clear idea about the costs and savings figures.

d) Data Analysis (QFD Part I: Steps 3 to Steps 7)

Data analyses for the quantitative phase of this study were completed by using the technique of QFD (Step 3 to Step 7 of QFD Part I). As mentioned previously, the questionnaire survey yielded data from three groups (employees, executives and supply chain members) of both case industries (Nahar and Paharika). The survey asked respondents to rate the probability and impact of risks, the relationship between risk and mitigation strategies, as well as relative costs. After obtaining data for each group, matrices for Step 3 to Step 6 of QFD Part I were formed by calculating the weighted average for each group. Later, QFD analysis was performed to develop a matrix for Step 7 of QFD Part I which was mentioned in the QFD process (Section 4.6.1). A short description of the quantitative data analysis is provided below.

(I) Degree of importance of individual risk was calculated using the following equation (Ward 1999; Cox Jr 2012):

$$DI = P * I$$

Where DI= Degree of importance, P = Probability score and I=Impact score.

Later the weights of DI were represented to the importance of risk and were set as the matrix for Step 3 of QFD Part I.

(II) The data regarding the relationship between risk and mitigation strategies were normalised by calculating the weights of the relationship data which were attained by the questionnaire survey. A cell containing the *i*th row and *j*th column of the REL score (relationship matrix) is assigned 0, 1, 5, 9 to represent a no, weak, medium or strong relationship between *i*th risk and *j*th strategies(Park and Kim 1998). For example, *i*th risk is highly influenced (mitigated) by the *j*th strategy, and then a nine point was assigned to the cell of these two attributes.In a similar way, a zero point was assigned to the cell when the *i*th risk could not be mitigated by the *j*th strategy. In this phase, the values for Step 4 of QFD Part I (in the QFD process) were obtained. Relationship data (REL) were averaged for the three respondent groups (ie. employees, executives and supply chain members).

(III) Data related to the relative cost (RC) was collected from the respondents who assigned a 100 for most costly strategy and a 10 for least costly strategy. These relative costs were then normalised for the matrix of Step 5 of QFD Part I in the QFD process. Total relative costs (TRC) were formed by adding the individual RC which was used later as budget items in the optimisation process.

(IV) The roof matrix for QFD Part I (Step 6) was developed by using the cost savings data (SV) which were collected from three executives from each case industry. These data were collected through a telephone conversation. They were asked to discuss the correlation of strategies which may yield savings when implemented simultaneously. They were also asked to state the expected percentage of savings. The range of percentages was fixed within 10 to 50. After obtaining this cost savings data, their weights were computed for the values of the roof matrix.

(V) The absolute importance (AI) relevant for each mitigation strategy was calculated. This importance strives to determine which strategy has the highest possible capability on risk mitigation. It takes into account the weights of risks or degree of importance (DI) and the relationship matrix (REL). The absolute importance of each mitigation strategy was then calculated by applying the following equation:

$$AI_j = \sum_{k=1}^{n} DI_k \times REL_{kj}, \forall_j = 1 \ldots\ldots 32$$

k=1…….45, the number of risk

j=1…….32, the number of mitigation strategy

Where, AI_j= absolute importance rating of strategies

DI_k = degree of importance (i.e. weights of risks)

k=1…….45, the number of the risk

j= 1…….32, the number of the mitigation strategy

REL_{kj}= relationship rating representing the strength of the relationship between risk and mitigation strategy.

The calculation of relative importance (RI) related to each mitigation strategy was also done in this step by normalising the AIs. The larger the RI_j, the more important is S_j (the strategy). Thus, without considering any other constraints (e.g. cost and time), strategies should be implemented into risk mitigation in the order of their relative importance rating to attain more success in mitigating risk.

e) Data Analysis (QFD Part II: Optimisation)

The data analysis for QFD Part II aimed to formulate the dairy supply chain risk mitigation problem with an appropriate mathematical programming model, which consists of two steps:

Step 1: Formulation of the dairy supply chain risk mitigation problem through a linear programming model (without savings).

Step 2: Formulation of the dairy supply chain risk mitigation problem through quadratic integer programming model (with savings).

As explained in Section 4.6.1, the analysis was performed for optimising the level of risk mitigation which was followed in Step VII in Section 4.4 (Research process). A brief description of these optimisation programmes follows.

Step 1: Formulation of the dairy supply chain risk mitigation problem through linear programming model (without savings)

In Step1 of QFD Part II, the optimisation of the dairy supply chain risk mitigation problem was formulated as a linear programming model using Microsoft Excel solver where the problem did not consider cost savings of the organisation that were achieved from the concurrent strategy implementation. Concurrent implementation means the implementation of two or more mitigation strategies at a time (Park and Kim 1998). To determine the optimum level of risk mitigation with limited resource constraints, the problem was formulated as a linear programming model for maximising the level of risk mitigation by selecting appropriate mitigation strategies which were formulated through the following equation:

$$Max f(x) = \sum_{j=1}^{n} (AI_j) X_j \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\text{s.t.} \sum_{j=1}^{n} RC_j \, X_j \leq B$$

Where AI_j= absolute technical importance rating of mitigation strategy S_j

X_j=decision variables [0 or 1] for mitigation strategy S_j

(i.e. if $S_j$is selected, x_j=1, otherwise it is 0)

J= 1…….32, the number of the mitigation strategy

RC_j= relative cost for implementing the mitigation strategy.

The objective function in the above formula is to maximise the level of risk mitigation from the selected mitigation strategies. At the time of selecting strategies to implement, the conventional QFD does not consider the savings of the organisation. As discussed earlier, the budget (B) has been taken as a percentage of total relative cost (TRC), for example, 90% of the TRC down to 10% of TRC. At 100% TRC as the budget, all strategies will be selected. Strategies should be selected in decreasing order of cost until the total cost of selected strategies does not exceed the limited repair budget.

Step 2: Formulation of dairy supply chain risk mitigation problem through quadratic integer programming model (with cost savings)

This step of QFD Part II was carried out to formulate the problem of dairy supply chain risk mitigation as a quadratic integer programming model since there are savings from simultaneous implementation of two mitigation strategies (Park and Kim 1998). If there are correlations among strategies, then some savings in resource consumption are expected when two or more correlated strategies are implemented simultaneously. The objective function of this problem is to maximise the level of risk mitigation which was solved with a quadratic integer programming technique using the following equation:

$$Max f(x) = \sum_{j=1}^{n} (AI_j) X_j \qquad \text{..... (2)}$$

$$\text{s.t.} \sum_{j=1}^{n} \mathrm{RC}_j \mathrm{X}_j - \sum_{i=1}^{n} \sum_{j>i}^{n} SV_{ij} X_j \leq \mathrm{B} \text{ (with cost savings)}$$

Where, AI_j= absolute technical importance rating of mitigation strategy S_j

X_j=decision variables [0 or 1] for mitigation strategy S_j

(i.e. if S_j is selected, x_j=1, otherwise it is 0)

J= 1…….32, the number of the mitigation strategy

RC_j= relative cost for implementing the mitigation strategy

B = budget available for implementing the risk mitigation strategy

SV= savings amount of resource (relative cost) usage associated with simultaneous implementation of two mitigation strategies.

It is noted that, the budget (B) will be as discussed previously i.e. budget will be 90% of TRC (total relative cost) down to 10% of TRC. As mentioned before, with the 100% of TRC as the budget all strategies will be selected.

After formulating the QFD problem as a mathematical problem shown in QFD Part II (Steps 1 & 2), the most appropriate mitigation strategies will be selected to mitigate dairy risks. The most appropriate mitigation strategies will be selected without considering the savings of organisation (discussed in Step 1 of QFD Part II). Similarly, the most appropriate mitigation strategies will selected considering the savings of organisational resource (Step 2).

4.8 DATA COLLECTION: PHASE 2

a) Questionnaire-based survey development

A questionnaire-based survey was designed to develop the relationship matrix between mitigation strategies and sustainable outcomes (see Appendix 4B). The survey was used to collect data for measuring the relationship between mitigation strategies and sustainable outcomes. This relationship was rated as 0, 1, 5, 9 (no realisation, little realisation, moderate realisation and strong realisation).

b) Sampling

A sample was taken from the targeted sample cited in Section 4.7.2(b). Only the executive members of these two dairy farms (Nahar Dairy and Paharika Dairy) were selected as the sample. The rationale for this decision was that the management have specific ideas about the better realisation of outcomes through the appropriate implementation of mitigation strategies. The sample size was determined as six, namely three executives from each dairy.

c) Data collection

The survey was conducted to collect required data for developing relationship matrices of strategies and outcomes for Phase two of the QFD analysis (Section 4.6.1). The optimised data (mitigation strategies) from Phase 1 were taken as data for the row (WHATs) and sustainable outcomes collected through qualitative interview (see Section 4.7.1) were taken as data for the column (HOWs). In this phase, data collection is based upon the degree of various sustainable outcomes achieved through implementation of different optimised mitigation strategies. The scores given by the respondents are gathered to identify the relationship between risk mitigation strategies and sustainable outcomes. The data related to the degree of importance (WHYs) which is the calculated RI values of the mitigation strategies are taken from Phase 1.

d) Data analysis

Data analyses for Phase 2 of the QFD analysis (see Figure 4.5) consisted of three steps:

Step 1 Developing the matrix

With a view to developing the matrix for 'WHATs', the optimised mitigation strategies from Phase 1 were considered as a row. Then to develop the matrix for 'HOWs', the sustainable outcomes were taken as a column.

Step 2 Developing the relationship matrix

The data regarding the relationship between optimised mitigation strategies and sustainable outcomes were normalised by calculating the weights of the relationship data collected through the survey. In this step, the values for the relationship matrix (WHATs vs. HOWs) were obtained.

Step 3 Calculating absolute importance

The absolute importance (AI) and relative importance (RI) for each sustainable outcome was calculated with a view to determine which outcome has the highest possible realisation on mitigation strategy implementation. It takes into account the RI values of mitigation strategies from Phase 1 as degree of importance (DI) and the relationship matrix (REL) developed in the previous step. The absolute importance of each outcome was then calculated by applying the following equation:

$$AI_{so} = \sum_{j=1}^{n} DI_j \times REL_{so,j}, \forall_{so} = 1 \ldots 15$$

J= 1…….32, the number of the mitigation strategy

so= 1 …….15, the number of the sustainable outcome

Where AI_{so}= absolute importance rating of strategies

DI_{k} = degree of importance (i.e. RI values of mitigation strategies)

so=1…….15, the number of outcome

j= 1…….32, the number of mitigation strategy

$REL_{so,j}$= relationship rating representing the strength of relationship between mitigation strategy and sustainable outcome.

After that, by normalising the AIs, the relative importance (RI) of each outcome was calculated. The highest value of RI represents the most attainable outcome.

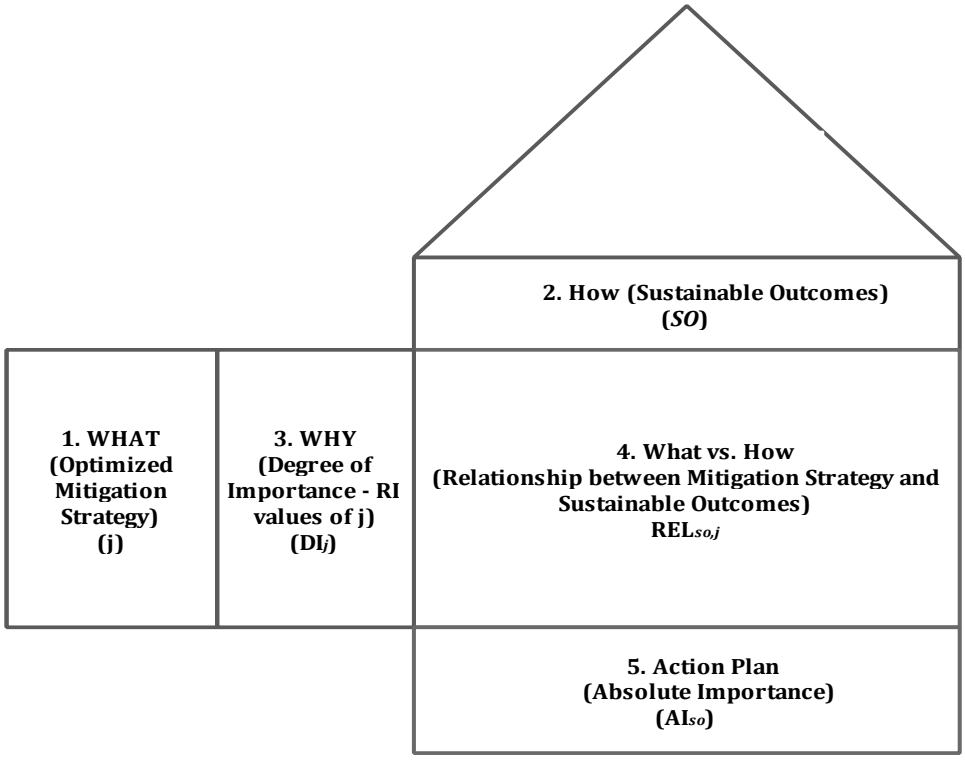


Figure 4.5: QFD Model – Phase 2

4.9 SUMMARY

This chapter described the research methodology and design. First, the research paradigm, mixed methods and design were explained. Then, the research processes were illustrated and clarified. A systematic overview of the research methods and tools used for this research was also presented. The chapter continued with a description of the two major stages of the research, comprising the qualitative study and the quantitative questionnaire-based survey. Details of sample selection, data collection, and data analysis for each stage were provided. In the next chapter, the research results are presented.

CHAPTER 5: RESULTS OF DATA ANALYSES

5.1 INTRODUCTION

This chapter presents the results of data analysis for the dairy supply chain risk mitigation model using Quality Function Deployment (QFD). The data collection and analysis processes were explained in the previous chapter. After obtaining all necessary data, two mathematical programming models (Linear Programming and Quadratic Programming) were used to determine the optimal sets of strategies to mitigate the risks associated with the dairy supply chain. The QFD method with the help of Microsoft Excel Solver was used to optimise the level of risk mitigation, taking into consideration organisational resource constraints.

This chapter is organised as follows. The first part discusses different problems that were faced at the time of data collection. The next part presents the findings of the qualitative data analysis from the in-depth interviews through which different risks, mitigation strategies and sustainable outcomes were identified from social, economic and environmental viewpoints. Then the results of quantitative data analysis of the questionnaire survey identify the probability impact of risks, relationship score of risk and strategy, and relative cost to design various matrices for QFD Part I. Then the QFD analyses for optimising the level of risk mitigation using the two different mathematical programming models are presented to understand how budget change affects the model output. Graphical presentation was then presented to observe the improvement of risk mitigation level over budget increment. Finally, the determination of optimal sets of mitigation strategies is presented.

5.2 PROBLEMS OF DATA COLLECTION

Several problems were faced in collecting data from the case industries. These problems related to the interviews and survey, limited understandings of Quality Function Deployment and delays in obtaining documents and records.

In-depth interview session

Some respondents were not inclined to reveal data relating to risks faced and the strategies they tried to adopt. Gradually, by using probe questions, related data were collected. Some respondents were not educated enough to answer the question

promptly. Therefore, much time and effort were needed to obtain data by assisting them to understand the questions accurately.

Questionnaire-based survey session

The quantitative data in this research was collected using a questionnaire-based survey. One issue with using questionnaires is that data is potentially vulnerable to common method bias (Podsakoff et al. 2003). For example, some respondents tried to guess the interviewers intention and answered accordingly, or each respondent perceived the ranking scale in a different manner. It was hard to collect suitable data by making respondents understand the research objective.

Quality Function Deployment (QFD) terminology

Most respondents did not know about Quality Function Deployment (QFD). So it was challenging to ascertain their understanding and collect data regarding the relationship matrix for QFD analysis. Although, it was time consuming, the respondents gradually started to understand the model and the purpose of the QFD modelling.

Documents and records

Both case study industries were not well organised in storing their data and documents. Due to the inappropriate storage of their documents and computer files, delays were caused in some situations.

5.3 IN-DEPTH INTERVIEWS

Semi-structured in-depth interviews (step III of section 4.4) with ten stakeholders of the two large-scale commercial dairy industries were conducted to fine tune and contextualise the dairy supply chain risks, mitigation strategies and sustainable outcomes identified in the literature. The questions asked respondents about how they determine the existence of supply chain risk in their organisation and the overall risk factors that the organisations are facing. Questions were then asked about risk factors, mitigation strategies and sustainable outcomes for specific levels (storage, processing and distribution) in the Bangladesh context.

This phase of the study contributes the refinement of risk factors, mitigation strategies and sustainable outcome of dairy industry which has been followed in step IV of section 4.4 (Research process). The identified risks and strategies were used to develop the matrices for Steps 1 and 2 of the QFD process which was shown in section 4.6.1

(The QFD Process). Details of the qualitative data collection were explained in section 4.6.1 under methodology. This section provides additional information about the data collected from qualitative interview.

5.3.1 Development of the in-depth interview questions

As mentioned before in Section 4.7.1, a total of14 questions were designed to cover the three main topics (risks, mitigation strategies and sustainable outcomes) of this study. The following table (Table 5.1) lists the interview questions.

Table 5.1: Interview Questions for Qualitative Data Collection

Sl No.	Questions
1	How does your organisation determine what supply chain risks exist?
2	What are the risks that your organisation is facing?
3	What risks do exist at storage level?
4	How often these risks may arise?
5	How these risks could be mitigated?
6	What will be the sustainable outcomes if these risks could be mitigated properly?
7	What risks do exist at processing level?
8	How often these risks may arise?
9	How these risks could be mitigated?
10	What will be the sustainable outcomes if these risks could be mitigated properly?
11	What risks do exist at distribution level?
12	How often these risks may arise?
13	How these risks could be mitigated?
14	What will be the sustainable outcomes if these risks could be mitigated properly?

The first question to the respondents was about how they determine the existence of supply chain risk in their organisation. The second question explored the overall risk factors that the organisations are facing. Risk factors, mitigation strategies and sustainable outcomes for specific levels (storage, processing and distribution) were identified. For this purpose, questions 3 to 6 were designed to refer to the storage level, questions 7 to 10 were designed to refer to the processing level, and questions 11 to 14 were designed to refer to the distribution level.

5.3.2 Respondents profile

Both case companies recommended that their experienced personnel participate in the interviews. This participation was on a voluntary basis. The only criterion required for

participants was to have experience in dairy industry activities. The ten interviewees included a managing director, production managers, farm managers and supervisors. Their tenures ranged from 8 to 25 years. The case industries had been established for more than 18 years, with the number of the employees ranging from 32 to 55. The present livestock holding by both farms indicated the farm size. The profile of the respondents and detail about the farms is presented in Table 5.2.

Table 5.2: Profile of the Respondents (In-depth interview)

Farm	Respondents	Position	No. of years at work	About the farms		
				Size (Number of employees)	Age of farm	No. of livestock
Nahar	A	Managing Director	25	55	24	560
	B	Production Manager	12			
	C	Supervisor	10			
	D	Farm Manager	12			
	E	Supervisor	9			
Paharika	F	Production Manager	13	32	18	352
	G	Supervisor	8			
	H	Farm Manager	15			
	I	Supervisor	11			
	J	Supervisor	10			

5.3.3 Findings: Risks (Inductive Analysis)

A number of factors and variables regarding risk issues (for both common and specific levels) and possible mitigation strategies along with probable sustainable outcomes after implementing strategies have been identified through extensive content analysis procedures. Initially, respondents identified 49 variables or issues influencing dairy supply chain risk issues. After combining these variables, 45 were named as distinct variables. These were then grouped into seven nodes: 'financial risk', 'technological shortage', 'human resource risk', 'government policy and support', 'political risk', 'mismanagement of staff' and 'natural risk'.

Detailed findings related to the risk factors (for both common and specific levels) with subsequent frequencies are shown in Tables 5.3, 5.4, 5.6 and 5.7. It is noted that 19 variables regarding risk issues were found in common at every level. The specific number of variables at each level was: storage level (6), processing level (13) and

distribution level (7). The risk factors and variables that are common to all levels (storage, processing and distribution) are shown in Table 5.3.

Table 5.3: Common Risk Factors and Variables (Storage, Processing and Distribution)

Sustainability aspects	Risk factors	Risk variables	Nahar					Paharika				
			A	B	C	D	E	F	G	H	I	J
Economical	Financial risk	Inadequate loan facilities	Y			Y						Y
		Complex loan procedures						Y				
		High rate of interest	Y									
		Inadequate finance			Y		Y	Y	Y	Y	Y	Y
		Absence of insurance or compensation coverage for dairy industry	Y					Y				
	Technological shortage	Shortage of improved technology (milking machine, feed mixture, grass cutting, improved processing, cooling facilities)				Y		Y	Y			
Social	Human resource risk	Labour disputes	Y		Y	Y			Y	Y		Y
		Illiteracy and inefficiency of worker	Y				Y				Y	
		Shortage of skilled staff	Y				Y	Y				
		Switching of staff frequently	Y			Y		Y				Y
	Government policy and support	Lack of fixed government policy in dairy sector	Y	Y	Y	Y	Y		Y	Y		
		Poor law and order situation (terrorism, musclemen ship)						Y		Y		
	Political risk	Hartal and strike cause delay in working process	Y	Y	Y	Y	Y		Y	Y	Y	Y
		Political Unrest and interference	Y	Y	Y		Y	Y	Y	Y	Y	Y
	Mismanagement and unethical behaviour of employees	Corruption (adulteration by mixing water)	Y	Y		Y	Y	Y				
		Damage of farm's assets			Y	Y	Y	Y	Y	Y		
		Theft	Y	Y	Y		Y	Y	Y	Y		
Environmental	Natural risk	Natural uncertainties (storm, excessive rain, flood)				Y	Y		Y		Y	Y
		Quick perishability of milk		Y		Y						

Table 5.3 shows that the variables related to political risk were identified by the interview participants. Both the risk variables 'Hartal and strike cause delay in working process' and 'Political unrest and interference' were identified by nine respondents. The participants also identified 'Lack of fixed government policy in dairy sector' and 'Theft' as common risk sources for storage, processing and distribution levels in the

dairy sector. 'Inadequate finance' which is related to financial risk was also identified by the participants as they mentioned that the scarcity of finance negatively affected all activities at every step. On the contrary, 'High rate of interest' and 'Complex loan procedures' were less frequently identified by the participants.

The specific risk factors and variables for storage, processing and distribution levels are presented in Tables 5.4–5.6. At the storage level, Table 5.4 shows that the risk variable 'Spoilage of milk through improper handling' related to mismanagement and unethical behaviour of employees was identified by the participants as a disturbing risk for the storage level of the dairy industry. They mentioned that because of the mismanagement and unethical behaviour of staff, a huge amount of milk is wasted and perishes during storage. The risk 'Bacterial contamination for improper temperature' is less important for the participants.

Table 5.4: Risk Factors and Variables (Storage Level)

Sustainability Aspects	Risk Factors	Risk Variables	Respondents									
			Nahar					Paharika				
			A	B	C	D	E	F	G	H	I	J
Economical	Hazard risk	Machine damage/breakdown at cold storage	Y						Y	Y		Y
	Technological shortage	Inadequate chilling facilities		Y		Y						
		Inadequate cold storage facilities		Y			Y	Y				
Social	Mismanagement and unethical behaviour of employees	Spoilage of milk through improper handling			Y		Y	Y	Y	Y		
Environmental	Natural risk	Bacterial contamination for improper temperature						Y				
		Pollution and Unhygienic environment								Y		Y

Risk sources for the processing level (shown in Table 5.5) highlights that the majority of the interview participants believe that, 'High cost of feed and medicine' that are attached to the organisation as input risk is highly risky for the processing level of the dairy industry. The risk 'Shortage of land for expanding farm' was also identified as a risk which hinders the expansion and development of farming activities. 'Bureaucratic

complexity on maintaining various formalities' is a less frequently identified risk source for the processing level of the dairy industry.

Table 5.5: Risk Factors and Variables (Processing Level)

Sustainability aspects	Risk factors	Risk variables	Respondents									
			Nahar					Paharika				
			A	B	C	D	E	F	G	H	I	J
Economical	Hazard risk	Cattle diseases	Y	Y			Y			Y	Y	Y
		Machine breakdown at processing unit				Y			Y			
		Fire at farm shed				Y			Y	Y		
		Accident (Staff injury)							Y	Y		
	Input risk	Inadequate supply of quality feed	Y							Y		Y
		High cost of feed and medicine	Y	Y	Y	Y		Y	Y	Y	Y	Y
		Scarcity of feed	Y				Y	Y	Y	Y		
		Lack of upgrade vaccination and veterinary services	Y									Y
	Poor infrastructural facilities	Shortage of land for expanding farm	Y	Y	Y	Y	Y		Y	Y	Y	
Social	Absence of government policy and support	Irregular supply of vaccine from government		Y			Y					
	Strategic risk	Competition among the farms	Y							Y		Y
		Bureaucratic complexity on maintaining various formalities									Y	
Environmental	Natural risk	Drought leads to a decline in milk production					Y		Y		Y	

At the distribution level, Table 5.6 shows that most of the interview participants identified the risk variable of 'Poor conditioned road for moving product' which cause delay and spoilage of milk at the time of milk distribution. Another risk 'Too long chain cause delay in product movement' was also identified by the majority of participants as they mentioned that for the perishable nature of milk delay in product movement results in spoilage or a low quality of product.

Table 5.6: Risk Factors and Variables (Distribution Level)

Sustainability aspects	Risk factors	Risk Variables	Respondents									
			Nahar					Paharika				
			A	B	C	D	E	F	G	H	I	J
Economical	Hazard risk	Accidents of transport vehicle	Y					Y	Y	Y	Y	
	Distribution risk	Existence of middlemen/ too many middlemen	Y		Y			Y				Y
		Too long chain cause delay in product movement	Y	Y			Y	Y	Y	Y		Y
	Poor infrastructural facilities	Poor conditioned road for moving product (delay and spoilage)	Y	Y		Y	Y	Y	Y	Y	Y	Y
		Inadequate transport facilities to move products frequently	Y		Y				Y		Y	Y
		Lack of milk tanker with chilling facilities		Y			Y	Y				
Social	Mismanagement and unethical behaviour of employees/ middlemen	Unethical behaviour of middle men (adulteration, added price, deprivation)		Y		Y		Y		Y	Y	

5.3.3.1 Description of risks

This content analysis shows that the dairy supply chain in Bangladesh is associated with different types of risks in its different sectors. These risks hinder the growth and development of the dairy industry. These risk factors are briefly discussed in this section. Details of the variables under each factor are discussed in Appendix 5A.

Financial risk

A number of financial risks were identified. These risks have a direct influence on the activities at all levels (storage, processing and distribution) (see Table 5.3). These risks arise from different financial occurrences that often hinder the growth and development of the dairy, and subsequently affect the actions of supply chain. Respondents talked about different financial risks such as inadequate loan facilities, complex loan procedures, high interest rates, inadequate finance and lack of insurance coverage. Regarding loan facility, respondent F mentioned that '*most of the financial institution in our country are not interested to invest in the dairy sector i.e. they are not interested to give a loan to the dairy industry*'. He also added that '*the existing loan*

procedure is too complex'. Participant A mentioned that, *'inadequate loan and inadequate finance are affecting the growth of their organisation'*. He also stated that, '*the rate of interest is just too high'*.

Technological risk

Some of the risks arise from technological shortages. Respondents mentioned a number of technological shortages which hampered and slowed down their production and operational activities. Technological shortages include inadequate chilling system, shortage of cold room, and absences of mechanised milking, feed mixture, improved processing facilities and so on. For example, 'w*e have shortage of upgrade technology in milk processing*', mentioned by respondent F. Another participant, respondent D, mentioned that, 'o*ur cooling infrastructures are not sufficient for our production*'. Respondent G discussed technological advancement, saying that, 's*till we are used to do 60% of milking manually which is time consuming, requiring more staff involvement and also increasing the risk of mismanagement and pollution*'.

Human resource risk

Human resource risks have been categorised into labour dispute, illiteracy and inefficiency of worker, shortage of skilled staff and frequent staff turnover. Farming businesses need efficient and experienced human resources. In this regard, respondent F from Paharika Dairy struggled to manage the staff for a long time. He uttered that, 'a*fter trained the staff and making them skilled, they switch way*'. Shortage of skilled and efficient workers slows the processing activities. '*Different workers from diverse background coming here … .although work direction is described to them clearly, but it is hard to make them understand properly…so for the inefficiency of them misuse of product increased*', stated by respondent E from Nahar Dairy.

Absence of fixed government policy

The lack of fixed government policy regarding the dairy industry and the poor law and order situations have a direct impact on storing, processing and distributing functions of dairy production. The majority of respondents reported that a lack of fixed government policy regarding feed management, breed management, loan disbursement and the central distribution of milk. Moreover, the legal and regulatory framework of the country is also characterised by a poor and non-transparent administrative and judicial system, bureaucratic complexities, political interference and musclemanship, and terrorism, for example. These issues are significantly affecting the smooth running of the dairy industry in the country. For example, respondent F

revealed that, '*sometimes we have to handle some unfair situation, which could be solved by the interference of political leader ... but it needs financial contribution to them'*. Another respondent H stated that, '*for getting easy loan we have to maintain a good relationship with the officers by giving them bribe and other facilities'.*

Political risk

The political environment of Bangladesh, which is affected by hartals, strikes and political instability, hampers the continuity of the production cycle. All respondents mentioned these risks which have a direct influence on processing and distribution activities. A series of prolonged hartal and strike cause delay in the whole working process. For example, respondent A stated that, '*for political unrest and long series of hartal and strike we cannot properly distribute our product (milk), which is perishable in nature'. 'Sometimes for political uncertainties we have to preserve large quantity of milk ... when we need to arrange more room for our chiller to store the undistributed product'*, said respondent D. Another respondent J mention that, '*last year three of our milk vans were attacked and completely damaged by the picketers at the time of distribution which resulted in financial loss for us.'*

Mismanagement and unethical behaviour of employees

Mismanagement and unethical behaviour of employees was also mentioned by most of the participants. This behaviour included corruption (mixing water with milk), damage of farm assets, spoilage of milk through improper handling and theft. Due to the mismanagement of staff, production costs also increased. In this regard, respondent I mentioned that, '*sometimes for the insincere working attitude of workers, we have to face many unexpected loss like damage of farm assets, spoilage of milk*'. Another respondent A stated that, '*as the income level of the people in our country is limited, so some unethical activities like theft, corruption and misuse are present in employees behaviour ... we have to aware about that, which is regular in our industry*'.

Natural risk

According to the respondents' opinions, the dairy supply chain in Bangladesh is also affected by natural risks. Natural risks include natural uncertainties (flood, storm, drought, too much humidity, and heavy rainfall), pollution and unhygienic environment, and the perishable nature of milk. These risks bring devastating loss for all members within the supply chain network. For example, respondent A stated that, '*our climate is very unpredictable...sometimes moisture is high...sometimes moisture is*

low … sometimes there is too much rainfall which creates problem in maintaining temperature.'

Hazard risk

Different types of hazard risks have been identified by the respondents. The nature of hazard risk is different for specific levels. These hazard risks include: machine damage at cold storage (storage); cattle diseases, fire at farm shed, staff injury (processing); and accident of transport vehicle (distribution).

Input risk

At the processing level, some input risks were mentioned by the respondents. Input risk occurs due to the disruptions to the supply of input. The most cited input risks were: inadequate supply of quality feed, scarcity of feed, lack of upgrade vaccination and veterinary services. Due to the input risk, production is hampered and production quantity fluctuates. All respondents except E complained about the high cost of feed and medicine that they need regularly. They also criticised the supply of vaccine from the government which is irregular and unsatisfactory.

Poor infrastructural facilities

This study found that poor infrastructural facilities not only hinder the growth and development of the industry but also hamper the smooth distribution of the product. Due to land shortage, the farms cannot be expanded. Regarding shortage of land, respondent A mentioned that, '*we have plans for expansion and diversification … but cannot convert those in action as we don't have enough land resources*'. Every respondent mentioned that, the poor condition of roads and highways created delays and caused spoilage when moving the product. Inadequate transport facilities and lack of milk tankers with chilling facilities were also mentioned by some of the respondents as a risk issue especially for the distribution level.

Strategic risk

This study finds that competition and bureaucratic complexity in maintaining formalities acted as daunting factors for the development of the industry. Regarding competition, respondents I mentioned that, *'competition is very high in our industry … we lost our customer due to the immense competition'*.

Unethical behaviour of middlemen

Middlemen are present at every stage of the supply chain. Specifically, they are very active at the distribution level. So exploitation by middlemen is considered another

major risk source. Respondents considered the middleman as the '*profit sucker*' and wished to get rid of their unethical activities like added price, adulteration and deprivation.

5.3.4 Findings: Mitigation Strategies (inductive analysis)

The qualitative data analysis revealed numerous risk mitigation strategies which were suggested by the respondents to mitigate the risks associated with dairy supply chain. When probed deeper about supply chain risk mitigation strategies, different respondents put forward different strategies. Some of them mentioned technological development, a few of them demanded insurance coverage of the facilities , a number of respondents stressed training management as well as human resource management, and others focused on government support, financial management, back-up capacity, off-farm income and investment, business policy and practice. Regarding mitigation strategies, respondent F stated that, '*as we deal with living things, risk could occur at any time … we have to always be ready to face and mitigate the risk*'. The frequencies of mitigation strategies for both common and specific (storage, processing and distribution) levels are presented in Tables 5.7, 5.8, 5.9 and 5.10. Detailed descriptions of all mitigation strategies are provided in Appendix 5B.

The analysis in Table 5.7 shows that 11 variables were identified as common mitigation strategies for all levels (storage, processing and distribution). Of these, only two variables were supported by most of the respondents. These variables are 'Adoption of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)' and 'Buying insurance against production losses'. Although none of the respondents supported the variables related to business policy and practice, this factor was supported by the literature.

Table 5.7: Common Mitigation Strategies (Storage, Processing and Distribution)

Mitigation strategy (Factor)	Mitigation strategy (Variable)	Nahar					Paharika				
		A	B	C	D	E	F	G	H	I	J
Technology development	Adoption of improved technology (milking machine, feed mixture, grass cutting, improved processing facilities)	Y	Y	Y	Y		Y	Y	Y		Y
Insurance management	Buying insurance against production loss.	Y					Y	Y	Y	Y	Y
Human resource management	Hiring skilled staff			Y		Y					
	Motivational and incentives facilities for staff			Y							
Government support	Initiative to remove political uncertainty						Y				
	Implementation of a fixed policy for dairy sector									Y	
Financial management	Assurance of adequate institutional credit support with low rate of interest.						Y				
Off-farm income and investment	Introducing off-farm activities								Y		
	Focus on value addition										Y
Business policy and practice	Promote sound business practices by cooperation, better coordination and information sharing										
	Reduction of risks through merger, acquisition and integration.										

At the storage level, two strategies for mitigating risks were identified (see Table 5.8). There was a strong support among the participants for the 'Arrangement of proper training to the staff regarding temperature control'. Raw milk needs to be placed immediately into the chiller to maintain 2–4 °C and has to be transported to the next vendor within 5–6 hours of milking due to its perishable nature (Javed 2004). For this reason, one concern is that employees need proper training to save the milk from spoilage.

Table 5.8: Mitigation Strategies (Storage Level)

Mitigation strategy (Factor)	Mitigation strategy (Variable)	Nahar					Paharika				
		A	B	C	D	E	F	G	H	I	J
Training Management	Arrangement of proper training to the staff regarding temperature control	Y	Y	Y	Y	Y	Y	Y	Y		
Backup capacity	Adoption of alternative supply of power for cold storage (powerful generator)	Y					Y	Y	Y		

To mitigate risk related to the processing level of the dairy industry, Table 5.9 shows that most respondents supported the arrangement of proper training of the staff regarding processing and hygiene management. This suggestion can be attributed to the fact that proper training of staff as well as management regarding processing and hygiene management has a positive effect on maintaining the quality of the product and enhancing goodwill of the organisation. There was also overwhelming support for both 'Arranging regular vaccination for cattle' and 'Focusing on certified feed supplier to get quality feed'. By contrast, the arrangement of adequate grassland for producing Napier grass was less well supported by the interview participants.

Table 5.9: Mitigation Strategies (Processing Level)

Mitigation strategy (Factor)	Mitigation strategy (Variable)	Nahar					Paharika				
		A	B	C	D	E	F	G	H	I	J
Training management	Arrangement of proper training to the staff regarding processing and hygiene management	Y	Y		Y		Y		Y		Y
Breed management	Attempts to create various cross breeds by adopting AI services.										
Government support	Lease abandoned land to the farmers for dairy farming	Y		Y	Y						
	Strengthen the regular supply of vaccine	Y	Y			Y					
	Initiative to reduce the cost of feed	Y	Y								
	Support to develop technology	Y	Y				Y				
Feed management	Focus on certified feed supplier to get quality feed.	Y			Y		Y	Y		Y	
	Arrangement of adequate grassland for producing Napier grass		Y								
Diseases management	Arrangement of regular vaccination for the cattle	Y				Y	Y	Y	Y	Y	
	Arrangement of improved and upgraded veterinary services									Y	Y
Infrastructural development	Building multi-storeyed complex for farm extension							Y		Y	Y

At the distribution level, Table 5.10 shows that the variable 'Building monitoring team' (described in Appendix 5B) related to human resource management was completely supported by the field study participants. This strategy was considered important for mitigating different risks related to the distribution level. There was also support for the arrangement of 'Direct marketing' (see Appendix 5B). Most of the participants

supported the notion that direct marketing will positively lead to the removal of unnecessary involvement of middlemen. The mitigation strategy 'Focus on product diversification' was less well supported by the participants.

Table 5.10: Mitigation Strategies (Distribution Level)

Mitigation strategy (Factor)	Mitigation strategy (Variable)	Nahar					Paharika				
		A	B	C	D	E	F	G	H	I	J
Human resource management	Building monitoring team	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Government support	Initiative to develop roads and highways			Y			Y	Y			
Transport Management	Arrangement of adequate number of transport	Y	Y	Y	Y		Y	Y		Y	
	Arrangement of refrigerated transport facilities	Y	Y	Y	Y		Y				Y
Infrastructural development	Development of roads and highway	Y	Y	Y	Y	Y		Y	Y		
Business practices and policy	Focus on product diversification										Y
	Removal of unnecessary influence of middlemen	Y	Y	Y	Y		Y		Y	Y	Y
	Direct marketing		Y	Y	Y	Y	Y	Y	Y	Y	Y

5.3.4.1 Description of mitigation strategies

Numerous strategies (Table 5.7, 5.8, 5.9 and 5.10) for mitigating dairy risks were identified from the content analysis. The mitigation strategies were shortlisted based on emphasis given in the interview phase to different levels of storage, processing and distribution. All variables of mitigation strategies are discussed in detail in Appendix 5B. Short descriptions of important mitigation strategies are discussed as follows.

Technological development

The mitigation strategy supported most by the respondents in dairy supply chain risk management is technological development. It includes adoption of improved technologies like mechanised milking, mechanised feed mixing, improved processing facilities and cold storage, adoption of RFID and so on. Most respondents agreed that technological development would be a means of enhancing productivity and profitability, reducing mismanagement, cost saving by less labour engagement and improving time management.

Insurance management

Insurance coverage against production loss can help the supply chain members to overcome different types of risks occurring from accidents, diseases, natural uncertainties and hazards. Regarding insurance coverage respondent A stated with frustration that, '*In our country, there is no insurance coverage for the dairy industry…in case of any disaster we face complexities to survive'*.

Human resource management

In farming, , human resource management as a mitigation strategy consists of hiring skilled staff, managing them through providing motivational and incentive facilities, arranging training for them and building a monitoring team. It is evident from the respondents that, skilled and efficient staff are needed for reducing risks regarding mismanagement, temperature maintenance, and different hazards (e.g. machine damage, staff injury).Most respondents stressed training management by stating that, *'Arranging training facilities for the staffs are indispensable for making them efficient and skilled'*. It also acts as a motivating factor. Regarding motivational and incentive facilities respondent E mentioned that, *'We have to arrange some recreational and motivational facilities for staff for making them enthusiastic in their work, like arranging various game competitions, medical allowances, bonus during religious festivals, arrangement of an annual picnic, etc.'.*

Government support

All participants emphasised the need for government support regarding implantation of a fixed policy for the dairy sector, removal of political uncertainties, strengthening the regular supply of vaccine, reducing cost of feed, leasing abandoned land for the dairy farmers and supporting the development of technology and infrastructure. Respondent E was frustrated about the supply of regular vaccine from the government by stating that, '*Sometimes we do not get supply of vaccine from the government at right time… then timely vaccination of the cattle could not be possible … if the government will be more careful about that … then we could manage good health of farm animals which will ensure us getting a calf in each year'*.

Feed management

Feed management is another mitigation strategy for dairy supply chain risk management identified by most of the respondents in this study. Feed management consists of focusing on certified feed suppliers to procure quality feed and regular

supply of feed. An arrangement of adequate land for producing Napier grass for cattle is also included in feed management. For example, respondent E stated that, '*If we can manage adequate land, then we could produce more Napier grass for cattle which reduce the consumption of less concentrate feeds...as a result feed cost will be saved and production will be increased for giving more grass*'.

Disease management

As a mitigation strategy, a number of respondents focused on the disease management by arranging regular, upgraded and improved vaccination for the cattle. Diseases in the livestock business are very devastating. Sometimes cataclysmic diseases cause dairy businesses to close down. So respondents stressed maintaining regular vaccination for the farms live stocks.

Infrastructural development

Infrastructural development consists of multi-storeyed building for farm expansion, and development of roads and highways. This development is important to maximise the productivity of farm and reduce risk relating to farm expansion and product distribution. For example, respondent F mentioned that, '*We have just improved the internal road from the project door to the main road...but the condition of the road before that is terrible, which always generates accidents, messed up the product, [caused] delay at the time of distribution...so government initiative and government support is needed to improve the condition of roads and highways*'.

Transport management

Arranging adequate transport and refrigerated transport facilities are included in transport management, which was identified as a prerequisite for effective distribution. Due to the rapid perishability of milk, quick distribution is needed. Transportation and distribution need to be done in insulated vehicles to avoid excessive temperature increases. For quick and timely distribution, managing adequate transportation is a must. Regarding refrigerated transport facilities, respondent F stated that, '*Last year we bought two cold vans...we are now tension free at the time of moving the product in long distance.*'

5.3.5 Sustainable Outcomes (inductive analysis)

Numerous economic, social and environmental outcomes were explored in the inductive phase of data analysis. These outcomes are shown in Table 5.11. Fifteen

sustainable outcomes were explored of which seven are directly related to economic benefit, five are linked with social welfare and the remaining three are related to environmental development. The field study participants were most supportive of cost minimisation as a sustainable outcome. Analysis from the field interviews highlights that the majority of the interview participants believe that the cost could be minimised after adopting different mitigation strategies. There was also support for the 'Increase in production'. Most participants supported the notion that adoption of diverse mitigation strategies will positively lead to reduction or mitigation of different risks and that will result in production increment. By contrast, 'Waste management' and 'Health improvement of cattle' are supported by only one interview participant. Some of these important sustainable outcomes are described below:

Table 5.11: Sustainable Outcomes

Sustainable Aspects	Outcomes	Nahar					Paharika				
		A	B	C	D	E	F	G	H	I	J
Economic	Profit maximisation	✓		✓	✓	✓			✓	✓	✓
	Cost minimisation	✓	✓	✓	✓	✓		✓	✓	✓	✓
	Increase in personal income	✓	✓				✓	✓	✓	✓	✓
	Increase in production	✓	✓	✓	✓	✓		✓	✓		✓
	Product quality improvement	✓	✓	✓	✓	✓	✓				
	Expansion of farming system						✓				
	Production of value added product and diversified product								✓		
Social	Goodwill enhancement										
	Supply of quality food				✓						
	Nutritional development		✓	✓			✓	✓	✓		
	Improvement of living standard						✓				
	Creation of employment opportunity						✓				
Environmental	Creation of sound working environment							✓	✓	✓	✓
	Waste management						✓				
	Health improvement of cattle(Animal Quality)					✓					

5.3.5.1 Description of sustainable outcomes

The descriptions of sustainable outcomes are below.

Profit maximisation

Profit is the main motive for all businesses. Without profit, no farm can operate its business for the long term. Consistent profit generation can help to achieve

sustainability. To make a consistent profit, a firm should conduct regular checks and balances between costs and profits.

Cost minimisation

Most of the businesses are trying their best to minimise their fixed and variable costs. By doing so, a farm can add more profit to its balance sheet. Minimisation of cost is not easy as it is directly related to the quality of products and services. A farm should take care of its redundant costs. When farms adopt different mitigation strategies simultaneously, extra costs can sometimes be avoided. For example, when a farm adopts the strategy of hiring skilled staff, then additional costs for training them could be reduced or avoided.

Increase in personal income

Although profit maximisation and income increment sound similar, there are differences between them. Income increment is a part of profit maximisation. When a company makes more profit, then the salary structure for the stakeholders is increased. As a result, employees from farm level to distribution level receive more salary than before which leads to an increment of income for each and every stakeholders.

Increase in production

Every production-oriented farm has the vision of attaining a goal within a particular time in terms of production, profit and scope. Dairy farms are no exception. Every dairy farm has an intention to increase productivity based on a time frame. It is done gradually as it is impossible to do it over a short span of time. The more production brings more profit. This is a simple and useful concept for a business to achieve maximum gain within their scope. The rate of production could be increased by mitigating different risks like mismanagement of staff, infrastructural risk and so on.

Product quality improvement

Quality is an important term, for farms and their customers. Customers will not be attracted if a company does not achieve optimum quality. Produced milk should have all the necessary ingredients so that customers can get the nutrition they desire from milk and milk-related products. Moreover, milk-related products should be maintained at the optimum temperature while it is travelling over long distances.

Expansion of farming system

Expansion is necessary for all types of business if they want to survive against the immense competition. Profit cannot be maximised if a farm is not expanded gradually. It is preferable for a dairy farm to establish their farming activities in a location where milk can be delivered immediately due to its perishable nature. Expansion may involve arranging land resources for cattle to ultimately increase total milk production. In this regard respondent A from Nahar Dairy mentioned that, '*We are thinking about a multi-storeyed complex for overcoming the land scarcity, but it will be hugely expensive as the design and structure of building should be different for cattle management ...if we could manage, then farming activities could be expanded with limited land resources*'.

Production of value added and diversified products

Dynamic marketing practices encourage farmers to generate more value-added and diversified products. By doing this, a farm can obtain maximum market accessibility while increasing its profit target. For example, a milk producer can adopt a policy to convert a proportion of milk into other value-added products like yogurt of different kinds, flavoured milk, ghee, butter and the like. If a company converts to such products successfully, they can hold a distinctive cluster of customers with better profitability. Respondents D from Nahar Dairy stated that, '*we can introduce to procure more value-added products to make an additional profit. Sometimes we cannot sell the produced milk within the same day, and then it will perish. In that case, we can introduce packaged milk including value-added products with the left over milk so that we can increase usual profit within the same resources.*'

Goodwill enhancement

Goodwill is an image which has additional worth for a company. Nobody can develop their goodwill within a short time but rather by producing optimum quality day after day. Products from a particular farm should be consistent in terms of quality, weight, colour, nutrition and so on. Once, goodwill is established for a farm, customers will be attracted to buy their products with satisfaction. By implementing different strategies regarding quality control, herd management, training management and so on, a company can achieve goodwill.

Supply of quality food

Quality means an essential or distinctive characteristic of particular products. Obviously, some government or related quality control organisations set a standard for

a product. By maintaining the standard, a company can maintain the quality of the product. As a result, customers procure quality products to meet their specific purposes of consumption.

Nutritional development

Dairy products are related to nutrition, and good nutrition can be maintained through the suitable intake (food) to the dairy cattle. They should be provided with a high standard diet so that the produced milk will be appropriately nutritious. In this case, a farm can recruit nutrition experts to cross-examine all the related issues so that produced milk will have appropriate nutrition. As a result of production increment, consumers may able to get milk and milk products at a low cost. When as a strategy, a farm recruits experts for quality control and cross examination of all nutritional issues, and then nutritional development could be easily achieved.

Improvement of living standard

People involved in farm activities should have a respectable living standard as part of their motivation to work. To do so, good packages are offered to the employees, which are directly related to farm profitability. When a business makes an optimum or desired profit, it can easily provide relevant facilities to its stakeholders to maintain a good quality living standard, which is helpful to improve the living standard of all.

Creation of employment opportunities

Employment opportunities create scope to involve more employees on the farm. More employment can be created to manage expansion of the business, better profitability and producing diversified products.

Creation of sound working environment

A sound working environment denotes maintaining standard occupational procedures for activities to be completed. The main requirements for a sound working environment are appropriate job roles, responsibilities, hierarchy, safety, environment and logistics. The sound working environment could be automatically attained when a company undertakes different strategies related to hygiene management, herd management and human resource management.

Waste management

Dairy is an industry where huge wastes are generated every day. A farm must think about wastes and their reuse so that the environment and hygiene can be managed properly. For example, cow dung can be used as raw materials for generating biogas which ultimately can be used for generating power. Regarding waste management, respondent F mentioned that, 'a *good portion of cow dung is used as a fertiliser for our plantation, while a slight portion of it is used as a raw material for fish feed in our farm*'. It is noted here that Nahar Dairy has already taken the initiative to produce biogas from farm waste and are successful in producing it. In this way waste is managed properly.

Health improvement of cattle (animal quality)

Animal quality is a significant issue all over the world. Quality in terms of breed is important for ultimate production of milk from a farm. A quality breed can produce more milk than the lower-quality breed. However, a farm needs to be careful to upgrade the breed as breed management relies on the surrounding environment (such as humid, temperature and weather). Farmers can gradually upgrade their cattle which may give them better sustainability on their livestock. Respondent E stressed the health improvement of cattle by stating that, '*if we can ensure good health of animals by proper feed management and disease management, then we will get a calf each year which will be profitable for farm'*.

5.3.6 Deductive analysis

A number of risk variables, mitigation strategies and sustainable outcomes were identified through the inductive phase of the study. These variables and factors then were labelled using deductive analysis in line with the exiting literature (Finch 2004; Jüttner, Peck and Christopher 2003; Mishra and Shekhar 2011; Rao and Goldsby 2009; Choudhary et al. 2011; Akcaoz, Kizilay and Ozcatalbas 2009; Carter and Rogers 2008a; Raha and Talukder 2004; Blos, Quaddus and Wee 2009; Manuj and Mentzer 2008b; Chowdhury 2007). In this deductive phase, justification of the selected risk variables, mitigation strategies and sustainable outcomes was provided with support from the literature. Most of the factors derived from the field study are supported based on uniformity with the existing literature.

Hence, the competency and adequacy of each variable are established based on the existing theory and empirical studies by which the justification is made. The field study

revealed that political unrest and interferences are causing various risks for the dairy industry. Local political leaders are very active to keep the businessmen under pressure to do something as per their instruction, and this hinders the normal flow of business activities. The respondents mentioned that their distributional activities are always hampered by different forms of political unrest. This finding is consistent with Rao and Goldsby's (2009) study, which found that political instability could be a key component of supply chain risk. Common risks embedded in storage, processing and distribution levels are shown in Table 5.12). For instance, financial risk factors have five different risks of inadequate loan facilities, complex procedures, high interest rates, inadequate finance and absence of compensation through insurance. Such risks are verified in the existing literature (the references are shown in Table 5.12). Similarly, other factors like technological shortage, human resource, government support and the like are listed in the same table with appropriate references.

Table 5.12: Common Risks with Relevant Literature

Risk factors	Risk Variables	References
Financial risk	Inadequate loan facilities	(Raha and Talukder 2004, Bari 2008, Halder and Barua 2003, Jabbar 2010, Ali and Kapoor 2008)
	Complex loan procedures	(Chowdhury 2007, Food 2011)
	High rate of interest	(Trkman and McCormack 2009, Ahsan 2011,Rao and Goldsby 2009, Food 2011)
	Inadequate finance	(Ali and Kapoor 2008, Giunipero and Eltantawy 2004, Chowdhury 2007, Ghani and Rahman 2004 , Ghani and Rahman 2004)
	Absence of insurance or compensation coverage for dairy industry	(Akcaoz, Kizilay, and Ozcatalbas 2009, Bari 2008, Jabbar 2010)
Technological shortage	Shortage of improved technology (milking machine, feed mixture, grass cutting, improved processing, cooling facilities)	(Akcaoz, Kizilay, and Ozcatalbas 2009, Ghani and Rahman 2004, Raha and Talukder 2004, Shrestha and Yadav 2004)
Human resource risk	Labour disputes	(Rao and Goldsby 2009, Peck 2005, Blos et al. 2009, Tang and Musa 2011)
	Illiteracy and inefficiency of worker	(Mishra and Shekhar 2011, Ali and Kapoor 2008, Shamsuddoha and Edwards 2000, Jabbar 2010)
	Shortage of skilled staff	(Ali and Kapoor 2008, Shamsuddoha and Edwards 2000, Hashmi 2004, Shrestha and Yadav 2004, Bari 2008)
	Switching of staff frequently	(Giunipero and Eltantawy 2004)

Government policy and support	Lack of fixed government policy in dairy sector	(Chowdhury 2007, Halder and Barua 2003, Choudhary et al. 2011, Akcaoz, Kizilay, and Ozcatalbas 2009,Rao and Goldsby 2009,Peck 2005, Food 2011)
	Poor law and order situation (terrorism, musclemen ship)	(Chowdhury 2007, Wagner and Neshat 2010, Trkman and McCormack 2009)
Political risk	Hartal and strike cause delay in working process	(Chowdhury 2007, Mishra and Shekhar 2011, Rao and Goldsby 2009, Jüttner, Peck, and Christopher 2003,Wagner and Neshat 2010)
	Political unrest and interference	(Choudhary et al. 2011,Akcaoz, Kizilay, and Ozcatalbas 2009,Ahsan 2011,Rao and Goldsby 2009, Trkman and McCormack 2009, Shamsuddin et al. 2007)
Mismanagement and unethical behaviour of employees	Corruption (adulteration by mixing water)	(Faye and Loiseau 2002Hashmi 2004, Abdullah 2004, Shrestha and Yadav 2004)
	Damage of farm's assets	(Mishra and Shekhar 2011)
	Theft	(Akcaoz, Kizilay, and Ozcatalbas 2009,Finch 2004, Blos et al. 2009)
Natural risk	Natural uncertainties (storm, excessive rain, flood)	(Finch 2004.Rao and Goldsby 2009, Peck 2005, Wagner and Neshat 2010, Trkman and McCormack 2009,Ali and Kapoor 2008,Choudhary et al. 2011, Blos et al. 2009)
	Quick perishability of milk	(Ghani and Rahman 2004, Choudhary et al. 2011, Shamsuddoha and Edwards 2000)

These risks are categorised according to their uniformity with the appropriate literature First, the risk factors for storage are presented in Table 5.13. The risk factors associated with storage level of the supply chain include: hazard, technology, mismanagement and unethical behaviour and natural risk. At the same time, various risk variables are related with each factor. For example, machine damage or breakdown of a cold storage machine is a kind of hazard risk that has already been pointed out in various literature (for example, Mishra and Shekhar 2011, Rao and Goldsby 2009, Jüttner, Peck, and Christopher 2003). The same variable under hazard risk was mentioned in the field study of this research.

Table 5.13: Risk Factors (Storage) with Relevant Literature

Risk factors	Risk Variables	References
Hazard risk	Machine damage/breakdown at cold storage	(Mishra and Shekhar 2011, Rao and Goldsby 2009, Jüttner, Peck, and Christopher 2003)
Technological shortage	Inadequate chilling facilities	(Raha and Talukder 2004, Choudhary et al. 2011, Abdullah 2004,Halder and Barua 2003, Ali and Kapoor 2008)
	Inadequate cold storage facilities	(Akcaoz, Kizilay, and Ozcatalbas 2009, Ghani and Rahman 2004, Raha and Talukder 2004, Ghani and Rahman 2004, Shrestha and Yadav 2004)
Mismanagement and unethical behaviour of employees	Spoilage of milk through improper handling	(Mishra and Shekhar 2011, Choudhary et al. 2011)
Natural risk	Bacterial contamination for improper temperature	(Mishra and Shekhar 2011, Choudhary et al. 2011, Shrestha and Yadav 2004)
	Pollution and Unhygienic environment	Blos et al. 2009, Choudhary et al. 2011, Akcaoz, Kizilay, and Ozcatalbas 2009, Choudhary et al. 2011, Khanna 2004, Abdullah 2004, Shrestha and Yadav 2004 (Blos et al. 2009, Choudhary et al. 2011, Akcaoz, Kizilay, and Ozcatalbas 2009, Choudhary et al. 2011, Khanna 2004, Abdullah 2004, Shrestha and Yadav 2004)

The risk factors for the processing level of a supply chain process are shown in Table 5.14. It identifies six different risk factors explored in the field study and literature. These factors are hazard, input, poor infrastructural facilities, absence of government policy, strategic and natural risk. These risk factors have different variables as well. For instance, drought leads to a decline in milk production due to the scarcity of green grass, which is a natural risk. The farmer cannot do anything about the natural risk as it is uncontrollable. In this situation, a farmer can explore alternative options to green grass so that milk production remains at an optimum level. Similarly, hazard risks are associated with cattle disease, machine breakdown at the processing unit, a fire at the farm sheds and staff injury. There might be more risks, but the risks listed are the ones that happen most frequently in the case companies.

Table 5.14: Risk Factors (Processing) with Relevant Literature

Risk Factors	Risk Variables	References
Hazard risk	Cattle diseases	(Akcaoz, Kizilay, and Ozcatalbas 2009, Finch 2004,Peck 2005, Saadullah 2000, Shamsuddoha and Edwards 2000, Ghani and Rahman 2004, Bari 2008, Halder and Barua 2003, Trkman and McCormack 2009, Choudhary et al. 2011, Shamsuddin et al. 2007)
	Machine breakdown at processing unit	(Mishra and Shekhar 2011, Rao and Goldsby 2009, Jüttner, Peck, and Christopher 2003)
	Fire at farm shed	(Jüttner, Peck, and Christopher 2003, Blos et al. 2009, Mishra and Shekhar 2011,Rao and Goldsby 2009, Trkman and McCormack 2009)
	Accident (Staff injury)	(Jüttner, Peck, and Christopher 2003, Mishra and Shekhar 2011, Wagner and Neshat 2010, Trkman and McCormack 2009, Tang and Musa 2011)
Input risk	Inadequate supply of quality feed	(Rao and Goldsby 2009, PRAN-RFL 2007, Saadullah 2000, Shamsuddoha and Edwards 2000)
	High cost of feed and medicine	(Mishra and Shekhar 2011,Ahsan 2011)
	Scarcity of feed	(Saadullah 2000, Rao and Goldsby 2009, Shamsuddoha and Edwards 2000, Raha and Talukder 2004, Ghani and Rahman 2004, Shrestha and Yadav 2004, Bari 2008, Halder and Barua 2003, Shamsuddin et al. 2007, Jabbar 2010)
	Lack of upgrade vaccination and veterinary services	(Rao and Goldsby 2009, Raha and Talukder 2004, Ghani and Rahman 2004, Bari 2008, Jabbar 2010)
Poor infrastructural facilities	Shortage of land for expanding farm	(Ghani and Rahman 2004, Ali and Kapoor 2008,Choudhary et al. 2011,Bari 2008)
Absence of government policy & support	Irregular supply of vaccine from government	(Akcaoz, Kizilay, and Ozcatalbas 2009, Shamsuddoha and Edwards 2000)
Strategic risk	Competition among the farms	(Manuj and Mentzer 2008, Abdullah 2004, Food 2011, Wagner and Neshat 2010, Halder and Barua 2003)
	Bureaucratic complexity on maintaining various formalities	(Chowdhury 2007)
Natural risk	Drought leads to a decline in milk production	(Choudhary et al. 2011, Wagner and Neshat 2010)

Table 5.15 represents the risk factors for distribution with relevant literature. The risk factors identified within the distribution level processing in the dairy are hazard,

distribution, poor infrastructure and mismanagement, and unethical behaviour of employees and middlemen. The table also lists the different risks variables which are related with each factor. For instance, common risks under the poor infrastructural facilities are poor conditioned road, inadequate transport facilities and lack of milk tanker with chilling facilities. These risk variables are also cross checked in the existing literature and all found in the field study.

Table 5.15: Risk factors (Distribution) with Relevant Literature

Risk Factors	Risk Variables	References
Hazard risk	Accidents of transport vehicle	(Jüttner, Peck, and Christopher 2003, Mishra and Shekhar 2011,Akcaoz, Kizilay, and Ozcatalbas 2009,Finch 2004, Wagner and Neshat 2010, Trkman and McCormack 2009, Tang and Musa 2011)
Distribution risk	Existence of middlemen/ too many middlemen	(Ali and Kapoor 2008,Hashmi 2004, Ahsan 2011, Ghani and Rahman 2004)
	Too long chain cause delay in product movement	(Ali and Kapoor 2008,Hashmi 2004, Ahsan 2011, Ghani and Rahman 2004, Mishra and Shekhar 2011, Choudhary et al. 2011,Peck 2005, Blos et al. 2009, Chowdhury 2007)
Poor infrastructural facilities	Poor conditioned road for moving product (delay and spoilage)	(Khanna 2004, Abdullah 2004, Ghani and Rahman 2004, Shrestha and Yadav 2004, Halder and Barua 2003, Ali and Kapoor 2008)
	Inadequate transport facilities to move products frequently	(Peck 2005, Chowdhury 2007, Khanna 2004, Abdullah 2004)
	Lack of milk tanker with chilling facilities	(Ali and Kapoor 2008, Raha and Talukder 2004, Halder and Barua 2003)
Mismanagement and unethical behaviour of employees/ middlemen	Unethical behaviour of middle men (adulteration, added price, deprivation)	(Faye and Loiseau 2002Hashmi 2004, Abdullah 2004, Shrestha and Yadav 2004, Saadullah 2000, Ali and Kapoor 2008, Ghani and Rahman 2004, Halder and Barua 2003, Shamsuddoha and Edwards 2000)

Seven different mitigation strategies are found from the field study. Table 5.16 shows the common mitigation strategies with relevant literature. These strategies are technology development, insurance management, human resource management, government support, financial management, off-farm income and investment and business policy and practice. These strategies along with their associated variables are supported with exiting literature. Various mitigation strategy variables are identified under each mitigation strategy factor. For instance, adoption of improved technology belongs to technology development factor as found in Choudhary et al. 2011,Ahsan 2011, Khanna 2004, Food 2011 and the field study.

Table 5.16: Common Mitigation Strategies with Relevant Literature

Mitigation Strategy (Factor)	Mitigation Strategy (Variable)	Reference
Technology development	Adoption of improved technology (milking machine, feed mixture, grass cutting, improved processing facilities)	(Choudhary et al. 2011,Ahsan 2011, Khanna 2004, Food 2011)
Insurance management	Buying insurance against production loss	(Akcaoz, Kizilay, and Ozcatalbas 2009,Ahsan 2011)
Human resource management	Hiring skilled staff	(Tipples and Morriss 2002; Morriss et al. 2006; Food 2011a)
	Motivational and incentives facilities for staff	(Abdullah 2004)
Government support	Initiative to remove political uncertainty	(Chowdhury 2007)
	Implementation of a fixed policy for dairy sector	(PRAN-RFL 2007, Shamsuddoha and Edwards 2000, Shrestha and Yadav 2004)
Financial management	Assurance of adequate institutional credit support with low rate of interest	(Ahsan 2011, Chowdhury 2007, Shamsuddoha and Edwards 2000, Shamsuddin et al. 2007)
Off-farm income and investment	Introducing off-farm activities	(Akcaoz, Kizilay, and Ozcatalbas 2009, Ahsan 2011)
	Focus on value addition	Shrestha and Yadav 2004, Group 2009, Ali and Kapoor 2008
Business policy and practice	Promote sound business practices by cooperation, better coordination and information sharing	(Choudhary et al. 2011, Jüttner, Peck, and Christopher 2003)
	Reduction of risks through merger, acquisition and integration	(Rao and Goldsby 2009, Peck 2005, Manuj and Mentzer 2008)

Table 5.17 lists different mitigation strategies for storage level that are identified through the field study. Training management and backup capacity are two factors found in the existing literature as well. For example, the field study supports training management on temperature control and hygiene management. Shamsuddoha and Edwards (2000) mentioned training management that could be overcome through arranging proper training programmes.

Table 5.17 Mitigation Strategies with Relevant Literature (Storage)

Mitigation strategy (Factor)	Mitigation Strategy (Variable)	Reference/Field study
Training management	Arrangement of proper training to the staff regarding temperature control	(Ahsan 2011, PRAN-RFL 2007, Shamsuddoha and Edwards 2000, Bennett 2004, Shrestha and Yadav 2004), Field study.
Backup capacity	Adoption of alternative supply of power for cold storage (powerful generator)	(Choudhary et al. 2011, Food 2011), Field study

The field study identified six different mitigation strategies (factors) of training management, breed management, government support, feed management, diseases management and infrastructural development (refer to Table 5.9). These mitigation strategies for the processing level were also supported by relevant literature (see Table 5.18). Each mitigation factor contains a few strategy variables to mitigate the relevant risks. For instance, lease abandoned land to farmers for dairy farming, strengthen the regular supply of vaccine, initiatives to reduce the cost of feed and support to develop technology are strategy variables under the government support factor. These variables which were identified through the field study are justified by the existing literature.

Table 5.18 Mitigation Strategies with Relevant Literature (Processing)

Mitigation Strategy (Factor)	Mitigation Strategy (Variables)	Reference/Field study
Training management	Arrangement of proper training to the staff regarding processing and hygiene management	(Ahsan 2011,PRAN-RFL 2007, Shamsuddoha and Edwards 2000, Shrestha and Yadav 2004, Shamsuddin et al. 2007) Field study
Breed management	Attempts to create various cross breeds by adopting AI services	(Ghani and Rahman 2004, Shamsuddoha and Edwards 2000, Ahsan 2011, Khanna 2004)
Government support	Lease abandoned land to the farmers for dairy farming	Raha and Talukder 2004, Field study
	Strengthen the regular supply of vaccine	(Choudhary et al. 2011, Shamsuddoha and Edwards 2000, Bari 2008, Shamsuddin et al. 2007), Field study
	Initiative to reduce the cost of feed	(Shamsuddoha and Edwards 2000, Abdullah 2004,Shrestha and Yadav 2004, Bari 2008, Shamsuddin et al. 2007), Field study
	Support to develop technology	(Chowdhury 2007, Shamsuddoha and Edwards 2000, Abdullah 2004,Shrestha

		and Yadav 2004), Field study
Feed management	Focus on certified feed supplier to get quality feed	(Choudhary et al. 2011, PRAN-RFL 2007, Khanna 2004)
	Arrangement of adequate grassland for producing Napier grass	(Raha and Talukder 2004), Field study
Diseases management	Arrangement of regular vaccination for the cattle	(Choudhary et al. 2011,Akcaoz, Kizilay, and Ozcatalbas 2009, Ghani and Rahman 2004, Khanna 2004), Field study
	Arrangement of improved and upgraded veterinary services	(Shamsuddoha and Edwards 2000, Khanna 2004, Shamsuddin et al. 2007), Field study
Infrastructural development	Building multi-storeyed complex for farm extension	Field study

The field study identified five different distribution mitigation strategies (factors), namely, human resource management, government support, transport management, infrastructural development and business practices and policy (see Table 5.10). These different mitigation strategies along with supporting literature are shown in Table 5.19. Various mitigation strategies (variables) are also identified under each factor. For example, under the business policy and practice factor, the following variables are identified: focus on product diversification, removal of unnecessary influence of middlemen and direct marketing variables.

Table 5.19 Mitigation Strategies with Relevant Literature (Distribution)

Mitigation strategy (Factor)	**Mitigation Strategy (Variable)**	**Reference/Field study**
Human resource management	Building monitoring team	(Ahsan 2011, Food 2011), Field study
Government support	Initiative to develop roads and highways	(Shamsuddin et al. 2007), Field study
Transport Management	Arrangement of adequate number of transport	Field study
	Arrangement of refrigerated transport facilities	(Abdullah 2004), Field study
Infrastructural development	Development of roads and highway	(Chowdhury 2007, Shamsuddin et al. 2007), Field study
Business practices and policy	Focus on product diversification	(Shrestha and Yadav 2004, Group 2009, Ali and Kapoor 2008), Field study
	Removal of unnecessary influence of middlemen	(Peck 2005, Sheffi and Rice 2005, Jüttner, Peck, and Christopher 2003), Field study
	Direct marketing	(Choudhary et al. 2011, (Akcaoz, Kizilay, and Ozcatalbas 2009), Field study

One of the major tasks of this research is to identify appropriate sustainable outcomes through mitigating existing supply chain risks. Section 5.3.5.1 discussed these sustainable outcomes in light of their economic, social and environmental aspects (see Table 5.11). The table also identified various outcomes under each aspect of sustainability. For instance, six different outcomes can be achieved through the economic aspect. These outcomes are supported by the literature (see Table 5.20). They are profit maximisation, cost minimisation, increase in personal income, increase in production, product quality improvement, expansion of farming system, production of value added product and diversified product.

Table 5.20: Sustainable Outcomes with Relevant Literature

Sustainable Aspects	Outcomes	Reference
Economic	Profit maximisation	(Wagner and Neshat 2010), field study
	Cost minimisation	(Carter and Rogers 2008, Bennett 2004, Abdullah 2004, Wagner and Neshat 2010, Fawcett, Magnan, and McCarter 2008), field study
	Increase in personal income	(Shamsuddoha 2009, Kabir and Huo 2011, Bari 2008Ghani and Rahman 2004, Jabbar 2010), field study
	Increase in production	(Abdullah 2004), field study
	Product quality improvement	(Carter and Rogers 2008, Raha and Talukder 2004, Abdullah 2004,Fawcett, Magnan, and McCarter 2008), field study
	Expansion of farming system	(Shamsuddoha and Edwards 2000, Jabbar 2010), field study
	Production of value added product and diversified product	(Abdullah 2004, Ghani and Rahman 2004), field study
Social	Goodwill enhancement	(Carter and Rogers 2008b), field study
	Supply of quality food	(Raha and Talukder 2004), field study
	Nutritional development	(Okano, Vendrametto, and Santos 2010, Bari 2008, Haque 2009, Ghani and Rahman 2004, Halder and Barua 2003), field study
	Improvement of living standard	(Bari 2008; Curtis 2011; Khan, Peters and Uddin 2009), field study
	Creation of employment opportunity	(Ritchie and Brnidley 2007a; Bari 2008), Abdullah 2004), field study
Environmental	Creation of sound working environment	(Carter and Rogers 2008, Group 2009), field study
	Waste management	(Loehr 1974, Al Mamun, Nasrat, and Debi 2012), field study
	Health improvement of cattle(Animal Quality)	(Okano, Vendrametto, and Santos 2010, Fawcett, Magnan, and McCarter 2008, Group 2009), field study

Strategies (outcomes) can be implemented for the economic gain of the concerned farms or industries. The field study explored 'Product quality improvement' as a sustainable outcome. It is found that a better quality product could be ensured through maintaining and implementing a set of standards regarding production methods. Carter and Roger (2008) found this sustainable outcome and mentioned that improvement of product quality is associated with the implementation of ISO 14000 standards.

5.3.7 THE QUALITY FUNCTION DEPLOYMENT ANALYSIS

This section presents and discusses the results of the data analysis using Quality Function Deployment (QFD) method. This analysis was based on the completion of questionnaire-based surveys conducted among three different groups of people (employees, executives and supply chain members) of the same two large-scale commercial dairy farms (Nahar and Paharika) (see Table 5.21 for a profile of the respondents). The first part of the survey (see Appendix 4A) collected data related to risk ratings, relationship scores of risks and strategies, and relative cost, while the second part (see Appendix 4B) collected data for developing a relationship matrix for the second phase of the QFD analysis. This data related to relationship scores of strategies and outcomes were collected from only the executive members of both farms. The respondents included six employees, three executives and two supply chain members from each dairy farm. The respondents had between 8–25 years of service experience in the dairy industry.

5.4 QUESTIONNAIRE-BASED SURVEY

This section discusses the results of the questionnaire-based survey (see Appendix 4A) which, as explained in step VI of section 4.4 (Research Process) of previous chapter (Chapter 4). A questionnaire survey was conducted among three different groups (employees, executives and supply chain members) of the same two large-scale commercial dairy farms (Nahar Dairy and Paharika Dairy). The first part of this survey collected data related to risk ratings, relationship scores of risks and strategies, and relative cost. The results of the data analysis using Quality Function Deployment (QFD) method are discussed in the following sections of this chapter. The second part of the survey (see Appendix 4B) was conducted to collect data for developing the relationship matrix for the second phase of the QFD analysis. This data related to relationship scores of strategies and outcomes were collected from only the executive members of

both farms. The sample of the questionnaire by which relationship data (strategies and outcomes) was conducted is shown in appendix 4B.

5.4.1 Respondents Profile

The 22 respondents involved in this quantitative phase were employees, executives and supply chain members of the two case industries. There were six employees, three executives and two supply chain members from each. The respondents had between eight and 25 years of service experience in the dairy industry. The employees of Nahar are N1, N2, N3, N4, N5, N6 and the executives of Nahar are N7, N8, and N9. The supply chain members of Nahar are N10, N11 (see Table 5.21). Similarly P1, P2, P3, P4, P5 and P6 are employees of Paharika and P7, P8, P9 are executives of Paharika and P10 and P11 are supply chain members of Paharika.

The data for the second part of the QFD analysis (Phase 2) were collected only from the executives of both farms. Respondents for Phase 2 are six executives, three from each farm: N7, N8 and N9 from Nahar Dairy and P7, P8 and P9 from Paharika Dairy (shown in Table 5.21)

Table 5.21: Background Information of Respondents

Dairy	Respondent No.	No. of years at work	Designation	
Nahar Dairy	N1	13	Supervisor	Employee
	N7	15	Production manager	Executive
	N8	25	Managing director	Executive
	N2	8	Assistant sales manager	Employee
	N3	15	Regional sales manager	Employee
	N4	12	Store keeper	Employee
	N5	10	Assistant manager	Employee
	N6	8	Store manager	Employee
	N9	12	Sales manager	Executive
	N10	11	Milk distributor	SC member
	N11	8	Feed supplier	SC member
Paharika Dairy	P1	12	Store keeper	Employee
	P2	18	Assistant store manager	Employee
	P7	11	Sales Manager	Executive
	P3	9	Regional sales manager	Employee
	P4	10	Assistant sales manager	Employee
	P5	12	Store manager	Employee
	P8	22	Managing director	Executive
	P9	20	Production manager	Executive
	P6	14	Assistant production manager	Employee
	P10	8	Milk distributor	SC Member
	P11	11	Feed supplier	SC Member

5.5 THE QFD PROCESS

The QFD process is an orderly sequence of activities, which uses a series of matrices to organise, analyse and compare information. It utilises a process, containing the result of research and analysis on customer groups and competitors, with the help of a powerful analytical framework, called the 'house of quality' matrix (Walker 2002). This matrix has its own shape with various rooms containing the result of different matrices of each phase. Normally, the QFD process begins with customer requirements and then translates the requirements into technical specifications (Bouchereau and Rowlands 2000a). While the methods of quantitative data analysis were explained in section 4.7.2 (d), in this phase the results of quantitative data analysis are presented.

5.5.1 QFD PART I: PHASE 1

After collecting all necessary data required for QFD analysis (explained in Section 4.6), in this phase various matrices for QFD analysis are formed. The matrices for Step 1 and Step 2 of QFD process (see Section 4.6.1) were developed from interview data, while the matrices for Step 3 to Step 7 of the QFD process (see Section 4.6.1) were developed from the data obtained through the survey. The results presented and discussed in this section are as follows: identifying risk (Step 1 of Section 4.6.1), identifying mitigation strategies (Step 2 of Section 4.6.1), calculating the degree of importance by prioritising the risk factors (Step 3 of Section 4.6.1), evaluating the relationship between risk and strategy (Step 4 of Section 4.6.1), identifying organisational resource constraints (Step 5 of Section 4.6.1), developing the roof matrix regarding the cost savings from concurrent implementation of two strategies (Step 6 of Section 4.6.1), and calculating the weights of mitigation strategies (Step 7 of Section 4.6.1).

5.5.1.1 Identifying Risks

Identification of risk consists of identifying and quantifying exposures that threaten a company's assets and profitability(Finch 2004). As mentioned in Section 5.3, to identify multiple dairy risks, interviews with key dairy industry stakeholders and a review of dairy sector documents was undertaken. After analysing the qualitative data using content analysis, different factors and variables of dairy supply chain risk were explored (explained in Section 5.3.3.1). Similar variables were combined to eliminate redundancies. Finally, 45 variables were classified as distinct variables that are grouped into seven factors. These factors are 'financial risk', 'technological risk', 'human resource risk', 'government policy and support', 'political risk', 'mismanagement of staff' and 'natural risk'. Under each risk factor, several risk

variables were named. These 45 risks relevant to the dairy supply chain were finalised as input data for the matrix development of Step 1 (WHATs) of QFD analysis.

As seen in Tables 5.3, 5.4, 5.5 and 5.6, some risks are common at every level (storage, processing and distribution), where some apply solely to one specific level. The detail of each risk factor was described in Section 5.3.3.1, whereas the descriptions of each risk variable are provided in Appendix 5A. Table 5.22 shows all risks. Risk 1 (R1) to risk 19 (R19) are common risk sources for every level. By contrast, the other risks only apply to specific levels, as follows: risk 20 (R20) to risk 25 (R25) apply solely to the storage level; risk 26 (R26) to risk 38 (R38) apply to the processing level; and risk 39 (R39) to risk 45 (R45) apply to the distribution level. More risks are associated with the processing level than with the storage and distribution levels.

Table 5.22: Dairy Supply Chain Risks

R1	=	Inadequate loan facilities	R24	=	Bacterial contamination for improper temperature
R2	=	Complex loan procedures	R25	=	Pollution and unhygienic environment
R3	=	High rate of interest	R26	=	Cattle diseases
R4	=	Inadequate finance	R27	=	Machine damage/breakdown at processing unit
R5	=	Absence of insurance or compensation coverage	R28	=	Fire at farm shed
R6	=	Shortage of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	R29	=	Accident (staff injury)
R7	=	Labour disputes	R30	=	Inadequate supply of quality feed
R8	=	Illiteracy and inefficiency of worker	R31	=	High cost of feed and medicine
R9	=	Shortage of skilled staff	R32	=	Scarcity of feed
R10	=	Switching of staff frequently	R33	=	Lack of upgrade vaccination and veterinary services
R11	=	Lack of fixed government policy in dairy sector	R34	=	Shortage of land for expanding farm
R12	=	Poor law and order situation (terrorism, musclemen ship)	R35	=	Irregular supply of vaccine from government
R13	=	Hartal and strike cause delay in work process	R36	=	Competition among the farms
R14	=	Political Unrest and interference	R37	=	Bureaucratic complexity on maintaining various formalities
R15	=	Corruption (adulteration by mixing water)	R38	=	Drought leads to a decline in milk production
R16	=	Damage of farm's assets	R39	=	Accidents of transport vehicle
R17	=	Theft	R40	=	Existence of middlemen/ too many middlemen

R18	=	Natural disaster (flood, excessive rain, storm)	R41	=	Too long chain cause delay in product movement
R19	=	Quick perishability of Milk	R42	=	Poor conditioned road for moving product (delay & spoilage)
R20	=	Machine damage/breakdown at cold storage	R43	=	Inadequate transport facilities to move products frequently
R21	=	Inadequate chilling facilities	R44	=	Lack of milk tanker (refrigerated)
R22	=	Inadequate cold storage	R45	=	Unethical behaviour of middle men (adulteration, added price, deprivation)
R23	=	Spoilage of milk through improper handling			

The detailed descriptions of these above mentioned risks are provided in Appendix 5A.

5.5.1.2 Identifying Risk Mitigation Strategies

From the qualitative data analysis (see Section 5.3.3.2), numerous strategies were suggested by the respondents as strategies to mitigate dairy risk. An extensive review of literature related to supply chain risk management and the qualitative interviews resulted in the listing of fourteen mitigation strategies. Some of these factors were described in Section 5.3.3.2. Table 5.23 represents the list of 32 mitigation strategies.

As shown previously in Tables 5.15, 5.16, 5.17 and 5.19, mitigation strategies S1 to S11 are common strategies for all levels (storage, processing and distribution), with the remainder of the mitigation strategies being applicable at only one specific level as follows: Strategy 12 (S12) and Strategy 13 (S13) are only effective for the storage level; Strategies S14 to S24 are possible mitigation strategies for the processing level; and strategiesS25 to S32 for the distribution level. Two strategies were suggested for the storage level, ten strategies were suggested for the processing level and seven strategies were suggested for the distribution level. A detailed description of all the variables of mitigation strategies is presented in Appendix 5B.

Table 5.23: Dairy Supply Chain Risk Mitigation Strategies

S1	=	Adoption of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	S17	=	Strengthen the regular supply of vaccine
S2	=	Buying insurance against production loss.	S18	=	Initiative to reduce the cost of feed
S3	=	Hiring skilled staff	S19	=	Support to develop technology
S4	=	Motivational and incentives facilities for staff	S20	=	Focus on certified feed supplier to get quality feed.
S5	=	Initiative to remove political uncertainty	S21	=	Arrangement of adequate grassland for producing Napier grass
S6	=	Implementation of a fixed policy for dairy sector	S22	=	Arrangement of regular vaccination for the cattle
S7	=	Assurance of adequate institutional credit support with low rate of interest	S23	=	Arrangement of improved and upgraded veterinary services
S8	=	Introducing off-farm activities	S24	=	Building multi-storeyed complex for farm extension
S9	=	Focus on value addition	S25	=	Building monitoring team
S10	=	Promote sound business practices by cooperation, better coordination and information sharing	S26	=	Initiative to develop roads and highways
S11	=	Reduction of risks through merger, acquisition and integration.	S27	=	Arrangement of adequate number of transport
S12	=	Arrangement of proper training to the staff regarding temperature control	S28	=	Arrangement of refrigerated transport facilities
S13	=	Adoption of alternative supply of power for cold storage (powerful generator)	S29	=	Development of roads and highway
S14	=	Arrangement of proper training to the staff regarding processing and hygiene management	S30	=	Focus on product diversification
S15	=	Attempts to create various cross breeds by adopting AI services.	S31	=	Removal of unnecessary influence of middlemen
S16	=	Lease abandoned land to the farmers for dairy farming	S32	=	Direct marketing

5.5.1.3 Degree of Importance (DI)

After obtaining the required data from the survey for the QFD analysis, the degree of importance for risks were calculated (as explained in Section 4.7.2 d). The data regarding probability and impact were collected using a 0–10 rating scale and later converted to a 0–1 scale. The findings from calculating the degree of importance for the three respondent groups (employee, executives and supply chain members) of Nahar Dairy is shown in Table 5.24. Here, 'P' refers to probability score, 'I' refers to impact

score, 'DI' refers to the product of risk and impact score, the degree of importance score (see Section 4.7.2d). The Nahar respondents are coded 'N1 … N11'with the employees (N1–N6), the executives (N7–N10) and the supply chain members (N10& N11). A similar table for the calculation of the degree of importance for Paharika Dairy's three groups of respondents is shown in Appendix 5C.

The result, according to the employees of Nahar Dairy, indicates that the most important risks for the dairy supply chain in Bangladesh are: 'Hartal and strike cause delay in work process' (R13), 'High rate of interest' (R3), 'Absence of insurance or compensation coverage' (R5), and 'Illiteracy and inefficiency of workers' (R8).The employee group of Nahar Dairy gave the highest priority to the risk 'Hartal and strike delay in work in process' (R13) with 65% importance (see Table 5.24). According to their opinion, the second most important risk is 'High rate of interest' (R3) with60% importance followed by another two risks with same degree of importance. These risks are 'Absence of insurance' and Compensation coverage' (R5) and 'Illiteracy and inefficiency of workers' (R8) with 59% importance. By contrast, the least important risk was (R29) 'Accident-staff injury' which is of 10% importance.

The executive group of Nahar Dairy identified the most important risk as(R13) 'Hartal and strike cause delay in work process' with 78% importance. This group also indicated two other risks as important by prioritising them with 70% importance. These two risks are: 'Lack of fixed government policy in dairy sector' (R11) and 'Existence of middlemen/too many middlemen' (R40). The 'Risk of accident' (R29) is less significant to them with 8% importance.

Nahar Dairy supply chain members indicated that the most important risk is 'Hartal and strike cause delay in work process' (R13) with 77% importance followed by another risk, 'Political unrest and interference' (R14) with 72% importance. Another important risk was (R44) 'Lack of milk tanker (refrigerated)' with 68% importance. Risk (R15) 'Corruption' scored 5% which is considered least important. In summary, according to all Nahar Dairy groups (employees, executives and supply chain members), the most important risk is 'Hartal and strike cause delay in work process' (R13).

Table 5.24: Calculation of Degree of Importance (Nahar)

SL	Risk	N1			N2			N3			N4			N5			N6					N7			N8			N9					N10			N11				
		P	I	DI	P	I	DI	P	I	DI	P	I	DI	P	I	DI	P	I	DI	Total	DI Av.	P	I	DI	P	I	DI	P	I	DI	Total	DI Av.	P	I	DI	P	I	DI	Total	DI Av.
1	Inadequate loan facilities	0.7	0.6	0.42	0.4	0.6	0.24	0.4	0.5	0.2	0.5	0.6	0.3	0.6	0.7	0.42	0.6	0.4	0.24	1.82	0.30	0.4	0.5	0.2	0.5	0.6	0.3	0.4	0.4	0.16	0.66	0.22	0.8	0.4	0.32	0.8	0.6	0.48	0.8	0.40
2	Complex loan procedures	0.5	0.4	0.2	0.6	0.7	0.42	0.6	0.5	0.3	0.8	0.9	0.72	0.8	0.4	0.32	0.2	0.2	0.04	2	0.33	0.7	0.8	0.56	0.7	0.4	0.28	0.3	0.5	0.15	0.99	0.33	0.8	0.4	0.32	0.6	0.6	0.36	0.68	0.34
3	High rate of interest	0.9	0.9	0.81	0.7	0.8	0.56	0.8	0.8	0.64	0.7	0.7	0.49	0.8	0.7	0.56	0.8	0.7	0.56	3.62	**0.60**	0.8	0.8	0.64	0.7	0.7	0.49	0.8	0.6	0.48	1.61	0.54	0.7	0.5	0.35	0.8	0.5	0.4	0.75	0.38
4	Inadequate finance	0.9	0.8	0.72	0.5	0.6	0.3	0.5	0.5	0.25	0.7	0.8	0.56	0.5	0.8	0.4	0.7	0.8	0.56	2.79	0.47	0.5	0.6	0.3	0.7	0.7	0.49	0.9	0.5	0.45	1.24	0.41	0.6	0.4	0.24	0.8	0.6	0.48	0.72	0.36
5	Absence of insurance or compensation coverage	0.9	0.9	0.81	0.8	0.4	0.32	0.8	0.7	0.56	0.9	0.9	0.81	0.8	0.9	0.72	0.6	0.5	0.3	3.52	**0.59**	0.7	0.8	0.56	0.9	0.9	0.81	0.7	0.8	0.56	1.93	**0.64**	0.8	0.4	0.32	0.6	0.6	0.36	0.68	0.34
6	Shortage of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	0.7	0.7	0.49	0.2	0.7	0.14	0.9	0.2	0.18	0.8	0.8	0.64	0.7	0.6	0.42	0.7	0.6	0.42	2.29	0.38	0.7	0.7	0.49	0.7	0.5	0.35	0.7	0.7	0.49	1.33	0.44	0.9	0.7	0.63	0.9	0.5	0.45	1.08	0.54
7	Labour disputes	0.6	0.7	0.42	0.4	0.8	0.32	0.6	0.4	0.24	0.8	0.9	0.72	0.8	0.9	0.72	0.7	0.7	0.49	2.91	0.49	0.8	0.7	0.56	0.7	0.7	0.49	0.7	0.5	0.35	1.4	0.47	0.4	0.5	0.2	0.4	0.4	0.16	0.36	0.18
8	Illiteracy and inefficiency of worker	0.8	0.9	0.72	0.6	0.7	0.42	0.8	0.6	0.48	0.9	0.9	0.81	0.9	0.7	0.63	0.7	0.7	0.49	3.55	**0.59**	0.6	0.7	0.42	0.7	0.7	0.49	0.8	0.9	0.72	1.63	0.54	0.6	0.6	0.36	0.7	0.6	0.42	0.78	0.39
9	Shortage of skilled staff	0.7	0.7	0.49	0.8	0.6	0.48	0.9	0.7	0.63	0.9	0.8	0.72	0.8	0.7	0.56	0.7	0.7	0.49	3.37	**0.56**	0.8	0.6	0.48	0.7	0.7	0.49	0.9	0.8	0.72	1.69	0.56	0.6	0.7	0.42	0.6	0.8	0.48	0.9	0.45
10	Switching of staff frequently	0.5	0.6	0.3	0.7	0.5	0.35	0.9	0.9	0.81	0.8	0.6	0.48	0.7	0.7	0.49	0.6	0.6	0.36	2.79	0.47	0.5	0.7	0.35	0.7	0.7	0.49	0.8	0.7	0.56	1.4	0.47	0.8	0.5	0.4	0.4	0.3	0.12	0.52	0.26
11	Lack of fixed government policy in dairy sector	0.6	0.7	0.42	0.9	0.8	0.72	0.9	0.7	0.63	0.7	0.7	0.49	0.7	0.5	0.35	0.8	0.8	0.64	3.25	0.54	0.8	0.7	0.56	0.9	0.9	0.81	0.9	0.8	0.72	2.09	**0.70**	0.6	0.5	0.3	0.8	0.5	0.4	0.7	0.35
12	Poor law and order situation (terrorism, musclemen ship)	0.6	0.6	0.36	0.8	0.7	0.56	0.8	0.7	0.56	0.5	0.7	0.35	0.8	0.9	0.72	0.7	0.7	0.49	3.04	0.51	0.7	0.9	0.63	0.5	0.5	0.25	0.8	0.7	0.56	1.44	0.48	0.8	0.8	0.64	0.8	0.7	0.56	1.2	0.60
13	Hartal and strike cause delay in work process	0.9	0.9	0.81	0.9	0.8	0.72	0.7	0.6	0.42	0.6	0.8	0.48	0.9	0.9	0.81	0.8	0.8	0.64	3.88	**0.65**	0.8	0.9	0.72	0.9	0.9	0.81	0.9	0.9	0.81	2.34	**0.78**	0.9	0.9	0.81	0.9	0.8	0.72	1.53	**0.77**
14	Political Unrest and interference	0.9	0.9	0.81	0.7	0.8	0.56	0.6	0.8	0.48	0.6	0.6	0.36	0.8	0.9	0.72	0.7	0.8	0.56	3.49	**0.58**	0.6	0.8	0.48	0.7	0.6	0.42	0.7	0.6	0.42	1.32	0.44	0.9	0.9	0.81	0.9	0.7	0.63	1.44	**0.72**
15	Corruption (adulteration by mixing water)	0.3	0.5	0.15	0.2	0.4	0.08	0.2	0.4	0.08	0.5	0.4	0.2	0.2	0.1	0.02	0	0.7	0	0.53	0.09	0.6	0.7	0.42	0	0	0	0.8	0.7	0.56	0.98	0.33	0.1	0.5	0.05	0.2	0.2	0.04	0.09	0.05
16	Damage of farm's assets	0.4	0.5	0.2	0.8	0.9	0.72	0.5	0.6	0.3	0.5	0.9	0.45	0.4	0.5	0.2	0.5	0.7	0.35	2.22	0.37	0.7	0.7	0.49	0.6	0.6	0.36	0.8	0.7	0.56	1.41	0.47	0.3	0.5	0.15	0.2	0.3	0.06	0.21	0.11
17	Theft	0.4	0.4	0.16	0.8	0.7	0.56	0.4	0.4	0.16	0.5	0.5	0.25	0.1	0.2	0.02	0.5	0.7	0.35	1.5	0.25	0.8	0.8	0.64	0.1	0.1	0.01	0.6	0.7	0.42	1.07	0.36	0.1	0.3	0.03	0.3	0.3	0.09	0.12	0.06
18	Natural disaster (flood, excessive rain, storm)	0.3	0.5	0.15	0.7	0.6	0.42	0.7	0.8	0.56	0.6	0.8	0.48	0.5	0.6	0.3	0.5	0.5	0.25	2.16	0.36	0.8	0.8	0.64	0.3	0.3	0.09	0.3	0.4	0.12	0.85	0.28	0.4	0.6	0.24	0.4	0.7	0.28	0.52	0.26
19	Quick perishability of Milk	0.4	0.6	0.24	0.7	0.6	0.42	0.7	0.5	0.35	0.6	0.7	0.42	0.3	0.5	0.15	0.3	0.4	0.12	1.7	0.28	0.6	0.8	0.48	0.3	0.3	0.09	0.4	0.3	0.12	0.69	0.23	0.6	0.8	0.48	0.7	0.5	0.35	0.83	0.42
20	Machine damage/breakdown at cold storage	0.4	0.5	0.2	0.6	0.7	0.42	0.5	0.6	0.3	0.6	0.5	0.3	0.2	0.2	0.04	0.2	0.2	0.04	1.3	0.22	0.5	0.6	0.3	0.2	0.2	0.04	0.2	0.3	0.06	0.4	0.13	0.7	0.7	0.49	0.4	0.7	0.28	0.77	0.39
21	Inadequate chilling facilities	0.3	0.5	0.15	0.4	0.5	0.2	0.2	0.2	0.04	0.7	0.5	0.35	0.1	0.1	0.01	0.1	0.1	0.01	0.76	0.13	0.8	0.9	0.72	0.2	0.2	0.04	0.5	0.3	0.15	0.91	0.30	0.8	0.7	0.56	0.5	0.7	0.35	0.91	0.46
22	Inadequate cold storage	0.7	0.8	0.56	0.7	0.6	0.42	0.4	0.5	0.2	0.8	0.8	0.64	0.2	0.4	0.08	0.2	0.4	0.08	1.98	0.33	0.6	0.8	0.48	0.2	0.2	0.04	0.3	0.4	0.12	0.64	0.21	0.8	0.7	0.56	0.8	0.7	0.56	1.12	0.56
23	Spoilage of milk through improper handling	0.4	0.4	0.16	0.4	0.5	0.2	0.1	0.2	0.02	0.9	0.9	0.81	0.1	0.1	0.01	0.1	0.1	0.01	1.21	0.20	0.5	0.7	0.35	0.2	0.2	0.04	0.1	0.2	0.02	0.41	0.14	0.8	0.5	0.4	0.5	0.5	0.25	0.65	0.33
24	Bacterial contamination for improper temperature	0.4	0.4	0.16	0.5	0.7	0.35	0.3	0.4	0.12	0.4	0.5	0.2	0.2	0.3	0.06	0.2	0.3	0.06	0.95	0.16	0.6	0.8	0.48	0.3	0.3	0.09	0.4	0.5	0.2	0.77	0.26	0.6	0.5	0.3	0.5	0.4	0.2	0.5	0.25
25	Pollution and Unhygienic environment	0.5	0.4	0.2	0.4	0.6	0.24	0.5	0.6	0.3	0.4	0.5	0.2	0.2	0.3	0.06	0.2	0.3	0.06	1.06	0.18	0.5	0.6	0.3	0.2	0.2	0.04	0.3	0.4	0.12	0.46	0.15	0.6	0.3	0.18	0.7	0.6	0.42	0.6	0.30
26	Cattle diseases	0.6	0.8	0.48	0.7	0.8	0.56	0.5	0.7	0.35	0.7	0.9	0.63	0.5	0.8	0.4	0.5	0.8	0.4	2.82	0.47	0.8	0.9	0.72	0.3	0.3	0.09	0.7	0.8	0.56	1.37	0.46	0.8	0.9	0.72	0.7	0.8	0.56	1.28	0.64
27	Machine damage/breakdown at processing unit	0.5	0.6	0.3	0.5	0.6	0.3	0.6	0.5	0.3	0.6	0.8	0.48	0.1	0.8	0.08	0.1	0.1	0.01	1.47	0.25	0.7	0.9	0.63	0.2	0.2	0.04	0.7	0.7	0.49	1.16	0.39	0.4	0.4	0.16	0.5	0.5	0.25	0.41	0.21
28	Fire at farm shed	0.6	0.8	0.48	0.7	0.8	0.56	0.2	0.6	0.12	0.5	0.8	0.4	0.4	0.1	0.04	0.4	0.9	0.36	1.96	0.33	0.5	0.5	0.25	0.1	0.1	0.01	0.2	0.3	0.06	0.32	0.11	0.2	0.9	0.18	0.3	0.7	0.21	0.39	0.20
29	Accident (Staff injury)	0.3	0.4	0.12	0.2	0.3	0.06	0.4	0.3	0.12	0.5	0.4	0.2	0.1	0.9	0.09	0.1	0.1	0.01	0.6	0.10	0.4	0.5	0.2	0.1	0.1	0.01	0.1	0.2	0.02	0.23	0.08	0.3	0.1	0.03	0.3	0.3	0.09	0.12	0.06
30	Inadequate supply of quality feed	0.5	0.5	0.25	0.5	0.6	0.3	0.8	0.6	0.48	0.7	0.8	0.56	0.4	0.1	0.04	0.4	0.5	0.2	1.83	0.31	0.8	0.9	0.72	0.5	0.5	0.25	0.4	0.5	0.2	1.17	0.39	0.6	0.4	0.24	0.7	0.8	0.56	0.8	0.40
31	High cost of feed and medicine	0.8	0.9	0.72	0.8	0.9	0.72	0.6	0.5	0.3	0.6	0.6	0.36	0.6	0.5	0.3	0.6	0.7	0.42	2.82	0.47	0.9	0.9	0.81	0.9	0.9	0.81	0.6	0.7	0.42	2.04	**0.68**	0.6	0.7	0.42	0.8	0.8	0.64	1.06	0.53
32	Scarcity of feed	0.8	0.8	0.64	0.5	0.7	0.35	0.6	0.5	0.3	0.5	0.8	0.4	0.3	0.7	0.21	0.3	0.5	0.15	2.05	0.34	0.6	0.6	0.36	0.7	0.7	0.49	0.4	0.5	0.2	1.05	0.35	0.4	0.6	0.24	0.8	0.9	0.72	0.96	0.48
33	Lack of upgrade vaccination and veterinary services	0.5	0.5	0.25	0.4	0.6	0.24	0.6	0.4	0.24	0.4	0.7	0.28	0.6	0.5	0.3	0.6	0.7	0.42	1.73	0.29	0.8	0.8	0.64	0.7	0.7	0.49	0.6	0.7	0.42	1.55	0.52	0.4	0.8	0.32	0.6	0.5	0.3	0.62	0.31
34	Shortage of land for expanding farm	0.8	0.8	0.64	0.7	0.8	0.56	0.8	0.6	0.48	0.9	0.8	0.72	0.7	0.7	0.49	0.7	0.7	0.49	3.38	**0.56**	0.9	0.9	0.81	0.6	0.6	0.36	0.2	0.3	0.06	1.23	0.41	0.7	0.4	0.28	0.6	0.5	0.3	0.58	0.29
35	Irregular supply of vaccine from government	0.3	0.4	0.12	0.8	0.7	0.56	0.9	0.6	0.54	0.8	0.6	0.48	0.7	0.7	0.49	0.7	0.5	0.35	2.54	0.42	0.8	0.9	0.72	0.6	0.6	0.36	0.6	0.7	0.42	1.5	0.50	0.5	0.6	0.3	0.7	0.8	0.56	0.86	0.43
36	Competition among the farms	0.5	0.5	0.25	0.6	0.5	0.3	0.2	0.3	0.06	0.4	0.4	0.16	0.4	0.5	0.2	0.4	0.3	0.12	1.09	0.18	0.4	0.5	0.2	0.3	0.3	0.09	0.4	0.5	0.2	0.49	0.16	0.8	0.2	0.16	0.5	0.4	0.2	0.36	0.18
37	Bureaucratic complexity on maintaining various formalities	0.5	0.5	0.25	0.7	0.8	0.56	0.6	0.8	0.48	0.7	0.6	0.42	0.5	0.3	0.15	0.5	0.6	0.3	2.16	0.36	0.4	0.5	0.2	0.5	0.5	0.25	0.6	0.7	0.42	0.87	0.29	0.3	0.2	0.06	0.7	0.4	0.28	0.34	0.17
38	Drought leads to a decline in milk production	0.4	0.5	0.2	0.6	0.5	0.3	0.5	0.7	0.35	0.5	0.8	0.4	0.5	0.6	0.3	0.5	0.4	0.2	1.75	0.29	0.5	0.4	0.2	0.3	0.3	0.09	0.2	0.3	0.06	0.35	0.12	0.8	0.5	0.4	0.2	0.7	0.14	0.54	0.27
39	Accidents of transport vehicle	0.4	0.6	0.24	0.8	0.9	0.72	0.8	0.6	0.48	0.9	0.9	0.81	0.2	0.4	0.08	0.2	0.6	0.12	2.45	0.41	0.6	0.9	0.54	0.2	0.7	0.14	0.7	0.6	0.42	1.1	0.37	0.7	0.4	0.28	0.6	0.5	0.3	0.58	0.29
40	Existence of middlemen/ too many middlemen	0.4	0.5	0.2	0.7	0.8	0.56	0.4	0.5	0.2	0.9	0.6	0.54	0.2	0.6	0.12	0.2	0.5	0.1	1.72	0.29	0.8	0.7	0.56	0.9	0.9	0.81	0.8	0.9	0.72	2.09	**0.70**	0.5	0.5	0.25	0.8	0.5	0.4	0.65	0.33
41	Too long chain cause delay in product movement	0.6	0.6	0.36	0.6	0.7	0.42	0.4	0.3	0.12	0.6	0.7	0.42	0.3	0.5	0.15	0.3	0.6	0.18	1.65	0.28	0.6	0.7	0.42	0.6	0.6	0.36	0.8	0.7	0.56	1.34	0.45	0.7	0.7	0.49	0.6	0.5	0.3	0.79	0.40
42	Poor conditioned road for moving product (delay & spoilage)	0.8	0.8	0.64	0.8	0.9	0.72	0.9	0.3	0.27	0.6	0.6	0.36	0.5	0.6	0.3	0.5	0.6	0.3	2.59	0.43	0.7	0.9	0.63	0.6	0.6	0.36	0.2	0.3	0.06	1.05	0.35	0.7	0.5	0.35	0.8	0.5	0.4	0.75	0.38
43	Inadequate transport facilities to move products frequently	0.5	0.6	0.3	0.7	0.8	0.56	0.7	0.8	0.56	0.7	0.8	0.56	0.7	0.6	0.42	0.7	0.8	0.56	2.96	0.49	0.6	0.8	0.48	0.8	0.8	0.64	0.5	0.5	0.25	1.37	0.46	0.8	0.6	0.48	0.8	0.6	0.48	0.96	0.48
44	Lack of milk tanker (refrigerated)	0.8	0.9	0.72	0.2	0.5	0.1	0.7	0.7	0.49	0.4	0.3	0.12	0.8	0.8	0.64	0.8	0.8	0.64	2.71	0.45	0.3	0.5	0.15	0.7	0.7	0.49	0.1	0.2	0.02	0.66	0.22	0.9	0.8	0.72	0.8	0.8	0.64	1.36	**0.68**
45	Unethical behavior of middle men (adulteration, added price, deprivation)	0.3	0.4	0.12	0.5	0.7	0.35	0.7	0.6	0.42	0.8	0.9	0.72	0.6	0.7	0.42	0.6	0.7	0.42	2.45	0.41	0.9	0.9	0.81	0.6	0.6	0.36	0.8	0.9	0.72	1.89	0.63	0.7	0.8	0.56	0.9	0.8	0.72	1.28	0.64

The risks ranking according to the degree of importance for the respondents from Paharika Dairy differed from Nahar Dairy. The priority rating of risk, according to the employee group of Paharika Dairy, indicates that 'Hartal and strike cause delay in work process' (R13) is the most important risk for the dairy supply chain in Bangladesh with 71% importance (see Appendix 5C), slightly higher than the 65% rating of Nahar Dairy employees. They indicated 'Absence of insurance and compensation coverage' (R5) as the second most important risk for the dairy supply chain with 65% importance. Two other risks of equal importance to them are 'High rate of interest' (R3) and 'Political unrest and interference' (R14) both with 58% importance. The risk (R15) 'Corruption caused by adulteration' is least important to them.

Paharika Dairy executives and supply chain members also agreed with the Nahar executives by giving highest priority to risk R13 'Hartal and strike cause delay in work process 'with 81% importance. The supply chain members of Paharika also observed that risks(R14)'Political unrest and interference 'and (R45)'Unethical behaviour of middle men (adulteration, added price, deprivation)'are equally important as (R13),as they scored the risks as 81% importance. According to the Paharika executives, other important risks are 'High rate of interest' (R3) and 'Shortage of land for expanding farm' (R34) with 67% and 63% importance respectively. On the contrary, according to the Paharika executives, the risk (R23) 'Spoilage of milk through improper handling 'was less important (8%) while the Paharika supply chain members group considered risk (R15) 'Corruption – adulteration by mixing water 'as less risky (0%). .

5.5.1.4 Identifying the relationship between risks and mitigation strategies

As explained in Section 4.7.2d, another important step of QFD Part 1 is to calibrate the relationship matrix. After identifying risks and possible strategies from the interview, these strategies were presented in the questionnaire and respondents were asked to score each strategy on a scale from (0–1–5-9) to indicate the degree of relationship between the risks and mitigation strategies (i.e. no–weak–medium-strong). After conducting the questionnaire survey, data related to relationship matrix were obtained from twenty two participants from both case industries. Table 5.25 shows how the raw data for relationship matrix were tabulated, where R*i*S*j* (i= 1…..45, j = 1…..32) represents the relationship scores (0–1–5–9) for the R*i*S*j* combination. The raw data is presented for various R*i*S*j* combinations per different respondents.

Table 5.25: Tabulation of Data regarding Risk and Strategy Relationship

Risk	Strategy				
	S1	**S2**	**S3**		**S32**
R1	R1S1	R1S2	R1S3	…	R1S32
R2	R2S1	R2S2	R2S3	…	R2S32
R3	R3S1	R3S2	R3S3	…	R3S32
⋮	…	…	…	…	⋮
R45	R45S1	R45S2	…	…	R45S32

Table 5.26 presents the raw relationship data for various R1S*j* combinations by all the respondents of Nahar Dairy. There are 45 risks and hence 45 matrices similar to Table 5.26 for the Nahar group. The same table shows that respondents N2 (Nahar employee 2) and N8 (Nahar executive 2) recorded the relationship between Risk 1 and Strategy 1 (R1S1) as strong by scoring it 9. By contrast, N3 (Nahar employee 3), N6 andN7 (Nahar executive) noted this relationship as weak by scoring it 1. The rest of the respondents scored 0 for this relationship (R1S1), indicating that there is no relationship between risk 1 (R1) and strategy 1 (S1).

Table 5.26: Tabulation of Data for Relationship Matrix (Nahar)

	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	Total
R1S1		9	1			1	1	9				21
R1S2												0
R1S3			9			5	9					23
R1S4							5					5
R1S5			1					9	1			11
R1S6	5	9	9	5		9	5		9	5		56
R1S7	9	5	5	9	5	9			5	9	9	65
R1S8		9	9	1			9	9			5	42
R1S9					9			5				14
R1S10				5	1		5				1	12
R1S11	1											1
R1S12												0
R1S13												0
R1S14												0
R1S15												0
R1S16												0
R1S17												0
R1S18		1										1
R1S19												0
R1S20												0
R1S21												0
R1S22												0
R1S23												0
R1S24												0
R1S25												0
R1S26												0
R1S27												0
R1S28												0
R1S29												0
R1S30												0
R1S31												0
R1S32												0

Note: R=Risk, S= Mitigation Strategies, N1-N11= Participants of survey from Nahar Dairy

When these data were tabulated, 45 Excel spread sheets containing the relationship scores were created for each farm (Nahar and Paharika). The relationships were constructed between45 risks and 32 mitigation strategies. The aggregate score was also obtained in the same Excel spread sheet. In order to create the relationship matrix for the QFD analysis, the weights of the total scores were calculated. To calculate the weighted average, the data were separated based on groups (employees, executives and supply chain members). A sample of this calculation (Relationship matrix for QFD analysis for Nahar Dairy) is shown in Table 5.27. Weighted averages are then placed into the section WHATs VS. HOWs (relationship matrix of risk and mitigation strategies) for QFD analysis. This process was mentioned in Step 4 of Section 4.6.1(The QFD process). The same process was carried out for developing the relationship matrices for Paharika Dairy (see Appendix 5D).

5.5.1.5 Identifying relative costs (cost constraints)

The details of data identification related to relative costs (cost constraints) were discussed in Section 4.7.2 (d). The data related to relative cost is used in QFD process (Step 5 - HOW MUCHs in Section 4.6.1).For both farms, the employee group consists of six participants, whereas the executive group consist of three participants and the supply chain members group consist of two participants. The results of relative cost identification is shown in Table 5.28.

According to all respondents from both farms, the highest cost will be required to implement Strategy (S1) 'Adoption of improved technology (milking machine, feed mixture, grass cutting, improved processing facilities)'. However, the total weighted value of the relative costs estimated by the groups of employee, executive and supply chain member of Nahar Dairy were 1098.33, 1286.67 and 985 respectively. According to the Paharika Dairy respondents, the total weighted value of the relative costs were estimated as 958.33, 1006.67 and 1015 respectively. All participants from both farms agreed that the implementation cost of S1 is the highest of all. However, Nahar employees estimated the cost of implementation of S1 as 88.33, while Nahar executives estimated the cost for same strategy as 93.33 and Nahar supply chain members estimated the cost as 100. This same costing occurred with the Paharika respondents.

Table 5.27: Value of Relationship Matrix for QFD Analysis (Nahar)

	N1	N2	N3	N4	N5	N6	Total	WA		N7	N8	N9	Total	WA		N10	N11	Total	WA
R1S1		9	1			1	11	1.83		1	9		10	3.33				0	0
R1S2							0	0.00					0	0.00				0	0
R1S3			9			5	14	2.33		9			9	3.00				0	0
R1S4							0	0.00		5			5	1.67				0	0
R1S5			1				1	0.17			9	1	10	3.33				0	0
R1S6	5	9	9	5		9	37	6.17		5		9	14	4.67		5		5	2.5
R1S7	9	5	5	9	5	9	42	7.00				5	5	1.67		9	9	18	9
R1S8		9	9	1			19	3.17		9	9		18	6.00			5	5	2.5
R1S9					9		9	1.50			5		5	1.67				0	0
R1S10				5	1		6	1.00		5			5	1.67			1	1	0.5
R1S11	1						1	0.17					0	0.00				0	0
R1S12							0	0.00					0	0.00				0	0
R1S13							0	0.00					0	0.00				0	0
R1S14							0	0.00					0	0.00				0	0
R1S15							0	0.00					0	0.00				0	0
R1S16							0	0.00					0	0.00				0	0
R1S17							0	0.00					0	0.00				0	0
R1S18		1					1	0.17					0	0.00				0	0
R1S19							0	0.00					0	0.00				0	0
R1S20							0	0.00					0	0.00				0	0
R1S21							0	0.00					0	0.00				0	0
R1S22							0	0.00					0	0.00				0	0
R1S23							0	0.00					0	0.00				0	0
R1S24							0	0.00					0	0.00				0	0
R1S25							0	0.00					0	0.00				0	0
R1S26							0	0.00					0	0.00				0	0
R1S27							0	0.00					0	0.00				0	0
R1S28							0	0.00					0	0.00				0	0
R1S29							0	0.00					0	0.00				0	0
R1S30							0	0.00					0	0.00				0	0
R1S31							0	0.00					0	0.00				0	0
R1S32							0	0.00					0	0.00				0	0

Note: R=Risk, S= Mitigation strategies, N1–N6= employees of Nahar, N7–N9= executives of Nahar, N10–N11= supply chain members of Nahar, WA= Weighted Average, for example, WA for R1S1 (employees) =1.83 [(9+1+1)/6)]

Table 5.28: Calculation of Total Relative Cost (Nahar and Paharika)

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30	S31	S32	
N1	90	10	40	30	10	20	20	50	40	10	10	40	70	10	50	20	10	10	20	10	60	10	30	70	10	10	50	30	10	20	10	20	
N2	80	60	40	50	20	40	20	10	30	20	40	30	10	20	10	10	10	20	30	10	20	10	30	40	50	10	70	60	20	10	20	20	
N3	90	60	50	30	20	40	20	40	10	20	30	10	40	10	30	10	20	10	10	10	20	10	20	30	50	20	70	50	30	40	30	30	
N4	90	60	70	80	10	70	40	50	70	50	60	30	50	50	10	20	20	20	10	10	10	20	20	50	60	50	50	60	40	50	40	60	
N5	80	40	70	10	30	10	10	40	70	30	10	20	30	20	10	10	10	10	30	50	40	40	70	60	10	10	50	80	10	20	20	30	
N6	100	80	100	80	10	30	50	20	70	40	20	10	50	10	40	10	20	20	60	40	40	40	60	40	70	20	60	80	40	50	20	20	
Total	**530**	**310**	**370**	**280**	**100**	**210**	**160**	**210**	**290**	**170**	**170**	**140**	**250**	**120**	**150**	**80**	**90**	**90**	**160**	**130**	**190**	**130**	**230**	**290**	**250**	**120**	**350**	**360**	**150**	**190**	**140**	**180**	
WA	**88.33**	**51.67**	**61.67**	**46.67**	**16.67**	**35.00**	**26.67**	**35.00**	**48.33**	**28.33**	**28.33**	**23.33**	**41.67**	**20.00**	**25.00**	**13.33**	**15.00**	**15.00**	**26.67**	**21.67**	**31.67**	**21.67**	**38.33**	**48.33**	**41.67**	**20.00**	**58.33**	**60.00**	**25.00**	**31.67**	**23.33**	**30.00**	**1098.33**
N7	100	20	100	20	20	80	40	20	30	10	30	40	60	50	10	10	20	30	100	10	10	30	30	50	60	40	50	60	40	40	10	60	
N8	90	60	60	80	10	80	50	30	40	10	50	40	60	50	10	10	20	30	40	10	10	30	30	50	60	40	50	60	40	40	10	60	
N9	90	40	50	70	10	30	20	40	50	20	50	20	70	10	50	30	20	10	60	20	30	30	30	80	30	70	50	70	40	50	10	20	
Total	**280**	**120**	**210**	**170**	**40**	**190**	**110**	**90**	**120**	**40**	**130**	**100**	**190**	**110**	**70**	**50**	**60**	**70**	**200**	**40**	**50**	**90**	**90**	**180**	**150**	**150**	**150**	**190**	**120**	**130**	**30**	**140**	
WA	**93.33**	**40.00**	**70.00**	**56.67**	**13.33**	**63.33**	**36.67**	**30.00**	**40.00**	**13.33**	**43.33**	**33.33**	**63.33**	**36.67**	**23.33**	**16.67**	**20.00**	**23.33**	**66.67**	**13.33**	**16.67**	**30.00**	**30.00**	**60.00**	**50.00**	**50.00**	**50.00**	**63.33**	**40.00**	**43.33**	**10.00**	**46.67**	**1286.67**
N10	100	50	40	20	10	40	40	40	20	20	30	10	30	10	50	60	10	10	10	40	30	20	20	60	20	20	50	60	50	40	20	20	
N11	100	50	60	40	10	10	50	20	20	30	30	10	30	20	10	20	10	10	10	30	40	20	20	40	20	20	40	60	40	10	10	30	
Total	**200**	**100**	**100**	**60**	**20**	**50**	**90**	**60**	**40**	**50**	**60**	**20**	**60**	**30**	**60**	**80**	**20**	**20**	**20**	**70**	**70**	**40**	**40**	**100**	**40**	**40**	**90**	**120**	**90**	**50**	**30**	**50**	
WA	**100.00**	**50.00**	**50.00**	**30.00**	**10.00**	**25.00**	**45.00**	**30.00**	**20.00**	**25.00**	**30.00**	**10.00**	**30.00**	**15.00**	**30.00**	**40.00**	**10.00**	**10.00**	**10.00**	**35.00**	**35.00**	**20.00**	**20.00**	**50.00**	**20.00**	**20.00**	**45.00**	**60.00**	**45.00**	**25.00**	**15.00**	**25.00**	**985.00**
P1	100	100	50	80	50	60	50	30	40	30	10	10	10	30	40	10	10	10	30	10	20	30	20	70	30	10	20	20	20	40	20	30	
P2	80	60	30	40	10	10	10	50	30	30	40	10	50	10	40	10	20	10	60	40	10	10	20	70	50	10	50	70	40	40	10	10	
P3	80	60	40	40	20	20	30	40	10	30	10	10	30	10	50	10	10	10	10	30	20	10	10	40	20	10	50	40	10	50	10	10	
P4	90	40	70	10	10	10	40	30	40	20	10	10	30	20	40	10	30	10	10	20	20	10	20	70	50	20	40	50	40	50	10	10	
P5	80	60	40	20	20	50	20	40	20	30	30	10	10	20	40	40	10	10	40	50	20	20	20	30	10	10	30	40	30	10	20	30	
P6	100	60	40	30	20	10	40	10	10	20	30	20	10	10	40	10	10	20	50	30	20	20	20	70	40	20	10	70	50	40	10	10	
Total	**530**	**380**	**270**	**220**	**130**	**160**	**190**	**200**	**150**	**160**	**130**	**70**	**140**	**100**	**250**	**90**	**90**	**70**	**200**	**180**	**110**	**100**	**110**	**350**	**200**	**80**	**200**	**290**	**190**	**230**	**80**	**100**	
WA	**88.33**	**63.33**	**45.00**	**36.67**	**21.67**	**26.67**	**31.67**	**33.33**	**25.00**	**26.67**	**21.67**	**11.67**	**23.33**	**16.67**	**41.67**	**15.00**	**15.00**	**11.67**	**33.33**	**30.00**	**18.33**	**16.67**	**18.33**	**58.33**	**33.33**	**13.33**	**33.33**	**48.33**	**31.67**	**38.33**	**13.33**	**16.67**	**958.33**
P7	80	60	60	50	30	50	30	40	50	30	30	10	10	10	70	10	20	10	30	40	20	10	10	40	30	10	50	10	10	50	10	20	
P8	100	60	50	50	10	10	40	50	10	20	30	10	40	20	20	10	20	20	10	20	20	30	20	50	30	10	40	50	10	10	20	10	
P9	100	80	50	80	40	60	60	40	10	20	20	20	40	30	40	10	10	30	10	10	20	10	10	60	20	10	50	50	40	40	30	30	
Total	**280**	**200**	**160**	**180**	**80**	**120**	**130**	**130**	**70**	**70**	**80**	**40**	**90**	**60**	**130**	**30**	**50**	**60**	**50**	**70**	**60**	**50**	**40**	**150**	**80**	**30**	**140**	**110**	**60**	**100**	**60**	**60**	
WA	**93.33**	**66.67**	**53.33**	**60.00**	**26.67**	**40.00**	**43.33**	**43.33**	**23.33**	**23.33**	**26.67**	**13.33**	**30.00**	**20.00**	**43.33**	**10.00**	**16.67**	**20.00**	**16.67**	**23.33**	**20.00**	**16.67**	**13.33**	**50.00**	**26.67**	**10.00**	**46.67**	**36.67**	**20.00**	**33.33**	**20.00**	**20.00**	**1006.67**
P10	100	20	40	20	10	10	40	30	20	20	20	20	40	20	20	30	10	30	10	40	40	50	50	60	30	10	40	50	40	20	20	30	
P11	100	30	40	20	10	10	50	30	20	20	20	30	60	30	20	20	10	10	30	40	50	20	50	70	40	10	50	60	40	20	10	20	
Total	**200**	**50**	**80**	**40**	**20**	**20**	**90**	**60**	**40**	**40**	**40**	**50**	**100**	**50**	**40**	**50**	**20**	**40**	**40**	**80**	**90**	**70**	**100**	**130**	**70**	**20**	**90**	**110**	**80**	**40**	**30**	**50**	
WA	**100.00**	**25.00**	**40.00**	**20.00**	**10.00**	**10.00**	**45.00**	**30.00**	**20.00**	**20.00**	**20.00**	**25.00**	**50.00**	**25.00**	**20.00**	**25.00**	**10.00**	**20.00**	**20.00**	**40.00**	**45.00**	**35.00**	**50.00**	**65.00**	**35.00**	**10.00**	**45.00**	**55.00**	**40.00**	**20.00**	**15.00**	**25.00**	**1015.00**

Note: N1–N6= employees of Nahar, N7–N9= executives of Nahar, N10–N11= SC members of Nahar, P1–P6= employees of Paharika, P7–P9= executives of Paharika, P10–P11= SC members of Paharika, S1 to S32= mitigation strategies.

5.5.1.6 Developing QFD roof matrix

To identify cost savings information, the related data were collected from the executives group through a telephone interview with three executives from each farm (Nahar and Paharika), which was mentioned in Section 4.7.2 (d). The executives said they may have some cost savings when two mitigation strategies are implemented at the same time. The numerical values of roof matrix are shown in the Tables 5.29 and 5.30.According to Table 5.29, Nahar estimated a relative cost of 93 and 70 for (S1)'Adoption of improved technology-milking machine, feed mixture, grass cutting, improved processing facilities' and (S3)'Hiring skilled staff', if they would like to implement the strategies separately. If both strategies are included together in a plan, the farm can save 23%. Similarly, 'Adoption of improved technology' (S1) and 'Focus on value addition' (S9) combined can save 40 which are from 30% of savings. Similarly, if 'Adoption of improved technology' (S1) and 'Adoption of alternative supply of power for cold storage (powerful generator)' (S13) are implemented simultaneously, 47 are saved due to 30% savings. It is noted that the cost savings data were collected from the opinion of the executives from both the farms.

Table 5.29: Cost Saving Data (Nahar)

Pair of Strategies		Relative Cost		Total Relative Cost	Saving %	Saving Amount	Cost Required After Saving
S1	S3	93	70	163	23	38	126
S1	S9	93	40	133	30	40	93
S1	S13	93	63	157	30	47	110

Table 5.30 shows the cost savings data for Paharika Dairy. Simultaneous implementation of 'Adoption of improved technology' (S1) and 'Buying insurance against production loss' (S2) can save 22% of farm budget. When 'Adoption of improved technology' (S1) and 'Hiring skilled staff' (S3) are implemented at the same time, they could save 30%. Similarly, 'Adoption of improved technology' (S1) and 'Adoption of alternative supply of power for cold storage-powerful generator' (S13) jointly save 23%. A roof matrix was developed from the cost savings data from Table 5.29 and 5.30. The roof matrix of Nahar and Paharika is shown in Figure 5.1 and Appendix 5E respectively. The roof matrix house contains with 32 mitigation strategies. The name of these strategies can be found in Table 5.23. Figure 5.1 presents cost savings data for Nahar Dairy. The highest three pairs of strategies with savings are shown in the roof. The other pairs of strategies have not scored significant savings.

Table 5.30: Cost Savings Data (Paharika)

Pair of Strategy		Relative Cost		Total of Relative Cost	Saving %	Saving Amount	Cost Required After Saving
S1	S2	93.33	66.67	160	22	35	125
S1	S3	93.33	53.33	147	30	44	103
S1	S13	93.33	30.00	123	23	28	95

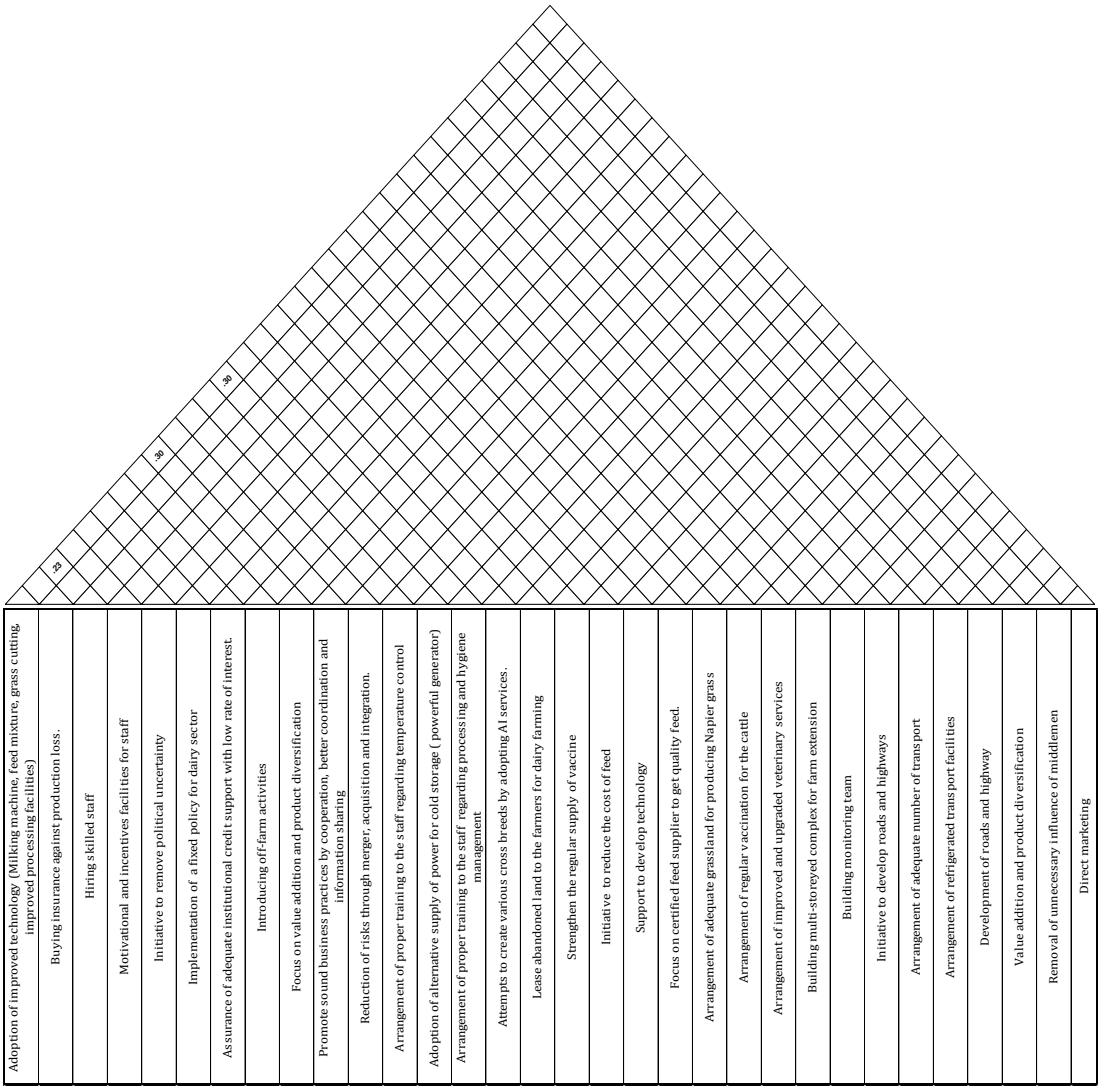


Figure 5.1: Roof Matrix (Nahar)

5.5.1.7 Absolute Importance (AI)

The method of calculating absolute importance (AI) appropriate for each strategy was explained in detail with formula in Step five of Section 4.7.2 (d). Absolute importance for each mitigation strategy is calculated using this formula. QFD results for AI (along with relative importance (RI) for Nahar employees is shown in Table 5.31. Similar tables for the remaining groups are placed in Appendices 5F, 5G, 5H, 5I and 5J.

With regard to prioritisation of mitigation strategies, Nahar employees suggested 'Hiring skilled staff' (S3) is the most important strategy for mitigating dairy risk. They also selected 'To create various cross breeds through adopting artificial insemination services' (S15) as the least important strategy. The calculated values of absolute importance are shown in the Table 5.31, where the highest AI value for S3 is 32.84 and the lowest AI value for S15 is 1.10. According to the Nahar executives (Table shown in Appendix 5F), the most important strategy to implement is 'Fixed policy for dairy sector' (S6) with an AI value of 38.48. They selected 'Product diversification' (S30) as the least important strategy with a value of 2.24.The Nahar supply chain members agreed with the executives in prioritising this mitigation strategy. According to them, (see Table in Appendix 5G) implementation of a 'Fixed policy for dairy sector' (S6) is the most important strategy. At the same time, they nominated 'Government initiative to develop roads and highways' (S26) as the least important strategy for mitigating different risks associated with the dairy sector in Bangladesh. The AI value of S6 is 29.15 while S26 is 0.

Paharika employees (Table shown in Appendix 5H) selected 'Hiring skilled staff' (S3) as the most important strategy with a value of 33.01 and 'Focus on product diversification' (S30) as less important with a value of 1.30. Paharika executives indicated (see Table in Appendix 5I) 'Fixed policy for dairy sector' (S6) as the most important strategy with a value of 29.23, and they agreed with Paharika employees on 'Focus on product diversification' (S30) as the least important strategy with a value of 2.11. Likewise, Paharika supply chain members (Table in Appendix 5J) selected 'Assurance of adequate institutional credit support with low rate of interest' (S7) as the most important strategy with an AI value of 21.67. The lowest AI value is 0 which is for 'Government initiative to develop roads and highways' (S26).

Table 5.31: QFD – Nahar Employees

	Strategy Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	
Risk Number	Risk / Mitigation Strategy	Degree of Importance	Adoption of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	Buying insurance against production loss.	Hiring skilled staff	Motivational and incentives facilities for staff	Initiative to remove political uncertainty	Implementation of a fixed policy for dairy sector	Assurance of adequate institutional credit support with low rate of interest.	Introducing off-farm activities	Focus on value addition	Promote sound business practices by cooperation, better coordination and information sharing	Reduction of risks through merger, acquisition and integration.	Arrangement of proper training to the staff regarding temperature control	Adoption of alternative supply of power for cold storage (powerful generator)	Arrangement of proper training to the staff regarding processing and hygiene management.	Attempts to create various cross breeds by adopting AI services.	Lease abandoned land to the farmers for dairy farming	Strengthen the regular supply of vaccine	Initiative to reduce the cost of feed	Support to develop technology	Focus on certified feed supplier to get quality feed.	Arrangement of adequate grassland for producing Napier grass	Arrangement of regular vaccination for the cattle	Arrangement of improved and upgraded veterinary services	Building multi-storeyed complex for farm extension	Building monitoring team	Initiative to develop roads and highways	Arrangement of adequate number of transport	Arrangement of refrigerated transport facilities	Development of roads and highway	Focus on product diversification	Removal of unnecessary influence of middlemen	Direct marketing	
1	Inadequate loan facilities	0.30	183	0.00	2.33	0.00	0.17	6.17	7.00	3.17	150	100	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
2	Complex loan procedures	0.33	0.17	0.00	150	0.00	0.00	4.00	7.67	100	0.17	0.83	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
3	High rate of interest	0.60	0.83	0.00	0.00	0.00	0.00	2.50	8.33	1.17	167	167	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
4	Inadequate finance	0.47	0.00	0.00	0.00	0.83	0.00	100	5.33	2.50	0.00	1.17	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	
5	Absence of insurance or compensation coverage	0.59	0.00	5.50	150	0.83	0.00	100	0.00	167	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
6	Shortage of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	0.38	9.00	0.00	4.00	150	0.00	0.00	100	0.17	0.00	0.17	0.17	0.83	0.17	0.83	0.83	0.00	0.00	150	8.33	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	3.17	0.00	0.00	0.83	0.83	
7	Labour disputes	0.49	150	0.00	6.33	7.67	0.00	0.17	0.00	0.00	0.17	0.17	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
8	Illiteracy and inefficiency of worker	0.59	100	0.00	6.83	4.00	0.00	0.00	0.00	0.83	0.00	100	0.17	3.33	0.00	5.33	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
9	Shortage of skilled staff	0.56	3.00	0.00	8.33	2.83	0.00	0.00	0.00	0.00	0.00	0.83	0.83	2.50	0.83	5.50	0.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
10	Switching of staff frequently	0.47	0.00	0.00	2.67	6.83	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	1.50	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
11	Lack of fixed government policy in dairy sector	0.54	100	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.83	0.17	0.00	0.00	0.00	0.00	2.50	0.17	0.17	1.50	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
12	Poor law and order situation (terrorism, musclemen ship)	0.51	0.00	0.00	0.00	0.00	2.00	4.17	0.00	0.00	0.00	0.83	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
13	Hartal and strike cause delay in work process	0.65	150	0.00	150	0.00	6.17	167	0.00	0.83	0.00	0.83	0.33	0.17	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
14	Political Unrest and interference	0.58	0.83	0.00	0.00	0.83	7.67	4.17	0.83	100	0.00	0.83	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
15	Corruption (adulteration by mixing water)	0.09	167	0.00	3.17	7.00	0.17	0.83	0.17	0.00	0.00	0.17	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.33	0.00	0.00	0.00	0.00	0.00	6.83	0.00	0.00	0.00	0.00	0.00	3.17	1.17	
16	Damage of farm's assets	0.37	3.00	3.33	4.67	3.17	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	4.50	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	2.33	4.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
17	Theft	0.25	4.67	0.00	183	3.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	6.17	0.00	0.00	0.00	0.00	0.00	0.17	0.00	
18	Natural disaster (flood, excessive rain, storm)	0.36	0.17	7.50	0.00	0.00	0.17	2.50	2.00	0.00	0.00	0.83	167	0.00	3.17	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.83	0.00	0.00	5.33	0.00	0.17	0.00	0.00	0.17	0.00	0.00	0.00	
19	Quick perishability of Milk	0.28	7.00	4.00	1.17	0.00	0.00	0.00	0.00	0.00	0.17	0.17	167	7.67	3.83	2.33	0.00	0.00	0.00	0.00	6.17	0.00	0.83	0.00	0.00	0.00	0.00	2.50	4.67	9.00	4.17	0.17	0.17	2.67	
20	Machine damage/breakdown at cold storage	0.22	100	7.50	4.17	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.67	4.00	3.17	0.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
21	Inadequate chilling facilities	0.13	5.50	0.00	167	0.00	0.00	0.00	4.00	0.00	0.17	1.67	167	0.83	2.50	0.17	0.00	0.00	0.00	0.00	5.50	0.00	0.00	0.00	0.00	0.83	0.00	0.00	1.50	3.83	0.17	0.00	0.00	2.50	
22	Inadequate cold storage	0.33	6.33	0.00	0.17	0.00	0.00	0.00	3.33	0.00	0.00	3.33	3.83	1.50	2.33	1.83	0.00	0.00	0.00	1.50	3.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50	3.17	0.83	0.00	0.00	2.50	
23	Spoilage of milk through improper handling	0.20	4.67	0.00	4.00	2.00	0.83	0.00	0.00	0.00	0.83	0.00	0.00	6.33	2.67	4.67	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	6.83	0.00	0.00	3.00	0.00	0.00	3.33	5.50	
24	Bacterial contamination for improper temperature	0.16	6.33	0.83	5.67	0.33	0.00	0.00	0.00	0.00	0.33	0.00	0.00	7.67	2.83	4.67	0.00	0.00	0.00	0.00	3.33	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.83	4.50	0.00	0.00	0.17	1.83	
25	Pollution and Unhygienic environment	0.18	6.17	0.00	5.33	1.83	0.00	1.67	0.00	0.00	0.00	0.00	1.83	0.00	0.00	8.33	0.00	0.00	0.00	0.00	1.50	0.00	0.00	3.17	3.17	0.00	2.50	0.00	0.00	0.00	0.00	0.83	0.00	0.00	
26	Cattle diseases	0.47	2.67	6.17	2.33	3.17	0.00	1.67	0.17	0.83	0.00	0.00	0.17	0.00	0.00	3.17	1.67	0.00	4.83	0.00	0.83	0.00	0.17	6.33	8.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
27	Machine damage/breakdown at processing unit	0.25	1.67	7.00	4.67	1.00	0.00	0.00	1.17	0.00	0.00	0.17	0.33	0.83	3.17	6.17	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
28	Fire at farm shed	0.33	0.00	7.17	0.83	0.00	0.00	1.67	0.83	0.00	0.00	0.17	1.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
29	Accident (Staff injury)	0.10	0.00	5.50	1.67	1.17	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.00	0.83	0.00	0.00	0.00	
30	Inadequate supply of quality feed	0.31	1.00	0.00	0.00	0.00	0.00	2.33	0.00	0.00	0.00	2.33	1.67	0.00	0.00	0.00	0.00	0.83	0.00	1.00	0.33	8.33	5.00	0.00	0.00	0.00	0.00	0.83	1.00	0.00	1.50	0.00	0.00	0.00	
31	High cost of feed and medicine	0.47	0.17	0.00	0.00	0.00	0.00	2.33	1.67	1.50	0.00	1.67	1.00	0.00	0.00	0.00	0.00	1.67	0.00	7.00	0.83	2.83	7.00	0.83	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	
32	Scarcity of feed	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.33	1.67	0.00	0.00	0.00	0.00	1.00	0.00	0.17	0.83	1.83	9.00	0.00	0.17	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
33	Lack of upgrade vaccination and veterinary services	0.29	0.00	0.00	0.00	0.00	0.00	6.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.67	0.00	0.83	0.00	0.00	5.67	7.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
34	Shortage of land for expanding farm	0.56	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	7.67	0.00	0.00	1.50	0.00	2.50	0.83	0.83	7.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
35	Irregular supply of vaccine from government	0.42	0.00	0.00	0.00	0.00	0.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	7.67	0.00	0.00	0.00	0.00	4.83	4.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
36	Competition among the farms	0.18	3.17	1.67	3.83	0.83	0.00	0.83	0.83	0.00	1.50	5.33	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.00	1.83	0.00	2.50	3.17	0.00	6.00	0.00	2.50	
37	Bureaucratic complexity on maintaining various formalities	0.36	0.00	0.00	6.83	0.17	0.00	6.17	0.00	0.00	0.17	0.17	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
38	Drought leads to a decline in milk production	0.29	2.50	2.33	1.50	0.00	0.00	0.00	0.00	4.50	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.00	1.50	0.00	0.83	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	
39	Accidents of transport vehicle	0.41	0.00	5.33	4.83	2.67	0.00	0.00	0.00	0.00	0.00	2.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.67	3.83	1.67	4.00	0.00	1.50	0.00	
40	Existence of middlemen/ too many middlemen	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	5.67	5.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	8.33	6.33	
41	Too long chain cause delay in product movement	0.28	0.17	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	5.50	3.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.00	1.50	0.00	1.00	0.83	0.00	0.00	0.00	0.00	7.67	7.00	
42	Poor conditioned road for moving product (delay & spoilage)	0.43	0.00	0.00	0.83	0.00	0.00	2.33	0.00	0.00	0.00	1.17	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	4.67	3.00	4.17	5.67	0.00	0.00	0.17	
43	Inadequate transport facilities to move products frequently	0.49	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	1.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.83	3.33	7.67	1.83	4.17	0.00	1.00	1.50	
44	Lack of milk tanker (refrigerated)	0.45	4.83	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	1.00	0.17	0.17	0.00	0.00	0.00	0.00	0.00	0.00	2.33	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.83	8.33	1.50	0.00	0.00	0.17	
45	Unethical behaviour of middle men(adulteration, added price, deprivation)	0.41	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	4.00	4.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00	4.17	0.00	0.83	2.33	0.00	0.00	7.00	6.33	
	Absolute Importance (AI)		26.37	20.72	32.84	19.83	9.75	28.66	17.34	8.22	2.27	18.33	15.97	9.92	6.47	17.48	1.10	7.15	6.09	5.25	19.14	5.77	10.27	8.51	12.22	8.78	9.91	6.57	10.26	15.28	8.89	1.68	9.85	11.77	392.67
	Relative Cost		88.33	51.67	61.67	46.67	16.67	35.00	26.67	35.00	48.33	28.33	28.33	23.33	41.67	20.00	25.00	13.33	15.00	15.00	26.67	21.67	31.67	21.67	38.33	48.33	41.67	20.00	58.33	60.00	25.00	31.67	23.33	30.00	1098.33
	Relative Importance		0.07	0.05	0.08	0.05	0.02	0.07	0.04	0.02	0.01	0.05	0.04	0.03	0.02	0.04	0.00	0.02	0.02	0.01	0.05	0.01	0.03	0.02	0.03	0.02	0.03	0.02	0.03	0.04	0.02	0.00	0.03	0.03	100

5.5.1.8 Relative Importance (RI)

The relative importance (RI) can be derived through transforming the absolute importance using certain formula (see Step five under Section 4.7.2(d)). The higher the RI_j, the more important the design attribute that should be applied to the product (Park and Kim 1998). Park and Kim (1998) explain that the higher the RI_j, the more important are the mitigation strategies that should be adopted to mitigate dairy supply chain risks. The Nahar Dairy respondent groups had different priorities and assigned the highest relative importance to different mitigation strategies. The employees ranked the most important mitigation strategy as 'Hiring skilled staff' (S3) with the highest RI value of 0.08(see Table 5.31). The executives selected 'Initiative to remove political uncertainty' (S5) as the most important strategy (see Appendix 5F) with the highest RI value of 0.08. On the other hand, Nahar supply chain members considered 'Implementation of a fixed policy for dairy sector' (S6) as the most important mitigation strategy with the highest RI value 0.09 (Appendix 5G).

The Paharika groups also selected different mitigation strategies as having the highest relative importance. The employees considered (S3)'Hiring skilled staff' with the highest RI value of 0.08, to be the most important, as did the Nahar employees (see Appendix5H).The Paharika executives considered the most important strategy to be 'Implementation of a fixed policy for dairy sector' (S6)with the highest RI value of 0.08 (see Appendix 5I). This is similar to the opinion of Nahar supply chain members. The Paharika supply chain members selected 'Assurance of adequate institutional credit support with low rate of interest' (S7) as the most important mitigation strategy. This has the highest RI value at 0.07 (see Appendix 5J).

5.5.2 QFD PART II: PHASE 1

QFD Part II essentially identifies optimal mitigation strategies via optimisation. There are two sequential steps involved in completing this part which was explained with Equations 1 and 2 in Section 4.7.2 (e). By following those equations, the optimisation results are provided in this section.

5.5.2.1 Formulation of dairy supply chain risk mitigation problems through (0, 1) linear programming (without savings)

The optimum level of risk mitigation with limited resource constraints is determined through following equation number 1, of Step 1 in Section 4.7.2 (e). The problem does

not take into account the cost savings of the organisation. The model is generated as illustrated in the following example.

The dairy supply chain risk mitigation problem for Nahar employees is formulated using Equation 1 in Section 4.7.2 (e). In this calculation, budget data was set to 1098.33 based on sum of relative costs.

Max $f(x)$= 26.37 X_1 + 20.72 X_2 + 32.84 X_3 + 19.83 X_4 + 9.75 X_5 + 28.66 X_6 + 17.34 X_7 + 8.22 X_8+ 2.27 X_9 + 18.33 X_{10} + 15.97 X_{11} + 9.92 X_{12} + 6.47 X_{13} + 17.48 X_{14} + 1.10 X_{15} + 7.15 X_{16} + 6.09 X_{17} + 5.25 X_{18} + 19.14 X_{19} + 5.77 X_{20} + 10.27 X_{21} + 8.51 X_{22} + 12.22 X_{23} + 8.78 X_{24} + 9.91 X_{25} + 6.57 X_{26} + 10.26 X_{27} + 15.28 X_{28} + 8.89 X_{29} + 1.68 X_{30} + 9.85 X_{31} + 11.77 X_{32}.

Subject to: 88.33 X_1 + 51.67 X_2 + 61.67 X_3 + 46.67 X_4 + 16.67 X_5 + 35.00 X_6 + 26.67 X_7 + 35.00X_8+ 48.33 X_9 + 28.33 X_{10} + 28.33 X_{11} + 23.33 X_{12} + 41.67 X_{13} + 20.00 X_{14} + 25.00 X_{15} + 13.33 X_{16} + 15.00 X_{17} + 15.00 X_{18} + 26.67 X_{19} + 21.67 X_{20} + 31.67 X_{21} + 21.67 X_{22} + 38.33 X_{23} + 48.33 X_{24} +.41.67 X_{25} + 20.00 X_{26} + 58.33 X_{27} + 60.00 X_{28} + 25.00 X_{29} + 31.67 X_{30} + 23.33 X_{31} + 30.00 X_{32}≤ 1098.33

[All X's = (0, 1)]

Note: 1 and 0 means selected and not selected respectively. Here, selected means 'can be implemented' and 0 means 'cannot be implemented'.

Data for the above model are collected from Table 5.31. Five different models are generated for the other participants: Nahar executives, Nahar supply chain members, Paharika employees, Paharika executives and Paharika supply chain members. These models are shown in Appendix 5K. The results of the optimisation model are shown in Table 5.32. The results are segregated into Nahar employees, executives and supply chain members. Nahar employees can implement all the strategies if they have a 100% budget. The farm can mitigate various risks within their operation using different budgets.

The above linear programming with a budget of 1098.33 is solved using the Solver module in Microsoft Excel. The following solution is found:

1. Objective function value of 392.67 at 100% budget as been calculated using Microsoft Excel Solver.

2. Decision variables: S1 to S32 = 1 (All strategies could be implemented. The name of strategies can be found in Table 5.23).
3. Total cost required: 1098.33.
4. 100% risk can be mitigated using a full budget.

The same linear programming model with a budget of 90% (988.50) is solved using the Solver module in Microsoft Excel. The following solution is found:

1. Objective function value of 382.83 at 90% budget has been calculated using Microsoft Excel Solver.
2. Decision variables:S1=…= S8=1, S9=0, S10=…= S12=1, S13= 0, S14=1, S15=0, S16=…=S32=1 (This means all the strategies will be implemented except S9, S13 and S15.).
3. Total cost required: 983.33.
4. 97.49% (382.83/392.67) risk can be mitigated.

Similarly, the model with a budget of 50% (549.17) is solved using the Solver module in Microsoft Excel. The following solution is found:

1. Objective function value of 279.72 at 50% budget has been calculated using Microsoft Excel Solver.
2. Decision variables:S1=S8=S9=S13 = S15 = S20 = S21 = S24 = … = S28 = S30 = 0, S2=…S7=S10…S12=S14=S16= … =S19=S22=S23=S31=S32=1 (This means all the strategies will be implemented except S9, S13 and S15.).
3. Total cost required: 546.67.
4. 71.23% (279.72/392.67) risk can be mitigated.

Finally, the model with a budget of 10% (109.83) is solved using the Solver module in Microsoft Excel. The following solution is found:

1. Objective function value of 82.62 at 10% budget has been calculated using Microsoft Excel Solver.
2. Decision variables:S6 = S7 = S14 = S19 = 1 could be implemented (28 strategies cannot be implemented at 10% budget.).
3. Total cost required: 108.33.
4. 21.04% (82.62/392.67) risk can be mitigated.

Likewise, from the results of Nahar executives (see Table 5.32), 29 strategies could be implemented under 90% of budget 97.27% (484.62/498.24) level of risk mitigation, where, S1 = … = S8 = 1, S10 = … = S12 = 1, S14 = … S29 = 1, S31= S32 =1 and S9= S13= S30= 0. Three strategies (S9, S13 and S30) out of 32 strategies cannot be implemented

due to a low percentage of the total budget. However, a 70.84% (352.95/498.24) level of risk mitigation could be achieved with 50% of the total budget and 16 strategies could be implemented, where, S2 = … S4 = S6 = S7 = S10 = S11=S12 = S14 = S17 = … S23 = S25 = S27 = S31 = S32 = 1 and S1 = S5 = S8 = S9 = S13= S15 = S16 = S20 = … = S22 = S24 = S26 = … S30=0. Only 5 strategies could be implemented and a 20.31% (101.21/498.24) level of risk could be mitigated under 10% budgets.

In the same way, Nahar supply chain members indicated that 90% of budget allows for mitigating 98.56% (324.85/329.59) of risks, where S1= S2 = S3 = S4 = S5 = S6 = S7 = S8 = S9 = S10 = S11 = S12 = S13 = S14 = S15=S17= S18 = S19 = S20 = S21 = S22 =S23=S25=S27= S28 = S29 = S30 = S31 = S32=1 and S16= S24 =S26=0. A 50% budget allows for mitigating 79.49% (114.23/329.59) of risks. In this situation 19 strategies could be implemented, where S2= S3 = S4 = S5 = S6 = S7 = S8 = S10 = S12 = S13 = S14 = S17 = S18 = S19 = S22=S23=S28 = S31 = S32 = 1 and S1 = S9 = S11 = S15 = S16=S20=S21=S24= S25 = S26 =S27=S29=S30=0. In the same way, with 10% of the budget, only seven strategies could be implemented with the achievement of 34.66% (114.23/329.59) level of risk mitigation i.e. S5=S6=S12=S14=S17=S19=S31=1 and S1= S2 = S3 = S4=S7= S8 = S9 = S10 =S11= S12 =S13 = S15 = S16 = S18 = S20= S21 = S22 = S23 = S24 = S25 = S26 = S27 = S28 = S29 =S30= S32= 0.

The results for the level of risk mitigation for the Paharika farm are now presented. According to the opinion of the Paharika employees (see Table 5.33), 98.66% (422.56/428.29) level of risk mitigation could be achieved under 90% of budget, where S1=…=S23=S25=…=S29 = S31 = S32 = 1 and S24 = S30 = 0. When the budget is reduced to 50%, 20 strategies could be implemented having 73.12% (313.17/428.29) of risk mitigation, where S1 = S8 = S9 = S15 = S20 = S21 = S24=S25=S27 = S28 = S29 = S30 = 0 and S2 = S2 = S3 = S4 = S5 = S6 = S7 = S10 = S11 = S12 = S13 =S14=S16= S17 = S18 =S19=S22=S23=S26=S31=S32=1. However, only 21.26% (91.09/428.29)level of mitigation could be achieved with 10% of the budget with the implementation of only five strategies where S6 = S10 = S12 = S14 = S31 = 1 and S1 = S2 = S3 = S4 =S5=S7= S8 =S9=S11=S13=S15=… =S30=S32=0.

Table 5.32: Optimisation of Risk Mitigation Level without Savings (Nahar Employees)

Objective function	Level of Risk Mitigation	cost constraints		Budgeted cost		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
392.67	100.00%	1098.33	<=	1098.33	100%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
382.83	97.49%	983.33	<=	988.50	90%	1	1	1	1	1	1	1	1	0	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
365.65	93.12%	878.33	<=	878.67	80%	1	1	1	1	1	1	1	1	0	1	1	1	0	1	0	1	1	0	1	1	1	1	1	1	1	1	0	1	1	0	1	1
343.99	87.60%	768.33	<=	768.83	70%	1	1	1	1	1	1	1	0	0	1	1	1	0	1	0	1	1	1	1	1	1	1	1	0	0	1	0	1	1	0	1	1
312.66	79.62%	655.00	<=	659.00	60%	1	1	1	1	1	1	1	0	0	1	1	1	0	1	0	1	1	1	1	0	0	1	1	0	0	1	0	0	1	0	1	1
279.72	71.23%	546.67	<=	549.17	50%	0	1	1	1	1	1	1	0	0	1	1	1	0	1	0	1	1	1	1	0	0	1	1	0	0	0	0	0	1	0	1	1
241.58	61.52%	438.33	<=	439.33	40%	0	1	1	1	1	1	1	0	0	1	1	1	0	1	0	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0
196.42	50.02%	326.67	<=	329.50	30%	0	0	1	1	1	1	1	0	0	1	1	1	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
143.67	36.59%	218.33	<=	219.67	20%	0	0	0	0	1	1	1	0	0	1	1	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
82.62	21.04%	108.33	<=	109.83	10%	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Optimisation of Risk Mitigation level without Savings (Nahar Executives)

Objective function	Level of Risk Mitigation	cost constraints		Budgeted cost	%	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
498.24	100.00%	1286.67	<=	1286.67	100%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
484.62	97.27%	1140.00	<=	1158.00	90%	1	1	1	1	1	1	1	1	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1
462.02	92.73%	1026.67	<=	1029.33	80%	1	1	1	1	1	1	1	0	0	1	1	1	0	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1
432.78	86.86%	896.67	<=	900.67	70%	1	1	1	1	1	1	1	0	0	1	1	1	0	1	0	0	1	1	1	1	1	1	1	0	1	0	1	0	1	0	1	1
396.05	79.49%	763.33	<=	772.00	60%	0	1	1	1	1	1	1	0	0	1	1	1	0	1	0	0	1	1	1	1	1	1	1	0	1	0	1	0	0	0	1	1
352.95	70.84%	640.00	<=	643.33	50%	0	1	1	1	0	1	1	0	0	1	1	1	0	1	0	0	1	1	1	0	0	0	1	0	1	0	0	0	0	0	1	1
300.73	60.36%	513.33	<=	514.67	40%	0	1	0	1	1	1	0	0	0	1	1	0	0	1	0	0	1	1	1	0	0	0	1	0	1	0	0	0	0	0	1	1
240.38	48.25%	380.00	<=	386.00	30%	0	0	0	0	1	1	1	0	0	1	0	0	0	1	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	1	1
176.43	35.41%	256.67	<=	257.00	20%	0	1	0	0	1	1	1	0	0	1	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
101.21	20.31%	120.00	<=	128.67	10%	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Optimisation of Risk Mitigation level without Savings (Nahar Supply Chain members)

Objective function	Level of Risk Mitigation	cost constraints		Budgeted cost		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
329.59	100.00%	985	<=	985.00	100%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
324.85	98.56%	875	<=	886.50	90%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	0	1	1	1	1	1	1
314.26	95.35%	785	<=	788.00	80%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	0	1	1	1	0	1	0	1	1	1	0	1	1
297.31	90.21%	680	<=	689.50	70%	1	1	1	1	1	1	1	1	0	1	0	1	1	1	0	0	1	1	1	0	0	1	1	0	0	0	1	1	0	1	1	1
280.02	84.96%	590	<=	591.00	60%	1	1	1	1	1	1	1	1	0	1	0	1	1	1	0	0	1	1	1	0	0	1	1	0	0	0	0	1	0	0	1	1
261.99	79.49%	490	<=	492.50	50%	0	1	1	1	1	1	1	1	0	1	0	1	1	1	0	0	1	1	1	0	0	1	1	0	0	0	0	1	0	0	1	1
238.14	72.25%	390	<=	394.00	40%	0	1	1	1	1	1	1	0	0	1	0	1	1	1	0	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	1	1
209.93	63.69%	290	<=	295.50	30%	0	0	1	0	1	1	1	0	0	1	0	1	0	1	0	0	1	1	1	0	0	1	1	0	0	0	0	0	0	0	1	1
169.13	51.31%	195	<=	197.00	20%	0	0	0	0	1	1	1	0	0	0	0	1	0	1	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	1	1
114.23	34.66%	95	<=	98.50	10%	0	0	0	0	1	1	0	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0

Paharika executives (Table 5.33) indicate that a 97.82% (366.81/374.98) level of mitigation could be achieved with a 90% budget. When the budget is lessened to 50%, 73.05% (273.91/374.98) of risks can be mitigated. They selected twenty nine strategies under 90% budget, whereS1=…= S12= S14= S16= …= S29= S31= S32=1 and S13= S15= S30= 0. Under 50% of the budget, twenty one strategies could be implemented where S3=S5=…=S8=S10=…=S12=S14=S16=…=S23=S26=S29= S31= S32=1 and S1=S2=S4=S9= S13= S15 = S24 = S25 = S27 = S28 = S30 = 0. In case the budget goes down to 10%, 23% (83.24/374.98) of risks can be mitigated where S1= …=S5= S7= S13= S15= S17=S18=S20=…=S22=S24=S32=0 and S6=S14=S19=S23=1.

Paharika supply chain members (see Table 5.33) considered that 98.07% (303.79/309.75) (29 strategies) mitigation level could be achieved with 90% of the budget, where S22=S24=S26=0 and S1= …= S21= S23= S25= S27=…=S32= 1. Eighteen strategies could be implemented (77.57%, 240.26/309.75) under a 50% budget, where S1= S8=…= S11 = S15 = S21 = … = S27 = S30 = 0 and S2 = …=S7=S12=… =S13=S16=…=S20=S28= S29= S31=S32=1. Using a 10% budget, a 30.76% (95.28/309.75) mitigation level could be achieved, where S4=S5= S6= S19= S31 = S32 = 1 and S1 = S2 = S3 = S7 = … = S18 = S20 = … = S30 = 0.. Table 5.33 shows the level of risk mitigation under different budget constraints for respondents from Paharika Dairy. For instance, changing budget levels will change the level of risk mitigation. All strategies cannot be implemented under any sort of budget constraints. Only when the budget is 100% is it possible to implement all strategies.

This section has clarified the formulation of dairy supply chain risk problems through (0, 1) linear programming (without savings) for both the farms at different levels of storage, processing and distribution. The outcome of these analyses is that a maximum budget will solve more and more problems in a farm. Obviously a lack of budget will create hindrances to implement strategies to mitigate the various risks on a priority basis. The next section will discuss these results using quadratic integer programming (with savings) for both the case farms.

Table 5.33: Optimisation of Risk Mitigation level without Savings (Paharika Employees)

Objective Function	Level of Risk Mitigation	Cost Constraints		Budgeted Cost		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
428.29	100.00%	958.33	<=	958.33	100%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
422.56	98.66%	861.67	<=	862.50	90%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1
407.25	95.09%	765.00	<=	766.67	80%	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	1	0	1	1	1	0	1	1	1	1	1	0	1	1
377.10	88.05%	666.67	<=	670.83	70%	1	1	1	1	1	1	1	0	0	1	1	1	1	1	0	1	1	1	1	0	1	1	1	0	0	1	1	1	0	0	1	1
343.73	80.26%	573.33	<=	575.00	60%	0	1	1	1	1	1	1	1	0	1	1	1	0	1	0	0	1	1	1	1	0	1	1	0	0	1	1	1	0	0	1	1
313.17	73.12%	478.33	<=	479.17	50%	0	1	1	1	1	1	1	0	0	1	1	1	1	1	0	1	1	1	1	0	0	1	1	0	0	1	0	0	0	0	1	1
270.31	63.11%	383.33	<=	383.33	40%	0	1	1	0	1	1	1	0	0	1	1	1	0	1	0	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0	1	1
224.38	52.39%	286.67	<=	287.50	30%	0	0	1	0	1	1	1	0	0	1	0	1	0	1	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	1	1
165.44	38.63%	191.67	<=	191.67	20%	0	0	1	0	1	1	1	0	0	1	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91.09	21.27%	95.00	<=	95.83	10%	0	0	0	0	0	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Optimisation of Risk Mitigation level without Savings (Paharika Executives)

Objective Function	Level of Risk Mitigation	Cost Constraints		Budgeted Cost		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
374.98	100.00%	1006.67	<=	1006.67	100%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
366.81	97.82%	900.00	<=	906.00	90%	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1
349.97	93.33%	803.33	<=	805.00	80%	1	1	1	1	1	1	1	1	0	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	0	1	0	1	1	0	1	1
323.25	86.21%	686.67	<=	704.67	70%	1	0	1	1	1	1	1	1	0	1	1	1	0	1	0	1	1	1	1	1	1	1	1	0	0	1	0	1	1	0	1	1
298.36	79.57%	590.00	<=	604.00	60%	1	0	1	0	1	1	1	1	0	1	1	1	0	1	0	1	1	1	1	1	1	1	1	0	0	1	0	0	1	0	1	1
273.91	73.05%	496.67	<=	503.33	50%	0	0	1	0	1	1	1	1	0	1	1	1	0	1	0	1	1	1	1	1	1	1	1	0	0	1	0	0	1	0	1	1
244.69	65.25%	400.00	<=	402.66	40%	0	0	1	0	1	1	1	0	0	1	1	1	0	1	0	1	1	1	1	0	1	1	1	0	0	0	0	0	1	0	0	1
204.00	54.40%	300.00	<=	302.00	30%	0	0	1	0	1	1	1	0	0	1	1	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0
150.40	40.11%	200.00	<=	201.33	20%	0	0	0	0	1	1	1	0	0	1	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
86.24	23.00%	100.00	<=	100.67	10%	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0

Optimisation of Risk Mitigation level without Savings (Paharika Supply Chain Members)

Objective Function	Level of Risk Mitigation	Cost Constraints		Budgeted cost		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
309.75	100.00%	1015.00	<=	1015.00	100%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
303.79	98.07%	905.00	<=	913.50	90%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1	1	1	1	1	1
294.36	95.03%	810.00	<=	812.00	80%	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	0	0	1	0	1	1	1	1	1	0	1	1
279.69	90.29%	710.00	<=	710.50	70%	1	1	1	1	1	1	1	0	0	1	0	1	1	1	1	0	1	1	1	1	0	0	1	0	0	0	1	1	1	0	1	1
260.23	84.01%	600.00	<=	609.00	60%	1	1	1	1	1	1	1	0	0	0	0	1	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	1	1	0	1	1
240.26	77.57%	500.00	<=	507.50	50%	0	1	1	1	1	1	1	0	0	0	0	1	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	1	1	0	1	1
217.37	70.17%	405.00	<=	406.00	40%	0	1	1	1	1	1	1	0	0	0	0	1	0	1	1	0	1	1	1	1	0	0	0	0	0	0	0	1	0	0	1	1
187.66	60.58%	300.00	<=	304.50	30%	0	0	1	0	1	1	1	0	0	0	0	1	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0	1	0	0	1	1
147.17	47.51%	200.00	<=	203.00	20%	0	0	0	1	1	1	1	0	0	0	0	0	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1
95.28	30.76%	100.00	<=	101.50	10%	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1

5.5.2.2 Formulation of dairy supply chain risk mitigation problems through (0, 1) quadratic integer programming (with savings)

Dairy supply chain risk mitigation problems are formulated as a quadratic integer programming model involving cost savings. The optimisation model for Nahar employees is formulated using equation mentioned in Step 2 under Section 4.7.2(e). Here, 1098.33 is used as the 100% budget. This total budget is calculated through summing up relative costs provided by Nahar employees.

Max $f(x)= 26.37 X_1 + 20.72 X_2 + 32.84 X_3 + 19.83 X_4 + 9.75 X_5 + 28.66 X_6 + 17.34 X_7 + 8.22X_8 + 2.27 X_9 + 18.33 X_{10} + 15.97 X_{11} + 9.92X_{12} + 6.47 X_{13} + 17.48 X_{14} + 1.10X_{15} + 7.15X_{16} + 6.09X_{17} + 5.25X_{18} + 19.14X_{19} + 5.77X_{20} + 10.27X_{21} + 8.51X_{22} + 12.22X_{23} + 8.78X_{24} + 0.91X_{25} + 6.57X_{26} + 10.26X_{27} + 15.28X_{28} + 8.89X_{29} + 1.68X_{30} + 9.85X_{31} + 11.77X_{32}$.

Subject to: $88.33 X_1 + 51.67 X_2 + 61.67 X_3 + 46.67 X_4 + 16.67 X_5 + 35.00 X_6 + 26.67 X_7 + 35.00X_8 + 48.33 X_9 + 28.33 X_{10} + 28.33 X_{11} + 23.33 X_{12} + 41.67 X_{13} + 20.00 X_{14} + 25.00 X_{15} + 13.33 X_{16} + 15.00 X_{17} + 15.00 X_{18} + 26.67 X_{19} + 21.67 X_{20} + 31.67 X_{21} + 21.67 X_{22} + 38.33 X_{23} + 48.33 X_{24} +.41.67 X_{25} + 20.00 X_{26} + 58.33 X_{27} + 60.00 X_{28} + 25.00 X_{29} + 31.67 X_{30} + 23.33 X_{31} + 30.00 X_{32} - 38 X_1X_3 - 40 X_1X_9 - 47 X_1X_{13} \leq 1098.33$

[All X's = (0, 1)].

The above model can be solved using a total budget of 1098.33 (sum of relative costs) for Nahar employees. Table 5.34 shows the optimisation results with savings using quadratic integer programming. The result shows that risk mitigation levels increased based on budget increments. When the budget is 100%, all the strategies could be implemented with a 100% level of mitigation. When the budget is starts to be reduced, the level of risk mitigation is also decreased. The reduction of the budget from 90% to 50% decreased the level of risk mitigation from 100% (392.67/392.67) to75.90% (298.02/392.67). Furthermore, if the budget decreased to 10%, the level of risk mitigation became 21.04% (82.62/392.67). The result also shows that, all strategies could be implemented with 90% of the budget, where S1 = … S32 = 1. Twenty strategies could be implemented with 50% of the budget, where S1 = … =S7=S10= … = S14 = S16 = … = S19 = S22 = S26 = S31 = S32=1 and S8=S9=S15=S20= S21 = S23 = S24 = S25 = S27 = … = S30=0. Four strategies could be implemented with 10% of the budget, where S6=S7=S14=S19=1 and S1=…= S5=S8= …= S13= S15=…= S18= S20=…=S32=0.

According to the Nahar executives (see Table 5.34), a 95.92% (477.93/498.24)level of risk was mitigated with 90% of budget. This budget allows mitigating 29out of 32 strategies. When the budget drops from 90% to 50%, 71.85% (357.98/498.24) of risks are mitigated. Seventeen strategies could be implemented under 50% budget, where S1 =… = S6 = S9 = … = S11 = S14 = S17=S18=S19=S21=…S23=S25=S31=S32=1 and S7=S8=S12=S13=S15=S16=S20=S21=S22=S24=S26=…=S30=0.Again a 10% budget can manage only 20.31% (101.21/498.24) of risk mitigation. Only five strategies could be implemented under such a budget, where S1 = … = S4 = S7 = … = S9 = S11 = … = S16=S18=…=S30=S32=0 and S5=S6=S10=S17=S31=1.

For the Nahar supply chain members, when the budget was reduced to 90% from100%, the level of risk mitigation remains 100%. The level of risk mitigation reduced from 100% to 85.69% (282.435/329.593) when the budget reduced to 50% from 90%. In this situation, 21 strategies could be implemented, where S1=…=S10=S12=…S14=S17=…=S19=S22=S23=S28=S31=S32=1 and S11=S15=S16 = S20 = S21 = S24 = … = S27 = S29 = S30 = 0. Another reduction of the budget from 50% to 10% results in a 34.66% (114.22/329.59) level of risk mitigation with seven mitigation strategies implemented, where S5=S6=S12=S14=S17=S19=S31=1 and S1=…=S4=S7=…=S11=S13=S15=S16=S18=S20=….=S30= S32=0.

Paharika employees considered that all strategies could be implemented with a 90% budget which had a 100% level of risk mitigation (see Table 5.35). In an 80% budget, the performance level of risk mitigation reduced to 98.66% (422.56/428.29) along with the implementation of thirty strategies, whereS1=…=S23= S25=…= S29=S31=S32=1 and S24=S30=0. However, an 81.76% (350.16/428.29) level of risk mitigation could be achieved with 50% of the total budget but only twenty two strategies could be implemented. Likewise, with the reduction of budget to 10%, only a 21.27% (91.09/428.29) level of risk mitigation could be achieved along with the implementation of only five strategies, where S6=S10= S12= S14=S31=1 and S1= …= S5= S7=…= S9= S11=S13=S15=…= S30= S32=0.

Table 5.34: Optimisation of Risk Mitigation level with Savings (Nahar Employees)

Objective Function	Level of Risk Mitigation	Cost Constraints		Budgeted Cost		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
392.67	100.00%	973.33	<=	1098.33	100%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
392.67	100.00%	973.33	<=	988.50	90%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
381.12	97.06%	868.33	<=	878.67	80%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1
360.95	91.92%	768.33	<=	768.83	70%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	0	1	0	1	1	0	1	1
332.19	84.60%	658.33	<=	659.00	60%	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	0	0	1	0	0	1	0	1	1
298.02	75.90%	548.33	<=	549.17	50%	1	1	1	1	1	1	1	0	0	1	1	1	1	1	0	1	1	1	1	0	0	1	0	0	0	1	0	0	0	0	1	1
256.07	65.21%	438.33	<=	439.33	40%	1	1	1	1	1	1	1	0	0	1	1	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
209.43	53.34%	325.00	<=	329.50	30%	1	0	1	0	1	1	1	0	0	1	1	1	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
149.29	38.02%	216.67	<=	219.67	20%	1	0	1	0	0	1	0	0	0	1	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
82.62	21.04%	108.33	<=	109.83	10%	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Optimisation of Risk Mitigation level with Savings (Nahar Executives)

Objective function	Level of Risk Mitigation	cost constraints		Budget	%	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
498.24	100.00%	1161.67	<=	1286.67	100%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
477.93	95.92%	1028.33	<=	1158.00	90%	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1
477.93	95.92%	1028.33	<=	1029.00	80%	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1
448.68	90.05%	898.33	<=	900.67	70%	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	0	1	0	1	0	1	1
411.88	82.67%	771.67	<=	772.00	60%	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1	1	1	0	1	1	1	0	1	0	0	0	0	0	1	1
357.98	71.85%	638.67	<=	643.33	50%	1	1	1	1	1	1	0	0	1	1	1	0	0	1	0	0	1	1	1	0	0	0	1	0	1	0	0	0	0	0	1	1
300.13	60.24%	511.67	<=	514.67	40%	1	1	1	0	1	1	1	0	1	1	0	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1
241.83	48.54%	383.33	<=	386.00	30%	0	1	0	0	1	1	0	0	0	1	0	0	0	1	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	1	1
176.43	35.41%	256.67	<=	257.33	20%	0	1	0	0	1	1	1	0	0	1	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
101.21	20.31%	120.00	<=	128.67	10%	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Optimisation of Risk Mitigation level with Savings (Nahar Supply Chain Members)

Objective function	Level of Risk Mitigation	cost constraints		Budgeted cost		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
329.59	100.00%	860	<=	985	100%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
329.59	100.00%	860	<=	886.5	90%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
326.83	99.16%	765	<=	788	80%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	0	1	1
316.68	96.08%	685	<=	689.5	70%	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	1	1	1	1	1	1	0	1	0	1	1	1	0	1	1
301.29	91.41%	585	<=	591	60%	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	0	1	1	1	0	1	1	1	0	1	0	0	1	1	0	1	1
282.44	85.69%	485	<=	492.5	50%	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	0	1	1	1	0	0	1	1	0	0	0	0	1	0	0	1	1
258.59	78.46%	385	<=	394	40%	1	1	1	1	1	1	1	0	1	1	0	1	1	1	0	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	1	1
232.94	70.67%	295	<=	295.5	30%	1	0	1	0	1	1	1	0	1	1	0	1	1	1	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	1	1
180.08	54.64%	195	<=	197	20%	1	0	1	0	1	1	0	0	1	0	0	1	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1
114.23	34.66%	95	<=	98.5	10%	0	0	0	0	1	1	0	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0

The result from the Paharika executives (see Table 5.35) found that all the strategies could be implemented with 90% of the budget and 100% (374.98/374.98) level of risk mitigation. However, the performance level of risk mitigation was reduced when a 50% budget is selected. With this budget, twenty one strategies could be implemented with the achievement of 78.04% (292.64/374.98) level of risk mitigation, where S1=…=S3=S5=…= S7= S10=…=S14=S16=…=S19=S21=…=S23=S29=S31=S32=1 and S4=S8=S9=S15=S20=S24= …=S28=S30= 0. Similarly, only five strategies could be implemented and a 23% (86.24/374.98) level of risk mitigation could be achieved with 10% of the budget, where S6=S14=S16=S19=S23=1 and S1= …= S5= S7=…= S13= S15=S17= S18=S20=…= S22=S24=…=S32=0.

Paharika supply chain members point out (see Table 5.35) that a 90% budget could achieve a 100% level of risk mitigation. However, with a 50% of budget would have an 84.37% (261.35/309.75) level of risk mitigation and nineteen strategies could be implemented, where S1= …=S7=S12=S13=S14=S17=…=S20=S25=S28= S29=S31=S32=1 and S8=…=S11=S15=S16= S21=… =S24=S26= S27= S30=0. Likewise, only six strategies could be implemented along with the achievement of 30.76% (95.29/309.75) level of risk mitigation by 10% of the total budget, where S1=…= S4= S7=…= S17= S20=…=S30=0 and S5=S6=S18= S19=S31=S32=1. Again the score of 0 and 1 represents 'could not implement' and 'could be implement' respectively.

These results are summarised and compared in graphical form presenting risk mitigation levels with and without savings at different budget level for both case farms. Figure 5.2 compares with and without savings for risk mitigation level of Nahar employees. The X-axis denotes the budget level and the Y-axis denotes the level of risk mitigation. The graph shows that the maximum level of risk mitigation could be achieved under the highest budgets. With the increments of the budget, the level of risk mitigation is also increased. For example, when savings are not considered, with the increment of the budget from 20% to 30% the change of risk mitigation level is 13.43% (50.02–36.59), while the increase caused by the budget changes from 219.67 to 329.50. Likewise, when savings are considered, the change in achieved level of risk mitigation is 15.32% (53.34–38.02), with the increase of budget from 20% to 30% which changes from 219.67 to 329.50. In this way, both the models (with savings and without savings) are compared with each other.

Table 5.35: Optimisation of Risk Mitigation level with Savings (Paharika Employees)

Objective function	Level of Risk Mitigation	cost constraints		Budgeted Cost		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
428.29	100.00%	851.33	<=	958.33	100%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
428.29	100.00%	851.33	<=	862.50	90%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
422.56	98.66%	754.67	<=	766.67	80%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1
407.25	95.09%	658.00	<=	670.83	70%	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	1	0	1	1	1	0	1	1	1	1	1	0	1	1
379.09	88.51%	574.67	<=	575.00	60%	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	1	0	0	1	1	0	0	1	1	1	0	0	1	1
350.16	81.76%	478.00	<=	479.17	50%	1	1	1	1	1	1	1	0	0	1	1	1	1	1	0	1	1	1	1	0	1	1	1	0	0	1	0	0	0	0	1	1
307.19	71.73%	383.00	<=	383.33	40%	1	1	1	0	1	1	1	0	0	1	1	1	1	1	0	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	1	1
250.30	58.44%	286.33	<=	287.50	30%	1	1	1	0	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
177.36	41.41%	188.00	<=	191.67	20%	1	1	1	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91.09	21.27%	95.00	<=	95.83	10%	0	0	0	0	0	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Optimisation of Risk Mitigation level with Savings (Paharika Executives)

Objective Function	Level of Risk Mitigation	Cost Constraints		Budgeted Cost		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
374.98	100.00%	899.67	<=	1006.67	100%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
374.98	100.00%	899.67	<=	906.00	90%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
365.11	97.37%	799.67	<=	805.00	80%	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1
345.79	92.22%	703.00	<=	704.67	70%	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1	0	1	1	0	1	1
320.48	85.46%	599.67	<=	604.00	60%	1	1	1	0	1	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1	1	0	1	0	0	1	0	1	1	0	1	1
292.64	78.04%	503.00	<=	503.33	50%	1	1	1	0	1	1	1	0	0	1	1	1	1	1	0	1	1	1	1	0	1	1	1	0	0	0	0	0	1	0	1	1
254.01	67.74%	396.33	<=	402.66	40%	1	1	1	0	1	1	1	0	0	1	1	0	1	1	0	1	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0
204.02	54.41%	301.33	<=	302.00	30%	1	0	1	0	1	1	0	0	0	1	1	0	1	1	0	1	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0
143.25	38.20%	200.00	<=	201.33	20%	0	0	0	0	1	0	1	0	0	1	1	0	0	1	0	1	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0
86.24	23.00%	100.00	<=	100.67	10%	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0

Optimisation of Risk Mitigation level with Savings (Paharika SC Members)

Objective Function	Level of Risk Mitigation	Cost Constraints		Budgeted Cost		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
309.75	100.00%	908.00	<=	1015.00	100%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
309.75	100.00%	908.00	<=	913.50	90%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
304.68	98.36%	793.00	<=	812.00	80%	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	0	1	1
295.10	95.27%	708.00	<=	710.50	70%	1	1	1	1	1	1	1	1	0	1	0	1	1	1	0	1	1	1	1	1	0	1	1	0	1	0	1	1	1	0	1	1
281.23	90.79%	608.00	<=	609.00	60%	1	1	1	1	1	1	1	0	0	1	0	1	1	1	0	1	1	1	1	1	0	0	1	0	0	0	1	1	1	0	1	1
261.35	84.37%	503.00	<=	507.50	50%	1	1	1	1	1	1	1	0	0	0	0	1	1	1	0	0	1	1	1	1	0	0	0	0	1	0	0	1	1	0	1	1
236.15	76.24%	403.00	<=	406.00	40%	1	1	1	1	1	1	1	0	0	0	0	0	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	1	0	0	1	1
200.24	64.64%	303.00	<=	304.50	30%	1	1	1	0	1	1	1	0	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1
147.17	47.51%	200.00	<=	203.00	20%	0	0	0	1	1	1	1	0	0	0	0	0	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1
95.29	30.76%	100.00	<=	101.50	10%	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1

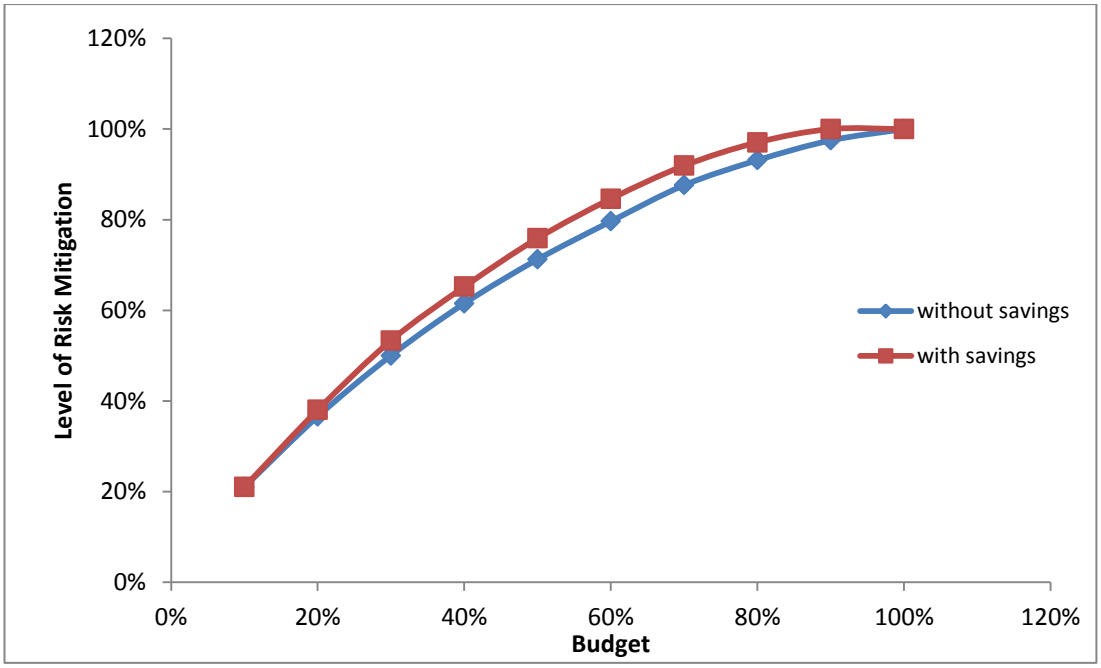


Figure 5.2: Comparison of Risk Mitigation Level between With Saving and Without Savings (Nahar Employees)

Figure 5.3 compares risk mitigation levels under different budgets (with saving and without savings) for Nahar Executives. The X-axis denotes budget level and the Y-axis the level of risk mitigation. The level of the risk mitigation curve is almost same from 10% to 50% of the budget. At 60% of the budget with savings considered, the level of risk mitigation is 70.43%. With the same budget if savings are not considered, the level of risk mitigation is 71.85%.

The results differ for the Nahar supply chain members. Figure 5.4 shows that when the budget moves from 20% to 30% without considering savings the change of risk mitigation level is 16.65% (51.31–34.66). At the same time, the budget changed from 197 to 295.50. For the same budget changes when savings are considered, the change in risk mitigation level is 19.98% (54.64–34.66) with the increase of budget from 197 to 295.50. Similar comparisons of the models with savings and without savings for other groups (employees, executives and supply chain members) for the Paharika farm are shown in Appendices 5L, 5M and 5N.

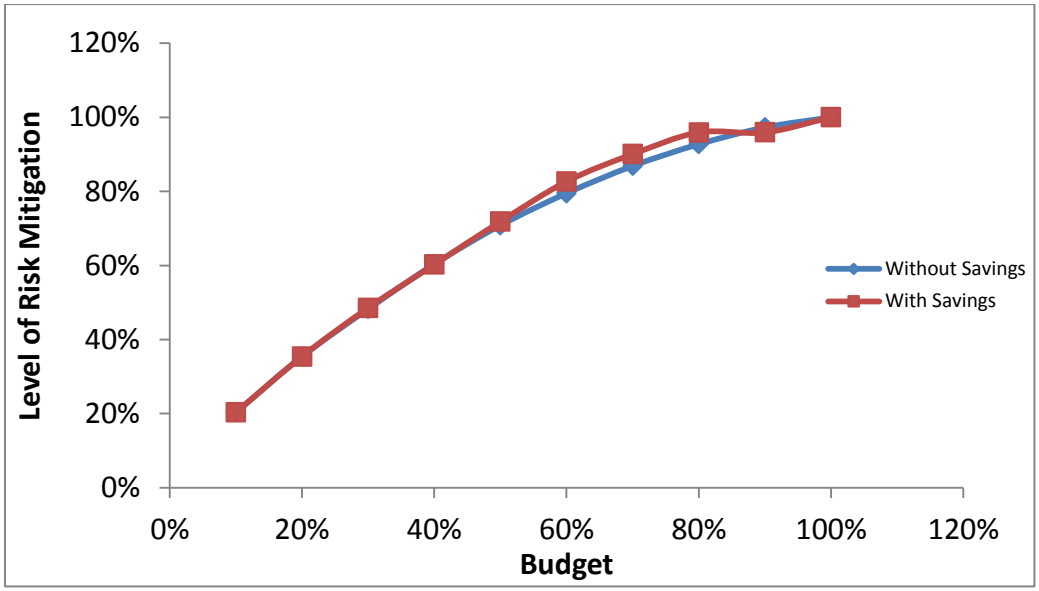


Figure 5.3: Comparison of Risk Mitigation Level between With Saving and Without Savings (Nahar Executives)

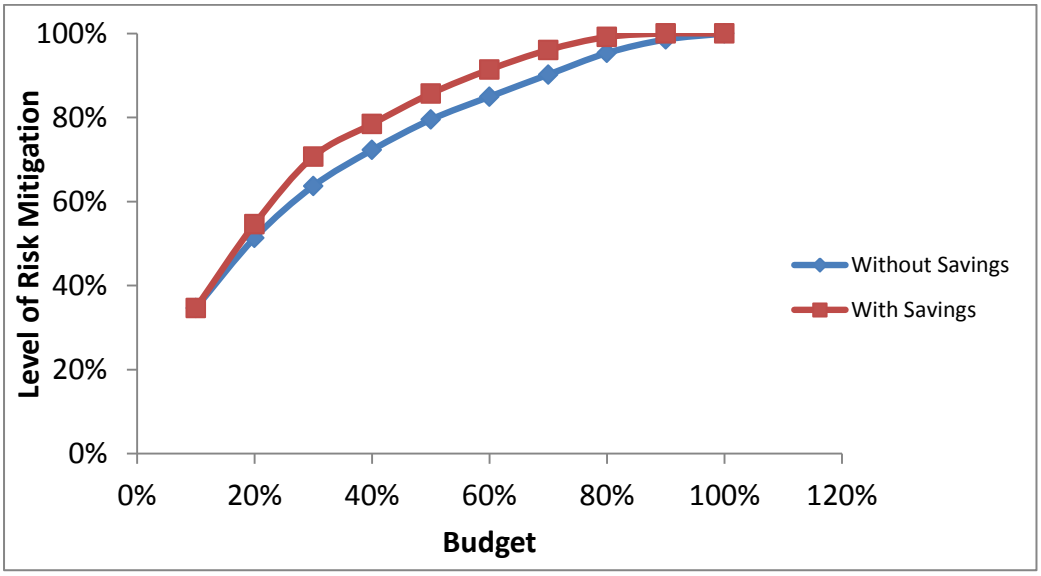


Figure 5.4: Comparison of Risk Mitigation Level between With Saving and Without Savings (Nahar Supply Chain Members)

5.6 QFD ANALYSIS: PHASE 2

As mentioned in Section 4.6.1 (The QFD process), Phase 2 of QFD analysis consists of three steps. Necessary data (optimised strategies) related to the row matrix (WHATs) are collected from Phase1 of the QFD analysis (see Tables 5.34 and 5.35). Sustainable outcomes scores are collected through qualitative interview (see Table 5.20) for using them as column matrix (HOWs). Then the matrices for Step 2 (relationship between strategy and outcome) are formed using survey data. The matrices for Step 3 (degree of importance) are formed from Phase 1 of the QFD analysis (RI values of mitigation

strategies). The RI values of optimised mitigation strategies are used as DI (Degree of Importance) value for Phase 2 of the QFD analysis.

5.6.1 Identifying optimised mitigation strategies and sustainable outcomes

In the first step of this phase of QFD analysis, the row matrix (WHATs) and the column matrix (HOWs) is developed. As mentioned previously in section 4.5.1 (The QFD Process) optimised strategies from phase 1 are considered as row (WHATs) and sustainable outcomes which were obtained from qualitative interview (shown in table 5.11) is considered as column (HOWs). For the Nahar Dairy, 26 optimum strategies (see Table 5.36a) are taken as WHATs, whereas the remaining six strategies (S8, S16, S24, S26, S28 and S30) are not optimised. At the same time, Table 5.36b shows the categorised optimum mitigation strategies for Nahar. These strategies could not be implemented with less than 80% budget (see Table 5.34 Optimisation of risk mitigation level with savings for Nahar Executives).

Similarly, twenty seven strategies were finalised for Paharika Dairy as WHATs (see Table 5.35). The remaining five strategies (S9, S15, S24, S27, and S30) are not considered as optimised strategies as they could not be implemented with less than an 80% budget. The column matrix (HOWs) for both dairies was developed by taking 15 sustainable outcomes obtained from the qualitative interviews (described in Section 5.3.5.1).

Fifteen sustainable outcomes are selected with a single notation in Table 5.37a. And Table 5.37b shows categorised sustainable outcomes for both the industry. Here, SO1 to SO7 are economic sustainable outcomes, SO8 to SO12 are social outcomes and SO13 to SO15 are environmental outcomes.

Table 5.36a: List of Optimised Mitigation Strategies for Nahar (WHATs)

S1	=	Adoption of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	S15	=	Attempts to create various cross breeds by adopting AI services.
S2	=	Buying insurance against production loss.	S17	=	Strengthen the regular supply of vaccine
S3	=	Hiring skilled staff	S18	=	Initiative to reduce the cost of feed
S4	=	Motivational and incentives facilities for staff	S19	=	Support to develop technology
S5	=	Initiative to remove political uncertainty	S20	=	Focus on certified feed supplier to get quality feed.
S6	=	Implementation of a fixed policy for dairy sector	S21	=	Arrangement of adequate grassland for producing Napier grass
S7	=	Assurance of adequate institutional credit support with low rate of interest	S22	=	Arrangement of regular vaccination for the cattle
S9	=	Focus on value addition	S23	=	Arrangement of improved and upgraded veterinary services
S10	=	Promote sound business practices by cooperation, better coordination and information sharing	S25	=	Building monitoring team
S11	=	Reduction of risks through merger, acquisition and integration.	S27	=	Arrangement of adequate number of transport
S12	=	Arrangement of proper training to the staff regarding temperature control	S29	=	Development of roads and highway
S13	=	Adoption of alternative supply of power for cold storage (powerful generator)	S31	=	Removal of unnecessary influence of middlemen
S14	=	Arrangement of proper training to the staff regarding processing and hygiene management	S32	=	Direct marketing

Table 5.36b: Categorised Optimum Mitigation Strategies for Nahar (WHATs)

Common strategies at every level	Strategies for the processing level
S1 = Adoption of improved technology (milking machine, feed mixture, grass cutting, improved processing facilities) S2 = Buying insurance against production loss S3 = Hiring skilled staff S4 = Motivational and incentives facilities for staff S5 = Initiative to remove political uncertainty S6 = Implementation of a fixed policy for dairy sector S7 = Assurance of adequate institutional credit support with low rate of interest S9 = Focus on value addition S10 = Promote sound business practices by cooperation, better coordination and information sharing S11 = Reduction of risks through merger, acquisition and integration	S14 = Arrangement of proper training to the staff regarding processing and hygiene management S15 = Attempts to create various cross breeds by adopting AI services. S17 = Strengthen the regular supply of vaccine S18 = Initiative to reduce the cost of feed S19 = Support to develop technology S20 = Focus on certified feed supplier to get quality feed S21 = Arrangement of adequate grassland for producing Napier grass S22 = Arrangement of regular vaccination for the cattle S23 = Arrangement of improved and upgraded veterinary services
Strategies for the storage level	**Strategies for the distribution level**
S12 = Arrangement of proper training to the staff regarding temperature control S13 = Adoption of alternative supply of power for cold storage (powerful generator)	S25 = Building monitoring team S27 = Arrangement of adequate number of transport S29 = Development of roads and highway S31 = Removal of unnecessary influence of middlemen S32 = Direct marketing

Table 5.37a: Probable Sustainable Outcomes

SO1=	Profit maximisation	SO8=	Goodwill enhancement
SO2=	Cost minimisation	SO9=	Supply of quality food
SO3=	Increase in personal income	SO10=	Nutritional development
SO4=	Increase in production	SO11=	Improvement of living standard
SO5=	Product quality improvement	SO12=	Creation of employment opportunity
SO6=	Expansion of farming system	SO13=	Creation of sound working environment
SO7=	Production of value added product and diversified product	SO14=	Waste management
		SO15=	Supply of quality food

Table 5.37b: Categorised Probable Sustainable Outcomes

Economic		Social	
SO1 =	Profit maximisation	SO8 =	Goodwill enhancement
SO2 =	Cost minimisation	SO9 =	Supply of quality food
SO3 =	Increase in personal income	SO10 =	Nutritional development
SO4 =	Increase in production	SO11 =	Improvement of living standard
SO5 =	Product quality improvement	SO12 =	Creation of employment opportunity
SO6 =	Expansion of farming system	**Environmental**	
SO7 =	Production of value added product and diversified product	SO13 =	Creation of sound working environment
		SO14 =	Waste management
		SO15 =	Supply of quality food

5.6.2 Identifying the relationship between mitigation strategies and sustainable outcomes

In the second step of Phase 2 of the QFD analysis, the relationship matrix is developed using the relationship data collected through the questionnaire survey. The optimised mitigation strategies and sustainable outcomes are finalised from Phase 1 of the QFD analysis and qualitative interview respectively. These were presented in the questionnaire for rating the relationship between strategy and outcomes. This four point rating scale is designed as (0–1–5-9) to indicate the degree of relationship. The four different rating points denote no realisation (0), little realisation (1), moderate realisation (5) and strong realisation. The data were collected from six executives of both farms. Executives only can provide accurate ideas about the farm's outcomes from strategic implementations. After averaging the collected score (for three executives from each farm), the results are placed as a relationship matrix for QFD analysis. The QFD analysis (Phase 2) for Nahar farm is shown in Table 5.38and for Paharika farm in Table 5.39.

5.6.3 Relative Importance (RI): Phase 2

The third step of the second phase of QFD analysis deals with the identification of the relative importance (RI) of sustainable outcomes. The relative importance (RI) of each sustainable outcome can be derived by transforming the absolute importance ratings (AI) into relative importance (RI) ratings. Absolute Importance (AI) rating can be calculated using the formula shown in Step V of Section 4.7(d). The RI values of optimised strategies from QFD analysis (Phase 1) are considered as DI (see Appendix

5F for Nahar).Then RI values are calculated through normalising the AI values. The higher RI value represents the most important design attribute (Park and Kim 1998). In this research, the higher RI value represents the better realisable sustainable outcome.

For Nahar, 'Cost minimisation' (SO2) is the best realisable outcome with the highest RI value 0.12 (shown in Table 5.38). The second most achievable outcome is 'Profit maximisation' (SO1) with an RI value of 0.11. The third most important realisable outcome is 'Increase in production' (SO4) with an RI value 0.10.By contrast, the least achievable outcome with the lowest RI value of 0.02 is 'Improvement of living standard' (SO11).

For Paharika Dairy, the most realisable sustainable outcome is 'Increase in production' (SO4) with the highest RI value of 0.15 (see Table 5.39). Two other important realisable outcomes are 'Cost minimisation' (SO2) and 'Profit maximisation' (SO1) with the RI values of 0.14 and 0.11 respectively. The least realisable outcome is 'Improvement of living standard' (SO11) with an RI value of 0.02.

Table 5.38: QFD Analysis Phase 2 (Nahar)

Outcomes No.			SO1	SO2	SO3	SO4	SO5	SO6	SO7	SO8	SO9	SO10	SO11	SO12	SO13	SO14	SO15	
Strategy No.	Sustainable Outcomes Mitigation Strategies	Degree of Importance	Profit maximisation	Cost minimisation	Increase in income	Increase in production	Product quality improvement	Expansion of farming system	Production of value added product and diversified product	Goodwill enhancement	Supply of quality food	Nutritional development	Improvement of living standard	Creation of employment opportunity	Creation of sound working environment	Waste management	Health improvement of cattle(Animal Quality)	
S1	Adoption of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	0.05	6.33	5.00	1.67	6.33	3.33	0.00	3.67	3.67	2.00	0.33	0.00	0.33	3.33	0.33	0.00	
S2	Buying insurance against production loss.	0.04	1.67	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
S3	Hiring skilled staff	0.06	5.00	3.67	3.33	3.67	0.67	3.67	2.33	2.33	2.00	3.33	1.67	0.33	3.33	0.00	3.67	
S4	Motivational and incentives facilities for staff	0.05	0.00	0.33	3.33	0.00	0.33	0.00	0.00	5.00	0.00	0.00	5.00	3.33	3.67	0.00	0.00	
S5	Initiative to remove political uncertainty	0.02	5.00	5.00	3.33	0.00	0.00	0.00	0.00	0.00	4.67	2.00	0.33	0.00	0.00	0.00	0.00	
S6	Implementation of a fixed policy for dairy sector	0.08	7.67	7.67	1.67	3.33	3.33	2.00	0.00	0.00	0.33	0.33	0.33	1.67	5.00	0.33	2.33	
S7	Assurance of adequate institutional credit support with low rate of interest.	0.04	0.00	4.67	0.00	3.67	0.33	7.67	5.00	0.00	3.33	3.33	0.33	0.00	0.00	3.33	6.33	
S9	Focus on value addition	0.01	6.33	2.00	0.00	3.33	2.33	2.00	7.67	3.67	0.67	2.00	0.00	5.00	0.00	2.00	0.00	
S10	Promote sound business practices by cooperation, better coordination and information sharing	0.04	3.33	5.00	0.00	4.67	3.67	2.33	5.00	0.33	0.33	3.67	0.00	1.67	2.00	2.33	0.67	
S11	Reduction of risks through merger, acquisition and integration.	0.04	5.00	5.00	0.00	6.33	2.33	6.33	6.33	5.00	2.33	3.67	0.00	0.67	3.67	0.67	5.00	
S12	Arrangement of proper training to the staff regarding temperature control	0.02	1.67	0.33	0.00	0.00	6.33	0.00	0.00	2.33	3.67	2.33	0.00	0.00	0.00	0.00	0.00	
S13	Adoption of alternative supply of power for cold storage (powerful generator)	0.02	0.33	0.00	0.00	0.00	6.33	0.00	1.67	1.67	1.67	2.00	0.00	0.00	0.00	0.00	0.00	
S14	Arrangement of proper training to the staff regarding processing and hygiene management	0.04	2.33	0.33	0.00	5.00	6.33	0.33	0.00	2.33	3.67	5.00	0.00	0.00	0.33	2.33	5.00	
S15	Attempts to create various cross breeds by adopting AI services.	0.01	5.00	0.00	0.00	6.33	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	6.33	
S17	Strengthen the regular supply of vaccine	0.03	0.00	0.00	0.00	3.67	0.33	0.00	0.00	3.33	0.00	2.00	0.00	0.00	0.00	0.00	4.67	
S18	Initiative to reduce the cost of feed	0.03	3.33	7.67	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.33	
S19	Support to develop technology	0.07	1.67	0.33	0.00	3.67	5.00	0.00	0.00	3.67	3.33	5.00	0.00	0.33	1.67	1.67	5.00	
S20	Focus on certified feed supplier to get quality feed.	0.01	0.00	5.00	0.00	3.67	0.33	0.00	0.00	0.00	2.00	1.67	0.00	0.00	0.00	0.00	7.67	
S21	Arrangement of adequate grassland for producing Napier grass	0.01	1.67	4.67	0.00	6.33	0.00	0.00	0.00	0.00	1.67	4.67	0.00	0.00	0.00	0.00	5.00	
S22	Arrangement of regular vaccination for the cattle	0.02	0.00	0.00	0.00	3.67	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	9.00	
S23	Arrangement of improved and upgraded veterinary services	0.02	0.00	0.00	0.00	6.33	1.67	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	6.33	
S25	Building monitoring team	0.05	5.00	3.67	2.33	2.00	4.67	0.00	0.00	3.67	5.00	3.67	0.00	3.33	2.33	0.33	0.33	
S27	Arrangement of adequate number of transport	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.67	5.00	0.67	0.00	3.33	0.00	0.00	0.00	
S29	Development of roads and highway	0.02	0.00	6.33	0.00	0.00	0.00	0.00	0.00	0.00	6.33	2.33	0.00	0.00	0.00	0.00	0.00	
S31	Removal of unnecessary influence of middlemen	0.04	5.00	6.33	3.33	0.00	4.67	0.00	0.33	4.67	3.67	1.67	0.33	0.00	0.00	0.00	0.00	
S32	Direct marketing	0.05	6.33	5.00	2.00	1.67	1.67	0.00	0.00	2.00	5.00	5.00	0.33	3.33	0.00	0.00	0.00	
	AI		2.92	3.15	0.99	2.55	2.20	1.05	1.07	1.96	2.07	2.07	0.43	0.93	1.42	0.54	2.18	25.52
	RI		0.11	0.12	0.04	0.1	0.09	0.04	0.042	0.08	0.08	0.08	0.02	0.04	0.056	0.02	0.085	1

Table 5.39: QFD Analysis Phase 2 (Paharika)

Outcomes NO.			SO1	SO2	SO3	SO4	SO5	SO6	SO7	SO8	SO9	SO10	SO11	SO12	SO13	SO14	SO15	
Strategy No.	Sustainable Outcomes Mitigation Strategies	Degree of Importance	Profit maximisation	Cost minimisation	Increase in income	Increase in production	Product quality improvement	Expansion of farming system	Production of value added product and diversified product	Goodwill enhancement	Supply of quality food	Nutritional development	Improvement of living standard	Creation of employment opportunity	Creation of sound working environment	Waste management	Health improvement of cattle(Animal Quality)	
S1	Adoption of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	0.07	9.00	3.67	0.00	7.67	0.33	2.00	3.33	3.67	2.00	0.33	0.00	0.00	2.00	1.67	0.00	
S2	Buying insurance against production loss.	0.04	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
S3	Hiring skilled staff	0.08	6.33	2.00	2.00	7.67	3.33	0.67	2.00	0.67	2.00	3.33	0.00	1.67	0.00	3.33	4.67	
S4	Motivational and incentives facilities for staff	0.04	2.00	1.67	2.00	2.00	0.00	0.33	0.00	3.67	0.33	0.33	2.33	0.00	0.33	0.00	0.00	
S5	Initiative to remove political uncertainty	0.05	5.00	5.00	0.33	1.67	0.00	0.00	0.00	0.00	3.67	1.67	0.00	0.00	0.33	0.00	0.00	
S6	Implementation of a fixed policy for dairy sector	0.08	6.33	9.00	1.67	1.67	6.33	2.00	0.00	0.67	7.67	5.00	2.00	2.00	0.67	0.00	5.00	
S7	Assurance of adequate institutional credit support with low rate of interest.	0.07	0.00	0.00	0.00	9.00	0.33	7.67	1.67	0.00	0.00	0.00	1.67	1.67	0.00	0.00	0.00	
S8	Introducing off-farm activities	0.03	1.67	0.00	3.33	0.00	0.00	5.00	5.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	
S10	Promote sound business practices by cooperation, better coordination and information sharing	0.04	3.67	6.33	0.67	5.00	1.67	3.33	2.00	0.67	0.00	0.33	0.00	2.00	2.33	0.00	0.00	
S11	Reduction of risks through merger, acquisition and integration.	0.04	3.33	7.67	2.00	6.33	2.00	2.00	3.33	0.33	0.33	0.67	0.33	2.33	0.67	1.67	0.00	
S12	Arrangement of proper training to the staff regarding temperature control	0.02	2.00	6.33	0.33	2.00	6.33	0.00	0.00	0.33	3.67	6.33	0.00	0.00	0.00	0.00	0.00	
S13	Adoption of alternative supply of power for cold storage (powerful generator)	0.01	0.67	4.67	0.00	6.00	5.00	0.00	0.00	1.67	2.33	0.33	0.00	0.00	0.00	0.00	0.00	
S14	Arrangement of proper training to the staff regarding processing and hygiene management	0.04	1.67	3.00	0.00	4.67	7.67	0.00	1.67	5.00	6.33	6.33	0.33	0.00	3.67	3.67	1.67	
S16	Lease abandoned land to the farmers for dairy farming	0.04	1.67	0.00	0.33	6.33	0.00	9.00	0.00	0.00	0.00	0.00	0.00	6.33	0.00	0.00	0.00	
S17	Strengthen the regular supply of vaccine	0.02	2.00	0.00	0.00	6.33	1.67	0.00	0.00	0.00	2.00	3.67	0.00	0.00	0.00	0.00	9.00	
S18	Initiative to reduce the cost of feed	0.03	2.00	9.00	0.33	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.33	
S19	Support to develop technology	0.05	5.00	1.67	1.67	7.67	2.33	4.67	3.33	2.33	2.00	2.00	0.00	0.00	1.67	4.67	1.67	
S20	Focus on certified feed supplier to get quality feed.	0.02	0.00	0.33	0.00	9.00	1.67	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	6.33	
S21	Arrangement of adequate grassland for producing Napier grass	0.03	2.00	9.00	0.67	6.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	5.00	
S22	Arrangement of regular vaccination for the cattle	0.01	0.00	0.00	0.00	5.00	3.33	0.00	0.33	1.67	1.67	0.33	0.33	0.00	0.00	0.00	9.00	
S23	Arrangement of improved and upgraded veterinary services	0.02	0.00	0.00	0.00	1.67	1.67	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	9.00	
S25	Building monitoring team	0.01	3.67	5.00	5.00	2.00	7.67	0.00	0.00	5.00	2.00	5.00	1.00	5.00	0.33	0.33	0.00	
S26	Initiative to develop roads and highways	0.01	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.33	0.00	0.00	0.00	0.00	0.00	
S28	Arrangement of refrigerated transport facilities	0.03	0.00	3.33	0.00	0.00	9.00	0.00	0.00	1.67	7.67	6.33	0.00	2.00	0.00	0.00	0.00	
S29	Development of roads and highway	0.02	0.00	6.33	0.00	0.00	0.00	0.00	0.00	0.00	3.67	3.67	0.33	0.00	0.00	0.00	0.00	
S31	Removal of unnecessary influence of middlemen	0.02	6.33	7.67	3.67	0.00	5.00	0.00	0.00	3.33	7.67	6.33	2.00	2.33	0.00	0.00	0.00	
S32	Direct marketing	0.02	6.33	6.33	5.00	0.00	5.00	0.00	0.00	0.33	5.00	5.00	0.67	6.33	0.00	0.00	0.00	
	AI		3.10	3.76	0.95	4.00	2.26	1.79	1.10	1.08	2.17	1.92	0.44	1.37	0.58	0.83	1.79	27.15
	RI		0.11	0.14	0.03	0.15	0.08	0.07	0.04	0.04	0.08	0.07	0.02	0.05	0.02	0.03	0.07	1

5.7 SUMMARY

This chapter has provided the numerical results to optimise the dairy supply chain risk mitigation problem. The results were obtained by following the Quality Function Deployment (QFD) technique based on two dairy case industries. The dairy supply chain risk mitigation problem was optimised for three different groups from both case industries through two types of mathematical programs. The problem was formulated by a linear equation model without consideration of cost savings. When cost savings were considered, the problem was formulated through quadratic integer programming. Importantly, all the necessary values, information and data flows were incorporated with the relevant variables to make the QFD model workable. The result of the analysis of the data and optimisation were also briefly explained in this chapter. The next chapter discusses the research outputs as per the research objectives and questions.

CHAPTER 6: DISCUSSION

6.1 INTRODUCTION

This chapter discusses and presents the findings of the survey that were analysed using the QFD model. It links the discussion of the QFD results with the research questions and objectives. Additional tables and figures are also presented in this chapter to demonstrate the connections between the QFD analyses, research questions and objectives. The first section describes the results for highly probable and high impact risks. The next section explores the highly important strategies for particular risks and compares adopted strategies for particular risks. The next section provides an interpretation of the results of optimal mitigation strategy in response to the second research question. The answers to the research questions are linked with their practical implications in the subsequent section. Possible outcomes emanating from implementing mitigation strategies are then discussed.

6.2 RESULTS FOR HIGHLY PROBABLE AND HIGH IMPACT RISKS

The frequency of risk occurrences and the impact of these risks significantly impact on the supply chain (Trkman and McCormack 2009). The findings of this section show the highest degree of importance for supply chain risks (see Table 5.24) and Appendix 5C. The highest three or four DI (Degree of Importance) values are shown in the following table (Table 6.1) to give a clear idea of the selected highly probable and high impact risks. Table 6.1 identifies highly probable and high impact risks for three groups (employee, executive, supply chain members) of both dairy farms (Nahar and Paharika). In this table, 'Hartal and strike cause delay in work process'(R13) is identified as selects as the most highly probable risk with high impact for respondents from both farms.

The movement of materials from one place to the other is certainly a concern for all stakeholders in a supply chain. Hartals and strikes often impede the transport of raw products from farm house to processing plant as well as the finished products to customers. Delays in the process hinder production and distribution and ultimately lead to customer dissatisfaction (Mishra and Shekhar 2011). So delay caused by hartals and strikes (R13), not only hampers production but also hinders the distribution process and causes products to perish on the way to some extent. This risk was found

to be high for all stakeholders at all levels of the supply chain process. Once the products are passed over to the distributor, then responsibility for these items is borne by them and any deviation in distribution results in penalisation. So this risk has a high impact as it not only results in penalisation, but also brings down profit.

Table 6.1: Identification of Highly Probable and High Impact Risks

Risks	Degree of Importance (DI)					
	Nahar Employees	Nahar Executives	Nahar Supply Chain	Paharika Employees	Paharika Executives	Paharika Supply Chain
R13	0.65	0.78	0.77	0.71	0.81	0.81
R3	0.60	-	-	0.58	0.67	-
R5	0.59	0.64	-	0.64	0.61	-
R8	0.59	-	-	-	-	-
R44	-	-	0.68	-	-	-
R14	-	-	0.72	0.58	-	0.81
R11	-	0.70	-	-	-	-
R40	-	0.70	-	-	-	-
R26	-	-	0.64	-		-
R45	-	-	-	-	-	0.81
R34					0.63	

The highly probable and high impact risks are shown in Table 6.2 below.

Table 6.2: Full Expression of Highly Probable and High Impact Risk

Risks No.		Risks Name
R3	=	High rate of interest
R5	=	Absence of insurance or compensation coverage
R8	=	Illiteracy and inefficiency of worker
R11	=	Lack of fixed government policy in dairy sector
R13	=	Hartal and strike cause delay in work process
R14	=	Political Unrest and interference
R26	=	Cattle diseases
R34	=	Shortage of land for expanding farm
R40	=	Existence of middlemen/ too many middlemen
R44	=	Lack of milk tanker (refrigerated)
R45	=	Unethical behaviour of middle men(adulteration, added price, deprivation)

Employees of both farms and Paharika executives mentioned 'High rate of interest' as one of the highly probable risks. Finch (2004) observes that companies that form supply chain partnerships with other companies that may not be equally sound financially increase their own levels of risk. Farmers have to pay a high rate of interest/financial charges against any kind of borrowed funds. So a rise in the interest rate escalates the cost of funds and consequently may have an impact on profitability (Food 2011a) which may, in turn, bring disaster for all parties within the chain.

The results of this study also reveal that employees and executives of both farms perceived 'Absence of insurance and compensation coverage' (R5) as a highly probable and high impact risk. In this regard, Kleindorfer and Saad (2005) opined that primary suppliers who face severe financial adversity could be particularly harmful for the overall supply chain. According to the Nahar employees, 'Illiteracy and inefficiency of worker' (R8) is also considered to be a highly probable risk with high impact. Illiteracy and inefficiency results in producers having limited access to the complexities of business practices and this creates difficulties, not only for them, but also for the downstream members of the supply chain (Mishra and Shekhar 2012).

Nahar executives mentioned R11, 'Lack of fixed government policy in dairy sector', as a highly probable and high impact risk. They considered that fixed government policies regarding stabilising market prices, controlling high prices of feed and medicine, setting a national milk grid, managing adequate processing facilities, and providing institutional loans through public services are essential for fostering the development and growth of the dairy sector in Bangladesh (Shamsuddoha and Edwards 2000). Government intervention is required to remove different political uncertainties which are responsible for creating various distributional risks as well as affecting the processing activities, by adopting appropriate regulatory actions. Although the Bangladesh government has taken various measures regarding breeding policies and the raising of commercial farms, to date, these government policies have failed to effectively alleviate the risks faced by the industry.

Nahar executives also worry about another highly probable risk, that is, 'Existence of middlemen/too many middlemen' (R40). Dairy production in Bangladesh involves a complex and a long supply chain consisting of too many middlemen. Milk reaches the city markets through a long chain of middlemen (Hashmi 2004). Between the producer and the consumer, costs and time are added for the passage of milk through the big collectors, for transport, for processing in chilling units and milk plants, for retailers till the milk reaches the consumer. The involvement of too many middlemen may result in increases in price and delays in product movement. Because of the perishable nature of milk, this delay creates risk for all members of supply chain.

Paharika supply chain members give the highest priority to 'Political unrest and interference' (R14) and 'Unethical behaviour of middlemen like adulteration, added

price and deprivation' (R45) as highly probable risks for the dairy supply chain with high impact. Rao and Goldsby (2009) and Akcaoz, Kizilay and Ozcatalbas (2009) discussed risk R14 and R45 is discussed by Chowdhury 2007; Blos, Quaddus and Wee 2009; Peck 2005. R14 is also perceived as a highly probable risk with high impact by the supply chain members of Nahar and the employees of Paharika Dairy. It is unfortunate that, although a favourable political and economic climate is a pre-condition for the development of any business in any country in the world, it is too polluted and confrontational in Bangladesh. Personal and political antagonism between political opponents and a lack of respect for the elementary principles of democratic governance have given birth to a culture of corruption, bribery, hooliganism, and musclemanship. All activities from the farm level to the top level are hindered by such political unrest and interference.

The involvement of middlemen is quite common in the Bangladesh dairy supply chain, where milk is likely to be adulterated through the changing of hands, by mixing with water to increase volume, adding sodium bicarbonate to minimise acidity and adding starch and sugar to increase solid content. Adulterated milk is the main carrier of dangerous diseases feared by consumers. Adulteration and contamination lead to quality deterioration which is also liable to abolish the goodwill of company. Supply chain members of Nahar identified 'Lack of refrigerated milk tanker' (R44) as high risk area with high impact. Milk has to be kept cold throughout the marketing chain as it has a tendency to spoil very quickly in the tropical weather. So the provision of refrigerated transport is necessary to keep it fresh (Abdullah 2004). Milk can be transported unrefrigerated for a short distance and duration but within 5-7 hours of milking, it begins to sour and becomes useless. As a result, the quality of product deteriorates.

It was estimated that around 35,000 litres of milk is spoiled every day in Bangladesh due to non-availability of a central milk collection system and good transport facilities (Rahman 2015). Most of the dairy companies, including the case companies, are used to adding ice to save milk from spoilage. It dilutes the milk, resulting in deteriorating quality and reduction of total solid contents (Curtis 2011).

Shortage of land for expanding farms (R34) was also perceived to be a highly probable risk area by Paharika executives, for whom farm expansion was not possible (Ali and Kapoor 2008; Choudhary et al. 2011). Executives of Paharika farm mentioned that it is

difficult to expand their farming activities due to the shortage of land. They also added that, because of the shortage of land, it is difficult to grow green fodder for their cattle. Due to the shortage of green pastures for cattle, they have to buy dry fodder in the market which is definitely costlier.

Cattle diseases (R26) pose the biggest risk to the dairy supply chain. Nahar supply chain members observed that there is a high frequency of occurrence of different cattle diseases in Bangladesh. This has high impact, causing substantial economic losses for the dairy industry. These diseases include anthrax, lumpy skin disease, rabies, bovine tuberculosis and brucellosis (Choudhary et al. 2011). Most of the diseases negatively affect milk production and some of them affect the fertility of animals. For example, brucellosis causes abortion during the pregnancy of cattle. The major causes of economic losses due to disease are mortality, morbidity and post slaughter condemnation. An outbreak of the abovementioned diseases could disrupt the normal flow of the milk supply chain in Bangladesh. The simple reason for the frequent outbreaks of cattle diseases in Bangladesh is the shortage of veterinary services and diagnostic laboratories. Although there are vaccines available to manage these diseases, they are still largely inaccessible in the public domain.

6.2.1 Mitigating strategies for the highly probable and high impact risks

This section discusses mitigation strategies for the highly probable and high impact risks based on relationship (REL) scores. For this purpose, highly probable and high impact risks are collected from Section 6.2. At the same time Table 6.3 represents selected mitigation strategies for highly probable and high impact risks. Twenty two mitigation strategies (Table 6.4) were selected on the basis of relationship scores considering the REL scores of equal to or more than 2.50. The relationship scores were collected using a four-point scale of 0, 1, 5 and 9. These four points denote no relation, little relation, moderate relation and strong relation respectively between risks and mitigation strategies. Hence, the REL scores of 2.50 and above stand between little relation and strong relation. Thus various risks can be mitigated through implementing strategies.

Table 6.3: Mitigation Strategies for Highly Probable and High Impact Risks

Risks	Mitigation Strategy	Nahar Employees	Paharika Employees	Nahar Executives	Paharika Executives	Nahar Supply Chain	Paharika Supply Chain
R3	S6	2.50					
	S7	8.33	9.00		7.67		
	S8		3.50		6.33		
	S10		2.50				
R5	S2	5.50	7.50	6.33	9.00		
	S6			6.00			
	S7			3.00			
	S11	2.50	4.33	4.67	3.33		
R8	S3	6.83					
	S4	4.00					
	S12	3.33					
	S14	5.33					
R11	S6			7.67			
	S18			3.33			
R13	S5	6.17	7.00	6.00	9.00	7.00	9.00
	S6		2.67	6.00	3.33	2.50	
	S18						4.50
R14	S5		9.17			9.00	9.00
	S6		3.33			3.00	
R26	S2					9.00	
	S6					2.50	
	S11					2.50	
	S15					5.00	
	S17					5.00	
	S22					9.00	
	S23					7.00	
R34	S16				9.00		
	S24				9.00		
R40	S10			3.33			
	S11			6.00			
	S25			6.00			
	S31			7.67			
	S32			9.00			
R44	S7					2.50	
	S10					2.50	
	S28					9.00	
R45	S10						2.50
	S11						2.50
	S31						9.00
	S32						7.00

Selected mitigation strategies are shown in table 6.4.These strategies are from table 6.3 with REL≥2.50.

Table 6.4: List of Selected Strategies

No.		Strategy Name	No.		Strategy Name
S2	=	Buying insurance against production loss.	S15	=	Attempts to create various cross breeds by adopting AI services.
S3	=	Hiring skilled staff	S16	=	Lease abandoned land to the farmers for dairy farming
S4	=	Motivational and incentives facilities for staff	S17	=	Strengthen the regular supply of vaccine
S5	=	Initiative to remove political uncertainty	S18	=	Initiative to reduce the cost of feed
S6	=	Implementation of a fixed policy for dairy sector	S22	=	Arrangement of regular vaccination for the cattle
S7	=	Assurance of adequate institutional credit support with low rate of interest	S23	=	Arrangement of improved and upgraded veterinary services
S8	=	Introducing off-farm activities	S24	=	Building multi-storeyed complex for farm extension
S10	=	Promote sound business practices by cooperation, better coordination and information sharing	S25	=	Building monitoring team
S11	=	Reduction of risks through merger, acquisition and integration.	S28	=	Arrangement of refrigerated transport facilities
S12	=	Arrangement of proper training to the staff regarding temperature control	S31	=	Removal of unnecessary influence of middlemen
S14	=	Arrangement of proper training to the staff regarding processing and hygiene management	S32	=	Direct marketing

Table 6.3 shows that stakeholders of both the case industries have suggested strategy (S5)'Initiative to remove political uncertainty' as the most important for mitigating risk (R13)'Hartal and strike cause delay in work process' which emerged as the most highly probable risk with high impact. A favourable political environment is the key factor for the development of any kind of business in any country in the world. Unfortunately the political environment is too polluted in Bangladesh (Chowdhury 2007). Such tumultuous political situations ultimately cause problems for businesses. Sometimes a series of frequent and prolonged hartals and strikes causes delays in the work process and supply network of dairy products. This also badly affects the health of the political environment and the socio-economic condition of the country as well. To remove this risk, Bangladesh needs to establish a market-oriented economy based on a sound regulatory structure and supported by the instruction of law (Chowdhury 2007). Government support with a stable policy and structure that direct all actors is the best guarantor of political stability.

Dairy executives report that they have requested all major political parties to protect this sector from political activities so that they can establish a smooth supply of dairy products all over the country. In response, political parties are strongly considering their appeal to protect their industry from such harmful political events. Recently, political activities like strikes and Hartals are not applicable for the supply of perishable goods so that industries will not be affected. This is a good sign, although

the dairy industry needs more support from political institutions that ultimately hold the power to produce effective policy and sustainable implementation of such policies.

Strategy (S7) 'Assurance of adequate institutional credit support with low rate of interest' is another important mitigation strategy to reduce the high impact of dairy risk. All the groups of Nahar Dairy have suggested this strategy for mitigating the three highly probable risks (R3, R5 and R44). These risks are associated with rates of interest, buying insurance and buying milk tankers. All these risks can be resolved once farms can receive credit support with low interest rates. In reality, institutional support for dairies is very limited in Bangladesh. In the absence of adequate institutional credit support, farmers cannot acquire loans during any type of hazard risks. In recent years, different NGOs have distributed 50–55% of their annual rural development loans to livestock activities (Jabbar 2010). However, only a small share of the disbursed loans goes to dairy farms, as most of the NGOs provide loans to the poor and landless farmers for raising small stock animals. Institutional credit support with a lower rate of interest is needed for the expansion of dairy farms, enabling them to cover various expenses relating to animal health, breed management, extension services, feed management and disease management.

The Bangladesh government has introduced a policy to disburse loans to farmers in the livestock sectors at low interest rates. At the same time, the World Bank, IMF, Asian Development Program (ADP), DFID, DANIDA and others introduced almost the same strategy for the sake of developing the dairy sector in Bangladesh. It may take a couple of decades to get ultimate results, but it is a good initiative for dairy farms to receive maximum support through these kinds of funds. Now, the dairy owners have started complaining about the loan strategies as they involve political people. Nevertheless, it is a good start which may result in something good for the country in general and the dairy sector in particular.

Likewise, mitigation strategy (S11) 'Reduction of risks through merger, acquisition and integration' could solve the risks R5, R26, R40 and R45. These risks are linked with insurance compensation, controlling cattle disease, removing too many middlemen and controlling unethical behaviour of middlemen. For example, if a few farms were to merge, then they could buy insurance, as the aggregate costs would be less than for an individual farm. On top of that, too many middlemen can be removed through mergers, acquisitions and the integration of several dairy farms. Integrated farms can establish

their own supply chain network to reduce the middlemen and control their unethical behaviour. Unfortunately, there is no example of a successful merger, acquisition or integration of dairy farms in Bangladesh. However, there are a number of cooperatives working together to collect milk from rural areas and supply it to processing centres for reprocessing. These cooperatives are successful enough to maximise their profit and involve a significant number of people. These cooperatives are characteristically similar to integrated networks, though it is a different concept from the merger. However, both the case industry employees, executives and supply chain members identified the importance of integration for making extra profit and adopting logistics support.

Furthermore, R3, R5, R11, R13, R14, and R26 can be controlled through Strategy (S6) 'Implementation of a fixed policy for dairy sector'. Reasonable interest rates, insurance coverage and compensation, a fixed government policy for the dairy industry, avoiding political activities and political unrest, and controlling cattle disease are the main risks mitigated through the use of strategy S6. Dairy industry stakeholders have long demanded such fixed government policy. They believe that the government is the only authority that can implement such changes through establishing rules, regulation and strict policies. Six groups from both case industries gave this strategy a high score in relation to these risks. They also opined that most of the problems can be solved if the government implements such policies for the sake of developing the dairy industry.

Four different mitigation strategies have been discussed in the above section. A total of twenty two strategies were selected by the different groups of the selected case industries. Table 6.3 shows that S31 and S32 are favoured by the Nahar executives and Paharika supply chain respectively. This may be because Nahar executives are focused on strategies of removal of middlemen and direct marketing, but Paharika executives are focused on other approaches based on their priorities and visionary plans. Sometimes, company executives directly interfere in supply chain and distribution work for the sake of making greater profits and earning goodwill and reputations. Again it depends on individual farm strategies and plans. The six groups suggested a few other mitigation strategies which are common between the two case industries, but they earned different REL scores. In fact REL scores determine the relationship status between risks and strategies. Strategies with higher scores get higher priority than strategies with lower REL scores. Therefore, this discussion is successfully

delivered the degree of relationship between risks and mitigation strategies of this study.

6.3 EXPLORING THE HIGHLY IMPORTANT STRATEGIES TO MITIGATE RISKS

This section explores the strategies for mitigating dairy risks on the basis of highest relative importance (RI). This refers to data on RI collected during Phase 1 of the QFD analysis (Section 5.5.1.8). The strategies with respect to the top five RIs for different groups are considered as highly important strategies to mitigate risks. At the same time, risks are ranked based on the relationship index (REL). This research considers the highest relationship score (REL) between risk and mitigation strategies as 6.0 and above scores of REL 6.0 and above indicate the most highly prioritised strategies to mitigate highly probable and high impact risks. Due to budget constraints, REL scores of 6.0 and above are considered instead of 5.0 or below. If the farm budget is sufficient, it can implement all the strategies to mitigate every risk. As mentioned before in Section 5.5.1.4, the linguistic scales used to determine relationships between risks and mitigation strategies were 0–1–5–9 (no–weak–medium–strong). The relationships between medium and strong (REL value more than6) are considered while the no and weak relationships are ignored. This section identifies appropriate strategies to mitigate risks for sustainable outcomes in the dairy industry. Tables 6.5, 6.6, 6.8, 6.9, 6.10, 6.11, 6.12 and 6.13 shows suitable strategies based on the judgment of different groups from the selected case industries. The calculation of RI values for different groups are shown in Chapter 5 (Table 5.31) and in Appendix 5 (Tables 5F, 5G, 5H, 5I and 5J).

Group 1: Employees

Nahar Dairy employees prioritised risks and mitigation strategies (see Table 6.5). Nahar employees considered three strategies for mitigating eleven risks based on highest RI values and REL scores respectively. This table shows that Nahar employees select the five highest mitigation strategies (S1, S2, S3, S4 and S6) to mitigate risks R1, R6, and R7. Other risks are also shown in Table 6.5. For example, if strategy S1 is implemented, then R6, R22, R24, and R25 could be mitigated for better performance. Likewise, R7, R8, R9 and R37 could be mitigated by implementing StrategyS3and R1, R11, R33 and R37 could be mitigated by implementing Strategy S6. The relationshipsofR6S1 and R11S6 scored the highest (9.00) among the REL scores. Hence, this highest relationship articulates that R6 and R11 could be best mitigated byS1 and S6 respectively. Table 6.5 also shows the specific relative importance (RI)

values of each particular mitigation strategy to identify the most suitable approach for the company. S3 has the highest RI value (0.08) than other strategies which highlights its priority over other strategies.

Table 6.5: Highly Important Strategies (Nahar Employees)

	Strategy Number	S1	S2	S3	S4	S 6
Risk Number	Mitigation Strategy / Risk	Adoption of improved technology (milking machine, feed mixture, grass cutting, improved processing facilities)	Buying insurance against production loss	Hiring skilled staff	Motivational and incentives facilities for staff	Implementation of a fixed policy for dairy sector
R1	Inadequate loan facilities					**6.17**
R 6	Shortage of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	**9.00**				
R 7	Labour disputes			**6.33**	**7.67**	
R 8	Illiteracy and inefficiency of worker			**6.83**		
R 9	Shortage of skilled staff			**8.33**		
R10	Switching of staff frequently				**6.83**	
R 11	Lack of fixed government policy in dairy sector					**9.00**
R15	Corruption (Adulteration by mixing water)				**7.00**	
R18	Natural disaster (flood, excessive rain, storm)		**7.50**			
R20	Machine damage/breakdown at cold storage		**7.50**			
R 22	Inadequate cold storage	**6.33**				
R 24	Bacterial contamination for improper temperature	**6.33**				
R 25	Pollution and Unhygienic environment	**6.17**				
R26	Cattle diseases		**6.17**			
R27	Machine damage/breakdown at processing unit		**7.00**			
R28	Fire at farm shed		**7.17**			
R 33	Lack of upgrade vaccination and veterinary services					**6.17**
R 37	Bureaucratic complexity on maintaining various formalities			**6.83**		**6.17**
Absolute Importance (AI)		26.37	20.72	32.84	19.83	28.66
Relative Importance (RI)		0.07	0.05	**0.08**	0.05	0.07

Note: Table containing all values is shown in Table 5.31 in Chapter 5

Strategy (S1) 'Adoption of improved technology' acquired the highest score (9) for mitigating risk R6 'Shortage of improved technology'. For instance, if a farm adopts improved technology in the form of milking machines, feed mixtures, grass cutting, or improved processing facilities, then they can easily overcome the shortage of improved technology. Choudhary et al. 2011 and Ahsan 2011 also emphasise the adoption of improved technologies. On the other hand, some respondents chose S6 which is related to the implementation of fixed government policy on dairy industry. This variable is discussed by Shamsuddoha and Edwards 2000 and Shrestha and Yadav 2004. So the respondents rightly expressed their opinions in relation to S1 and S6. 'Implementation

of fixed government policy' (S6) and 'Lack of fixed government policy in dairy sector' (R11) have a strong relationship and thus risk R11 can be solved through implementing strategy S6.

If there is a fixed government policy for the dairy industry, farms can access many facilities at a time to mitigate multiple risks. For example, if there was a fixed government policy regarding a system for moving milk from the rural milk sheds to urban milk consuming demand centres, producers would get a good price without middlemen deprivation. Simultaneously, this would be helpful for developing a regular and secure market for their products. Although S1 and S6 have high REL scores, (S3) 'Hiring skilled staff' acquires the highest RI which makes it most important of the five strategies. Farms can hire skilled people (S3) more easily than they can than adopt the strategy (S1) 'Adoption of improved technology' due to costs. Adaptation of new technologies costs more than hiring skilled staff for particular tasks. Application of (S6) 'Implementation of fixed government policy' is also beyond the control of farms as it comes from a government authority. This statement is verified by the previous cases of China's milk scandal and food product policy for industrialised and developing countries respectively (Henson and Reardon 2005; Jia et al. 2012).

Paharika employees categorised existing risks and mitigation strategies as shown in Table 6.6. They classified five mitigation strategies and 23 risks based on the highest RI and REL scores respectively. They selected mitigation strategies (S1, S2, S3, S6 and S7) to mitigate risks R1-R6, R8, R9, R11, R16, and others. For instance, if mitigation strategy S3is chosen, then risks R8, R9, R20, R23 and R37 could be mitigated in the Paharika dairy industry for maximum output. Similarly, Strategy (S2)'buying insurance against production loss' could mitigate risks R5, R16, R18, R20, R27, R28, and R29. This finding supports the earlier findings of Wolf, Roy Black and Hadrich (2009) and Van Asseldonk and Meuwissen (2006) concerning the way a farm/industry can protect its assets from different unusual incidents, including natural disasters. Risks R1, R2, R3, and R4 could be mitigated by employing Strategy (S7) 'adequate institutional credit support with low rate of interest'.R3S7, R6S1, R9S3, R11S6 and R22S1 have the highest REL scores. Ahsan (2011), Chowdhury (2007), Shamsuddoha and Edwards (2000) and Shamsuddin, Alam, Hossein, Goodger, Bari, Ahmed, Hossain, et al. (2007) have also found that adequate financial credit support can solve a number of problems for a farm.

Table 6.6 shows the RI values and highlights the most appropriate strategy from among the whole list. It shows that S3 has a higher RI value than the other four strategies. This means that S3 is the most important of all the strategies. The strategy of 'Hiring skilled staff (S3)' has the highest score (9) for the risk of 'Shortage of skilled staff (R9)'. The shortage of skilled staff could be mitigated by hiring skilled staff at different levels of operation in the dairy farms. Tipples and Morriss 2002 and Morriss et al. 2006 also saw this as the solution to a shortage of skilled staff. Employees from both farms detected five strategies but they prioritised a different number of risks (see Table 6.7). Nahar employees identified 18 risks while Paharika employees identified 23 risks. In contrast, employees of both farms scored the same RI value for S3. In terms of strategy ranking, S1, S2, S3 and S6 are common, whereas Paharika included the additional strategy of S7. Table 6.7 also shows the relationship scores for Nahar and Paharika respectively.

Group 2: Executives

Table 6.8 shows that Nahar executives referred to five strategies (S3, S4, S6, S19 and S25). According to them, the most important strategy for mitigating dairy risk is (S6) 'Implementation of a fixed policy for dairy sector) which has the highest RI value of 0.08. Shamsuddoha and Edwards (2000) and Shrestha and Yadav (2004) also emphasise the importance of this strategy. Appropriate and essential fixed policies can help farmers boost their existing operations for greater profitability. There are significant relationships between R10S4, R15S25, R17S25, R21S19, R22S19 and R24S3 as all of these possess the highest REL score which is 9.00. Nahar executives highlighted Strategy S6 (0.08) to mitigate four different risks,(R5, R11, R12, and R35).

Executives also prioritised S3 (0.06) for mitigating six risks (R6, R7, R8, R23, R24 and R25). Similarly, implementation of Strategy S25 (0.05) can mitigate or minimise risks R15, R17 and R45. Likewise, the effects of risks R10, R16, R17, R23 and R37 could be reduced by applying Strategy S4 (0.05). These findings on implementing mitigation strategies for particular risks are also reflected in the real-life dairy supply chain. For example, on farms which focus on different incentives for staff (S4), such as bonuses, financial rewards, medical allowances, and house rent, the frequency rate of switching of staff (R10) from this farm is reduced by a striking amount. Theft (R17) and different forms of mismanagement of employees (R16, R23) could also be controlled by providing various social and financial benefits. Abdullah (2004) discusses this in his research on cost effective technologies for milk preservation and processing.

Table 6.6: Highly Important Strategies (Paharika Employees)

	Strategy Number	S 1	S 2	S 3	S 6	S 7
Risk Number	Mitigation Strategy / Risk	Adoption of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	Buying insurance against production loss.	Hiring skilled staff	Implementation of a fixed policy for dairy sector	Assurance of adequate institutional credit support with low rate of interest.
R 1	Inadequate loan facilities					**8.33**
R 2	Complex loan procedures					**7.00**
R 3	High rate of interest					**9.00**
R 4	Inadequate finance					**7.67**
R 5	Absence of insurance or compensation coverage		**7.50**			
R 6	Shortage of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	**9.00**				
R 8	Illiteracy and inefficiency of worker			**6.83**		
R 9	Shortage of skilled staff			**9.00**		
R 11	Lack of fixed government policy in dairy sector				**9.00**	
R 16	Damage of farm's assets		**6.17**			
R 18	Natural disaster (flood, excessive rain, storm)		**8.33**			
R 19	Quick perishability of milk	**8.33**				
R 20	Machine damage/breakdown at cold storage		**6.83**	**6.17**		
R 21	Inadequate chilling facilities	**7.00**				
R 22	Inadequate cold storage	**9.00**				
R 23	Spoilage of milk through improper handling			**8.33**		
R 24	Bacterial contamination for improper temperature	**7.67**				
R 27	Machine damage/breakdown at processing unit		**6.83**			
R 28	Fire at farm shed		**7.50**			
R 29	Accident (Staff injury)		**6.17**			
R 35	Irregular supply of vaccine from government					
R 37	Bureaucratic complexity on maintaining various formalities			**6.33**		
R 44	Lack of milk tanker (refrigerated)	**7.00**				
Absolute Importance (AI)		28.70	28.46	33.01	27.13	27.65
Relative Importance (RI)		0.07	0.07	**0.08**	0.06	0.06

Note: Table containing all values is shown in appendix 5H.

Table 6.7: Nahar Employees vs. Paharika Employees

Particulars	Nahar Dairy	Paharika Dairy
Total Strategies Selected	5	5
Total Risks Considered	18	23
Highest RI Value	0.08	0.08
Important Strategies	S3, S6, S1, S2, S4	S3, S1, S2, S7, S6
Top Relationships (at least 5)	R6S1, R11S6, R9S3, R22S1, R3S7	R3S7, R6S1, R9S3, R11S6, R22S1

Table 6.8: Highly Important Strategies (Nahar Executives)

	Strategy Number	S 3	S 4	S 6	S19	S25
Risk Number	Mitigation Strategy / Risk	Hiring skilled staff	Motivational and incentives facilities for staff	Implementation of a fixed policy for dairy sector	Support to develop technology	Building monitoring team
R 5	Absence of insurance or compensation coverage			**6.00**		
R 6	Shortage of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	**6.33**			**6.00**	
R 7	Labour disputes	**6.00**				
R 8	Illiteracy and inefficiency of worker	**6.33**				
R10	Switching of staff frequently		**9.00**			
R11	Lack of fixed government policy in dairy sector			**7.67**		
R12	Poor law and order situation (terrorism, musclemen ship)			**7.67**		
R15	Corruption (adulteration by mixing water)					**9.00**
R16	Damage of farm's assets		**6.00**		**6.00**	**7.67**
R17	Theft		**6.33**		**6.33**	**9.00**
R21	Inadequate chilling facilities				**9.00**	
R22	Inadequate cold storage				**9.00**	
R23	Spoilage of milk through improper handling	**7.67**	**6.33**			**6.33**
R24	Bacterial contamination for improper temperature	**9.00**			**6.00**	
R25	Pollution and Unhygienic environment	**6.00**				
R26	Cattle disease				**6.00**	
R32	Scarcity of feed				**6.00**	
R34	Support to develop technology				**6.00**	
R35	Irregular supply of vaccine from government			**6.00**		
R37	Bureaucratic complexity on maintaining various formalities		**6.00**			
R40	Existence of middlemen/ too many middlemen					**6.00**
R41	Too long chain cause delay in product movement					**6.00**
R45	Unethical behaviour of middle men(adulteration, added price, deprivation)					**7.67**
Absolute Importance (AI)		29.16	25.74	38.48	34.06	26.54
Relative Importance (RI)		0.06	0.05	**0.08**	0.07	0.05

Note: Table containing all values is shown in Appendix 5F.

Table 6.9 shows the ranked risks and mitigation strategies as described by Paharika executives. In Table 6.9, Paharika executives' identified five mitigation strategies associated with twenty four risks having the highest RI and REL scores respectively. The executives identified five mitigation strategies, (S1, S3, S5, S6 and S7), to mitigate risks R1, R3, R4, R6 and others shown in Table 6.9. The executives opined that risks R6, R17, R19, R21-R25 and R44 could be mitigated by implementing Strategy S1 (0.07). Interestingly, although Strategy S6 gained highest RI value (0.08), it can mitigate only three risks (R11, R33 and R37). This is because it is beyond the control of the farm

(Shamsuddoha and Edwards 2000, Shrestha and Yadav 2004). The relevant policy comes from a government authority which has no connection with farm decisions. Without government intervention, farms cannot enact any policy for the betterment of their business.

Table 6.9: Highly Important Strategies (Paharika Executives)

	Strategy Number	**S1**	**S3**	**S5**	**S6**	**S7**
Risk Number	**Mitigation Strategy** / **Risks**	**Adoption of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)**	**Hiring skilled staff**	**Initiative to remove political uncertainty**	**Implementation of a fixed policy for dairy sector**	**Assurance of adequate institutional credit support with low rate of interest.**
R 1	Inadequate loan facilities					**9.00**
R 3	High rate of interest					**7.67**
R 4	Inadequate finance					**9.00**
R 6	Shortage of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	**9.00**	**6.33**			**9.00**
R 7	Labour disputes		**6.00**			
R 8	Illiteracy and inefficiency of worker		**9.00**			
R 9	Shortage of skilled staff		**7.67**			
R 11	Lack of fixed government policy in dairy sector				**9.00**	
R12	Poor law and order situation (terrorism, musclemen ship)			**7.67**		
R13	Hartal and strike cause delay in work process			**9.00**		
R14	Political Unrest and interference			**9.00**		
R 16	Damage of farm's assets		**6.00**			
R 17	Theft	**9.00**				
R 19	Quick perishability of milk	**9.00**				
R 20	Machine damage/breakdown at cold storage		**6.33**			
R 21	Inadequate chilling facilities	**9.00**				
R 22	Inadequate cold storage	**9.00**				
R 23	Spoilage of milk through improper handling	**9.00**				
R 24	Bacterial contamination for improper temperature	**7.67**	**6.33**			
R 25	Pollution and Unhygienic environment	**9.00**				
R 33	Lack of upgrade vaccination and veterinary services				**7.67**	
R 37	Bureaucratic complexity on maintaining various formalities				**6.33**	
R 39	Accidents of transport vehicle		**6.33**			
R 44	Lack of milk tanker (refrigerated)	**9.00**				
Absolute Importance (AI)		24.45	29.12	19.93	29.23	24.71
Relative Importance (RI)		0.07	0.08	0.05	**0.08**	0.07

Note: Table containing all values is shown in Appendix 5I.

S3 (0.08) could also decrease risks R6-R9, R16, R20, R24 and R39, and the deployment of Strategy S7 (0.07) would improve the situation in relation to risks R1, R3, R4, and R6. The results obtained from the QFD analysis (shown in Table 6.9) show that R6S1, R17S1, R19S1, R21S1, R22S1, R23S1, R25S1 and R44S1 scored highest of all REL scores for Strategy S1. At the same time, R8S3 and R11S6 gained the highest REL scores under Strategies S3 and S6 respectively. Strategy S7 prioritised risks R1, R4 and R6 in regards to highest REL scores. Ahsan (2011), Chowdhury (2007), Shamsuddoha and Edwards (2000), Shamsuddin et al. (2007) discuss the importance of an assurance of adequate institutional credit support with a low rate of interest. Low interest can save a farmer in a various ways, including reducing costs and increasing profitability. Table 6.9 also shows aggregate RI value to measure the top most highly prioritised approaches among thirty two mitigation strategies. S6 (0.08) has a higher RI value than other strategies. This means that S6 is the most important strategy, although S1 and S3 can mitigate the maximum number of risks with different scores.

The strategy of 'Assurance of adequate institutional credit support with low rate of interest (S7)' gained the highest score (9.00) for the risks of 'Inadequate loan facilities (R1)', 'Inadequate finance (R2)' and 'Shortage of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities) (R6)'. It is understandable that credit support with low interest could solve the problem of inadequate loan facilities, over expenses for with high interest for buying sophisticated improved technology. Such improvements on several existing risks could help the farm to gain more profit through reducing costs and adopting technological equipment for better efficiency.

Paharika and Nahar executives have also selected five strategies (shown in Table 6.10). Three strategies (S1, S3 and S6) are common to both farms, but Nahar executives have chosen Strategy S4 while Paharika executives have selected Strategy S7. The table also shows the top four relationship scores for each farm. In fact they have prioritised many other risk and strategy relationships through positioning different scores.

Table 6.10: Nahar Executives vs. Paharika Executives

Particulars	Nahar Dairy	Paharika Dairy
Total Strategies Selected	5	5
Total Risks Considered	23	24
RI Value	0.08	0.08
Important Strategies	S6, S19, S3, S25 and S4	S6, S3, S7, S1 and S5
Top Relationship (at least four)	R10S4, R15S25, R17S25 and R22S19	R1S7, R4S7, R6S1 and R6S7

Group 3: Supply chain members

In this study, Nahar supply chain members opined that (See Table 6.11) five major strategies (S1, S3, S6, S7 and S14) have the highest capacity to mitigate sixteen different risks, R1, R2, R3, R6 R8 and others, based on highest RI values. Among those strategies, the most important is S6 with an RI value of 0.09. The highest relationship score (REL) (9.00)was achieved by relationships R1S7, R3S7, R6S1, R9S3, R11S6, R19S1, R20S3, R33S6 and a few others. They suggested that 'Shortage of skilled staff' (R9) and 'Machine breakdown from improper handling' (R20) could be best mitigated by Strategy (S3) 'Hiring skilled staff'. In practice, skilled staff can easily be trained to deal with sophisticated matters such as bacterial contamination, temperature management, value addition and technological device usage. The milking machine is one of the important instruments for the dairy industry and staff can be trained to use it appropriately to get maximum production. All these problems can be solved through hiring skilled staff.

Table 6.11: Highly Important Strategies (Nahar Supply Chain)

	Strategy Number	**S1**	**S 3**	**S 6**	**S 7**	**S14**
Risk Number	**Risk** / **Mitigation Strategy**	**Adoption of improved technology (milking machine, feed mixture, grass cutting, improved processing facilities)**	**Hiring skilled staff**	**Implementation of a fixed policy for dairy sector**	**Assurance of adequate institutional credit support with low rate of interest.**	**Arrangement of proper training to the staff regarding processing and hygiene management**
R 1	Inadequate loan facilities				**9.00**	
R 2	Complex loan procedures				**7.00**	
R 3	High rate of interest				**9.00**	
R 6	Shortage of improved technology (milking machine, feed mixture, grass cutting, improved processing facilities)	**9.00**				
R 8	Illiteracy and inefficiency of worker		**7.00**			
R 9	Shortage of skilled staff		**9.00**			**9.00**
R11	Lack of fixed government policy in dairy sector			**9.00**		
R19	Quick perishability of milk	**9.00**				**7.00**
R20	Machine damage/breakdown at cold storage		**9.00**			
R21	Inadequate chilling facilities	**9.00**				
R24	Bacterial contamination for improper temperature	**7.00**	**7.00**			**7.00**
R25	Pollution and Unhygienic environment					**9.00**
R27	Machine damage/breakdown at processing unit		**7.00**			**9.00**
R30	Inadequate supply of quality feed			**7.00**		
R33	Lack of upgrade vaccination and veterinary services			**9.00**		
R35	Irregular supply of vaccine from government			**7.00**		
Absolute Importance (AI)		18.03	21.90	29.15	27.49	18.50
Relative Importance (RI)		0.05	0.07	**0.09**	0.08	0.06

Note: Table containing all values is shown in appendix 5G.

On the other hand, Table 6.12 shows the hierarchical risks and mitigation strategies selected by Paharika supply chain members. They have selected seventeen risks and five important mitigation strategies relying on highest RI and REL scores respectively. Here, Paharika supply chain members identified five mitigation strategies, S1, S5, S7, S28 and S31, which can alleviate risks R1-R3, R6, R12-R15, R19 and others. For example, supply chain members judged Strategy S7 (0.07) as the most important strategy to reduce risks R1, R2 and R3. Similarly, R12, R13 and R14 could be mitigated through implementing Strategy S5.

Table 6.12: Highly Important Strategies (Paharika Supply Chain)

	Strategy Number	**S 1**	**S 5**	**S 7**	**S28**	**S31**
Risk Number	**Mitigation Strategy / Risks**	**Adoption of improved technology (milking machine, feed mixture, grass cutting, improved processing facilities)**	**Initiative to remove political uncertainty**	**Assurance of adequate institutional credit support with low rate of interest.**	**Arrangement of refrigerated transport facilities**	**Removal of unnecessary influence of middlemen**
R 1	Inadequate loan facilities	0.00	0.00	**9.00**	0.00	0.00
R 2	Complex loan procedures	0.00	0.00	**9.00**	0.00	0.00
R 3	High rate of interest	0.00	0.00	**9.00**	0.00	0.00
R 6	Shortage of improved technology (milking machine, feed mixture, grass cutting, improved processing facilities)	**9.00**	0.00	5.00	0.00	0.00
R12	Poor law and order situation (terrorism, musclemen ship)	0.00	**9.00**	0.00	0.00	0.00
R13	Hartal and strike cause delay in work process	0.00	**9.00**	0.00	0.00	0.00
R14	Political Unrest and interference	0.00	**9.00**	0.00	0.00	0.00
R15	Corruption (adulteration by mixing water)	**7.00**	0.00	0.00	0.00	0.00
R19	Quick perishability of milk	**9.00**	0.00	0.00	4.50	0.00
R21	Inadequate chilling facilities	**9.00**	0.00	5.00	4.50	0.00
R22	Inadequate cold storage	**9.00**	0.00	5.00	4.50	0.00
R24	Bacterial contamination for improper temperature	**7.00**	0.00	0.00	4.50	0.00
R40	Existence of middlemen/too many middlemen	0.00	0.00	0.00	0.00	**9.00**
R41	Too long chain cause delay in product movement	0.00	0.00	0.00	0.00	**9.00**
R42	Poor conditioned road for moving product (delay & spoilage)	0.00	0.00	0.00	**9.00**	0.00
R44	Lack of milk tanker (refrigerated)	0.00	0.00	0.00	**9.00**	0.00
R45	Unethical behaviour of middlemen (adulteration, added price, deprivation)	0.00	0.00	0.00	0.00	**9.00**
Absolute Importance (AI)		19.97	20.62	21.67	21.25	18.45
Relative Importance (RI)		0.06	0.07	0.07	0.07	0.06

Note: Table containing all values is shown in appendix 5J.

The strategy of 'Initiative to remove political uncertainty (S5)' was perceived to be one of the important strategies for solving three major risks. These three risks are 'Poor

law and order situation (terrorism, musclemenship) (R12)', 'Hartal and strike cause delay in work process (R13)' and 'Political unrest and interference (R14)'. Bangladesh is an unstable country in regard to political uncertainty. Political uncertainty consists of corruption of political leaders, personal and political antagonism between political opponents, musclemenship, and hooliganism. Moreover, different political parties have diverse policies which hinder the consistent development of the dairy industry. In this situation, if the government or related authorities were to take the initiative to reduce such uncertainties, such problems could be removed from the dairy industry. Distribution and other operations of the dairy industry would be smooth if political uncertainties were removed.

Both groups of supply chain members have chosen five strategies (Table 6.13), but they have selected different strategies and risks in light of their practical experiences. Paharika employees selectedS1, S3, S6, S7 and S14, whereas Nahar employees selected S1, S5, S7, S28 and S31 relying on highest RI values. Nahar and Paharika Dairies scored different RI values of 0.09 and 0.07. Table 6.13 shows the top four relationships scores for Nahar and Paharika respectively.

Table 6.13: Nahar Supply Chain vs. Paharika Supply Chain

Particulars	Nahar Dairy	Paharika Dairy
Total Strategies Selected	5	5
Total Risks Considered	16	17
RI Value	0.09	0.07
Strategy Ranking	S6, S7, S3, S14 and S1	S7, S28, S5, S1 and S31
Top Relationship (at least four)	R1S7, R3S7, R9S3 and R11S6	R1S7, R2S7, R3S7 and R6S1

At the end, it is observed that both farms and their stakeholders (employees, executives and supply chain members) are looking for suitable strategies which can be implemented in their industry for more sustainable outcomes. Different stakeholders have chosen different numbers and types of strategies and risks based on their particular farm requirements. Interestingly, stakeholders prioritised few risks and strategies out of the thirty-two strategies and forty-five risks. Most were treated as insignificant based on QFD analyses.

6.4 OPTIMAL MITIGATION STRATEGIES

A number of mitigation strategies were identified by optimising the level of risk mitigation based on the QFD analysis in Section 5.5.2. The details of optimisation results were shown in table 5.32 and table 5.33. For the ease of discussion the a summary of these results is provided in table 6.14 and 6.15.The optimum mitigation

strategies for all respondents of both companies are listed in Tables 6.14 and 6.15 and Appendices 6A, 6B, 6C and 6D.

Once the QFD model is formulated using the linear programming model (without savings) and quadratic integer programming model (with savings) (shown in Section 5.62), the most appropriate strategies could be determined to mitigate dairy risks with limited organisational resources. It is assumed that a 100% budget could implement all strategies listed by the respondents. When the budget is less than full capacity (100%), further analysis is needed to determine how many strategies could be implemented under a limited budget (less than 100%).

According to the Nahar employees (Table 6.14), Strategies S6, S7, S14 and S19 are the most optimum that could be implemented under different budgets ranging from100% to 10%. These strategies are selected without considering savings. This means that a reduction in the budget would not affect the implementation of these strategies. However, when savings are considered, then S7 and S19 could not be implemented with 20% and 30% of the budgeted amount respectively. By contrast, the remaining two strategies, 'Implementation of a fixed policy for dairy sector' (S6) and 'Arrangement of proper training to the staff regarding processing and hygiene management' (S14), could be implemented with a reduced budget.

Table 6.14: Optimisation results for Nahar Employees

Strategies	Budgeted Cost (Without Savings)										Budgeted Cost (With Savings)									
	100%	**90%**	**80%**	**70%**	**60%**	**50%**	**40%**	**30%**	**20%**	**10%**	**100%**	**90%**	**80%**	**70%**	**60%**	**50%**	**40%**	**30%**	**20%**	**10%**
	1,098.33	988.50	878.67	768.83	659.00	549.17	439.33	329.50	219.67	109.83	1098.33	988.50	878.67	768.83	659.00	549.17	439.33	329.50	219.67	109.83
S1	✓	✓	✓	✓	✓	×	×	×	×	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
S2	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓	✓	✓	✓	✓	✓	✓	×	×	×
S3	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
S4	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	✓	×	×	×
S5	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×
S6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S7	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓
S8	✓	✓	✓	×	×	×	×	×	×	×	✓	✓	✓	✓	×	×	×	×	×	×
S9	✓	×	×	×	×	×	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×
S10	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
S11	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×
S12	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×
S13	✓	×	×	×	×	×	×	×	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	×
S14	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S15	✓	×	×	×	×	×	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×
S16	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×
S17	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×
S18	✓	✓	×	✓	✓	✓	×	×	×	×	✓	✓	✓	✓	×	✓	×	×	×	×
S19	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓
S20	✓	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×
S21	✓	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×
S22	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓	✓	✓	✓	✓	✓	✓	×	×	×
S23	✓	✓	✓	✓	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×
S24	✓	✓	✓	×	×	×	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×
S25	✓	✓	✓	×	×	×	×	×	×	×	✓	✓	✓	×	×	×	×	×	×	×
S26	✓	✓	✓	✓	✓	×	×	×	×	×	✓	✓	✓	✓	✓	✓	×	×	×	×
S27	✓	✓	×	×	×	×	×	×	×	×	✓	✓	✓	×	×	×	×	×	×	×
S28	✓	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓	✓	×	×	×	×	×	×
S29	✓	✓	✓	✓	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×
S30	✓	✓	×	×	×	×	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×
S31	✓	✓	✓	✓	✓	✓	✓	×	✓	×	✓	✓	✓	✓	✓	✓	✓	×	×	×
S32	✓	✓	✓	✓	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	✓	×	×	×	×
Total Selected Strategies	32	29	26	24	21	19	15	11	9	4	32	32	29	27	24	20	15	12	7	4
Objective Function	392.67	382.83	365.65	343.99	312.66	279.72	241.58	196.42	143.67	82.62	392.67	392.67	381.12	360.95	332.19	298.02	256.07	209.43	149.29	82.62
Level Of Risk Mitigation	100.00%	97.49%	93.12%	87.60%	79.62%	71.23%	61.52%	50.02%	36.59%	21.04%	100.00%	100.00%	97.06%	91.92%	84.60%	75.90%	65.21%	53.34%	38.02%	21.04%

The result obtained from Nahar executives (Appendix 6A) shows that when savings are not taken into consideration, then four strategies (S6, S10, S17 and S31) could be implemented with any rate of reduced budget (10–100%). However, when savings are taken into consideration, five strategies (S5, S6, S10, S17 and S31) could be implemented with a changed budget. Therefore, Strategy S5 could be implemented with any kind of changed budget when a farm takes savings into consideration. According to Nahar supply chain members (see Appendix 6B), seven strategies (S5, S6, S12, S14, S17, S19, and S31) could be implemented with a reduction in budget regardless of whether they take savings into consideration or not.

According to the Paharika employees (see Table 6.15) when savings are not taken into consideration, four strategies (S6, S10, S12 and S14) are optimal as they could be implemented for any rate of reduction in the budget. However, when savings are taken into consideration, only two strategies (S6 and S14) are optimal, as they could be implemented with any rate of reduction in the budget. The Paharika executives named StrategiesS6, S14, S16, and S19 (Appendix 6C) as optimal, because they could be implemented under different rates of reduced budget (10–100%) when savings are not taken into consideration. However, when savings are taken into consideration, S6'Implementation of a fixed policy for dairy sector 'could not be implemented with a 20% reduction in the budgeted amount. Instead, S23'Arrangement of improved and upgraded veterinary services' could be implemented at any rate of reduction in the budget when savings are taken into consideration.

According to the Paharika supply chain members, five strategies (S5, S6, S19, S31 and S32) could be implemented under different budgets ranging from 10% to 100%, when savings are not taken into consideration (Appendix 6D). However, when savings are taken into consideration, an additional strategy (S18) is considered as an optimal strategy together with the other five strategies.

Table 6.15: Optimisation results for Paharika Employees

Strategies	Budgeted cost (without savings)										Budgeted cost (with savings)									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
	958.33	862.50	766.67	670.83	575.00	479.17	383.33	287.50	191.67	95.83	958.33	862.50	766.67	670.83	575.00	479.17	383.33	287.50	191.67	95.83
S1	✓	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
S2	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
S3	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
S4	✓	✓	✓	✓	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	✓	×	×	×	×
S5	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
S6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S7	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×
S8	✓	✓	✓	×	✓	×	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×
S9	✓	✓	×	×	×	×	×	×	×	×	✓	✓	✓	×	×	×	×	×	×	×
S10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×
S11	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×
S12	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×
S13	✓	✓	✓	✓	×	✓	×	×	×	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	
S14	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S15	✓	✓	×	×	×	×	×	×	×	×	✓	✓	✓	×	×	×	×	×	×	×
S16	✓	✓	✓	✓	×	✓	✓	×	×	×	✓	✓	✓	✓	✓	✓	×	×	×	×
S17	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	✓	×	×	×
S18	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	×	×	×	×
S19	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	✓	×	×	×
S20	✓	✓	×	×	×	×	×	×	×	×	✓	✓	✓	×	×	×	×	×	×	×
S21	✓	✓	✓	✓	✓	×	×	×	×	×	✓	✓	✓	✓	×	✓	×	×	×	×
S22	✓	✓	✓	✓	✓	✓	×	✓	×	×	✓	✓	✓	✓	✓	✓	✓	×	×	×
S23	✓	✓	✓	✓	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	✓	✓	×	×	×
S24	✓	×	×	×	×	×	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×
S25	✓	✓	✓	×	×	×	×	×	×	×	✓	✓	✓	✓	×	×	×	×	×	×
S26	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓	✓	✓	✓	✓	✓	×	×	×	×
S27	✓	✓	✓	✓	✓	×	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×
S28	✓	✓	✓	✓	✓	×	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×
S29	✓	✓	✓	×	×	×	×	×	×	×	✓	✓	✓	✓	×	×	×	×	×	×
S30	✓	×	×	×	×	×	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×
S31	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓
S32	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×
Total selected strategies	32	30	27	24	22	20	16	13	8	5	32	32	30	27	24	22	17	12	7	5
Objective Function	428.29	422.56	407.25	377.10	343.73	313.17	270.31	224.38	165.44	91.09	428.29	428.29	422.56	407.25	379.09	350.16	307.19	250.30	177.36	91.09
Level Of risk mitigation	100.00%	98.66%	95.09%	88.05%	80.26%	73.12%	63.11%	52.39%	38.63%	21.27%	100.00%	100.00%	98.66%	95.09%	88.51%	81.76%	71.73%	58.44%	41.41%	21.27%

All respondents, except the Paharika executives, agreed that the implementation of a fixed policy for the dairy sector (S6) would be the most optimal strategy that could be implemented within budget constraints (see Table 6.16). The government of the country is liable to implement different policies, but the stakeholders of the company have to spend a portion of the budget to adopt and implement government policies. According to the respondents, , government policy is required to resolve different risks in the dairy industry by taking appropriate regulatory actions such as by establishing a national milk grid, stabilising market prices, controlling high prices of feed and medicine, developing different infrastructures, strengthening the regular supply of vaccine and providing institutional loans with a lower interest rate through public services, with the overall objective of accomplishing full economic effectiveness.

Table 6.16: Comparison of Optimisation Results

Groups	Nahar Employees	Nahar Executives	Nahar SC Members	Paharika Employees	Paharika Executives	Paharika SC Members
Optimum Strategies	S6, S14	S6, S10, S17, S31	S5, S6, S12, S14, S17, S19 S31	S6, S14	S14, S16, S19	S5, S6, S19, S30, S31
Total	2	4	7	2	3	5

A fixed government policy is needed for developing a national milk grid, a government system for moving milk from the rural milk sheds to urban milk consuming demand centres. With the help of such a system, producers would get a good price without having to pay middlemen and simultaneously it would be helpful for developing a regular and secure market for their products. However, there is no national milk grid in Bangladesh. The development of a milk grid for the dairy industry would help to increase milk production and reduce the current losses. So attention should be given to their establishment by the government.

To reduce different risks associated with the dairy industry, the government could implement various policies including the provision of institutional loans, extension services for breeding and raising cattle, and removing uncertainties created by hartals, strikes and different political risks. To mitigate political uncertainties, the government could develop and implement a policy to ensure that transport of dairy products is excluded from political strikes. By implementing such a policy, the government could save dairy transports from damage triggered by strikers. Thus, a good number of risks could be mitigated through implementing a fixed policy for the dairy industry.

However, such policy would have to come from a government authority and they would have to have an allocated budget for adopting the strategies.

'Arrangement of proper training to the staff regarding processing and hygiene management' (S14) was considered as an optimum mitigation strategy by all groups except Nahar executives and Paharika a supply chain member. These two groups regarded 'Removal of unnecessary influence of middlemen' (S31) as the optimum mitigation strategy. Both strategies could be implemented with a budget ranging from 10% to 100%.

Bangladesh does not have enough facilities for training and creating skilled manpower at the higher and middle levels. A study on the Bangladesh dairy industry conducted by Shamsuddin, Alam, Hossein, Goodger, Bari, Ahmed, Hossain, et al. (2007) reveals that training management is an important risk mitigation strategy. As milk is highly perishable, it needs extra care in storing and processing. To ensure product quality, milk has to be chilled at $4^{o}C$ within a couple of hours of milking. This is the most favoured method for sustaining good quality milk for processing and consumption.

Hygiene practice in production and processing is another important issue for retaining the quality of products. However, there is lack of awareness of practices for clean and hygienic milk production in Bangladesh. Animals are not properly cleaned while milking and the utensils used for milking and storing milk are of poor quality metal and construction. Milking is done in an unclean environment where dust, dung and flies are usually present and this can be an additional source of contamination and quality deterioration. So training of staff (S14) is needed in basic hygiene practices in order to strengthen their capacity to procure quality milk through a proper management system. Farmers prioritised their need for training in management of profitable farms, and the need for training of inseminators and veterinarians to enable them to deliver effective services (Shamsuddin, Alam, Hossein, Goodger, Bari, Ahmed, Hossain, et al. 2007). In this regard, the prominent agricultural universities in the country could establish dairy technology centres where training could be provided to the workers, dealers and other supply chain members in various aspects of nutrition, hygiene and quality control. Moreover, the government could sponsor vocational training centres and mass awareness training programmes using mass media. The curriculum of these training centres and training programmes could be expanded to include training for

agents involved in the supply chain on various issues regarding production, nutrition, hygiene and transportation.

It has also been observed that the elimination of the unnecessary influence of middlemen from the supply chain is very important for the betterment of business. Middlemen are responsible for product adulteration as well as farmers deprivation. While carrying milk, they are used to adding ice to the milk to prevent heat spoilages, especially in extreme weather conditions. Another wicked practice among the middlemen is to add water to the milk in order to increase volume. This practice not only harms the consumer financially, but also brings adverse health effects, because in many instances, dirty and contaminated water is added. Moreover, producers rely on middlemen to sell raw milk and they cannot realise a good and predictable price for their milk. Farmers in rural areas/remote areas far from cities or towns receive the minimum milk price. Milk price for producers near the peri-urban areas is much lower and the middlemen take the maximum share of the price realised from the consumer. So implementation of appropriate government policies and the merger and acquisition of farms would be effective strategies to remove the unnecessary influence of middlemen from the Bangladesh dairy supply chain.

6.5 RELIABILITY AND VALIDITY OF THE QFD MODEL

The reliability and validity of the QFD model are discussed in the following section.

6.5.1 Model reliability

Reliability tests are absent from most of the QFD-related research studies. By comparison, this research conceptualises a reliability measure for QFD research. This study considers particular variables which were identified as high risks in the field study. Then the existing literature was examined for confirmations of these high risks and their variables. For instance, R26 (Cattle Diseases) scored a DI value (Degree of Importance) of 0.64 which is one of the highly probable and high impact risks according to the Nahar supply chain members. The same risk was found in the existing literature where it was identified as a high risk for the dairy industry (Choudhary et al. 2011). Other researchers, including Akcaoz, Kizilay, and Ozcatalbas 2009, Finch 2004, Peck 2005, Saadullah 2000, Shamsuddoha and Edwards 2000, Ghani and Rahman 2004, Bari 2008, Halder and Barua 2003, Trkman and McCormack 2009, and Shamsuddin et al. 2007) found the same in their studies. Furthermore, Paharika executives identified R3 (High rate of interest) and R34 (shortage of land for expanding farm) as highly probable and high impact risks which are also evident in the current

literature (Trkmanand McCormack 2009, Ahsan 2011, Rao and Goldsby 2009, Ghani and Rahman 2004, Ali and Kapoor 2008, Choudhary et al. 2011, Bari 2008). All found the same variable as one of the major risks for their individual research context. Therefore, it can be said that this research and its variables are reliable in the light of existing research and field studies on the dairy industry.

6.5.2 Model Validity

Every research study has a general expectation that its findings will correspond with reality. It is evident that a focus on validity in QFD related research is absent in the existing literature. This research study attempted to validate its findings by comparing the outcomes of one case with another. Two case industries were examined in this study to validate the results. For example, risk R13 (Hartal and strike cause delay in work process) was identified as a highly probable risk with high impact by the three different groups from both industries. These three different groups are employees, executives and supply chain members. Respondents from these three groups mentioned R13 in their responses. They also explained how this risk can damage their current business, when, for instance, employees cannot come to daily work due to political unrest like hartals and strikes. At the same time, executives cannot get together in their work to take important and instant decisions, and supply chain members fail to get their products to the destination. As milk is perishable, it needs quick processing and quick distribution. But hartals and strikes hamper the physical distribution of the product. The current study is validated by having similar opinions from six different groups within the two different case industries. This also proves that the data is completely biasfree and expresses the real situation of the process.

6.6 ADDRESSING THE RESEARCH QUESTIONS

This section links the discussion of QFD results with the research objectives and questions. In support of this connection, additional tables are presented.

6.6.1 RESEARCH QUESTION 1: How can sustainability theory be used to categorise the risks associated with the dairy supply chain in Bangladesh?

The current study has focused on developing and designing appropriate supply chain risk mitigation strategies for the dairy industry in Bangladesh. In doing so, the study has identified several risks to the triple bottom line associated with sustainability. Previous chapters have presented a number of tables to show the existing risks and their high probability and high impact to the dairy industry. This current section

particularly addresses research Question 1 which categorises the risks in the light of sustainability.

The following discussion presents details of the dairy supply chain risks related to economic, social and environmental sustainability, and shows how sustainability theory can be used to categorise the dairy supply chain risks.

In this research the categorisation of risks and outcomes is framed by sustainability theory (Carter and Rogers 2008b). According to Carter and Rogers (2008b), sustainability incorporates environmental, social and economic components that allow an organisation to achieve long term economic viability. Sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their needs" (WCED 1987, 8). On the other hand, potential initiatives for reducing long term risks related to resource depletion, fluctuation in energy costs, pollution and waste management can also be described as sustainability (Shrivastava 1995). Taking into consideration the three sustainability components, this research categorised dairy supply chain risks as economic, social or environmental risks (shown in Table 6.17). This categorisation is useful for developing risk mitigation strategies which will lead to sustainable outcomes for the dairy sector.

Table 6.17: Categorisation of Risks using Sustainability Aspects

Sustainability Aspects	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21	R22	R23	R24	R25	R26	R27	R28	R29	R30	R31	R32	R33	R34	R35	R36	R37	R38	R39	R40	R41	R42	R43	R44	R45	Total
Economical	Y	Y	Y	Y	Y	Y														Y	Y	Y				Y	Y	Y	Y	Y	Y	Y	Y	Y					Y	Y	Y	Y	Y	Y		24
Social							Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y						Y												Y	Y	Y									Y	16
Environmental																		Y	Y					Y	Y													Y									5

Note: This table is generated from table 5.3, 5.4, 5.5, and 5.6 in Chapter 5.

Economic Risks

Economic risks are associated with fluctuations in the levels of economic activity and prices (Oxelheim and Wihlborg 1987). The most leading economic risks are price fluctuations which may arise from changes in the cost of goods (inflation), relative changes in the prices of inputs such as labour or raw material, and interest rates(Miller 1991). Dairy farmers face different economic risks due to their limited ability to forecast factors like the high cost of feed and medicine, high interest rates, inadequate loan facilities, and so on. Dairy farmers in Bangladesh consider the risk of credit unavailability as another major economic risk in this industry. Credit unavailability is the fundamental risk troubling the dairy farmers of developing countries (Bardhan et al. 2006). Credit facilities can play a significant role in overcoming liquidity constraints to enable dairy farmers to meet operating costs. But credit accessibility for livestock activities, especially in the dairy industry, is very limited. Moreover, complex loan procedures, high rates of interest, and cumbersome selection criteria for screening loan applicants do not allow the dairy industries to benefit from the credit market (Jabbar 2010). 45riskswere identified for the Bangladesh dairy industry (see Table 5.22) and 24 were categorised as economic risks (see Table 6.17).

Table 6.18 lists the economic risks based on the opinions of respondents from different groups within the case industries. The table shows that R1 to R6, R20 to R22, R26 to R34 and R39 to R44 were considered to be economic risks. These risks were identified in the inductive phase (qualitative phase) of this study which was discussed in Chapter 5. They were also identified in the deductive phase of the study through an examination of the literature. For instance, (R1)'Inadequate loan facilities 'was considered to be an economic risk because farms cannot implement the necessary processing without having adequate loan facilities. If a farm possesses inadequate loan facilities, it may fail to adopt the latest technology, such as milking machines, chiller machines, transport vehicles, and the like. Without such facilities, the farm concerned will be unable to meet economic goals like appropriate production, profits and expansions.

(R26) 'Cattle disease' is another economic risk which has already been discussed in Chapter 5. This is considered to be an economic risk based on possible economic losses. Cattle disease will lessen milk production and increase the mortality of milking cows. Such losses are directly related to the economic matters of a farm. For this reason,

respondents have considered it as an economic risk. Other risks are also categorised as economic risks and the logic behind this categorisation is detailed in Table 6.18.

Table 6.18: List of Economic Risks

Risk No.		Risk Name	Risk No.		Risk Name
R1	=	Inadequate loan facilities	R29	=	Accident (Staff injury)
R2	=	Complex loan procedures	R30	=	Inadequate supply of quality feed
R3	=	High rate of interest	R31	=	High cost of feed and medicine
R4	=	Inadequate finance	R32	=	Scarcity of feed
R5	=	Absence of insurance or compensation coverage	R33	=	Lack of upgrade vaccination and veterinary services
R6	=	Shortage of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	R34	=	Shortage of land for expanding farm
R20	=	Machine damage/breakdown at cold storage	R39	=	Accidents of transport vehicle
R21	=	Inadequate chilling facilities	R40	=	Existence of middlemen/ too many middlemen
R22	=	Inadequate cold storage	R41	=	Too long chain cause delay in product movement
R26	=	Cattle diseases	R42	=	Poor conditioned road for moving product (delay & spoilage)
R27	=	Machine damage/breakdown at processing unit	R43	=	Inadequate transport facilities to move products frequently
R28	=	Fire at farm shed	R44	=	Lack of milk tanker (refrigerated)

Social Risks

Social risks are related to legal issues and human resources (Ali and Kapoor 2008). According to Dunn and Herring (1983), Social risks arise from people's attitudes, philosophies and beliefs that are not reflected in the current business practice and government policy. Government and society are integral parts of social risks (Rao and Goldsby 2009). In the same literature, terrorism activities are also considered to be social risks. The key sources of social risk are government rules and regulation, human resource risk, family issues and unemployment (Ali and Kapoor 2008). Various drivers of social risks in dairy farming are shown in Table 6.17. The table shows that 16 of the 45 risks are identified as social risks. Social risks were included in the list of identified risks to the dairy industry presented in Chapter 5 (see Table 5.22). These social risks are reiterated in Table 6.19.

Table 6.19 shows the social risks which have been identified from respondents' interviews and later cross-checked with the existing literature. It is always challenging to match the interview opinions with the literature as different environments have

identical situations in regards to social risks. The table shows that R7 to R17, R23, R34 to R37 and R45 were considered to be social risks. They were identified in the inductive and deductive phases of the qualitative part of this research described in Chapter 5. Moreover, these risks were also identified through an examination of the existing literature. For instance, (R12) 'Poor law and order situation, terrorism, musclemenship' is identified as one of the social risks because poor law and order situations create a number of social risks like terrorism (bribery, forced contributions, and the creation of panic) and musclemenship (forced to do something illegal). Moreover, theft, corruption, adulteration and contamination, and deteriorating product quality are also associated with the same risk. These issues can directly related to social problems such as losing employment, decreasing income, increasing antisocial activities, demoralising entrepreneurs, hindering usual supply chain processes, obstructing middlemen processes and the like.

Table 6.19: List of Social Risks

Risk No.		Risk Name	Risk No.		Risk Name
R7	=	Labour disputes	R15	=	Corruption (adulteration by mixing water)
R8	=	Illiteracy and inefficiency of worker	R16	=	Damage of farm's assets
R9	=	Shortage of skilled staff	R17	=	Theft
R10	=	Switching of staff frequently	R23	=	Spoilage of milk through improper handling
R11	=	Lack of fixed government policy in dairy sector	R35	=	Irregular supply of vaccine from government
R12	=	Poor law and order situation (terrorism, musclemen ship)	R36	=	Competition among the farms
R13	=	Hartal and strike cause delay in work process	R37	=	Bureaucratic complexity on maintaining various formalities
R14	=	Political Unrest and interference	R45	=	Unethical behaviour of middle men (adulteration, added price, deprivation)

(R36) 'Competition among the farms' is also regarded as a social risk in both the qualitative interviews and the literature. For example, if competition among the farms is intense, farms may fail to achieve their optimum goals including profit maximisation and cost minimisation. Such problems ultimately create societal problems like unhealthy competition among the farms and actors on the farms. Such unhealthy competition leads to deteriorating product quality, employees' mismanagement, illegal practices, too much employee switching, sometimes decreased salaries due to insufficient company profits, and others. The rest of the social risks also have

associated reasons for being considered as social risks. Such categorisation is validated by the literature and higher official interviews. Ultimately, these sixteen social risks are somehow hindering social activities which create problems for the concerned farms and prevent them from operating their existing business processes.

Environmental Risks

Environmental risks are those which affect the overall activities of an industry due to weather dependency (Ali and Kapoor 2008). Natural uncertainties are the major source of environmental risk in the dairy industry. These include various risk sources such as flood, drought, heavy rainfall, too much humidity and so on. The impact of environmental risks is one of the serious concerns for the dairy industry as it can hardly be controlled. These risks can extremely impair a farm's activities and reduce overall farming production (Miller 1991). In this research, the literature review and consultation with industry stakeholder's found five environmental risks (see Table 6.17). The leading environmental risk sources in dairy production included 'natural uncertainties (storm, excessive rain, flood)' (R18), 'quick perishability of milk' (R19), 'bacterial contamination caused by improper temperature' (R24), 'pollution and unhygienic environments' (R25), and 'drought' (R38).

Risk (R18) 'natural uncertainties (storm, excessive rain, and flood)' is considered to be one of the major environmental risks which directly damage dairy farms in Bangladesh. Bangladesh is a country with a high prospect of natural disasters such as floods, storms, cyclones, high tides and excessive rains). Dairy housing, cattle management, and the supply chain network are hampered by natural disasters like excessive rainfall, floods, too much humidity and sudden storms. In addition, dairy farming depends on green grass which farms manage through Napier grass cultivation in enclosed lands. This hybrid grass cultivation is hindered by natural disasters which ultimately affect dairy production and cattle health. Furthermore, the possibility of dairy diseases increases at post-natural disasters. Thus, above discussions attempted to response the first research question which categorise the dairy supply chain risks in light of sustainability theory.

6.6.2 RESEARCH QUESTION 2: What are the optimal strategies to mitigate the highly probable and high impact risks to the dairy supply chain in Bangladesh?

This particular section discusses optimal mitigation strategies for highly probable and high impact risks to the dairy supply chain in Bangladesh. The second research

question aims to find most suitable mitigation strategies for the existing dairy supply chain risks. Previous QFD analyses found many risks and mitigation strategies with high relationship scores and ranked them in order of priority. Obviously, the highest REL score suggests the most suitable strategies to be implemented to mitigate particular risks. It is quite impossible for a farm to mitigate all of the risks by implementing each and every strategy. It is not also justifiable due to budget constraints and the scope of the farms.

In this situation, this research identifies the most important and well-ordered mitigation strategies which can be implemented. Priority is given to REL scores of five (5.00) and above. Table 6.20 lists mitigation strategies and related risks where the relationship score is five and above. This particular section considers highly probable and high impact risks (see Section 6.2) and optimum mitigation strategies (see Section 6.4). After scrutiny of risks and mitigations strategies, the researcher found four risks and five mitigation strategies with REL scores of five and above. This means that there are five different relationships (indicating a strong match between risk and mitigation strategy) that need to be implemented as soon as farms can get the opportunity.

Table 6.20 shows the top most highly probable and high impact risks that can be mitigated through highly related mitigation strategies. For instance, R3 (High rate of interest) can be mitigated appropriately through strategy S7 (Assurance of adequate institutional credit support with low rate of interest) at different levels of budget except 20% budget. This means that a 20% budget cannot mitigate that risk, but it can be mitigated under any other circumstances. On the other hand, risk R8 (Illiteracy and inefficiency of worker) can be mitigated through the S3 (Hiring skilled staff) and S14 (Arrangement of proper training to the staff regarding processing and hygiene management) mitigation strategies. However, although risk R8 can be mitigated through Strategy S14 at any level of budget from 10% to 100%, in the same circumstances, S3 cannot be applied at the 10% budget level. Therefore, decision makers will choose the strategy that can be implemented at maximum level of budget for their convenience.

Table 6.20: Optimal Strategies to Mitigate Highly Probable and High Impact Risks (Nahar Employees)

High Probable and High Impact Risks	Highly related Strategies	Optimisation Results
R3	S7	S7 is selected at any budget level except 20% of budget
R5	S2	S2 is selected at any budget level except 30%,20% and 10% of budget
R8	S3, S14	S3 is selected at any budget level except 10% of budget S14 is selected at any budget level within 10% to 100%
R13	S5	S5 is selected at any budget level except 20% and 10% of budget

Nahar executives identified four different risks (highly probable and high impact) that can be mitigated through nine different mitigation strategies. Table 6.21 shows that R5, R11, R13 and R40 are rated as highly probable and high impact risks. At the same time these four major risks can be resolved by implementing mitigation strategies S2, S5, S6, S11, S25, S31 and S32. Farm executives have confidence in implementing these seven strategies to mitigate four major risks. They believe that R5 can be mitigated through implementing (S2)'Buying insurance against production loss' and (S6)'Implementation of fixed policy in dairy sector'. These risks are related to insurance compensation, lack of suitable policies and political events like hartals and strikes. The farm executives also gave a high score to(S31)'Removal of unnecessary influence of middlemen' to mitigate (R40)'Too many middlemen'. This means, both the middlemen related risks can be resolved through eliminating redundant middlemen. For illustration, risk R40 can be mitigated through strategies S11, S25, S31 and S32 at different levels of budget. S31 can resolve R40 at the maximum point of budget from 10% to 100%. On the other hand, (R13) 'Hartal and strike cause delay in work process' can be mitigated through (S5) 'Initiative to remove political uncertainty' and (S6) 'Implementation of a fixed policy for dairy sector', both of which can be implemented at every level of budget of 10% to 100%. This means that executives will prefer S5 and S6 as these can be implemented without taking further consideration of budget deficiency.

Table 6.21: Optimal Strategies to Mitigate Highly Probable and High Impact Risks (Nahar Executives)

High Probable and High Impact Risks	Highly related Strategies	Optimisation Results
R5	S2, S6	S2 is selected at any budget level except 10% of budget S6 is selected at any budget level within 10% to 100%
R11	S6	S6 is selected at any budget level within 10% to 100%
R13	S5, S6	S5 and S6 are selected at any budget level within 10% to 100%
R40	S11, S25, S31 and S32	S11 is selected at any budget level except 40%, 30%, 20% and 10% S25 is implemented at any budget except 40%, 20% and 10% S31 is implemented at any budget level within 10% to 100% S32 is implemented at any budget level except 20% and 10%

Table 6.22 shows the opinions of supply chain members relating to the most highly probable and high impact risks which can be mitigated through highly relevant mitigation strategies. For example, (R13) 'Hartal and strike cause delay in work process' can be mitigated effectively through Strategy S5 at every point of budget of 10% to 100%. The same thing applies to risk (R14) 'Political unrest and interference 'which can also be mitigated by (S5) 'Initiative to remove political uncertainty' at all levels of budget. These strategies are suitable for the industry and can be easily applied under any circumstances without having a second thought. On the other hand, (S17)'Strengthen the regular supply of vaccine' can mitigate (R26)'Cattle diseases' at diverse levels of budget. However, (S2) 'Buying insurance against production loss', (S15) 'Attempts to create various cross breeds by adopting AI services', (S22) 'Arrangement of regular vaccination for the cattle' and (S23)'Arrangement of improved and upgraded veterinary services can mitigate risk (R26) 'Cattle diseases' at selected levels of budget. In this situation, industry will consider relevant mitigation strategies that can be implemented at every level of budget. Later, they will start considering minimum to maximum amount of budget availability to implement such strategies to overcome various risks. Therefore, supply chain members will indicate those strategies which can be executed at minimum level of budget for their suitability.

Table 6.22: Optimal Strategies to Mitigate Highly Probable and High Impact Risks (Nahar SC members)

High Probable and High Impact Risks	Highly Related Strategies	Optimisation Results
R13	S5	S5 is implemented at any budget level within 10% to 100%
R14	S5	S5 is implemented at any budget level within 10% to 100%
R26	S2,S15, S17, S22, S23	S2 is implemented at any budget level except 30%, 20% and 10% of budget S15 is implemented at 100%, 90% and 80% of budget. S17 is implemented at any budget level within 10% to 100% S22 is implemented at any budget level except 20% and 10% of budget S23 is implemented at any budget level except 30%, 20% and 10% of budget
R44	S28	S28 is implemented at any level except 40%, 30%, 20% and 10% of budget

Paharika employees (see Table 6.23), like Nahar employees, consider their choices of strategies to mitigate risks and they suggest that (R5)'Absence of insurance or compensation coverage', (R1)'Hartal and strike cause delay in work process' and (R14)'Political unrest and interference' are mitigated by (S2)'Buying insurance against production loss' and (S5)'Initiative to remove political uncertainty' respectively. These strategies can be implemented at various levels of budget from 20% to 100% but they are not suitable for 10% level of budget. Strategy S7 (Assurance of adequate institutional credit support with low rate of interest) can resolve the problem of risk (R3) 'High rate of interest'. This how, Paharika employees provided their opinion relating to highly probable and high impact risks that can be eliminated through different mitigation strategies.

Table 6.23: Optimal Strategies to Mitigate Highly Probable and High Impact Risks (Paharika Employees)

High Probable and High Impact Risks	Highly Related Strategies	Optimisation Results
R3	S7	S7 is implemented at any budget level except 20% and 10% of budget
R5	S2	S2 is implemented at any budget level except 10% of budget
R13	S5	S5 is implemented at any budget level except 10% of budget
R14	S5	S5 is implemented at any budget level except 10% of budget

Table 6.24 shows that Paharika executives have chosen highly related mitigation strategies to alleviate the various existing risks. (R34) 'Shortage of land for expanding farm' can be mitigated through (S16) 'Lease abandoned land to the farmers for dairy farming' and (S24) 'Building multi-storeyed complex for farm extension'. The QFD analysis shows that S16 can be implemented to mitigate R34 at any level of budget, whereas S24 can be implemented only at 100%, 90% and 80% of budget level. This means that S24 takes more budget than S16 to resolve the issue of R34. (S7) 'Assurance of adequate institutional credit support with low rate of interest' and (S8) 'Introducing off-farm activities; can be deployed to mitigate R3 'High rate of interest'. S5 'Initiative to remove political uncertainty' and S2 'Buying insurance against production loss' can be deployed to mitigate risks (R5) 'Absence of insurance or compensation coverage' and (R13) 'Hartal and strike cause delay in work process' respectively. Paharika executives delivered their opinion relating to highly probable and high impact risks that can be eliminated through different mitigation strategies at various level of budget. But according to them that S8 and S16 are the most optimal mitigation strategies as these two could be implemented at any budget level from 10% to 100%.

Table 6.24: Optimal Strategies to Mitigate Highly Probable and High Impact Risks (Paharika Executives)

High Probable and High Impact Risks	Highly Related Strategies	Optimisation Results
R3	S7, S8	S7 is implemented at any budget level except 30% and 10% of budget S8 is implemented at any level except 50%, 40%, 30%, 20% and 10% of budget
R5	S2	S2 is implemented at any level except 30%, 20% and 10% of budget
R13	S5	S5 is implemented at any level except 10% of budget
R34	S16, S24	S16 is implemented at any level of budget S24 is implemented at only 100%, 90% and 80% of budget

Table 6.25 shows responses from Paharika supply chain members concerning their selections of highly related strategies to mitigate risks. The table shows that (R13) 'Hartal and strike cause delay in work process' and (R14) 'Political unrest and interference can be mitigated through (S5) 'Initiative to remove political uncertainty' at any level of budget (10-100%). (S31) 'Removal of unnecessary influence of middlemen' and (S32) 'Direct marketing' can mitigate (R45) 'Unethical behaviour of middle men (adulteration, added price, deprivation)' at all levels of budget. Paharika supply chain

members selected S5 as the most optimal mitigation strategy, because this strategy is applicable at all budget levels to mitigate two different highly probable risks with high impact.

Table 6.25: Optimal Strategies to Mitigate Highly Probable and High Impact Risks (Paharika SC Members)

High Probable and High Impact Risks	Highly Related Strategies	Optimisation Results
R13	S5	S5 is implemented at any level of budget
R14	S5	S5 is implemented at any budget level
R45	S31, S32	S31 is implemented at any budget level S32 is implemented at any budget level

In short, the groups of employees, executives and supply chain members of Nahar and Paharika selected different mitigation strategies to mitigate various risks. Later, QFD analyses determined the budget and found the strategies appropriate for different levels of budget. Obviously, decision makers will choose optimal strategies which can be implemented at all levels of budget due to monetary constraints. Nevertheless, there are number of risks and strategies which gained REL scores below six. This does not mean that those strategies cannot be implemented to alleviate a few risks. This research has only discussed highly prioritised strategies to mitigate related risks. If a farm can manage funds to implement all the strategies, they can implement other strategies as well. This section has discussed Research Question 2 which is concerned with identifying optimal mitigation strategies to alleviate related highly probable and high impact risks to the dairy supply chain. Above discussions were answered the research question two through describing the relevant strategies to mitigate the highly probable and high impact risks within the dairy supply chain.

6.6.3 RESEARCH QUESTION 3: What are the probable outcomes of implementing the mitigation strategies at the organisation level?

A good performance outcome is the result of effective and efficient management (Ritchie and Brnidley 2007b). This section provides detailed results of probable outcomes after implementing particular strategies to mitigate different supply chain risks. As mentioned in Section 5.3.5.1, this research measures outcomes in terms of economic, social and environmental sustainability. Based on the RI values of different economic, social and environmental outcomes, all the results for Nahar and Paharika Dairies are ranked twice. The integrated approach and the segmented approach are employed to prioritise the outcomes in two different ways. Integrated ranking grades

the results collectively (see Table 6.26) and segmented ranking grades them in terms of specific aspects of sustainability (see Table 6.27). The lists for sustainable outcomes are found from the table 5.37a and 5.37b in chapter 5 (QFD analysis phase 2). A few of the outcomes carry the same importance to the farm. But a number of outcomes do not have same importance to the farm due to dearth of substantial benefits. An individual farm will implement these strategies based on prioritise sustainable outcome according to their urgency.

Table 6.26: Overall Ranking of Sustainable Outcomes

Sustainability Aspects	Sustainable Outcomes	RI Values		Order of Importance	
		Nahar	Paharika	Nahar	Paharika
Economic	Profit maximisation(SO1)	0.11	0.11	2	3
	Cost minimisation (SO2)	0.12	0.14	1	2
	Increase in personal income(SO3)	0.04	0.03	7	8
	Increase in production (SO4)	0.10	0.15	3	1
	Product quality improvement (SO5)	0.09	0.08	4	4
	Expansion of farming system(SO6)	0.04	0.07	7	5
	Production of value added product and diversified product (SO7)	0.04	0.04	7	7
Social	Goodwill enhancement(SO8)	0.08	0.04	5	7
	Supply of quality food (SO9)	0.08	0.08	5	4
	Nutritional development (SO10)	0.08	0.07	5	5
	Improvement of living standard (SO11)	0.02	0.02	8	9
	Creation of employment opportunity (SO12)	0.04	0.05	7	6
Environmental	Creation of sound working environment (SO13)	0.06	0.02	6	9
	Waste management (SO14)	0.02	0.03	8	8
	Health improvement of cattle(Animal Quality) (SO15)	0.09	0.07	4	5

Integrated Approach

In the integrated approach, outcomes are ranked with all three aspects of sustainability combined (see table 6.27). Nahar has given top priority to the outcome SO2 'Cost minimisation' with an RI value of 0.12, but Paharika has identified SO4 'Increase in production' as the top most achievable outcome with an RI value of 0.15. In fact, the two case farms have given identical responses in regard to sustainable outcomes and their priority to work on their own farm. Initially, Nahar gave top ranking to cost minimisation which is logical in terms of their existing operation. They have moderate production with a big market share and they are focusing on minimising the cost so

that profit can be maximised. On the other hand, Paharika is lagging behind optimum production and they desire to increase production so as to maximise their market share.

Table 6.27: Segmented Ranking of Sustainable Outcomes

Sustainability Aspects	Sustainable Outcomes	RI Values		Order of Importance	
		Nahar	Paharika	Nahar	Paharika
Economic	Profit maximisation(SO1)	0.11	0.11	2	3
	Cost minimisation (SO2)	0.12	0.14	1	2
	Increase in personal income(SO3)	0.04	0.03	5	7
	Increase in production (SO4)	0.10	0.15	3	1
	Product quality improvement (SO5)	0.09	0.08	4	4
	Expansion of farming system(SO6)	0.04	0.07	5	5
	Production of value added product and diversified product (SO7)	0.04	0.04	5	6
Social	Goodwill enhancement(SO8)	0.08	0.04	1	4
	Supply of quality food (SO9)	0.08	0.08	1	1
	Nutritional development (SO10)	0.08	0.07	1	2
	Improvement of living standard (SO11)	0.02	0.02	3	5
	Creation of employment opportunity (SO12)	0.04	0.05	2	3
Environmental	Creation of sound working environment (SO13)	0.06	0.02	2	3
	Waste management (SO14)	0.02	0.03	3	2
	Health improvement of cattle(Animal Quality) (SO15)	0.09	0.07	1	1

Nahar identified SO1 'Profit maximisation', but Paharika consider this to be the third most achievable outcome. Paharika considered outcome SO2 as the second most achievable outcome, but that was ranked as the most achievable outcome by Nahar Dairy. Paharika Dairy considered 'Production increment' (SO4) to be the most achievable outcome but Nahar Dairy expressed a different opinion by ranking this as the third most achievable outcome. Both dairies have chosen similar outcomes but they ranked them in different ways. Different opinions were given in light of individual farm situations, needs and priorities.

Both dairies agreed on ordering the outcomes SO5 'Product quality improvement', SO10 'Nutritional development', SO7 'Production of value added product and diversified product', and SO14 'Waste management'. The order of importance of these outcomes was 4, 5, 7 and 8 respectively. These four outcomes are an integral part of a

sustainable modern dairy industry. Product quality and nutritional value are especially important with regard to dairy products. Furthermore, dairy generates huge wastes which need to be reused and recycled to reduce waste hazards and make additional by-products to achieve greater profitability.

It can be seen from Table 6.26 that the dairies differ significantly in their opinions regarding the achievement of outcome SO13 'Creation of sound working environment'. Nahar Dairy ranked SO13as sixth with an RI value of 0.06, whereas Paharika Dairy gave it the lowest possible ranking with an RI value of 0.02. Nahar is more optimistic than Paharika regarding the achievement of this outcome. The reason for this is that Nahar has already adopted such measures to create a sound working environment whereas Paharika is still struggling to accomplish this outcome. In reality, Nahar Dairy has efficiently adopted improved technologies and hired more skilled staff than Paharika Dairy.

Segmented Approach

The segmented approach is used to order the outcomes in respect of the three aspects of sustainability: economic, social and environmental (see Table 6.27). Individual aspects of sustainability are considered to rank the outcomes. So the outcomes are ordered discretely under economic, social and environmental issues. The results of this prioritisation are discussed as follows:

Economically Sustainable Outcomes

The results of the QFD analysis show that for Nahar Dairy, the most achievable of all the economic outcomes is 'Cost minimisation' (0.12). The second most achievable economic outcome is SO1'Profit maximisation' (0.11). Respondents identified (SO4) 'Increase in production' (0.10) as the third most achievable outcome. It is also observed that, among all the economic outcomes, 'Increase in income' (SO3), 'Expansion of farming system' (SO6) and 'Production of value added product and diversified product' (SO7) have the same rating of importance, which is 0.04.

In practice, outcome scores of seven and above are intricately related to economic issues which can help achieve economic sustainability. For example, if a farm can minimise its costs, this will directly influence the economic status of that farm. A farm can minimise its costs through reducing feed costs, controlling middlemen influences, hiring skilled staff and the like. On top of that, direct government help through fixing appropriate policies and improving roads and highways can reduce farm costs as well.

The QFD analysis shows that 'Increase in production' (SO4), 'Cost minimisation' (SO2) and 'Increase in income' (SO3) are the top three achievable economic sustainable outcomes for Paharika Dairy. Paharika Dairy identified SO4 (0.15) as the top most achievable economic outcome, whereas Nahar Dairy identified (SO4) as the third most achievable outcome. As the second most achievable economic outcome, Paharika Dairy identified SO2 (0.14) while Nahar Dairy identified SO1. As the third most achievable economic outcome, Paharika Dairy identified SO1 (0.11) whereas Nahar Dairy identified SO4 (0.10).

Both dairies are in agreement regarding the achievement of outcomes SO5 and SO6. Although the RI values differ, the order of importance is same for these outcomes. Product quality improvement (SO5) and expansion of farming system (SO6) have acquired the same order of importance which is 4 and 5 respectively. For example, product quality improvement and expansion of farm are strategies that must be adopted if possible. It is quite impossible for farms to survive in a competitive environment without expanding individual farms and making product improvements. In practice, production can be increased through expanding a farm and this may result in sustainable economic outcomes for the concerned farm and its stakeholders.

The two dairies had different opinions regarding the achievement of outcomes SO3 'Increase in personal income' and SO4 'Increase in production'. Nahar Dairy prioritised SO3 as fifth while Paharika Dairy ranked it as seventh in order of importance. Likewise SO4 was considered by Paharika to be the most achievable economic outcome but it was considered by Nahar to be the third most achievable outcome. For instance, Nahar observed that they may increase staff salaries once they can maximise profits or minimise costs. On the other hand, Paharika did not show a similar intention to increase staff's personal income.

Social Sustainable Outcomes

Regarding social sustainable outcomes, Nahar Dairy has graded three social outcomes with the same rating of importance (Table 6.27). These outcomes are 'Goodwill enhancement (SO8)', 'Supply of quality food (SO9)' and 'Nutritional development (SO10)'. The RI value collected from the QFD analysis (Table 5.38) of all three outcomes is 0.08. So these three outcomes are considered to be the most achievable social outcomes. 'Creation of employment opportunity (SO12)' and 'Improvement of living standard (SO11)' hold the second and third highest degrees of relative importance which are 0.04 and 0.03 respectively. Thus Nahar consider SO12 and SO11

to be the second and third most achievable social outcomes respectively. For instance, 'Enhanced goodwill' (SO8) can provide societal benefits such as social status, increased respectability, remuneration and employment guarantee for the related stakeholders. On the other hand, 'Employment creation' (SO12) and 'Living standard improvement' (SO11) are the second and third most achievable outcomes for the dairy industry. If a dairy farm is expanded from time to time, it can employ more people and increase their living standard, which is a positive social outcome.

Paharika (Table 6.27), it is obtained from QFD analysis that (see the table 5.39) the top most achievable social outcome is 'Supply of quality food' (SO9) with the highest RI value of 0.08. SO10 'Nutritional development' is considered to be the second most achievable social outcome with the second highest RI value of 0.07. The third most achievable social outcome is 'Creation of employment opportunity' (SO12) with the third highest RI value of0.05. In reality, quality food supply will have a great impact resulting in societal outcomes like a healthier society, nutritional improvement and superior quality food.

In comparison, Nahar identified three social outcomes (SO8, SO9 and S010) with the same RI value of 0.08 which are considered to be the most achievable outcomes. However, Paharika gave top priority to SO9 (0.08) and SO10 (0.07) and SO12 (0.05) which are ranked the second and third most achievable social outcomes respectively. Both dairies agreed that 'Improvement of living standard' (SO11) is the least achievable social outcome resulting from the application of suggested mitigation strategies. Although the RI value of SO11 of 0.02 is the same for both dairies, they ranked SO11 differently. Nahar ranked it as the third most achievable social outcome while Paharika ranked it as the fifth most achievable social outcome.

Environmentally Sustainable Outcomes

With regard to environmentally sustainable outcomes, results obtained from the QFD analysis, show that Nahar Dairy (see Table 6.22) identified 'Health improvement of cattle (Animal Quality) (SO15) as the most achievable outcome from among all the possible environmentally sustainable outcomes. For instance, animal quality results in improved genetics as well as increased production. If one milking cow produces three times as much milk as a normal breed animal, the environment can be better managed within that farm, because of the savings on space and food. Such genetics can lower the burden on the surrounding environment of the farm. The highest RI value for environmental sustainability, which is 0.09, is given to outcome SO15. 'Creation of

sound working environment '(SO13), with an RI value of 0.06, is considered to be the second most achievable environmental outcome. 'Waste management' (SO14) with an RI value of 0.02, is identified by Nahar as the third lowest and least achievable environmental outcome. Waste management is a very important matter in modern society. Dairy wastes can be used to make further by-products, including biogas, fertilisers, fish feed and artificial burning appliances.

In contrast, Paharika Dairy gave the highest RI value (0.07) toSO15. This implies that 'Health improvement of cattle (Animal Quality)' (SO15) is the most achievable environmental outcome likely through applying the recommended mitigation strategies. 'Waste management' (SO14) holds the second highest RI value (0.03) which identifies it as the second most achievable environmental outcome. Lastly, SO13 'Creation of sound working environment' with the lowest RI value of 0.02, is identified by Paharika Dairy as the least achievable environmental outcome. Implementation of SO13 would improve the working environment through hygiene atmosphere, cleanliness and disease control management.

There is no significant difference between the opinions of Nahar and Paharika Dairies regarding the achievement of environmental outcomes. Although the RI values given to SO13 are quite different, their order of importance is the same, at second and third respectively. Nahar identified outcome SO13 (0.06) as the second most achievable environmental outcome, whereas Paharika saw it as the least achievable environmental outcome with an RI value of 0.02. Both dairies identified outcome (SO15) as the top most achievable environmental outcome.

6.7 SUMMARY

This chapter discussed the findings which were based on the combination of literature review and QFD analysis on dairy supply chain risk mitigation management. The clarification of the findings has been carried out to support the research questions. The findings reveal that real-life dairy supply chains could achieve sustainability if dairy farms were to implement the suggested mitigation strategies. Sometimes, a maiden strategy implementation can mitigate more than one risk for the dairy industry in Bangladesh. Finally, this chapter has provided a guideline for adopting appropriate strategies to mitigate possible risks and enhance economic, social and environmental sustainability. The following chapter provides concluding remarks and future directions arising from the current research.

CHAPTER 7:
CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

7.1 INTRODUCTION

The final chapter of this thesis recaps all the research that has been conducted to complete this study. A review of the literature revealed that the Quality Function Deployment (QFD) technique has not been used in dairy supply chain risk management to date. The literature was reviewed and practical interviews were conducted to identify existing supply chain risks. Subsequently, QFD played a vital role in identifying high impact and highly probable risks and strategies for their mitigation. After undertaking a through literature review regarding various theoretical and industrial aspects of the research problem, the next section provides a summary of the research questions and objectives.

The research theme, methodology, analysis, results and discussion are also included in this section. To conduct this research, in-depth interviews were undertaken with different stakeholders of two case industries to identify different supply chain risks and risk mitigation strategies, along with different possible outcomes after implementing the various risk mitigation strategies in the dairy industry (Chapter 5). The qualitative interviews were employed to contextualise the factors and variables in the current settings. Based on the findings of the qualitative interviews and the literature, different supply chain risks, risk mitigation strategies and possible sustainable outcomes (associated with Bangladesh dairy sector) were identified. Later, quantitative data was collected through a questionnaire survey for QFD analysis to ascertain probability and impact ratings of risk, relationship ratings of risk and mitigation strategies, and relative cost for implementing each strategy. The data from the questionnaire survey were analysed using the QFD (Quality Function Deployment) technique.

Data related to probable sustainable outcomes were also collected through the questionnaire survey. Later these data were analysed using the networked QFD technique. The findings of the literature review and an analysis of the qualitative data and quantitative data were presented in Chapter 5. A brief discussion of the analysis was presented in Chapter 6. How the research findings contribute to existing knowledge in terms of methodology, theory and practice are also addressed in this

chapter and the implications and limitations of the study are highlighted. In the final section, several ideas for future research are outlined.

7.2 SUMMARY OF THE RESEARCH

There is a genuine lack of empirical studies on supply chain risk management, and even more so in relation to the dairy supply chain. The dairy industry in Bangladeshis a major sub-sectors which serves to alleviate poverty and create employment and thus contributes to the economic and social development of the country. In spite of having such great potential, the dairy industry has not attracted much attention from academics or government officials from the beginning. Most of the dairy industries in Bangladesh face various risks associated with feed, breed, land scarcity, diseases, logistics facilities and many others arising from economic, social, political, and environmental issues. In recent years, although supply chain risk management is a burning issue, very limited study has been conducted in this field, especially in the Bangladesh context. Till now, very few studies have been conducted in relation to the basic components of the dairy industry in Bangladesh and discussion has been confined to dairy production, consumption and marketing in Bangladesh (Halder and Barua 2003), policy barriers for the dairy value chain (Jabbar 2010), problems and prospects of smallholder dairy production (Singh and Pandir 2001), feeding strategy for dairy development (Khan, Peters and Uddin 2009), social gains from dairy development (Haque 2009) and vertical integration in the Bangladesh dairy sector (Raha and Talukder 2004).

In recent years, the Bangladesh dairy industry has developed significantly with a systematic production process within a commercial environment. New entrepreneurs are becoming involved in small scale dairy farming in urban and peri-urban areas (Saadullah 2001; Imtiaz and Rana 2014; Rahman 2014). The dairy industry contributes significantly towards the country's GDP. This sector is also an important and growing sector of Bangladesh's economy, which is increasingly proving to be a worthwhile livelihood option for a large number of households engaged in milk production and trade.

The dairy sector in Bangladesh is well integrated into the mixed farming system (Saadullah 2001; Devendra and Thomas 2002; Imtiaz and Rana 2014). Cattle are reared not only for eating purposes but also to earn cash through selling a variety of products like milk, milk made products, meat, manure and skin (Ahuja and Redmond

2004; Sultana 2002; Rahman 2014). Although the dairy sector contributes significantly to the economic development of Bangladesh, there are still some risks associated with this sector which handicap its growth and development. The development, structure, risk, scope and contribution of the Bangladesh dairy industry were discussed in Chapter 2. Chapter 2 also described the research case industry operation. The description is also presented the Bangladesh dairy operation and case industry operation to this thesis.

The intention and uniqueness of this research is expressed in Chapter 2 based on its importance for filling the gap in the current literature and practice. The scope and focus of the research are also included in that chapter to highlight the boundaries of the current research. The research objectives and research questions were also included, together with an explanation of the reasons for taking this particular research direction. Then the relevant literature was reviewed in Chapter 3 to identify the research gap. At the same time the aptness and the worthiness of the current research were discussed in light of the research gap.

In terms of methodology, this research took a mixed methods approach that combined both qualitative and quantitative methods in a three-phase data collection process (as described in Chapter 4). A rigorous research process was also described in that chapter (see Figure 4.2). The research employed a Quality Function Deployment (QFD) technique using a quantitative approach which was also detailed in the methodological section of the thesis. The first phase involved qualitative research designed to identify different risks existing at the storage, processing and distribution levels of the dairy supply chain, various possible mitigation strategies to mitigate those risks, and different probable outcomes. Data gathered from the in-depth interviews were combined with data from the literature review collected by means of content analysis (as described in chapter 5).

The quantitative phase of the research involved the development and administration of the questionnaire for the research survey with a view to collecting data for QFD analysis (as described in Chapter 4). After obtaining the required data, different matrices for QFD analysis were developed. Later, the calculations for the quantitative analysis were made, as described in Chapter 5. The QFD analysis revealed that additional research was required to identify the sustainable outcomes referred to in the research question. This requirement led to the third phase of the research.

Telephone interviews were conducted to gather in-depth knowledge about the probable sustainable outcomes after applying different optimal mitigation strategies (as described in Chapter 5). Overall, the findings identified the prioritised dairy supply chain risks, important risk mitigation strategies and most realisable sustainable outcomes (as described in Chapter 6). Chapter 6 focused on discussing the answers to the research questions one after another with related results from the data analyses. The reliability and validity of the QFD model were also discussed in this chapter.

7.3 CONTRIBUTIONS OF THE RESEARCH

7.3.1 Theoretical Contributions

This study makes several theoretical contributions. The leading theoretical contribution refers to the identification of supply chain risks associated with the dairy sector of Bangladesh in a sustainability context(Carter and Rogers 2008a). The study is also explored the possible sustainable outcomes of developing risk mitigation strategies. Such strategies can be helpful for improving farm's productivity and efficiency. These variables are related with the contingency theory (Zeithaml, Varadarajan and Zeithaml 1988b) which can assist to reduce or eliminate dairy supply chain risks. The study identified 45 supply chain risks of various kinds. Risks were then categorised in terms of different operational levels, such as storage, processing and distribution. Such categorisation of risks helped the researcher to identify the most problematic areas at different levels. Categorised risks were then sub-categorised in terms of the three aspects of sustainability: economic, social and environmental. Later these risks were arranged according to their high probability and high impact on existing operations.

The second theoretical contribution of this study is to develop a Quality Function Deployment (QFD)-based supply chain risk mitigation model for the Bangladesh dairy industry. By employing QFD analysis, this research was able to categorise different risks to the dairy supply chain that are highly probable with high impact. The effectiveness of risk mitigation strategies in terms of budget constraints was also revealed through the use of the Quality Function Deployment (QFD) tool and the possible sustainable outcomes were determined using networked QFD. So this research is a comprehensive version of real-life practice in mitigating different dairy supply chain risks by applying effective and appropriate mitigation strategies that bring sustainable benefits for the farmers, society and the environment. This study incorporates scattered risks and their suitable mitigation strategies into one

framework for the sake of better risk management which, in turn, leads to better productivity.

Another contribution of this study is the confirmation of a number of important risk factors and mitigation strategies associated with dairy supply chain risk management. The risk factors were classified according to sustainability theory and these were separated according to individual sectors, such as risks in the storage sector, risks in the processing sector and risks in the distribution sector. Risks common to all sectors and risks specific to each individual sector were also included in the study. The mitigation strategies were also classified in the same way. This study also contributes by revealing sustainable outcomes that could be achieved through the application of different risk mitigation strategies. The different kinds of risk include financial, technological, human resource, political and natural risks. The risk mitigation strategies consist of training management, breed management, diseases management, infrastructural support and government support. The model is unique in the sense that the factors and variables of risk, mitigation strategies and outcomes have been identified and finalised from data from a qualitative field study together with previous literature. Thereby, this study contributes to the body of knowledge as there is no previous research on dairy supply chain risk mitigation that identifies the supply chain risks in terms of sustainability and simultaneously explains the possible mitigation strategies for different risks along with probable sustainable outcomes. This massive interaction of risks, risk mitigation strategies and sustainable outcomes had not been found in any previous research. Thus this specific contribution enriches the relevant knowledge of Bangladesh dairy supply chain risk management.

Finally, the use of the Quality Function Deployment (QFD) technique in this study enables identification of the highly probable and high impact risks, most important mitigation strategies to reduce or mitigate those risks, and most achievable sustainable benefits from mitigating those risks. This model also reflects the budget constraints that must be considered when applying different risk mitigation strategies, especially in case of dairy supply chain risk mitigation in Bangladesh. This technique can track possible disasters in time by identifying upcoming risk and by adopting a preventive approach in advance. By doing so, the dairy industry can avoid financial losses and take care to identify possible risks in different sectors (storage, processing, and distribution). In this way the QFD-based model for dairy supply chain risk mitigation adds to knowledge about prediction in an unpredictable situation.

7.3.2 Practical Contribution

This study makes some specific contributions to real life practice for the dairy industry in Bangladesh. The following sections underline the practical contribution of this study.

Firstly, the study contributes to the Bangladesh dairy industry in terms of risk identification. The research showed that the Bangladesh dairy industry is still unstructured due to several risks which hinder its growth and development. This suggests that dairy industry stakeholders need a structured and effective approach for identifying dairy supply chain risks. In the context of this research, dairy supply chain risks embedded in storage, processing and distribution are identified in view of their economic, social and environmental aspects. The economic risks come from shortage of funds; the social risks arise from the influence of social pressure; and environmental risks come from natural uncertainties. All possible risks are gathered and analysed in this study. Furthermore, these risks are also categorised on the basis of their high probability and high impact. Therefore, not only in the dairy industry, but in any other livestock industry, concerned authorities may consider the findings of this study useful as a guide to identify possible risks for specific levels.

Secondly, the study explored the possible strategies to mitigate the risks related to the dairy industry in Bangladesh. Using the QFD approach, these strategies were also analysed in relation to their budget constraints. The optimum mitigation strategies according to the opinion of different stakeholders (employees, executives and supply chain members) were determined from this analysis. Thus it is expected that practical application of the study contributes significantly to the dairy sector of Bangladesh in terms of planning and determining appropriate and effective strategies to mitigate existing or potential risks.

Thirdly, a number of sustainable outcomes are also identified from the findings of this study. The most realisable outcome through implementation of mitigation strategy is traced out with the help of QFD analysis. For example, cost minimisation is identified as the most attainable economic outcome where supply of quality food is fixed as the most realisable social outcome. Improvement of animal health is identified as the most attainable environmental outcome. These sustainable outcomes could be achieved through mitigation strategy implementation. So the outcomes of this research will benefit the dairy stakeholders, supply chain members, the concerned livestock ministry and officials by providing ideas for realisable sustainable outcomes.

Fourthly, the dairy supply chain risk mitigation model has become the top priority for the case industries to implement within their supply chain network. The QFD technique is an effective way to track the most important strategies for mitigating highly probable and high impact risks in the dairy supply chain. The industry can identify potential risks in advance and can adopt time-based strategies to mitigate different risks associated with this industry's storing, processing and distributing activities. Such a facility would help the industry to improve productivity by achieving sustainable growth.

Finally, the research model can generate a clear idea of different risks in the dairy supply chain, possible strategies for mitigating those risks, along with probable sustainable outcomes. Thus, if the model is applied to dairy practice, decision making will be easy and smooth. Prediction can assist the relevant authorities to identify different dairy risks and help them to prepare themselves in order to prevent or lessen the effects of those risks by taking proper time-based decisions.

7.4 IMPLICATIONS FOR THE DAIRY INDUSTRY AND POLICY MAKERS

The major implication of this research is its practical implementation and interpretation by the dairy stakeholders, policy makers, concerned livestock ministry and officials. The practice of supply chain risk management is still a very new concept in the Bangladesh dairy sector. Many companies in Bangladesh are not even serious about the formal management of their supply chain. The findings of this research will contribute to the dairy supply chain process by identifying the existing risks embedded in the dairy sector. The research identifies different categories of dairy supply chain risk in Bangladesh and emphasises categorising highly probable and high impact risks, along with suggesting effective mitigation strategies. Therefore the practical application of this research will contribute significantly to the dairy sector of Bangladesh in terms of taking the decision to mitigate the existing risks. The outcomes of this study will benefit the dairy stakeholders, supply chain members, concerned authorities and policy makers who significantly contribute to the practical aspects of the Bangladesh dairy industry.

The supply chain risk mitigation model could be adopted to increase productivity and bring sustainable development to the Bangladesh dairy industry through effective supply chain risk mitigation. Through QFD analysis, the best alternative from a variety of different risk mitigation strategies can be easily selected. So using this technique,

and supported by the relevant software application, the management of dairy industries may be able to judge their decisions more efficiently compared to the traditional method. In addition, the level of risk mitigation taking into consideration various budget constraints could be realised through QFD analysis. Industry personnel can identify the different levels of risk mitigation with changing budgets and this would help them to decide whether or not their risk could be mitigated with their budgeted amount.

7.5 RESEARCH LIMITATIONS

There are some limitations of this research which are detailed as follows:

Firstly, the qualitative data for this research were collected through in-depth interviews. All the factors and variables were composed through qualitative data which were collected via a rigorous questionnaire survey. A number of factors and variables were identified in the qualitative phase of the research. The outcome of the questionnaire survey was subject to quantitative analyses of various factors and variables. Obviously, misleading (if there is any) information may lead to inaccurate judgement of research findings. The research examined two case industries to determine the aggregate situation in the dairy industry of Bangladesh. It is a little risky to attempt to generalise from these to the whole scenario, although the research has selected the most scientific dairy farms in the case area. There would be greater justification for such a generalisation if more case industries could be added to construct a huge data base.

Secondly, the research considered the Bangladesh dairy industry as its field rather than considering other countries. So the findings of the study are a generic picture of the Bangladesh dairy industry which may not reflect the situation of a different country. For example, political risks are frequent in Bangladesh but may not be so frequent in another country.

Thirdly, this research was conducted among stakeholders (employees, executives and supply chain members) of two case dairy farms in Bangladesh. Most of the respondents were not educated and capable enough to understand the objectives of the research. Hence, the original questionnaire, which was written in English, needed to be translated into local language. It was observed that respondents did not feel free to express the real true scenarios relating to the risks they suffer and strategies they

adopt, thus giving rise to problems related to accuracy. Based on the abovementioned limitations, some important directions for future research can be suggested, which are highlighted in the next section.

7.6 FUTURE DIRECTIONS

The findings of this research relating to supply chain risk, supply chain risk mitigation, sustainability, sustainable outcomes, QFD and the Bangladesh dairy industry can be extended in future in a variety of ways. This study had only a small geographic coverage and a sample of only two case industries in one particular country. A model developed for a specific industry within a particular country may not work in the same way in another country, but might provide guidelines and information for the same kind of study. The present study has taken the first step by using information from one particular country and this can be extended to other countries. Further research could also be conducted to test the model on dairy industries of different sizes.

This study is the first example of research based on sustainability theory and using the QFD method on SCRM in the Bangladesh dairy industry. It is recommended that more research be conducted to reveal the importance of QFD for appropriate policy making related to the same types of industry. More research work would definitely help farmers and decision makers to achieve better productivity and time-based decision making.

Without undermining the findings of the present study, it is acknowledged that the sample size used in this research is small. Therefore, future research could be conducted using larger samples to draw accurate conclusions about the risks, risk mitigation strategies and attainable sustainable outcomes associated with the dairy industry in Bangladesh.

Although Quality Function Deployment (QFD) technique was used in the current research to identify important mitigation strategies and detect sustainable outcomes, the application of QFD involves very lengthy and complex procedures that need massive calculations. The reliability and validity of the QFD method should be further examined and verified. Other decision making techniques could be incorporated in further research to increase the applicability and usefulness of decision making.

REFERENCES

Abdullah, Dr. Muhammad. 2004. "Cost Effective Technologies for Milk Preservation and Processing by Dairy Smes." In *Sustainable Dairy-sector Development for Poverty Reduction*, *Pakistan,* 22 to 27 November. 41-47. Asian Productivity Organization (APO).

ACF. 2012. "Performance & Competitiveness of the Dairy Value-Chain in Zambia." In *A vibrant multi-stakeholder consultative platform in the Zambian agricultural sector*, *Lusaka, Zambia,* 02 July. 1-4. The Agricultural Consultative Forum Secretariat.

Ahern, Jack, Sarel Cilliers, and Jari Niemelä. 2014. "The Concept of Ecosystem Services in Adaptive Urban Planning and Design: A Framework for Supporting Innovation." *Landscape and Urban Planning* 125: 254-259.

Ahsan, Dewan Ali. 2011. "Farmers' Motivations, Risk Perceptions and Risk Management Strategies in a Developing Economy: Bangladesh Experience." *Journal of Risk Research* 14 (3): 325-349.

Ahuja, Vinod, and Elizabeth Redmond. 2004. "Livestock Services and the Poor." *Tropical Animal Health and Production* 36 (3): 247-268.

Aitken, James M. 1998. "Supply Chain Integration within the Context of a Supplier Association: Case Studies of Four Supplier Associations; In: Peck, Helen. 2006. "Reconciling Supply Chain Vulnerability, Risk and Supply Chain Management." International Journal of Logistics: Research and Applications No. 9 (2):128.", Cranfield University.

Akao, Y. 1990. *Quality Function Deployment (Qfd) - Integrating Customers' Requirements into Product Design, English Translation Copyright* USA: Productivity Press.

Akao, Yoji. 1994. "Development History of Quality Function Deployment." *The Customer Driven Approach to Quality Planning and Deployment*: 339.

———. 1997. "Qfd: Past, Present, and Future" *International Symposium on QFD*,

———. 2004. "Quality Function Deployment."

Akcaoz, Handan, Hatice Kizilay, and Orhan Ozcatalbas. 2009. "Risk Management Strategies in Dairy Farming: A Case Study in Turkey." *Journal of Animal and Veterinary Advances* 8 (5): 949-958.

Al-Mashari, Majed, Mohamed Zairi, and David Ginn. 2005. "Key Enablers for the Effective Implementation of Qfd: A Critical Analysis." *Industrial management & Data systems* 105 (9): 1245-1260.

Ali, Jabir, and Sanjeev Kapoor. 2008. "Farmers' Perception on Risks in Fruits and Vegetables Production: An Empirical Study of Uttar Pradesh." *Agricultural Economics Research Review* 21 (2008).

Altekruse, Sean F, Norman J Stern, Patricia I Fields, and David L Swerdlow. 1999. "Campylobacter Jejuni--an Emerging Foodborne Pathogen." *Emerging infectious diseases* 5 (1): 28.

Atkinson, Giles, Susana Mourato, and S Szymanski. 2006. "Quantifying the "Un-Quantifiable": Valuing the Intangible Impacts of Hosting the Summer Olympic Games." *London, unpublished manu-script, London School of Economics and Imperial College London*.

Bader, Pascal. 2008. Sustainability – from Principle to Practice , . *Goethe-Institut*.

Bagheri, Ali, and Peder Hjorth. 2007. "Planning for Sustainable Development: A Paradigm Shift Towards a Process-Based Approach." *Sustainable Development* 15 (2): 83-96.

Bailey, Kenneth. 2008. *Methods of Social Research*: SimonandSchuster. com.

Barabas, J. 1995. "An Alternative Method of Milk Treatment." *World animal review* 83: 71-73.

Bardhan, Dwaipayan, YPS Dabas, SK Tewari, and Avadhesh Kumar. 2006. "An Assessment of Risk Attitude of Dairy Farmers in Uttaranchal (India)" *Proc. of the Agricultural Economists Conference, Gold Coast, Australia, August*,

Bari, Md. Ehsanul. 2008. *Action Plan for Dairy Development in Bangladesh*. Dhaka.

Barrera-Roldán, Adrián, and Américo Saldıvar-Valdés. 2002. "Proposal and Application of a Sustainable Development Index." *Ecological Indicators* 2 (3): 251-256.

BBS. 2008. "Statistical Yearbook of Bangladesh." Government of Bangladesh.

———. 2010. Rural Povery Portal. Accessed 29/03/2012, http://www.ruralpovertyportal.org/web/guest/country/statistics/tags/bangladesh.

Beedell, JDC, and Tahir Rehman. 1999. "Explaining Farmers' Conservation Behaviour: Why Do Farmers Behave the Way They Do?" *Journal of Environmental management* 57 (3): 165-176.

Belisle, Peter T. 2011. "Sustainability/Climate Change." *Strategic Planning for Energy and the Environment* 30 (4): 71-78.

Berg, Bruce Lawrence. 2004. *Qualitative Research Methods for the Social Sciences*. Vol. 5: Pearson Boston.

Bernard, H. Russell. 2012. *Social Research Methods: Qualitative and Quantitative Approaches*: Sage Publications, Incorporated.

Berry, Danny, Denis R Towill, and Nick Wadsley. 1994. "Supply Chain Management in the Electronics Products Industry." *International Journal of Physical Distribution & Logistics Management* 24 (10): 20-32.

Bettis, R. A. 1982. "Risk Considerations in Modelling Corporate Strategy" *Academy of management proceeding.*,

Bevilacqua, Maurizio, FE Ciarapica, and G Giacchetta. 2006. "A Fuzzy-Qfd Approach to Supplier Selection." *Journal of Purchasing and Supply Management* 12 (1): 14-27.

Bicheno, John. 1994. "The Quality 50: A Guide to Gurus, Tools, Wastes, Techniques and Systems." *Buckingham, PICSIE*.

Blos, Mauricio F., Mohammed Quaddus, H.M. Wee, and Kenji Watanabe. 2009. "Supply Chain Risk Management (Scrm): A Case Study on the Automotive and Electronic Industries in Brazil." *Supply Chain Management: An International Journal* 14 (4): 247–252.

Bob, King. 1989. "Better Designs in Half the Time." *Goal/QPC, Methuen MA*.

Bogataj, David, and Marija Bogataj. 2007. "Measuring the Supply Chain Risk and Vulnerability in Frequency Space." *International Journal of Production Economics* 108 (1): 291-301.

Boggess, William G, Kwabena A Anaman, and Gregory D Hanson. 1985. "Importance, Causes and Management Responses to Farm Risks: Evidence from Florida and Alabama." *Southern Journal of Agricultural Economics* 17 (2): 105-116.

Bossen, IL. 1991. "Quality Function Deployment. A Practitionerïs Approach." Marcel Dekker. USA.

Bossert, James L. 1991. *Quality Function Deployment: A Practitioner's Approach*: ASQC Quality Press Milwaukee, WI.

Bottani, Eleonora, and Antonio Rizzi. 2006. "Strategic Management of Logistics Service: A Fuzzy Qfd Approach." *International Journal of Production Economics* 103 (2): 585-599.

Bouchereau, V, and H Rowlands. 1999. "Analytical Approaches to Qfd." *Manufacturing Engineer* 78 (6): 249-254.

Bouchereau, Vivianne, and Hefin Rowlands. 2000a. "Methods and Techniques to Help Quality Function Deployment (Qfd)." *Benchmarking: An International Journal* 7 (1): 8-20.

———. 2000b. "Quality Function Deployment: The Unused Tool." *Engineering Management Journal* 10 (1): 45-52.

Boyazoglu, J. 2002. "Livestock Research and Environmental Sustainability with Special Reference to the Mediterranean Basin." *Small Ruminant Research* 45: 193-200.

Brindley, Clare. 2004. *Supply Chain Risk*: Ashgate Aldershot.

Brown, Patrick G. 1991. "Qfd: Echoing the Voice of the Customer." *AT&T Technical Journal* 70 (2): 18-32.

Carnevalli, Jose A, and Paulo Cauchick Miguel. 2008. "Review, Analysis and Classification of the Literature on Qfd—Types of Research, Difficulties and Benefits." *International Journal of Production Economics* 114 (2): 737-754.

Carter, C.R., and M.M. Jennings. 2004. "The Role of Purchasing in Corporate Social Responsibility: A Structural Equation Analysis." *Journal of Business Logistics* 25 (1): 145-86.

Carter, Craig R., and Dale S. Rogers. 2008a. "A Framework of Sustainable Supply Chain Management: Moving toward New Theory." *International Journal of Physical Distribution & LogisticsManagement* 38 (5): 360-387.

———. 2008b. "A Framework of Sustainable Supply Chain Management: Moving toward New Theory." *International Journal of Physical Distribution & Logistics Management* 38 (5): 360-387.

Chaddad, Fabio R, and Michael L Cook. 2004. "Understanding New Cooperative Models: An Ownership–Control Rights Typology." *Applied Economic Perspectives and Policy* 26 (3): 348-360.

Chan, Lai-Kow, and Ming-Lu Wu. 2002. "Quality Function Deployment: A Literature Review." *European Journal of Operational Research* 143 (3): 463-497.
ChartsBin. 2015. Current Worldwide Total Milk Consumption Per Capita. Accessed April 10,
Chen, Liang-Hsuan, and Wen-Chang Ko. 2010. "Fuzzy Linear Programming Models for Npd Using a Four-Phase Qfd Activity Process Based on the Means-End Chain Concept." *European Journal of Operational Research* 201 (2): 619-632.
Chesterton, RN, DU Pfeiffer, RS Morris, and CM Tanner. 1989. "Environmental and Behavioural Factors Affecting the Prevalence of Foot Lameness in New Zealand Dairy Herds—a Case-Control Study." *New Zealand Veterinary Journal* 37 (4): 135-142.
Choudhary, Vikas, Anton Van Engelen, Sam Sebadduka, and Pablo Valdivia. 2011. *Uganda Dairy Supply Chain Risk Assessment*. Switzerland
Chowan, Monoj. 2015. Status of Dairy Management in Bangladesh, february 28, Dairy management in Bangladesh, Sonapahar, Mirarsharai Chittagong, Bangladesh.
Chowdhury, Mohammed S. 2007. "Overcoming Entrepreneurship Development Constraints: The Case of Bangladesh." *Journal of Enterprising Communities: People and Places in the Global Economy* 1 (3): 240-251.
Christopher, Martin. 1992. "Logistics &." *Supply Chain Management*.
Christopher, Martin, and Hau Lee. 2004. "Mitigating Supply Chain Risk through Improved Confidence." *International Journal of Physical Distribution & Logistics Management* 34 (5): 388-396.
Christopher, Martin, and Helen Peck. 2004. "Building the Resilient Supply Chain." *International Journal of Logistics Management, The* 15 (2): 1-14.
Cohen, Barney. 2006. "Urbanization in Developing Countries: Current Trends, Future Projections, and Key Challenges for Sustainability." *Technology in society* 28 (1): 63-80.
Cohen, Lou, and Lou Cohen. 1995. *Quality Function Deployment: How to Make Qfd Work for You*: Addison-Wesley Reading, MA.
Cohen, Philip R, and Hector J Levesque. 1990. "Intention Is Choice with Commitment." *Artificial intelligence* 42 (2): 213-261.
Collard, Natalie, and Charles McElhone. 2014. *Australian Dairy Industry*. Melbourne, Australia.
Colletti, Joe, Steven Hoff, Janette Thompson, and John Tyndall. 2006. "Vegetative Environmental Buffers to Mitigate Odor and Aerosol Pollutants Emitted from Poultry Production Sites" *Proceedings of The Workshop on Agricultural Air Quality: State of Science, Potomac, MD*,
Cooper, C.M., M.D. Lambert, and D.J. Pagh. 1997. "Supply Chain Management: More Than a New Name for Logistics." *International Journal of Logistics Management* 8 (1): 1-9.
Corbin, Juliet, and Anselm Strauss. 2008. "Basics of Qualitative Research." Thousand Oaks, CA: Sage.
Council, Supply-Chain. 1999. *Supply-Chain Council*: The Council.
Cox, J.F., J.H. Blackstone, and M.S. Spencer. 1995. "Apics Dictionary (8th Ed.)." Falls Church, VA: American Production and Inventory Control Society.
Cox Jr, Louis Anthony Tony. 2012. "Evaluating and Improving Risk Formulas for Allocating Limited Budgets to Expensive Risk-Reduction Opportunities." *Risk Analysis* 32 (7): 1244-1252.
Creswell, J W. 2008. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*: Sage Publications, Incorporated.
Creswell, John W. 2002. "Educational Research: Planning, Conducting, and Evaluating Quantitative."
———. 2013. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*: Sage.
Croom, Simon, Pietro Romano, and Mihalis Giannakis. 2000. "Supply Chain Management: An Analytical Framework for Critical Literature Review." *European journal of purchasing & supply management* 6 (1): 67-83.
Cross, John A. 2006. "Restructuring America's Dairy Farms*." *Geographical Review* 96 (1): 1-23.
Curtis, Mark. 2011. *Milking the Poor: How Eu Subsidies Hurt Dairy Producers in Bangladesh*. Dhaka: Actionaid.
Dahlgaard, K. Kanji 1994. " Break Down Barriers between Departments." *Advances in Total Quality Management*: 81-89.
Daily, B.F., and S. Huang. 2001. "Achieving Sustainability through Attention to Human Resource Factors in Environmental Management." *International journal of operations & production Management* 21 (12): 1539-52.

Daily, Gretchen C., and Paul R. Ehrlich. 1992. "Population, Sustainability, and Earth's Carrying Capacity." *BioScience* 42 (10): 761-771.
Darnhofer, Ika, Stéphane Bellon, Benoît Dedieu, and Rebecka Milestad. 2011. "Adaptiveness to Enhance the Sustainability of Farming Systems." In *Sustainable Agriculture Volume 2*, 45-58. Springer.
Das, S.C., S.D. Chowdhury, M.A. Khatun, M. Nishibori, N. Isobe, and Y. Yoshimura. 2008. "Poultry Production Profile and Expected Future Projection in Bangladesh." *World's Poultry Science Journal* 64 (01): 99-118. doi: doi:10.1017/S0043933907001754.
Davis, Kingsley. 1990. "Population and Resources: Fact and Interpretation." *Population and Development Review* 16: 1-21.
Day, Ronald G. 1993. *Quality Function Deployment: Linking a Company with Its Customers*. Vol. 180: ASQC Quality Press Milwaukee WI.
de Jong, Peter. 2013. "The Future of Sustainable Dairy Production." *Sustainable Dairy Production*: 243-250.
Deimel, Mark, Mechthild Frentrup, and Ludwig Theuvsen. 2008. "Transparency in Food Supply Chains: Empirical Results from German Pig and Dairy Production." *Journal on Chain and Network Science* 8 (1): 21-32.
Denzin, Norman K., and Yvonna S. Lincoln. 2011. *The Sage Handbook of Qualitative Research*: SAGE Publications, Incorporated.
Devendra, C, and D Thomas. 2002. "Crop–Animal Interactions in Mixed Farming Systems in Asia." *Agricultural Systems* 71 (1): 27-40.
Diesendorf, Mark. 2000. "Sustainability and Sustainable Development." *Sustainability: The corporate challenge of the 21st century*: 19-37.
DLS. 2005. *Development and Activities of Livestock-an Overview*. Dhaka.
———. 2010. *Development and Activities of Livestock-an Overview*. Dhaka.
———. 2012. *Livestock Production and Information*. Dhaka. www.dls.gov.bd.
———. 2014. *Livestock Production and Information*. Dhaka. www.dls.gov.bd.
Dobson, William D. 1990. "Dairy Board." *Agribusiness* 6 (6): 541-558.
Dries, Liesbeth, Etleva Germenji, Nivelin Noev, and Johan FM Swinnen. 2009. "Farmers, Vertical Coordination, and the Restructuring of Dairy Supply Chains in Central and Eastern Europe." *World development* 37 (11): 1742-1758.
Du, XQ, H Greenfield, DR Fraser, KY Ge, ZH Liu, and W He. 2002. "Milk Consumption and Bone Mineral Content in Chinese Adolescent Girls." *Bone* 30 (3): 521-528.
Dunn, John, and RJ Herring. 1983. "Country Risk: Social and Cultural Aspects." *Managing international risk*: 139-68.
Dwivedi, YK. 2007. *Consumer Adoption and Usage of Broadband*. NY: IRM Press.
Edwards, D.R., and T.C. Daniel. 1992. "Environmental Impacts of on-Farm Poultry Waste Disposal-a Review." *Bioresource Technology* 41 (1): 9-33.
Eisenhardt, Kathleen M, and Melissa E Graebner. 2007. "Theory Building from Cases: Opportunities and Challenges." *Academy of management journal* 50 (1): 25-32.
Elkington, John. 1994. "Towards the Sustainable Corporation: Win-Win-Win Business Strategies for Sustainable Development." *California Managemnet Review* 36 (2): 90-100.
———. 1998. *Cannibals with Forks: The Triple Bottom Line of the 21st Century Business*. Vol. Reprint 2002. Stoney Creek, CT.: New Society Publishers.
———. 2004. "Enter the Triple Bottom Line." *The triple bottom line: Does it all add up*: 1-16.
Ellram, L., and M. Cooper. 1993. "Characteristics of Supply Chain Management and the Implications for Purchasing and Logistics Strategy." *International Journal of Logistics Management* 4 (2): 1-10.
Ellram, Lisa M. 1991. "Supply-Chain Management: The Industrial Organisation Perspective." *International Journal of Physical Distribution & Logistics Management* 21 (1): 13-22.
Erlich, P.R., and A.H. Erlich. 1991. *The Population Explosion*. New York, NY: Touchstone.
Ermer, Donald S, and Mark K Kniper. 1998. "Delighting the Customer: Quality Function Deployment for Quality Service Design." *Total Quality Management* 9 (4-5): 86-91.
Ertay, Tijen, Gülçin Büyüközkan, Cengiz Kahraman, and Da Ruan. 2005. "Quality Function Deployment Implementation Based on Analytic Network Process with Linguistic Data: An Application in Automotive Industry." *Journal of Intelligent & Fuzzy Systems: Applications in Engineering and Technology* 16 (3): 221-232.
Fairclough, Norman. 2003. *Analysing Discourse: Textual Analysis for Social Research*: Routledge.

Faisal, Mohd Nishat. 2010. "Sustainable Supply Chains: A Study of Interaction among the Enablers." *Business Process Management Journal* 16 (3): 508-529.
Fałkowski, Jan. 2012. "Dairy Supply Chain Modernisation in Poland: What About Those Not Keeping Pace?" *European Review of Agricultural Economics* 39 (3): 397-415.
FAOSTAT. 2014. Milk Production Worldwide FAO. http://www.adbi.org/3rdpartycdrom/2005/06/01/1507.fao.agriculture.statistics/.
Fawcett, Stanley E, Gregory M Magnan, and Matthew W McCarter. 2008. "Benefits, Barriers, and Bridges to Effective Supply Chain Management." *Supply Chain Management: An International Journal* 13 (1): 35-48.
Faye, B, and G Loiseau. 2002a. "Sources of Contamination in Dairy Supply Chains and Approaches to Quality Control." *International Cooperation in International Research for Agricultural Development (CIRAD) -FAO*, *Montpellier, France,*
———. 2002b. "Sources of Contamination in Dairy Supply Chains and Approaches to Quality Control." *International Cooperation in International Research for Agricultural Development (CIRAD) -FAO*, *Montpellier, France,*
Fiedler, Fred E. 1971. "Validation and Extension of the Contingency Model of Leadership Effectiveness: A Review of Empirical Findings." *Pshycological Bulletin* 76 (2): 128-148.
Filipovic, D, and M Kokaj. 2009. "The Comparison of Hand and Machine Milking on Small Family Dairy Farms in Central Croatia." *Livestock Research for Rural Development* 21 (5): 4.
Finch, Peter. 2004. "Supply Chain Risk Management." *Supply Chain Management: An International Journal* 9 (2): 183-196.
Flaten, Ola, Gudbrand Lien, Matthias Koesling, Paul Steinar Valle, and Martha Ebbesvik. 2005. "Comparing Risk Perceptions and Risk Management in Organic and Conventional Dairy Farming: Empirical Results from Norway." *Livestock Production Science* 95 (1): 11-25.
Fortuna, Ronald M. 1988. "Beyond Quality-Taking Spc Upstream." *Quality Progress* 21 (6): 23-28.
Fowler, CT. 1991. "Qfd-Easy as 1-2-3." *1991 SAVE (Society of American Engineers) Proceedings* 26: 177-82.
Gephart, Robert. 1999. "Paradigms and Research Methods" *Research Methods Forum*: Basic Books.
Ghani, Nasimul, and Mohammed Habibur Rahman. 2004. "Sustainable Dairy-Sector Development for Poverty Reduction " In *APO Seminar on Sustainable Dairy-sector Development for Poverty Reduction*, *Pakistan,* 22-27 November.
Ghosh, Ashoke Kumar, and Keshav Lall Maharjan. 2001. "Impacts of Dairy Cooperative on Rural Income Generation in Bangladesh." *Journal of International Development and Cooperation* 8 (1): 67–90.
Giannakis, MIHALIS, Simon Croom, and Nigel Slack. 2004. "Supply Chain Paradigms." *Understanding Supply Chains, Oxford University Press, UK*: 1-22.
Giunipero, Larry C, and Reham Aly Eltantawy. 2004. "Securing the Upstream Supply Chain: A Risk Management Approach." *International Journal of Physical Distribution & Logistics Management* 34 (9): 698-713.
Giunipero, Larry C, and Dawn H Pearcy. 2000. "World-Class Purchasing Skills: An Empirical Investigation." *Journal of Supply Chain Management* 36 (3): 4-13.
Gladwin, T.N., J.J. Kennelly, and T. Krause. 1995. "Shifting Paradigms for Sustainable Development: Implications for Management Theory and Research." *Academy of Management Review* 20 (4): 874-907.
Go´ncz, E., U. Skirke, H. Kleizen, and M. Barber. 2007. "Increasing the Rate of Sustainable Change: A Call for a Redefinition of the Concept and the Model for Its Implementation." *Journal of Cleaner Production* 15 (6): 525-37.
Godfray, H Charles J, John R Beddington, Ian R Crute, Lawrence Haddad, David Lawrence, James F Muir, Jules Pretty, Sherman Robinson, Sandy M Thomas, and Camilla Toulmin. 2010. "Food Security: The Challenge of Feeding 9 Billion People." *science* 327 (5967): 812-818.
Goel, Veena, and Suku Bhaskarkan. 2010. "Supply Chain Management in a Private Farming Vis-À-Vis Cooperative Processing and Distribution Environment of Dairy Sector in India." *Journal of Food Products Marketing* 16 (2): 212-231.
Goodland, Robert, and Herman Daly. 1996. "Environmental Sustainability: Universal and Non-Negotiable." *Ecological Applications*: 1002-1017.

Greene, Jennifer C, Valerie J Caracelli, and Wendy F Graham. 1989a. "Toward a Conceptual Framework for Mixed-Method Evaluation Designs." *Educational evaluation and policy analysis* 11 (3): 255-274.

Greene, Jennifer C., Valerie J. Caracelli, and Wendy F. Graham. 1989b. "Toward a Conceptual Framework for Mixed-Method Evaluation Designs." *Education Evaluation and Policy Analysis* 11: 255-274.

Griffin, Abbie. 1992. "Evaluating Qfd's Use in Us Firms as a Process for Developing Products." *Journal of Product Innovation Management* 9 (3): 171-187.

Griffin, Abbie, and John R Hauser. 1992. "Patterns of Communication among Marketing, Engineering and Manufacturing—a Comparison between Two New Product Teams." *Management science* 38 (3): 360-373.

———. 1993. "The Voice of the Customer." *Marketing science* 12 (1): 1-27.

Gunasekaran, A. 1998. "Agile Manufacturing: Enablers and an Implementation Framework." *International Journal of Production Research* 36 (5): 1223-1247.

Ha, Dr. Jong Kyu, and Hyun Jin Kim. 2004. "Management of Dairy-Animal Feeding for Better Productivity and Food Safety." In *Sustainable Dairy-sector Development for Poverty Reduction*, *Faisalabad, Pakistan,* November 25-35. Asian Productivity Organization (APO).

Habiba, Umma, Rajib Shaw, and Yukiko Takeuchi. 2011. "Drought Risk Reduction through a Socio-Economic, Institutional and Physical Approach in the Northwestern Region of Bangladesh." *Environmental Hazards* 10 (2): 121-138.

Hair, JF, AH Money, and P Samouel. 2007. *Research Methods for Business*. USA: Wiley.

Halder, Shantana R, and Proloy Barua. 2003. *Dairy Production, Consumption and Marketing in Bangladesh*. Dhaka.

Hall, David C., Md. Golam Shah Alam, and Shankar K. Raha. 2012. "Improving Dairy Production in Bangladesh: Application of Integrated Agriculture and Ecohealth Concepts." *International Journal of Livestock Production* 3 (3): 29-35.

Hall, Ralph. 2012. "Mixed Methods: In Search of a Paradigm." *Vortrag. Download (am 10.01. 2013) unter: http://www. auamii. com/proceedings_Phuket_2012/Hall. pdf*.

Han, S Bruce, Shaw K Chen, Maling Ebrahimpur, and Manbir S Sodhi. 2001. "A Conceptual Qfd Planning Model." *The international Journal of Quality and Reliability Management* 18 (8/9): 796-812.

Haque, S A M Anwarul. 2009. "Bangladesh: Social Gains from Dairy Development." *Smallholder dairy development: Lessons learned in Asia*: 8-21.

Harding, Jennifer A, K Popplewell, Richard YK Fung, and Abdul R Omar. 2001. "An Intelligent Information Framework Relating Customer Requirements and Product Characteristics." *Computers in Industry* 44 (1): 51-65.

Harland, Christine, Richard Brenchley, and Helen Walker. 2003. "Risk in Supply Networks." *Journal of Purchasing and Supply management* 9 (2): 51-62.

Hart, S.L. 1995. "A Natural-Resource-Based View of the Firm." *Academy of Management Review* 20 (4): 986-1014.

Hart, Stuart L. 1997. "Beyond Greening: Strategies for a Sustainable World." *Harvard business review* 75 (1): 66-77.

Harwood, Joy L, Richard Heifner, Keith Coble, Janet Perry, and Agapi Somwaru. 1999. *Managing Risk in Farming: Concepts, Research, and Analysis*: US Department of Agriculture, Economic Research Service.

Hashmi, Arshad Hussain. 2004. "Role of Small and Medium Enterprises (Smes) in Sustainable Dairy Development in Pakistan." In *The seminer on sustainable dairy development for poverty reduction*, *Faisalabad,* 22 to 27 NOvember. Asian productivity organisation (APO), Government of Pakistan.

Hemme, T. 2010. *Ifcn Dairy Report 2010*. Kiel, Germany, Website: www.ifcndairy.org.

Hemme, T O, and A R Khan. 2004. *A Review of Milk Production in Bangladesh with Particular Emphasis on Small Scale Prodicers*. Rome.

Hemme, Torsten, and Mohammad Uddin. 2009. *Dairy Case Study: Bangladesh Vs. The Eu*. Kiel, Germany. http://www.oxfam.de/sites/www.oxfam.de/files/20091128_Englischsprachige_Hintergrundstudie_des_IFCN.pdf.

Hendricks, K B, and V. R. Singhal. 2003. "The Effect of Supply Chain Glitches on Shareholder Value." *Journal of Operations Management* 21 (5): 501–522.

Hendrickson, Mary, William D Heffernan, Philip H Howard, and Judith B Heffernan. 2001. "Consolidation in Food Retailing and Dairy." *British Food Journal* 103 (10): 715-728.

Henriques, A., and J. Richardson. 2004. *The Triple Bottom Line: Does It All Add Up?* London: Earthscan.

Henson, Spencer, and Thomas Reardon. 2005. "Private Agri-Food Standards: Implications for Food Policy and the Agri-Food System." *Food policy* 30 (3): 241-253.

Hill, M.R. 2001. "Sustainability, Greenhouse Gas Emissions, and International Operations Management." *International Journal of Operations & Production Management,* 21 (12): 1503-20.

Howell, David. 2000. "Making Wishes Come True." *Professional Engineering* 13 (3): 39.

Hsieh, C.-H. and Y.-C. Wu 2016. A New QFD Model for Strategic Resource Based Product Innovation. ISPIM Innovation Symposium, The International Society for Professional Innovation Management (ISPIM).

Huq, Khondaker Muzammel. 2007. *Integrated Energy and Food Security Farming through Mini Dairy Farms in Bangladesh*. Dhaka, Bangladesh.

Imtiaz, MA, and S Rana. 2014. "Problems Faced by the Small Scale Dairy Owners in Receiving Veterinary Services in Selected Areas of Chittagong." *Bangladesh Journal of Veterinary Medicine* 12 (1): 63-65.

IRIN. 2013. *Bangladesh: Poultry Industry Still Reeling from Bird Flu*. http://www.irinnews.org/report/96056/bangladesh-poultry-industry-still-reeling-from-bird-flu.

Islam, S M Fakhrul, M A Jabbar, S K Ehui, Chris Delgado, Md. Kamruzzaman, and Md. Aminul Islam. 2002. *Differential Impacts of Policy and Scale Factors on Dairy Producers in Bangladesh*. Dhaka.

Islam, SM Fakhrul, MA Jabbar, SK Ehui, M KAMRUZZAMAN, and MA ISLAM. 2001. "Differential Impacts of Policy Scale Factors on Dairy Producers in Bangladesh" *Proceeding of Workshop on Policy and Institutional Factors Affecting Poultry and Daily Producers in Bangladesh, Dhaka*,

IUF. 2013a. *Indian Dairy Industry*. USA: IUF. www.iuf.org/sites/cms.iuf.org/files/USA%20Dairy%20Industry.pdf.

———. 2013b. *United States of America Dairy Industry*. USA. www.iuf.org/sites/cms.iuf.org/files/USA%20Dairy%20Industry.pdf.

Jabbar, Mohammad A. 2010. *Policy Barriers for Dairy Value Chain Development in Bangladesh with a Focus on the North West Region*.

Jahan, N, and H Rahman. 2003. "Livestock Services and the Poor in Bangladesh: A Case Study." *Edited by S. Chipeta, an initiative by DANIDA, IFAD and the World Bank*.

Javed, Muhammad Nasir. 2004. "Sustainable Development of the Cottage Dairy Sector in Asia and the Pacific–Challenges and Opportunities." *Part III Country Papers* 85 (82.2): 108-109. www.apo-tokyo.org/publications/wp-content/.../pjrep-04-ag-ge-sem-16.pdf.

Jennings, P.D., and P.A. Zandbergen. 1995. "Ecologically Sustainable Organizations: An Institutional Approach." *The Academy of Management review* 20 (4): 1015-1052.

Jia, Xiangping, Jikun Huang, Hao Luan, Scott Rozelle, and Johan Swinnen. 2012. "China's Milk Scandal, Government Policy and Production Decisions of Dairy Farmers: The Case of Greater Beijing." *Food Policy* 37 (4): 390-400.

Johnson, R Burke, and Anthony J Onwuegbuzie. 2004. "Mixed Methods Research: A Research Paradigm Whose Time Has Come." *Educational researcher* 33 (7): 14-26.

Johnson, R. B. 2004. "Mixed Methods Research: A Research Paradigm Whose Time Has Come." *Educational Researcher* 33 (7): 14.

Jones, T.C., and D.W. Riley. 1985. "Using Inventory for Competitive Advantage through Supply Chain Management." *International Journal of Physical Distribution & Materials Management* 15 (5): 16-26.

Jüttner, Uta. 2005. "Supply Chain Risk Management: Understanding the Business Requirements from a Practitioner Perspective." *International Journal of Logistics Management, The* 16 (1): 120-141.

Jüttner, Uta, Helen Peck, and Martin Christopher. 2003. "Supply Chain Risk Management: Outlining an Agenda for Future Research." *International Journal of Logistics : Research & Applications* 6 (4): 197-210.

Kahneman, Daniel, and Amos Tversky. 1979. "Prospect Theory: An Analysis of Decision under Risk." *Econometrica: Journal of the Econometric Society*: 263-291.

Kahraman, Cengiz, Tijen Ertay, and Gülçin Büyüközkan. 2006. "A Fuzzy Optimization Model for Qfd Planning Process Using Analytic Network Approach." *European Journal of Operational Research* 171 (2): 390-411.

Kang, Suk-Ho, Bokyoung Kang, Kwangsup Shin, Daeyoung Kim, and Jihee Han. 2012. "A Theoretical Framework for Strategy Development to Introduce Sustainable Supply Chain Management." *Procedia-Social and Behavioral Sciences* 40: 631-635.

Karim, Zahurul, Khan Shahidul Huque, Md. Golam Hussain, Zulfiqar Ali, and Mosharraf Hossain. 2010. "Growth and Development Potential of Livestock and Fisheries in Bangladesh." In *Bangladesh Food Security Investment Forum*, *Dhaka*.

Kenny, Andrew A. 1988. "A New Paradigm for Quality Assurance." *Quality Progress* 21 (6): 30-32.

Khan, MJ, KJ Peters, and MM Uddin. 2009. "Feeding Strategy for Improving Dairy Cattle Productivity in Small Holder Farm in Bangladesh." *Bangladesh Journal of Animal Science* 38 (1-2): 67-85.

Khanna, Rattan Sagar. 2004. "Sustainable Development of the Cottage Dairy Sector in Asia and the Pacific – Challenges and Opportunities." In *The Seminar on Sustainable Dairy-sector Development for Poverty Reduction*, *Faisalabad,* 22 to 27 November. 7-20. Faisalabad: Asian Productivity Organization (APO), Government of Pakistan. www.apo-tokyo.org/publications/wp-content/.../pjrep-04-ag-ge-sem-16.pdf.

Kleindorfer, Paul R, and Germaine H Saad. 2005. "Managing Disruption Risks in Supply Chains." *Production and operations management* 14 (1): 53-68.

Kliebenstein, James. 1998. *Economic and Associated Social and Environmental Issues with Large-Scale Livestock Production Systems*. https://www.researchgate.net/publication/254424998_Economic_and_Associated_Social_and_Environmental_Issues_with_Large-Scale_Livestock_Production_Systems.

Knips, Vivien. 2005. "Developing Countries and the Global Dairy Sector Part I Global Overview." *FAO, Pro-Poor Livestock Policy Inniciative*.

———. 2006. *Developing Countries and Global Sector Part Ii: Country Case Studies*.

Kocabasoglu, Canan, Carol Prahinski, and Robert D. Klassen. 2007. "Linking Forward and Reverse Supply Chain Investments: The Role of Business Uncertainty." *Journal of Operations Management* 25: 1141-1160.

Komiyama, Hiroshi, Kazuhiko Takeuchi, Hideaki Shiroyama, and Takashi Mino. 2011. *Sustainability Science: A Multidisciplinary Approach*: United Nations University.

Kopczak, Laura Rock. 1997. "Logistics Partnerships and Supply Chain Restructuring: Survey Results from the Us Computer Industry." *Production and Operations Management* 6 (3): 226-247.

Krauss, Steven Eric. 2005. "Research Paradigms and Meaning Making: A Primer." *The qualitative report* 10 (4): 758-770.

Kress, Guenther G, Randi L Miller, and Gus Koehler. 2010. "Strategic Perspectives on State Government as a Promoter of International Trade and Investment: The Case of California." *INTERNATIONAL JOURNAL OF ORGANIZATION THEORY AND BEHAVIOR* 13 (3): 378-407.

Kumar, Ruchira, and Vegard Iversen. 2012. *Pran Dairy : Indirect Employment and Poverty Reduction Effects in the Supply Chain* Washington DC. http://documents.worldbank.org/curated/en/2012/01/18433652/pran-dairy-indirect-employment-poverty-reduction-effects-supply-chain.

Kutucuoglu, KY, Jamil Hamali, Zahir Irani, and JM Sharp. 2001. "A Framework for Managing Maintenance Using Performance Measurement Systems." *International Journal of Operations & Production Management* 21 (1/2): 173-195.

Lal, R., D.O. Hansen, N. Uphoff, and S.A. Slack. 2002. *Food Security and Environmental Quality in the Developing World*. Boca Raton, FL.: CRC Press.

Lambert, Douglas M., and Martha C. Cooper. 2000. "Issues in Supply Chain Management." *Industrial Marketing Management* 29: 65-83.

Lambert, Douglas M., James R. Stock, and Lisa M. Ellram. 1998. *Fundamentals of Logistics Management*: Irwin/McGraw-Hill Chicago, IL.

Larraâin, Jorge. 1979. *The Concept of Ideology*: University of Georgia Press (Athens).

Lee, Hau L. 2004. "The Triple-a Supply Chain." *Harvard business review* 82 (10): 102-113.

Lee, Hau L, and Corey Billington. 1992. "Managing Supply Chain Inventory: Pitfalls and Opportunities." *Sloan management review* 33 (3).

Lee, Hau L, and Shu Ming Ng. 1997. "Introduction to the Special Issue on Global Supply Chain Management." *Production and Operations Management* 6 (3): 191-192.
Lim, Puay Cheng, and Nelson KH Tang. 2000. "The Development of a Model for Total Quality Healthcare." *Managing Service Quality* 10 (2): 103-111.
Lincoln, Yvonna S, and Egon G Guba. 1994. "Competing Paradigms in Qualitative Research." *Handbook of qualitative research*: 105-117.
Linton, Jonathan D., Robert Klassen, and Vaidyanathan Jayaraman. 2007. "Sustainable Supply Chains: An Introduction." *Journal of Operations Management* 25 (6): 1075–1082.
Lummus, R. R., and K.L. Alber. 1997. *Supply Chain Management: Balancing the Supply Chain with Customer Demand*. Alexandria,VA.: APICS Educational and Research Foundation, Inc.,.
Lummus, Rhonda R., and Robert J. Vokurka. 1999. "Defining Supply Chain Management: A Historical Perspective and Practical Guidelines." *Industrial Management & Data Systems* 99 (1): 11-17.
Malhotra, Naresh K. 2008. *Marketing Research: An Applied Orientation, 5/E*: Pearson Education India.
Manuj, Ila, and John T Mentzer. 2008a. "Global Supply Chain Risk Management." *Journal of Business Logistics* 29 (1): 133-155.
———. 2008b. "Global Supply Chain Risk Management Strategies." *International Journal of Physical Distribution & Logistics Management* 38 (3): 192-223.
Markley, Melissa J, and Lenita Davis. 2007. "Exploring Future Competitive Advantage through Sustainable Supply Chains." *International Journal of Physical Distribution & Logistics Management* 37 (9): 763-774.
Marshall, Catherine, and Gretchen B Rossman. 2010. *Designing Qualitative Research*: Sage.
———. 2014. *Designing Qualitative Research*: Sage publications.
Martin, Sandra. 1996. "Risk Management Strategies in New Zealand Agriculture and Horticulture." *Review of Marketing and Agricultural Economics* 64: 31-44.
Matell, Michael S, and Jacob Jacoby. 1972. "Is There an Optimal Number of Alternatives for Likert-Scale Items? Effects of Testing Time and Scale Properties." *Journal of Applied Psychology* 56 (6): 506.
Maxwell, D., and R. van der Vorst. 2003. "Developing Sustainable Products and Services." *Journal of Cleaner Production* 11 883-895.
McEachern, Morven, and Gary G Warnaby. 2005. "Improving Customer Orientation within the Fresh Meat Supply Chain: A Focus on Assurance Schemes." *Journal of Marketing Management* 21 (1-2): 89-115.
McGillivray, Glenn. 2000. "Commercial Risk under Jit." *Canadian Underwriter* 67 (1): 26-30.
McMichael, Anthony J., Colin D. Butler, and Carl Folke. 2003. "New Visions for Addressing Sustainability." *Science* 302 (5652): 1919-1920.
Mentzer, J.T., W. Dewitt, J.S. Keebler, S. Min, N.W. Nix, C.D. Smith, and Z.G. Zacharia. 2002. "Defining Supply Chain Management." *Journal of Business Logistics* 22 (2): 1-25.
Meuwissen, Miranda PM, Annet GJ Velthuis, Henk Hogeveen, and Ruud BM Huirne. 2003. "Traceability and Certification in Meat Supply Chains." *Journal of Agribusiness* 21 (2): 167-182.
Miles, Matthew B, and A Michael Huberman. 1994a. "An Expanded Sourcebook Qualitative Data Analysis."
———. 1994b. *Qualitative Data Analysis: An Expanded Sourcebook*: Sage.
Miller, K. 1991. "A Framework for Integrated Risk Management in International Business." *Journal of International Business Studies* 23 (2): 311-31.
Mingers, John. 2003. "The Paucity of Multimethod Research: A Review of the Information Systems Literature." *Information Systems Journal* 13 (3): 233-249.
Mishra, Pramod Kumar, and B Raja Shekhar. 2012. "Evaluating Supply Chain Risk in Indian Dairy Industry: A Case Study." *International Journal of Decision Sciences, Risk and Management* 4 (1): 77-91.
Mishra, Pramod Kumar, and B. Raja Shekhar. 2011. "Impact of Risks and Uncertainties on Supply Chain: A Dairy Industry Perspective." *Journal of Management Research* 3 (2:E11): 1-18.
Morriss, Stuart, Claire Massey, Ross Flett, Fiona Alpass, and Frank Sligo. 2006. "Mediating Technological Learning in Agricultural Innovation Systems." *Agricultural Systems* 89 (1): 26-46.
Myers, M. 1997. "Qualitative Research in Information Systems." *MIS Quarterly* 21 (2): 241-242.

Narasimhan, Ram, and Srinivas Talluri. 2009. "Perspectives on Risk Management in Supply Chains." *Journal of Operations Management* 27 (2): 114-118.

Nasir, Tasnuba, Mohammed Quaddus, and Mohamamd Shamsuddoha. 2014. "Dairy Supply Chain Risk Management in Bangladesh: Field Studies of Factors and Variables." *Jurnal Teknik Industri* 16 (2): 127-138.

Nasir, Tasnuba, Mohammad Shamsuddoha, and Mohammed Quaddus. "Dairy Supply Chain: A Simulation Study." *INTERNATIONAL JOURNAL OF ECONOMICS & SOCIAL SCIENCE VOLUME 2 (2013)*: 89.

Nelson, Dave, Patricia E Moody, and Rick Mayo. 1998. *Powered by Honda: Developing Excellence in the Global Enterprise*: Wiley New York.

Neuman, W L. 1997. *Social Research Methods*.

Neuman, William Lawrence. 2005. *Social Research Methods: Quantitative and Qualitative Approaches*: Allyn and Bacon.

Nielsen, Nicolaj Ingemann, and Klaus Lønne Ingvartsen. 2004. "Propylene Glycol for Dairy Cows: A Review of the Metabolism of Propylene Glycol and Its Effects on Physiological Parameters, Feed Intake, Milk Production and Risk of Ketosis." *Animal Feed Science and Technology* 115 (3): 191-213.

Norman, Wayne, and Chris MacDonald. 2004. "Getting to the Bottom of" Triple Bottom Line"." *Business Ethics Quarterly*: 243-262.

Okano, Marcelo Tsuguio, Oduvaldo Vendrametto, and Osmildo Sobral dos Santos. 2010. "Organizing the Dairy Chain through Productivity Indicators for a Sustainable Supply Chain." In *International Conference on Chemistry and Chemical Engineering (ICCCE 2010)*, *São Paulo, Brazil*. ICCCE.

Orlikowski, Wanda J., and Jack J. Baroudi. 1991. "Studying Information Technology in Organizations: Research Approaches and Assumptions." *Information Systems Research* 2 (1).

Ostrom, Elinor. 2002. *The Drama of the Commons*: National Academies Press.

Oxelheim, Lars, and Clas Wihlborg. 1987. *Macroeconomic Uncertainty-International Risks and Opportunities for the Corporation*: John Wiley & Sons.

Park, Taeho, and Kwang-Jae Kim. 1998. "Determination of an Optimal Set of Design Requirements Using House of Quality." *Journal of operations management* 16 (5): 569-581.

Patankar, Mahesh, Anand Patwardhan, and Geert Verbong. 2010. "A Promising Niche: Waste to Energy Project in the Indian Dairy Sector." *environmental science & policy* 13 (4): 282-290.

Patrick, George F, and Wesley N Musser. 1997. "Sources of and Responses to Risk: Factor Analyses of Large-Scale Us Cornbelt Farmers." *Risk management strategies in agriculture* 7.

Patrick, George R, Paul N Wilson, Peter J Barry, William G Boggess, and Douglas L Young. 1985. "Risk Perceptions and Management Responses: Producer-Generated Hypotheses for Risk Modeling." *Southern Journal of Agricultural Economics* 17 (2): 231-238.

Payraudeau, Sylvain, and Hayo MG van der Werf. 2005. "Environmental Impact Assessment for a Farming Region: A Review of Methods." *Agriculture, Ecosystems & Environment* 107 (1): 1-19.

Peacocka, C., and D.M. Shermanb. 2010. "Sustainable Goat Production: Some Global Perspectives." *Small Ruminant Research* (89): 70-80.

Peck, Helen. 2005. "Drivers of Supply Chain Vulnerability: An Integrated Framework." *International Journal of Physical Distribution & Logistics Management* 35 (4): 210-232.

Podsakoff, Philip M, Scott B MacKenzie, Jeong-Yeon Lee, and Nathan P Podsakoff. 2003. "Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies." *Journal of applied psychology* 88 (5): 879.

Ponomarov, Serhiy Y, and Mary C Holcomb. 2009. "Understanding the Concept of Supply Chain Resilience." *International Journal of Logistics Management, The* 20 (1): 124-143.

PRAN-RFL. 2007. *The Development of Dairy Industry in Bangladesh*. Dhaka.

PRAN. 2005. Pran Dairy Website. PRAN. www.pranfoods.net/.

Prasad, B. 1993. "Product Planning Optimization Using Quality Function Deployment." *Artificial intelligence in optimal design and Manufacturing*: 117-152.

Qian, Guixia, Xiaochuan Guo, Jianjun Guo, and Jianguo Wu. 2011. "China's Dairy Crisis: Impacts, Causes and Policy Implications for a Sustainable Dairy Industry." *International Journal of Sustainable Development & World Ecology* 18 (5): 434-441.

Qiang, SHEN, HOU Yun-xian, LU Xian-glin, HU Xiao-jing, and HUANG Ling-ling. 2010. "Study on the Quality-Control Mechanism of Dairy Supply Chain for Single Moral Hazard." In *17th International Conference on Management Science & Engineering Melbourne, Australia,* November 24-26.

Quaddus, Mohammed, and Jun Xu. 2005. "Adoption and Diffusion of Knowledge Management Systems: Field Studies of Factors and Variables." *Knowledge-Based Systems* 18 (2): 107-115.

Raha, S. K., and R. K. Talukder. 2004. "Vertical Integration in the Dairy Sector in Bangladesh the Case of Bangladesh Milk Producers Co-Operative Union Ltd." *Bangladesh Journal of Political Economy Vol. 20, No 1* 20 (1).

Rahman, M. Rakibur. 2015. Dairy Management and Implication of Modern Technologies, March 21, Development of Bangladesh dairy industries Mirarsharai, Chittagong, Bangladesh.

Rahman, Md. 2014. *Milk Production and Its Influential Factors in Different Dairy Cattle Genetic Resources of Comilla District*.

Raihan, Selim, and Nahid Mahmud. 2008. Trade and Poverty Linkages: A Case Study of the Poultry Industry in Bangladesh. CUTS International. http://www.cuts-citee.org/pdf/rreport08-08.pdf.

Raja, RH. 2001. "Pakistan Smallholder Dairy Production and Marketing" *Smallholder dairy production and marketing—opportunities and constraints: Proceedings of a South-South workshop*,

Rao, Shashank, and Thomas J. Goldsby. 2009. "Supply Chain Risks: A Review and Typology." *The International Journal of Logistics Management* 20 (1): 97-123.

Rasul, Golam, and Gopal B Thapa. 2004. "Sustainability of Ecological and Conventional Agricultural Systems in Bangladesh: An Assessment Based on Environmental, Economic and Social Perspectives." *Agricultural systems* 79 (3): 327-351.

Raven, Peter H. 2002. "Science, Sustainability, and the Human Prospect." *Science* 297 (5583): 954-958.

Ravindranath, Nijavalli H, and David Oakley Hall. 1995. *Biomass, Energy and Environment: A Developing Country Perspective from India*: Oxford University Press.

RD_Food. 2011. "Rangpur Dairy." edited by Rangpur Dairy & Food Products Limited, Dhaka.

Rice, James B, and Federico Caniato. 2003. "Supply Chain Response to Terrorism: Creating Resilient and Secure Supply Chains." *Report by MIT Center for Transportation and Logistics*.

Ritchie, Bob, and Clare Brindley. 2007. "Supply Chain Risk Management and Performance: A Guiding Framework for Future Development." *International Journal of Operations & Production Management* 27 (3): 303-322.

Ritchie, Bob, and Clare Brnidley. 2007a. "Supply Chain Risk Management and Performence
a Guiding Framework for Future Development." *International journal of operations and production management* 27 (3): 303-322.

———. 2007b. "Supply Chain Risk Management and Performence : A Guiding Framework for Future Development." *International journal of operations and production management* 27 (3): 303-322.

Ritchie, Bob, and David Vaughan Marshall. 1993. *Business Risk Management*: Chapman & Hall.

Ritchie, Jane, and Jane Lewis. 2003. *Qualitative Research Practice: A Guide for Social Science Students and Researchers*: SAGE Publications Limited.

Roth, Aleda V, Andy A Tsay, Madeleine E Pullman, and John V Gray. 2008. "Unraveling the Food Supply Chain: Strategic Insights from China and the 2007 Recalls*." *Journal of Supply Chain Management* 44 (1): 22-39.

Saadullah, M. 2001. "Smallholder Dairy Production and Marketing in Bangladesh" *Smallholder diary production and marketing—opportunities and constraints: Proceedings of a South-South Workshop*,

Saadullah, M. 2000. "Smallholder Dairy Production and Marketing in Bangladesh.".

———. 2011. Smallholder Dairy Production and Marketing in Bangladesh. Accessed 14/11/2012, http://www.ilri.cgiar.org/InfoServ/Webpub/fulldocs/South_South/ch06.htm.

Saha, P M. 2007. Asia-Pacific Supply Chain Management: Weak Links in Bangladesh. *The Ethical Corporation Magazine*.

SAI. 2009. *Principles & Practices for Sustainable Dairy Farming*. www.saiplatform.org/uploads/Library/PPsDairy2009-2.pdf.

Sarkis, J. 2001. "Manufacturing's Role in Corporate Environmental Sustainability." *International Journal of Operations & Production Management* 5 (6): 666-86.

Saunders, MJ. 1995. "Chains, Pipelines, Networks and Value Stream: The Role, Nature and Value of Such Metaphors in Forming Perceptions of the Task of Purchasing and Supply Management" *First Worldwide Research Symposium on Purchasing and Supply Chain Management*,

Savitz, Andrew W., and K. Weber. 2006. *The Triple Bottom Line*. San Francisco, CA.: Jossey-Bass.

Schmitz, Andy. 2012. Oakhurst Dairy: Operations Management and Sustainability. http://2012books.lardbucket.org/books/sustainable-business-cases/s14-case-oakhurst-dairy-operations.html.

Schoenherr, Tobias, VM Rao Tummala, and Thomas P Harrison. 2008. "Assessing Supply Chain Risks with the Analytic Hierarchy Process: Providing Decision Support for the Offshoring Decision by a Us Manufacturing Company." *Journal of Purchasing and Supply Management* 14 (2): 100-111.

Schwandt, T. A. 1994. "Constructivist, Interpretivist Approaches to Human Inquiry " In *Handbook of Qualitative Research*, eds N. K. Denzin and Y. S. Lincoln. Thousand Oaks, California: Sage Publications.

Seawright, Jason, and John Gerring. 2008. "Case Selection Techniques in Case Study Research a Menu of Qualitative and Quantitative Options." *Political Research Quarterly* 61 (2): 294-308.

Shahin, Arash. 2005. "Quality Function Deployment: A Comprehensive Review." *Available Source: http://www. dci. ir/ravabet/f/shahin. pdf*.

Shahnaz, Parvin, Kei-ichi Shimazaki, and Isao Kato. 2004. "Mil and Milk Prodicts in Bangladesh." *Journal of Rakuno Gakuen University* 29 (1): 9-16.

Shamsuddin, M, J U Ahmed, M G S Alam, and P C Modak. 1987. "Effect of Age of Semen on Conception Rate under Farm Condition." *Bangladesh Veterinary Journal* 21: 51-58.

Shamsuddin, M, MM Alam, MS Hossein, WJ Goodger, FY Bari, TU Ahmed, and MM Hossain. 2007. "Participatory Rural Appraisal to Identify Needs and Prospects of Market-Oriented Dairy Industries in Bangladesh." *Tropical Animal Health and Production* 39: 567-581.

Shamsuddin, M, MM Alam, MS Hossein, WJ Goodger, FY Bari, TU Ahmed, MM Hossain, and AHMSI Khan. 2007. "Participatory Rural Appraisal to Identify Needs and Prospects of Market-Oriented Dairy Industries in Bangladesh." *Tropical animal health and production* 39 (8): 567-581.

Shamsuddoha, A K, and Geoff Edwards. 2000. "Dairy Industry in Bangladesh: Problems and Prospects." In *AARES 2000 Conference*, *School of Business, La Trobe University*.

Shamsuddoha, Mohammad. 2009. "Dairy Farming-an Alternative Income Generating Activity." *The Bulletin UASVM* 66 (2): 352-356.

———. 2012. "Achieving Sustainability through Poultry Supply Chain" *Emerging Research Initiatives and Developments in Business: CGSB Research Forum 2012*, *Perth, Australia*: Curtin University.

———. 2014. "Integrated Supply Chain Model for Sustainable Poultry Production in Bangladesh: A System Dynamics Approach." Dissertation, Graduate School of Business (GSB), Curtin University, Perth, Australia. http://espace.library.curtin.edu.au:80/R?func=dbin-jump-full&local_base=gen01-era02&object_id=199515.

———. 2015. Prospects and Problems of Dairy Industry in Bangladesh, March 25, Information about Bangladesh dairy, South Khulshi, Chittagong, Bangladesh.

Shamsuddoha, Mohammad, Desmond Klass, and Mohammed Quaddus. 2011. "A Simulation Supply Chain Model for a Sustainable and Environment Friendly Poultry Industry: Insights from Bangladesh." In *Australian and New Zealand Academy of Management (ANZAM)*, *Wellington, New Zealand,* December 07-09. edited by Kevin Voges and Bob Cavana, 1-12. Newzealand

Shamsuddoha, Mohammad, Mohammed Quaddus, and Desmond Klass. 2011. "Reducing Environmental Hazards through Reverse Supply Chain Model " *5TH Asian Business Research Conference*, *Dhaka, Bangladesh*: World Business Institute (WBI).

Sheffi, Yosef. 2005. *The Resilient Enterprise: Overcoming Vulnerability for Competitive Advantage*: Mit Press.
Sheffi, Yossi, and J Rice. 2005. "A Supply Chain View of the Resilient Enterprise." *MIT Sloan Management Review* 47 (1).
Shrivastava, P. 1995. "The Role of Corporations in Achieving Ecological Sustainability " *Academy of Management Review* 20 (4): 936-60.
Shubik, Martin, and Richard J Herring. 1986. "Political Risk: Analysis, Process, and Purpose." *Managing International Risk,(Cambridge: Cambridge University Press) pp*: 109-138.
Sikdar, Subhas K. 2003. "Sustainable Development and Sustainability Metrics." *AIChE journal* 49 (8): 1928.
Simon, Herbert A. 1987. "Making Management Decisions: The Role of Intuition and Emotion." *The Academy of Management Executive (1987-1989)*: 57-64.
Simpson, James R. 2006. "China's Dairy Industry: Current Situation and Long-Term Projections" *China's Evolvling Agriculture Economy conference*,
Singh, Katar, and RS Pandir. 2001. "Problems and Prospects of Small Holder Dairy Production and Marketing in South Asia: An Overview" *Regional paper presented in South-South Workshop, March*,
Smith, J K. 1983. "Quantitative Versus Qualitative Research: An Attempt to Clarify the Issue." *Educational Researcher* 12 (3): 6-13.
Solaiman, Mohammed, and Ataur Rahman Belal. 1999. "An Account of the Sustainable Development Process in Bangladesh." *Sustainable Development* 7 (3): 121-131.
Sonesson, U, and J Berlin. 2003. "Environmental Impact of Future Milk Supply Chains in Sweden: A Scenario Study." *Journal of Cleaner Production* 11 (3): 253-266.
Sower, Victor E, Michael J Savoie, and Stephen Renick. 1999. *An Introduction to Quality Management and Engineering: Based on the American Society for Quality's Certified Quality Engineer Body of Knowledge*. Vol. 1: Prentice Hall.
Starik, M., and G.P. Rands. 1995. "Weaving an Integrated Web: Multilevel and Multisystem Perspectives of Ecologically Sustainable Organizations." *Academy of Management Review* 20 (4): 908-35.
Statistica. 2014. Major Producers of Cow Milk Worldwide in 2013, by Country (in Million Metric Tons). Statista, Inc. http://www.statista.com/statistics/268191/cow-milk-production-worldwide-top-producers/.
Stocker, GD. 1991. "Using Qfd to Identify Customer Needs." *Quality Progress* 24 (1): 120-120.
Stulz, René M. 1996. "Rethinking Risk Management." *Journal of applied corporate finance* 9 (3): 8-25.
Sultana, Nasrin. 2002. "Conceptualising Livelihoods of the Extreme Poor." *Dhaka: Proshika, mimeo*.
Svensson, G. 2000. "A Conceptual Framework for the Analysis of Vulnerability in Supply Chains." *International Journal of Physical Distribution & Logistics Management* 30 (9/10): 21-35.
Svensson, G. 2007. "Aspects of Sustainable Supply Chain Management (Sscm): Conceptual Framework and Empirical Example." *Supply Chain Management* 12 (4): 262-266.
Swanson, R A, and E F Holton. 2009. *The Process of Framing Research in Organizations*: Berrett-Koehler Publishers.
Tait, Peter, and Iris Vessey. 1988. "The Effect of User Involvement on System Success: A Contingency Approach." *MIS Quarterly* 12 (1): 91-108.
Tan, K.C., R.B. Handfield, and D.R. Krause. 1998. "Enhancing Firm's Performance through Quality and Supply Base Management: An Empirical Study." *International Journal of Production Research* 36 (10): 2813-2837.
Tan, Keah Choon. 2002. "Supply Chain Management: Practices, Concerns, and Performance Issues." *Journal of Supply Chain Management* 38 (1): 42-53.
Tang, Christopher S. 2006a. "Robust Strategies for Mitigating Supply Chain Disruptions." *International Journal of Logistics: Research and Applications* 9 (1): 33-45.
Tang, Christopher, and Brian Tomlin. 2008. "The Power of Flexibility for Mitigating Supply Chain Risks." *International Journal of Production Economics* 116 (1): 12-27.
Tang, Ou. 2006b. "Perspectives in Supply Chain Risk Management. ." *International Journal of Production Economics* 103 (2): 451–488.
Tang, Ou, and S Nurmaya Musa. 2011. "Identifying Risk Issues and Research Advancements in Supply Chain Risk Management." *International Journal of Production Economics* 133: 25-34.

Tashakkori, A., and C. Teddlie. 1998. *Mixed Methodology: Combining Qualitative and Quantitative Approaches*. Vol. 46, *Applied Social Research Methods Series*. California: Sage Publications, Inc.

Tashakkori, Abbas, and Charles Teddlie. 2003. "The Past and Future of Mixed Methods Research: From Data Triangulation to Mixed Model Designs." *Handbook of mixed methods in social and behavioral research*: 671-701.

Teddlie, Charles, and Abbas Tashakkori. 2003. "Major Issues and Controveries Inthe Use of Mixed Methods in the Social and Behvioral Sciences." *Handbook of mixed methods in social & behavioral research*: 3-50.

TheDairySite. 2013. The Bangladesh Dairy Market: Times of Change. USDA. Accessed April 10, http://www.thedairysite.com/articles/3633/the-bangladesh-dairy-market-times-of-change/#sthash.HWdkR4La.dpuf.

Thomas, Andrew P. 1986. "The Contingency Theory of Corporate Reporting: Some Empirical Evidence." *Accounting, Organizations and Society* 11 (3): 253-270.

Thornton, Philip K. 2010. "Livestock Production: Recent Trends, Future Prospects." *Philosophical Transactions of the Royal Society B: Biological Sciences* 365 (1554): 2853-2867.

Thun, Jorn-Henrik, and Daniel Hoenig. 2011. "An Empirical Analysis of Supply Chain Risk Management in the German Automotive Industry." *International Journal of ProductionEconomics* 131: 242-249.

Tilman, David, Kenneth G Cassman, Pamela A Matson, Rosamond Naylor, and Stephen Polasky. 2002. "Agricultural Sustainability and Intensive Production Practices." *Nature* 418 (6898): 671-677.

Tilman, David, David Wedin, and Johannes Knops. 1996. "Productivity and Sustainability Influenced by Biodiversity in Grassland Ecosystems."

Ting, Wenlee. 1988. "Multinational Risk Assessment and Management: Strategies for Investment and Marketing Decisions." *The International Executive* 30 (2-3): 31-33.

Tipples, Rupert, and Stuart Morriss. 2002. "The Farm Labour Crisis." *Primary Industry Management* 5 (3): 25-27.

Tosi, Henry L., and John W. Slocum. 1984. "Contingency Theory: Some Suggested Directions." *Journal of Management 1984 10: 9* 10 (1): 9-26.

Tress, Bärbel, Gunther Tress, and Gary Fry. 2006. "Defining Concepts and the Process of Knowledge Production in Integrative Research." *From landscape research to landscape planning*: 13-26.

Trkman, Peter, and Kevin McCormack. 2009. "Supply Chain Risk in Turbulent Environments - a Conceptual Model for Managing Supply Chain Network Risk." *International Journal of Production Economics* 119: 247–258.

Uddin, M M, M N Sultana, O A Ndambi, O Alqaisi, T Hemme, and K J Peters. 2011. "Milk Production Trends and Dairy Development in Bangladesh." *Outlook on AGRICULTURE* 40 (3): 263-271.

Uddin, R. 2003. "Existing Extension System: Strengths, Weaknesses and Proposed Reforms in Bangladesh" *Regional Workshop on Operationalizing Reforms in Agricultural Extension in South Asia New Delhi, India*,

UNDP. 2009. Human Developmet Report. UNDP. Accessed September 05, http://www.undp.org/content/undp/en/home/ourwork/crisispreventionandrecovery/overview.html and http://hdrstats.undp.org/en/countries/country_fact_sheets/cty_fs_BGD.html.

van Asseldonk, Marcel APM, and Miranda PM Meuwissen. 2006. "Public and Private Schemes Indemnifying Epidemic Livestock Losses in the European." *The Economics of Livestock Disease Insurance: Concepts, Issues and International Case Studies*: 115.

Venkatesh, Viswanath. 2006. "Where to Go from Here? Thoughts on Future Directions for Research on Individual-Level Technology Adoption with a Focus on Decision Making*." *Decision Sciences* 37 (4): 497-518.

Venkatesh, Viswanath, Susan A Brown, and Hillol Bala. 2013. "Bridging the Qualitative-Quantitative Divide: Guidelines for Conducting Mixed Methods Research in Information Systems." *MIS quarterly* 37 (1): 21-54.

Wagner, Stephan M, and Christoph Bode. 2006. "An Empirical Investigation into Supply Chain Vulnerability." *Journal of Purchasing and Supply Management* 12 (6): 301-312.

Wakeford, Jeremy J. 2012. "Socioeconomic Implications of Global Oil Depletion for South Africa: Vulnerabilities, Impacts and Transition to Sustainability." Stellenbosch: Stellenbosch University.

Walker, Mike. 2002. "Customer-Driven Breakthroughs Using Qfd and Policy Deployment." *Management Decision* 40 (3): 248-256.

Wang, Hsiao-Fan, and Wei-Kuo Hong. 2007. "An Integrated Service Strategy by Qfd Approach: A Case of a Telecom Company in Taiwan." *International Journal of Management and Decision Making* 8 (2): 251-267.

Wang, Qingbin, Robert Parsons, and Guangxuan Zhang. 2010. "China's Dairy Markets: Trends, Disparities, and Implications for Trade." *China Agricultural Economic Review* 2 (3): 356-371.

Wang, Yanling, and Xiaohua Yu. 2012. "Productivity, Efficiency and Structural Problems in Chinese Dairy Farms." *China Agricultural Economic Review* 4 (2): 168-175.

Ward, Stephen C. 1999. "Assessing and Managing Important Risks." *International Journal of Project Management* 17 (6): 331-336.

WCED. 1987. *Our Common Future (the Brundtland Report), Chapter 2: Towards Sustainable Development*. New York, NY.

Wein, Lawrence M, and Yifan Liu. 2005. "Analyzing a Bioterror Attack on the Food Supply: The Case of Botulinum Toxin in Milk." *Proceedings of the National Academy of Sciences of the United States of America* 102 (28): 9984-9989.

Whiteman, Gail, and William H Cooper. 2000. "Ecological Embeddedness." *Academy of Management Journal* 43 (6): 1265-1282.

Wilkes, Gerald Alfred, and William Alwyn Krebs. 1995. *Collins English Dictionary: An Extensive Coverage of Contemporary International and Australian English*: HarperCollinsPublishers.

Wilson, David C. 1982. "Electricity and Resistance: A Case Study of Innovation and Politics." *Organization Studies* 3 (2): 119-140.

Wilson, PN, TR Luginsland, and DV Armstrong. 1988. "Risk Perceptions and Management Responses of Arizona Dairy Producers." *Journal of Dairy Science* 71 (2): 545-551.

Wiseman, Robert M, and Luis R Gomez-Mejia. 1998. "A Behavioral Agency Model of Managerial Risk Taking." *Academy of management Review* 23 (1): 133-153.

Wisner, Joel, Keah-Choon Tan, and G Leong. 2015. *Principles of Supply Chain Management: A Balanced Approach*: Cengage Learning.

Wolf, Christopher A, J Roy Black, and Joleen C Hadrich. 2009. "Upper Midwest Dairy Farm Revenue Variation and Insurance Implications." *Agricultural Finance Review* 69 (3): 346-358.

Yin, Robert K. 2011. *Applications of Case Study Research*: Sage.

Yin, Robert K. 1994. *Case Study Research: Design and Methods*. Vol. 2nd ed. Newbury Park, CA: Sage.

———. 2003. *Case Study Research: Design and Methods*. Vol. 5th Ed.: Sage.

———. 2009. *Case Study Research: Design and Methods*.

Zeithaml, Valarie A., P Rajan Varadarajan, and Carl P Zeithaml. 1988a. "The Contingency Approach: Its Foundations and Relevance to Theory Building and Research in Marketing." *European Journal of Marketing* 22 (7): 37-64.

Zeithaml, Valarie A., P. Rajan Varadarajan, and Carl P. Zeithaml. 1988b. "The Contingency Approach: Its Foundations and Relevance to Theory Building and Research in Marketing." *European Journal of Marketing* 22 (7): 37 - 64.

Zia, U. 2007. "Improved Market Access and Smallholder Dairy Farmer Participation for Sustainable Dairy Development." *Consultancy Report CFCIFIGMDP/16FT. Lessons Learned Study. Islamabad, Pakistan*.

ZIA, UMME. 2006. "Analysis of Milk Marketing Chain."

Zikmund, William. 2000. *G.(2000), Business Research Methods*. Fort Worth, TX: Dryden Press.

Zokaei, Keivan, and Peter Hines. 2007. "Achieving Consumer Focus in Supply Chains." *International Journal of Physical Distribution & Logistics Management* 37 (3): 223-247.

Zsidisin, George A, Alex Panelli, and Rebecca Upton. 2000. "Purchasing Organization Involvement in Risk Assessments, Contingency Plans, and Risk Management: An Exploratory Study." *Supply Chain Management: An International Journal* 5 (4): 187-198.

4 A. Survey Questionnaires

This survey questionnaire is for Supply Chain Risk Management for Dairy Industry in Bangladesh. It consists of two sections: (i) Probability of occurrence and likely impact of a Dairy risk and (ii) Risk mitigation strategies for the risks and cost of implementation risk mitigation strategy.

Section 1: Probability of occurrence and likely impact of dairy risk

The dairy supply chain, which entangles several stakeholders, may get disrupted due to various risks arising within the chain. Proper identification, frequent realisation of risks and effective management strategies are most essential for the better performance of the supply chain. Through review of literature, dairy supply chain risks existing in Bangladesh are identified. However, these risks are contextual and vary greatly in regard to their occurrence and likely impact to the supply chain. For each of the risks listed in this section, please circle the number that best indicates the likely occurrence of a particular risk and its likely impact on the dairy supply chain for Bangladesh. The sequence followed in presenting the risks does not represent any importance or priority of the risk over other in the supply chain.

Risk Probability Cannot occur — May or may not occur — Certain to occur 0 — 5 — 9 Probability scale Please circle as appropriate	Risk Sl. No.	Dairy Supply Chain Risk	Impact of Risk Low — Moderate — High 0 — 5 — 9 Impact scale Please circle as appropriate
0 123456789	1	Inadequate loan facilities	0 123456789
0 123456789	2	Complex loan procedures	0 123456789
0 123456789	3	High rate of interest	0 123456789
0 123456789	4	Inadequate finance	0 123456789
0 123456789	5	Absence of insurance or compensation coverage	0 123456789
0 123456789	6	Shortage of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	0 123456789
0 123456789	7	Labour disputes	0 123456789
0 123456789	8	Illiteracy and inefficiency of worker	0 123456789
0 123456789	9	Shortage of skilled staff	0 123456789
0 123456789	10	Switching of staff frequently	0 123456789
0 123456789	11	Lack of fixed government policy in dairy sector	0 123456789
0 123456789	12	Poor law and order situation (terrorism, musclemen ship)	0 123456789

0 123456789	13	Hartal and strike cause delay in work process	0 123456789
0 123456789	14	Political Unrest and interference	0 123456789
0 123456789	15	Corruption (adulteration by mixing water)	0 123456789
0 123456789	16	Damage of farm's assets	0 123456789
0 123456789	17	Theft	0 123456789
0 123456789	18	Natural disaster (flood, excessive rain, storm)	0 123456789
0 123456789	19	Quick perishability of Milk	0 123456789
0 123456789	20	Machine damage/breakdown at cold storage	0 123456789
0 123456789	21	Inadequate chilling facilities	0 123456789
0 123456789	22	Inadequate cold storage	0 123456789
0 123456789	23	Spoilage of milk through improper handling	0 123456789
0 123456789	24	Bacterial contamination for improper temperature	0 123456789
0 123456789	25	Pollution and Unhygienic environment	0 123456789
0 123456789	26	Cattle diseases	0 123456789
0 123456789	27	Machine damage/breakdown at processing unit	0 123456789
0 123456789	28	Fire at farm shed	0 123456789
0 123456789	29	Accident (Staff injury)	0 123456789
0 123456789	30	Inadequate supply of quality feed	0 123456789
0 123456789	31	High cost of feed and medicine	0 123456789
0 123456789	32	Scarcity of feed	0 123456789
0 123456789	33	Lack of upgrade vaccination and veterinary services	0 123456789
0 123456789	34	Shortage of land for expanding farm	0 123456789
0 123456789	35	Irregular supply of vaccine from government	0 123456789
0 123456789	36	Competition among the farms	0 123456789
0 123456789	37	Bureaucratic complexity on maintaining various formalities	0 123456789
0 123456789	38	Drought leads to a decline in milk production	0 123456789

0 123456789	39	Accidents of transport vehicle	0 123456789
0 123456789	40	Existence of middlemen/ too many middlemen	0 123456789
0 123456789	41	Too long chain cause delay in product movement	0 123456789
0 123456789	42	Poor conditioned road for moving product (delay & spoilage)	0 123456789
0 123456789	43	Inadequate transport facilities to move products frequently	0 123456789
0 123456789	44	Lack of milk tanker (refrigerated)	0 123456789
0 123456789	45	Unethical behaviour of middle men (adulteration, added price, deprivation)	0 123456789

Section 2: Dairy Supply Chain Risk Mitigation Strategies

I. Instructions to assess the relation between risks and risk mitigation strategies:

Risk mitigation is the action which is taken for preventing possible risk to people or property. Risk mitigation strategies are actions that help industry to avoid or minimize impacts of risks and help to achieve business objectives. Through the review of literature, risk mitigation strategies for dairy supply chain risks are identified and presented in the following table with dairy supply chain risk issues. Not all strategies are relevant, appropriate or effective with same level of performance to mitigate a specific risk.

Please assess each strategy in relation to its relevance to a particular risk and score it based on the following scale.

1--- Little relevant
5---moderately relevant
9---Highly relevant

II. Assessment of relative cost of implementing risk mitigation strategies:

Relative cost of risk mitigation strategy is the cost of implementation of risk mitigation

a) Assess the largest cost of implementation a risk mitigation strategy; Score it as 100.
b) Assess the lowest cost of implementation a risk mitigation strategy; Score it as 10
c) Assess the remaining risk mitigation strategies compared to the highest and lowest cost strategies and score a number in between 10 and 100.

Note: Example of assessment matrix (partial) is provided in Appendix 1 for your convenience.

I. Assessment of relation between risks and risk mitigation strategies
Appendix 4A1: (First 23 Risk with first 11 mitigation strategy)

	Strategy Number	1	2	3	4	5	6	7	8	9	10	11
Risk Number	Risk Mitigation Strategy / Dairy Supply Chain Risk	Adoption of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	Buying insurance against production loss.	Hiring skilled staff	Motivational and incentives facilities for staff	Initiative to remove political uncertainty	Implementation of a fixed policy for dairy sector	Assurance of adequate institutional credit support with low rate of interest	Introducing off-farm activities	Focus on value addition	Promote sound business practices by cooperation, better coordination and information sharing	Reduction of risks through merger, acquisition and integration
1	Inadequate loan facilities											
2	Complex loan procedures											
3	High rate of interest											
4	Inadequate finance											
5	Absence of insurance or compensation coverage											
6	Shortage of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)											
7	Labour disputes											
8	Illiteracy and inefficiency of worker											
9	Shortage of skilled staff											
10	Switching of staff frequently											
11	Lack of fixed government policy in dairy sector											
12	Poor law and order situation (terrorism, musclemen ship)											
13	Hartal and strike cause delay in work process											
14	Political Unrest and interference											
15	Corruption (adulteration by mixing water)											
16	Damage of farm's assets											
17	Theft											
18	Natural disaster (flood, excessive rain, storm)											
19	Quick perishability of Milk											
20	Machine damage/breakdown at cold storage											
21	Inadequate chilling facilities											
22	Inadequate cold storage											
23	Spoilage of milk through improper handling											

Appendix: 4A2 (Second 22 Risk with first 11 mitigation strategy)

	Strategy Number	1	2	3	4	5	6	7	8	9	10	11
Risk Number	Risk Mitigation Strategy / Dairy Supply Chain Risk	Adoption of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	Buying insurance against production loss.	Hiring skilled staff	Motivational and incentives facilities for staff	Initiative to remove political uncertainty	Implementation of a fixed policy for dairy sector	Assurance of adequate institutional credit support with low rate of interest.	Introducing off-farm activities	Focus on value addition	Promote sound business practices by cooperation, better coordination and information sharing	Reduction of risks through merger, acquisition and integration.
24	Bacterial contamination for improper temperature											
25	Pollution and Unhygienic environment											
26	Cattle diseases											
27	Machine amage/breakdown at processing unit											
28	Fire at farm shed											
29	Accident (Staff injury)											
30	Inadequate supply of quality feed											
31	High cost of feed and medicine											
32	Scarcity of feed											
33	Lack of upgrade vaccination and veterinary services											
34	Shortage of land for expanding farm											
35	Irregular supply of vaccine from government											
36	Competition among the farms											
37	Bureaucratic complexity on maintaining various formalities											
38	Drought leads to a decline in milk production											
39	Accidents of transport vehicle											
40	Existence of middlemen/too many middlemen											
41	Too long chain cause delay in product movement											
42	Poor conditioned road for moving product (delay & spoilage)											
43	Inadequate transport facilities to move products frequently											
44	Lack of milk tanker (refrigerated)											
45	Unethical behaviour of middle men (adulteration, added price, deprivation)											

Appendix: 4A3 (First 23 Risk with second 12 mitigation strategy)

	Strategy Number	12	13	14	15	16	17	18	19	20	21	22	23
Risk Number	Risk Mitigation Strategy / Dairy Supply Chain Risk	Arrangement of proper training to the staff regarding temperature control	Adoption of alternative supply of power for cold storage (powerful generator)	Arrangement of proper training to the staff regarding processing and hygiene management	Attempts to create various cross breeds by adopting AI services.	Lease abandoned land to the farmers for dairy farming	Strengthen the regular supply of vaccine	Initiative to reduce the cost of	Support to develop technology	Focus on certified feed supplier to get quality feed.	Arrangement of adequate grassland for producing Napier	Arrangement of regular vaccination for the cattle	Arrangement of improved and upgraded veterinary services
1	Inadequate loan facilities												
2	Complex loan procedures												
3	High rate of interest												
4	Inadequate finance												
5	Absence of insurance or compensation coverage												
6	Shortage of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)												
7	Labour disputes												
8	Illiteracy and inefficiency of worker												
9	Shortage of skilled staff												
10	Switching of staff frequently												
11	Lack of fixed government policy in dairy sector												
12	Poor law and order situation (terrorism, musclemen ship)												
13	Hartal and strike cause delay in work process												
14	Political Unrest and interference												
15	Corruption (adulteration by mixing water)												
16	Damage of farm's assets												
17	Theft												
18	Natural disaster (flood, excessive rain, storm)												
19	Quick perishability of Milk												
20	Machine damage/breakdown at cold storage												
21	Inadequate chilling facilities												
22	Inadequate cold storage												
23	Spoilage of milk through improper handling												

Appendix: 4A4 (Second 22 Risk with second 12 mitigation strategy)

	Strategy Number	12	13	14	15	16	17	18	19	20	21	22	23
Risk Number	Risk Mitigation Strategy / Dairy Supply Chain Risk	Arrangement of proper training to the staff regarding temperature control	Adoption of alternative supply of power for cold storage (powerful generator)	Arrangement of proper training to the staff regarding processing and hygiene management	Attempts to create various cross breeds by adopting AI services.	Lease abandoned land to the farmers for dairy farming	Strengthen the regular supply of vaccine	Initiative to reduce the cost of feed	Support to develop technology	Focus on certified feed supplier to get quality feed	Arrangement of adequate grassland for producing Napier grass	Arrangement of regular vaccination for the cattle	Arrangement of improved and upgraded veterinary services
24	Bacterial contamination for improper temperature												
25	Pollution and Unhygienic environment												
26	Cattle diseases												
27	Machine damage/breakdown at processing unit												
28	Fire at farm shed												
29	Accident (Staff injury)												
30	Inadequate supply of quality feed												
31	High cost of feed and medicine												
32	Scarcity of feed												
33	Lack of upgrade vaccination and veterinary services												
34	Shortage of land for expanding farm												
35	Irregular supply of vaccine from government												
36	Competition among the farms												
37	Bureaucratic complexity on maintaining various formalities												
38	Drought leads to a decline in milk production												
39	Accidents of transport vehicle												
40	Existence of middlemen/ too many middlemen												
41	Too long chain cause delay in product movement												
42	Poor conditioned road for moving product (delay & spoilage)												
43	Inadequate transport facilities to move products frequently												
44	Lack of milk tanker (refrigerated)												
45	Unethical behaviour of middle men (adulteration, added price, deprivation)												

Appendix: 4A5 (First 23 Risks with third 09 mitigation strategy)

	Strategy Number	24	25	26	27	28	29	30	31	32
Risk Number	Risk Mitigation Strategy / Dairy Supply Chain Risk	Building multi-storeyed complex for farm extension	Building monitoring team	Initiative to develop roads and highways	Arrangement of adequate number of transport	Arrangement of refrigerated transport facilities	Development of roads and highway	Focus on product diversification	Removal of unnecessary influence of middlemen	Direct marketing
1	Inadequate loan facilities									
2	Complex loan procedures									
3	High rate of interest									
4	Inadequate finance									
5	Absence of insurance or compensation coverage									
6	Shortage of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)									
7	Labour disputes									
8	Illiteracy and inefficiency of worker									
9	Shortage of skilled staff									
10	Switching of staff frequently									
11	Lack of fixed government policy in dairy sector									
12	Poor law and order situation (terrorism, musclemen ship)									
13	Hartal and strike cause delay in work process									
14	Political Unrest and interference									
15	Corruption (adulteration by mixing water)									
16	Damage of farm's assets									
17	Theft									
18	Natural disaster (flood, excessive rain, storm)									
19	Quick perishability of Milk									
20	Machine damage/breakdown at cold storage									
21	Inadequate chilling facilities									
22	Inadequate cold storage									
23	Spoilage of milk through improper handling									

Appendix: 4A6 (Second 22 Risk with third 09 mitigation strategy)

	Strategy Number	24	25	26	27	28	29	30	31	32
Risk Number	Risk Mitigation Strategy / Dairy Supply Chain Risk	Building multi-storeyed complex for farm extension	Building monitoring team	Initiative to develop roads and highways	Arrangement of adequate number of transport	Arrangement of refrigerated transport facilities	Development of roads and highway	Focus on product diversification	Removal of unnecessary influence of middlemen	Direct marketing
24	Bacterial contamination for improper temperature									
25	Pollution and Unhygienic environment									
26	Cattle diseases									
27	Machine damage/breakdown at processing unit									
28	Fire at farm shed									
29	Accident (Staff injury)									
30	Inadequate supply of quality feed									
31	High cost of feed and medicine									
32	Scarcity of feed									
33	Lack of upgrade vaccination and veterinary services									
34	Shortage of land for expanding farm									
35	Irregular supply of vaccine from government									
36	Competition among the farms									
37	Bureaucratic complexity on maintaining various formalities									
38	Drought leads to a decline in milk production									
39	Accidents of transport vehicle									
40	Existence of middlemen/ too many middlemen									
41	Too long chain cause delay in product movement									
42	Poor conditioned road for moving product (delay & spoilage)									
43	Inadequate transport facilities to move products frequently									
44	Lack of milk tanker (refrigerated)									
45	Unethical behaviour of middle men (adulteration, added price, deprivation)									

B. Assessment of Relative Cost of Implementing Mitigation Strategies

Mitigation Strategies	1	2	3	4	5	6	7	8	9	10	11
	Adoption of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	Buying insurance against production loss.	Hiring skilled staff	Motivational and incentives facilities for staff	Initiative to remove political uncertainty	Implementation of a fixed policy for dairy sector	Assurance of adequate institutional credit support with low rate of interest	Introducing off-farm activities	Focus on value addition and product diversification	Promote sound business practices by cooperation, better coordination and information sharing	Reduction of risks through merger, acquisition and integration
Relative Cost											

Mitigation Strategies	12	13	14	15	16	17	18	19	20	21	22	23
	Arrangement of proper training to the staff regarding temperature control	Adoption of alternative supply of power for cold storage (powerful	Arrangement of proper training to the staff regarding processing and	Attempts to create various cross breeds by adopting AI services.	Lease abandoned land to the farmers for dairy farming	Strengthen the regular supply of vaccine	Initiative to reduce the cost of feed	Support to develop technology	Focus on certified feed supplier to get quality feed.	Arrangement of adequate grassland for producing Napier grass	Arrangement of regular vaccination for the cattle	Arrangement of improved and upgraded veterinary services
Relative Cost												

Mitigation Strategies	24	25	26	27	28	29	30	31	32
	Building multi-storeyed complex for farm extension	Building monitoring team	Initiative to develop roads and highways	Arrangement of adequate number of transport	Arrangement of refrigerated transport facilities	Development of roads and highway	Value addition and product diversification	Removal of unnecessary influence of middlemen	Direct marketing
Relative Cost									

Response Sample for Appendix 4A (I & II)

	Strategy Number	1	2	3	4	5	6	7	8	9	10	11
Risk Number	Risk Mitigation Strategy / Dairy Supply Chain Risk	Adoption of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	Buying insurance against production loss.	Hiring skilled staff	Motivational and incentives facilities for staff	Initiative to remove political uncertainty	Implementation of a fixed policy for dairy sector	Assurance of adequate institutional credit support with low rate of interest.	Introducing off-farm activities	Focus on value addition and product diversification	Promote sound business practices by cooperation, better coordination and information sharing	Reduction of risks through merger, acquisition and integration.
1	Inadequate loan facilities	9					5	9	1			
2	Complex loan procedures											
3	High rate of interest							9	1			
4	Inadequate finance							9				5
5	Absence of insurance or compensation coverage						9	5				5
6	Shortage of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	9		5			5	5			5	5
7	Labour disputes			5	9						1	
8	Illiteracy and inefficiency of worker			1	9							
9	Shortage of skilled staff			9	9						5	1
10	Switching of staff frequently			9	5						9	1
11	Lack of fixed government policy in dairy sector				9						5	1
12	Poor law and order situation (terrorism, musclemen ship)						9					
13	Hartal and strike cause delay in work process					9	9				5	
14	Political Unrest and interference		5			9	5					
15	Corruption (adulteration by mixing water)		5			9	5					
16	Damage of farm's assets				9		5					

17	Theft		9	1	9			1				1
18	Natural disaster (flood, excessive rain, storm)		5		9							
19	Quick perishability of Milk		9								5	5
20	Machine damage/breakdown in cold storage	9	9	5	5							
21	Fire in chilling centre		9	9								
22	Inadequate chilling facilities	9	5	9				9				
23	Inadequate cold storage	9										
	Relative Cost	90	90	90	50	40	60	80	50	70	60	40

4B. Survey questionnaires
Survey Questionnaire for QFD Part III
Instructions to assess the relation between risk mitigation strategies and sustainable outcomes

Through the review of literatures, qualitative interview and optimisation by QFD method some risk mitigation strategies for dairy supply chain risks are finalised and presented in the following table with sustainable outcomes. Not all outcomes are achievable with same level of implementing mitigation strategies.

Please assess each outcome in relation to its relevance to a particular strategy and score it based on the following scale.

0--- No relevant
1--- Little relevant
5---Moderately relevant
9---Highly relevant

Appendix 4B: Assessment of Relation between Mitigation Strategies and Sustainable Outcomes

SL No	Sustainable Outcome / Mitigation Strategy	Profit maximisation	Cost minimisation	Increase in income	Increase in production	Product quality improvement	Expansion of farming system	Production of value added product and diversified product	Goodwill enhancement	Supply of quality food	Nutritional development	Improvement of living standard	Creation of employment opportunity	Creation of sound working environment	Waste management	Health improvement of cattle(Animal Quality)
S1	Adoption of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)															
S2	Buying insurance against production loss.															
S3	Hiring skilled staff															
S4	Motivational and incentives facilities for staff															
S5	Initiative to remove political uncertainty															
S6	Implementation of a fixed policy for dairy sector															
S7	Assurance of adequate institutional credit support with low rate of interest.															
S8	Introducing off-farm activities															
S9	Focus on value addition															
S10	Promote sound business practices by cooperation, better coordination and information sharing															
S11	Reduction of risks through merger, acquisition and integration.															
S12	Arrangement of proper training to the staff regarding temperature control															
S13	Adoption of alternative supply of power for cold storage (powerful generator)															
S14	Arrangement of proper training to the staff regarding processing and hygiene management															
S15	Attempts to create various cross breeds by adopting AI services															

S16	Lease abandoned land to the farmers for dairy farming															
S17	Strengthen the regular supply of vaccine															
S18	Initiative to reduce the cost of feed															
S19	Support to develop technology															
S20	Focus on certified feed supplier to get quality feed.															
S21	Arrangement of adequate grassland for producing Napier grass															
S22	Arrangement of regular vaccination for the cattle															
S23	Arrangement of improved and upgraded veterinary services															
S24	Building multi-storeyed complex for farm extension															
S25	Building monitoring team															
S26	Initiative to develop roads and highways															
S27	Arrangement of adequate number of transport															
S28	Arrangement of refrigerated transport facilities															
S29	Development of roads and highway															
S30	Focus on product diversification															
S31	Removal of unnecessary influence of middlemen															
S32	Direct marketing															

5A. DESCRIPTION OF IDENTIFIED RISKS

Inadequate Loan Facilities (R1)

Scarcity of loan facilities is one of the main problems in dairy farming. Farmers are struggling to manage fund from the financial institution due to lack of security, complex loan procedures, high interest rates and the likes.

Complex Loan Procedures (R2)

Loan procedures are often complex in terms of various documents submission, security terms and conditions, mortgage fixed assets or deposits, and time. There are number of documents needs to be submitted for a loan application even it will not be a successful one. Such documents are difficult to prepare and need to collect from different authorities like previous loan profile, environment certificates, ledger history, customer information and distributors profile and so on.

High Rate of Interest (R3)

Dairy loan interest rate is so high in compare to general loan. Dairy is identified as vulnerable business in Bangladesh due to the number of problems incorporated with this industry. For this, financial institutions have set high interest rate for the sake of recovery assurance and possibility of default loan. For example, government banks offers 15% -18% whereas private banks charges more than 20% which is almost unbearable.

Inadequate Finance (R4)

The sources of dairy finance are limited. Usually, farmers have the capability to extend their farm but failed to do so due to inadequate finance supplied from financier and own sources.

Absence of Insurance or Compensation Coverage (R5)

In Bangladesh, it is yet to develop insurance system for dairy cattle which cause uncertainties in a disaster situation like flood, fire, political unrest, and disease.

Shortage of Improved Technology (Milking Machine, Feed Mixture, Grass Cutting, Improved Processing Facilities) (R6)

Farmers are facing problem in collecting and managing milking machine, feed mixture, grass cutting and other improved technology. Most of them are absent in medium size farms due to lack of finances and feasibility of the particular farm.

Labour Disputes (R7)

Dairy industry in Bangladesh is always facing labour disputes. They need to focus to eliminate labour disputes for smooth dairy processing in their farms.

Illiteracy and Inefficiency of Worker (R8)

Most of the dairy workers are illiterate to understand the dairy process. They are ready to be instructed but not to be instructing somebody. It is hard to work with so many illiterate workers who do not understand the consequences of an incident. At the same time, they are treated and found as inefficient due to their ignorant observance.

Shortage of Skilled Staff (R9)

There are no registered dairy workers in Bangladesh. Workers can switch the industry at any time. They do not have any specialized training on dairy management. They learn by observance from the existing employees. They are often switching their working place for the sake of better facilities like improved wages, bonus, facilities and locations. Once they learnt so many things and get enough experience, they want to switch to the other farms for better facilities. This is why; dairy industry is facing frequent staff mobility which suffers them shortage of skilled staff.

Switching of Staff Frequently (R10)

Better package (wages and other facilities) inspire a worker to move their existing work place. Consequently, dairy industry facing immediate problem to manage their process efficiently in absence of experienced employees.

Lack of Fixed Government Policy in Dairy Sector (R11)
Till now, Bangladesh government did not make relevant policy for the dairy sector. The dairy industry eagerly looks for improved policy on dairy zones, tax free imported equipment's, training facilities to the dairy workers, loan facilities and so many related issues.

Poor Law and Order Situation (Terrorism, Musclemen Ship) (R12)
Poor law and order situation makes this industry more vulnerable. Local musclemen are always creating problems in the name of various donations.

Hartal and Strike Cause Delay in Work Process (R13)
Political hartal and strike cause the delay in supply of milk and value added milk products to the final destination. Sometimes, hartal and strike calls for several days or more. In this situation, there is no alternative to save the perishable products like milk which causes huge capital losses for the farmers.

Political Unrest and Interference (R14)
Political unrests and interferences are causing various risks for the dairy industry. Local political leaders are forcing the farmers to do something opposite which hinders their business. For instance, they insist the farmers not to send their milk to the distributors to favour hartal announcer.

Corruption (Adulteration by Mixing Water) (R15)
The most common adulteration problem in dairy is to mixing water into the milk by the employees or distributors.

Damage of Farm's Assets (R16)
Generally, dairy workers are illiterate and inefficient which cause huge damage of farms assets. They do not do all these intentionally rather doing it for ignorant mind.

Theft (R17)
Theft case is also common in dairy farms in Bangladesh as the workers came from very poor family. They cannot stop themselves not to do so due to long sufferings from deficiency.

Natural Disaster (Flood, Excessive Rain, Storm) (R18)
Bangladesh is a country of natural disaster like flood, cyclone, over rain, shortage of rain and too much heat and humid. Dairy farmers suffer from all these disaster in various terms.

Quick Perishability of Milk (R19)
Milk and milk related products are highly perishable in nature. For this characteristic, farmers are facing problems to reach higher distance consumers and distributors. Sometimes, their milk gets perished on the way to the ultimate destination which makes huge loss for them.

Machine Damage/Breakdown at Cold Storage (R20)
Cold storage damage/breakdown cause enormous problem for the farmers. Dairy farmers collected milk twice in a day. They usually store their evening collection which is for less than the morning collection. Cold storage breakdown or damage failed to supply stored milk in the next morning. Such collected milk becomes waste due to machine damage.

Inadequate Chilling Facilities (R21)
Chilling facilities is not available in most of the farms in Bangladesh. Sometimes, farm increases their production without considering adequate chilling facilities based on current milk productions.

Inadequate Cold Storage (R22)
Dairy farmers are always facing problems for storing their milk for as many days as they can. This facility requires massive investments which is almost impossible to manage for them.

Spoilage of Milk through Improper Handling (R23)
Milk is highly perishable product and need to maintain optimum temperature throughout the processing from its collection from the farms. Sometimes, inefficient and ignorant workers handle the milk improperly which cause spoilage.

Bacterial Contamination for Improper Temperature (R24)
Bacterial contamination is obvious if prescribed temperature will not maintain in collected milk. Bacterial contamination causes the collected milk as waste.

Pollution and Unhygienic Environment (R25)
Dairy farms must maintain required biosecurity to protect pollution and unhygienic environment. Polluted and unhygienic farms affected through the various diseases.

Cattle Diseases (R26)
Cattle disease in dairy is common as different age group of cattle have the different risk of having diseases. Disease may cause less milk production, increase overall expenditure and cattle dead.

Machine Damage/Breakdown at Processing Unit (R27)
In processing unit, machine damage and breakdown hampers to process the milk and milk related value added products.

Fire at Farm Shed (R28)
There is always having a risk of fire which may cause burn the whole farms including cattle and processing units.

Accident (Staff Injury) (R29)
Sometimes farmers have reported staff injury from the farming and processing level. Such accident may cause harms for the concern farm.

Inadequate Supply of Quality Feed (R30)
Quality feed is necessary for better milk production and decent nutrition for the dairy cattle. Otherwise, farms may suffer from inadequate productions, improper fertility and nutrition etc.

High Cost of Feed and Medicine (R31)
High cost of feed and medicine will increase the unit cost of milk and mill related value added products. To minimize this, the cost should be reduced as less as they can to gain maximum profitability.

Scarcity of Feed (R32)
Sometimes feed stock is scarce due to flood, cyclone and import related problems. Poultry stock must need consistent supply of nutritious feed to get better productivity and profitability.

Lack of Upgrade Vaccination and Veterinary Services (R33)
Vaccination and veterinary services are very important for the farm to manage healthy cattle. These two facilities are almost unavailable or inadequate in the regional areas where dairy farms exist.

Shortage of Land for Expanding Farm (R34)
Bangladesh is densely populated country where vacant land is almost non-exist around the farm. But dairy need expanded land to do grass cultivation and cattle movement.

Irregular Supply of Vaccine from Government (R35)
Government officials are reluctant to supply adequate vaccine through regional artificial insemination centre.

Competition among the Farms (R36)
Intense competition makes this business worst. Unhealthy competition creates an artificial crisis and reduced milk price by the giant farmers. In this way, small and medium farmers drain out from the milk market within short time.

Bureaucratic Complexity on Maintaining Various Formalities (R37)
Any formal approval from government official gives a bureaucratic complication to process. For instance, importing milk machine and applying for the finance needs highest bureaucratic process to achieve.

Drought Leads to a Decline in Milk Production (R38)
Green grass is the key for better milk production. In dry season, there are less green grass in the field to serve the cattle which hampers the milk productions.

Accidents of Transport Vehicle (R39)
The roads and highway is not structured and scientific in Bangladesh. Accidents are part and parcel of daily lives. An accident of transport vehicle is one of the common issues which cause significant amount of loss for the farmers.

Existence of Middlemen/ Too Many Middlemen (R40)
Too many middlemen exist in the dairy sector in Bangladesh. Too many middlemen increase prices for the ultimate milk and milk related product.

Too Long Chain Cause Delay in Product Movement (R41)
Long supply chain is ultimately making delay of reaching milk to the final destination. It caused risks on wasting milk and increases the cost at the day end.

Poor Conditioned Road for Moving Product (Delay & Spoilage) (R42)
The condition of roads and highways are very poor in terms of structure, maintenance, space and quality. This is why; the milk product may reach in delay with a chance of spoilage.

Inadequate Transport Facilities to Move Products Frequently (R43)
A transport facility is not available due to lack of finance for a farm. They need to hire the milk van which cost them additional money. Moreover, they failed to supply the milk frequently rather waiting for the third party services.

Lack of Milk Tanker (Refrigerated) (R44)
In the tropical weather condition, raw milk has a tendency to spoil very fast with short shelf life. Most of the dairy farms in Bangladesh transport milk after adding ice as a means to 'preserve' and save milk from spoilage, which deteriorates quality. Considering the weather conditions, milk tanker (refrigerated) is needed to transport milk to long distance. Milk tanker is also need significant amount of finance to manage and to maintain. Unfortunately, there are limited use of milk tanker in Bangladesh do not have such facilities.

Unethical Behaviour of Middle Men (Adulteration, Added Price, Deprivation) (R45)
Unethical behaviour like adulteration, price hike and deprivation creates more problems for the dairy farms.

5B. Description of Identified Mitigation Strategies
Adoption of Improved Technology (Milking Machine, Feed Mixture, Grass Cutting, Improved Processing Facilities) (S1)
Improved technology like incorporating milking machine, feed mixture, and grass cutting devices can increase efficiency which leads more profitability and productivity in a dairy farm.

Buying Insurance against Production Loss (S2)
Production loss can be happened frequently in dairy industry due to natural disasters, man and machine made problems like adulteration, inefficient handling of milk and machine breakdown. Proper insurance policy can give some sort of assurance against various production losses Insurance coverage against production loss can help the supply chain members to overcome

different types of risks occurred from accidents, diseases, natural uncertainties and hazard risks. Regarding insurance coverage respondent A stated with frustration that, 'In our country, there is no insurance coverage for the dairy industry…in case of any disaster we face complexities to survive'.

Hiring Skilled Staff (S3)
Skilled staff can handle a process more efficiently than an ordinary unskilled staff. For this, dairy industry focuses on hiring skilled staff to things done more efficiently.

Motivational and Incentives Facilities for Staff (S4)
Lucrative wages, incentives and appropriate motivation can assist a staff to reach perfection in doing a particular work. Zero motivation will demoralize them not to do such work effectively. For instance, better facilities can hold a staff for the long run to work in an industry in an efficient manner.

Initiative to Remove Political Uncertainty (S5)
Political uncertainty has major influence over the industry. Industry can spend some money to increase social awareness along with political parties so that they can escape from the political bad affects.

Implementation of a Fixed Policy for Dairy Sector (S6)
Dynamic dairy policy is a long time demand to the government for the sake of structuring the farms and farms-related supply chain. Obviously, improved policy will have better consequences over making profit and productivity.

Assurance of Adequate Institutional Credit Support with Low Rate of Interest (S7)
Interest rate is one of the main factors to get a long term loan to develop modern dairy farm having all logistic facilities. At present, interest rate is too high to bear the cost by the farm. If dairy industry can get assurance of adequate loan facilities with bearable interest rate, industry will grow and improve their facilities instantly.

Introducing Off-Farm Activities (S8)
Integration of some off-farm activities can bring more profits to the concern industry. For instance, planting vegetables and local fruits can be adding more profit to their ledger having minimum investment. It can be done within their dairy premises using cow dung as fertilizers.

Focus on Value Addition (S9)
Farms can focus more on value addition through making value added milk product like sweets. In addition, industry can concentrate on utilizing farm wastes to make biogas, fertilizers and artificial charcoals. If they have huge production of value added products then they can commercial it for making extra profits.

Promote Sound Business Practices by Cooperation, Better Coordination and Information Sharing (S10)
Dynamic business practices, coordination among various supply chain parties and sharing information among the stakeholders can make this industry more profitable and rich.

Reduction of Risks through Merger, Acquisition and Integration (S11)
Sometimes, industry can use the business concepts like merger acquisition and integration of similar supply chain members to reduce cost to get competitive advantage.

Arrangement of Proper Training to the Staff Regarding Temperature Control (S12)
Temperature is the primate matter for milk related product as it is highly perishable in nature. Relevant staff members should get proper training to handle the produced milk to avoid hazard.

Adoption of Alternative Supply of Power for Cold Storage (Powerful Generator) (S13)
Powerful generator is almost necessary in dairy industry in Bangladesh as central power supply is not consistent enough. So, adopting a powerful generator can save from the spoilage of milk.

Arrangement of Proper Training to the Staff Regarding Processing and Hygiene Management (S14)
Staff members who are related with milk processing and hygiene management, they should get modern training. Such training can maintain smooth processing and hygiene in the farm and its processing.

Attempts to Create Various Cross Breeds by Adopting AI Services (S15)
Artificial insemination (AI) is an important matter for cross breed cattle. AI service is controlled by the government livestock ministry through zonal AI centre. If AI centre imports different improved breed from dairy developed country, farmers can easily improve their cattle breed day by day.

Lease Abandoned Land to the Farmers for Dairy Farming (S16)
In Bangladesh, land is scarce to the farm owner. In this situation, government can take initiative to provide abandoned property as a lease to the farmers. In this way, farmers can get it in cheapest price to increase their productivity.

Strengthen the Regular Supply of Vaccine (S17)
Vaccination is an important part of rearing dairy cattle. Disease and health are relied based on proper vaccination. Vaccine should be given on prescribed time. Consequently, relevant authority should supply those vaccines on time so that farmers can be benefited in terms of maintaining cattle.

Initiative to Reduce the Cost of Feed (S18)
The cost of dairy products mostly depends on feed costs. If relevant authorities take initiative to reduce feed cost, the farmers will be privileged to reduce the costs of milk.

Support to Develop Technology (S19)
Government can support the farmers to develop necessary devices using local materials. For instance, one imported milk machine may cost 10,000 dollars. If local engineers have the opportunity to carry research on it to build it in locally, they may reduce 50% cost.

Focus on Certified Feed Supplier to Get Quality Feed (S20)
Feed quality is essential for the dairy cattle for providing optimum productions, maintaining good health and nutrition and long-term genetic maintenance. In this case, government can make a policy to encourage certified feed supplier to maintain good quality feed for the dairy farms.

Arrangement of Adequate Grassland for Producing Napier Grass (S21)
Dairy cattle are fond of green grass. It is almost unavailable as most of the dairy does not have enough land to cultivate it. Nippier is a German green grass breed which can be cultivated in small piece of land. This can be collected within 3 weeks cycle then it grows up again. The more green grass provides to the farm, the fertility and production problem will be less.

Arrangement of Regular Vaccination for the Cattle (S22)
A dairy farm must maintain prescribed vaccination for the cattle to maintain healthy fertility and optimum production.

Arrangement of Improved and Upgraded Veterinary Services (S23)
Veterinary services are upgrading day by day relied on technological development. Therefore, responsible authorities needs to arrange improved technology in veterinary services or upgrade existing services for the sake of betterment of dairy sector.

Building Multi-Storeyed Complex for Farm Extension (S24)
Dairy in Bangladesh need to find a way to build multi-storeyed farm so that more cattle can be accommodated in one dairy complex. It is essential for Bangladesh case as land is unavailable and rare to the dairy owners.

Building Monitoring Team (S25)
Farm should build a monitoring team for various supply chain members to observe their activities in favour of their advancement. Monitoring team can be built in the government, association, cooperation and regional level as well.

Initiative to Develop Roads and Highways (S26)
It is mandatory have a good structure of roads and highway to mobilize dairy milk and milk related products towards other cities and regions.

Arrangement of Adequate Number of Transport (S27)
It is always vital to keep adequate and relevant transport based on farm production. Available transport can provide instant service to the supply chain members to get the products on time.

Arrangement of Refrigerated Transport Facilities (S28)
Milk is perishable in nature and it needs refrigerated transport to carry it to the long distance places. Farms need to arrange chiller van to mobilize their products to the final destinations.

Development of Roads and Highway (S29)
Government or local authority need to take initiative to develop road system from the remote farms to the highway to travel their products to the final destinations.

Focus on Product Diversification (S30)
Product diversification is popular concept of minimizing risk of making losses. A dairy farm can take initiative to diverse their business such as converting milk into value added product like sweets, yogurt, Ghee and the likes. On the other hand, some other agriculture products can be cultivated in the same premises.

Removal of Unnecessary Influence of Middlemen (S31)
Farmers should always find a way to minimize middlemen so that they can keep maximum profit share. Too many middlemen will reduce profitability.

Direct Marketing (S32)
It is always intelligent to deliver their products through one stop service or using direct marketing. If a farm can implement direct marketing policy, they can hold maximum profit share by not splitting it to other supply chain members. A few giant farms already working on it to hold most of the supply chain activities within their own process to reduce ultimate costs.

Appendix 5C: Calculation of DI (Paharika)

SL	Risk	P1			P2			P3			P4			P5			P6				
		P	I	DI	P	I	DI	P	I	DI	P	I	DI	P	I	DI	P	I	DI	Total	DI Av.
1	Inadequate loan facilities	0.7	0.6	0.42	0.7	0.6	0.42	0.4	0.6	0.24	0.5	0.5	0.25	0.6	0.5	0.3	0.5	0.5	0.25	1.88	0.31
2	Complex loan procedures	0.9	0.8	0.72	0.5	0.7	0.35	0.6	0.7	0.42	0.5	0.5	0.25	0.7	0.6	0.42	0.7	0.7	0.49	2.65	0.44
3	High rate of interest	0.9	0.9	0.81	0.9	0.7	0.63	0.8	0.8	0.64	0.5	0.5	0.25	0.9	0.8	0.72	0.7	0.6	0.42	3.47	**0.58**
4	Inadequate finance	0.8	0.8	0.64	0.6	0.8	0.48	0.7	0.8	0.56	0.9	0.9	0.81	0.8	0.6	0.48	0.5	0.5	0.25	3.22	0.54
5	Absence of insurance or compensation coverage	0.9	0.9	0.81	0.7	0.9	0.63	0.9	0.9	0.81	0.9	0.9	0.81	0.6	0.3	0.18	0.8	0.8	0.64	3.88	**0.65**
6	Shortage of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	0.8	0.8	0.64	0.3	0.7	0.21	0.6	0.7	0.42	0.9	0.9	0.81	0.7	0.3	0.21	0.7	0.7	0.49	2.78	0.46
7	Labour disputes	0.7	0.8	0.56	0.4	0.9	0.36	0.5	0.6	0.3	0.5	0.1	0.05	0.1	0.2	0.02	0.9	0.9	0.81	2.1	0.35
8	Illiteracy and inefficiency of worker	0.8	0.7	0.56	0.8	0.7	0.56	0.8	0.9	0.72	0.5	0.9	0.45	0.8	0.3	0.24	0.8	0.8	0.64	3.17	0.53
9	Shortage of skilled staff	0.7	0.8	0.56	0.7	0.9	0.63	0.9	0.9	0.81	0.5	0.5	0.25	0.4	0.2	0.08	0.7	0.8	0.56	2.89	0.48
10	Switching of staff frequently	0.6	0.8	0.48	0.7	0.8	0.56	0.5	0.7	0.35	0.5	0.5	0.25	0.2	0.6	0.12	0.6	0.7	0.42	2.18	0.36
11	Lack of fixed government policy in dairy sector	0.9	0.8	0.72	0.9	0.3	0.27	0.9	0.9	0.81	0.9	0.5	0.45	0.6	0.5	0.3	0.8	0.8	0.64	3.19	0.53
12	Poor law and order situation (terrorism, musclemen ship)	0.7	0.8	0.56	0.9	0.8	0.72	0.9	0.9	0.81	0.5	0.9	0.45	0.6	0.3	0.18	0.8	0.8	0.64	3.36	0.56
13	Hartal and strike cause delay in work process	0.9	0.9	0.81	0.8	0.8	0.64	0.9	0.9	0.81	0.9	0.9	0.81	0.7	0.8	0.56	0.8	0.8	0.64	4.27	**0.71**
14	Political Unrest and interference	0.7	0.8	0.56	0.6	0.9	0.54	0.6	0.8	0.48	0.9	0.9	0.81	0.6	0.7	0.42	0.8	0.8	0.64	3.45	**0.58**
15	Corruption (adulteration by mixing water)	0.3	0.5	0.15	0.1	0.2	0.02	0.2	0.1	0.02	0.1	0.5	0.05	0.3	0.3	0.09	0.2	0.2	0.04	0.37	0.06
16	Damage of farm's assets	0.8	0.8	0.64	0.7	0.7	0.49	0.3	0.5	0.15	0.9	0.9	0.81	0.3	0.4	0.12	0.5	0.5	0.25	2.46	0.41
17	Theft	0.9	0.9	0.81	0.7	0.6	0.42	0.2	0.4	0.08	0.5	0.5	0.25	0.4	0.4	0.16	0.3	0.3	0.09	1.81	0.30
18	Natural disaster (flood, excessive rain, storm)	0.7	0.8	0.56	0.7	0.8	0.56	0.5	0.7	0.35	0.5	0.9	0.45	0.6	0.7	0.42	0.7	0.7	0.49	2.83	0.47
19	Quick perishability of Milk	0.7	0.7	0.49	0.5	0.6	0.3	0.4	0.5	0.2	0.5	0.5	0.25	0.8	0.9	0.72	0.4	0.4	0.16	2.12	0.35
20	Machine damage/breakdown at cold storage	0.6	0.9	0.54	0.5	0.7	0.35	0.5	0.6	0.3	0.5	0.9	0.45	0.8	0.8	0.64	0.2	0.2	0.04	2.32	0.39
21	Inadequate chilling facilities	0.5	0.6	0.3	0.6	0.9	0.54	0.8	0.7	0.56	0.5	0.9	0.45	0.7	0.6	0.42	0.2	0.7	0.14	2.41	0.40
22	Inadequate cold storage	0.8	0.9	0.72	0.7	0.8	0.56	0.9	0.9	0.81	0.8	0.1	0.08	0.8	0.7	0.56	0.2	0.7	0.14	2.87	0.48
23	Spoilage of milk through improper handling	0.2	0.7	0.14	0.4	0.3	0.12	0.3	0.4	0.12	0.5	0.5	0.25	0.2	0.1	0.02	0.2	0.2	0.04	0.69	0.12
24	Bacterial contamination for improper temperature	0.2	0.7	0.14	0.8	0.8	0.64	0.7	0.8	0.56	0.5	0.9	0.45	0.4	0.2	0.08	0.6	0.6	0.36	2.23	0.37
25	Pollution and Unhygienic environment	0.5	0.7	0.35	0.6	0.4	0.24	0.3	0.4	0.12	0.5	0.5	0.25	0.8	0.6	0.48	0.3	0.3	0.09	1.53	0.26
26	Cattle diseases	0.8	0.8	0.64	0.6	0.7	0.42	0.7	0.8	0.56	0.5	0.9	0.45	0.5	0.8	0.4	0.5	0.5	0.25	2.72	0.45
27	Machine damage/breakdown at processing unit	0.6	0.9	0.54	0.7	0.5	0.35	0.4	0.5	0.2	0.5	0.9	0.45	0.5	0.6	0.3	0.4	0.4	0.16	2	0.33
28	Fire at farm shed	0.3	0.9	0.27	0.4	0.9	0.36	0.3	0.2	0.06	0.9	0.5	0.45	0.8	0.7	0.56	0.2	0.2	0.04	1.74	0.29
29	Accident (Staff injury)	0.1	0.3	0.03	0.3	0.5	0.15	0.3	0.4	0.12	0.5	0.5	0.25	0.2	0.1	0.02	0.2	0.2	0.04	0.61	0.10
30	Inadequate supply of quality feed	0.5	0.6	0.3	0.6	0.5	0.3	0.8	0.7	0.56	0.5	0.5	0.25	0.5	0.5	0.25	0.5	0.5	0.25	1.91	0.32
31	High cost of feed and medicine	0.7	0.8	0.56	0.7	0.7	0.49	0.9	0.9	0.81	0.5	0.9	0.45	0.6	0.6	0.36	0.7	0.7	0.49	3.16	0.53
32	Scarcity of feed	0.5	0.7	0.35	0.4	0.5	0.2	0.7	0.8	0.56	0.5	0.1	0.05	0.7	0.6	0.42	0.4	0.3	0.12	1.7	0.28
33	Lack of upgrade vaccination and veterinary service	0.7	0.7	0.49	0.6	0.9	0.54	0.8	0.9	0.72	0.5	0.9	0.45	0.8	0.9	0.72	0.2	0.2	0.04	2.96	0.49
34	Shortage of land for expanding farm	0.7	0.8	0.56	0.6	0.8	0.48	0.9	0.9	0.81	0.5	0.5	0.25	0.7	0.5	0.35	0.5	0.5	0.25	2.7	0.45
35	Irregular supply of vaccine from government	0.6	0.7	0.42	0.6	0.7	0.42	0.9	0.9	0.81	0.8	0.5	0.4	0.7	0.2	0.14	0.7	0.7	0.49	2.68	0.45
36	Competition among the farms	0.3	0.8	0.24	0.4	0.4	0.16	0.4	0.3	0.12	0.5	0.9	0.45	0.8	0.7	0.56	0.2	0.1	0.02	1.55	0.26
37	Bureaucratic complexity on maintaining various formalities	0.4	0.6	0.24	0.6	0.7	0.42	0.6	0.7	0.42	0.3	0.9	0.27	0.4	0.4	0.16	0.4	0.4	0.16	1.67	0.28
38	Drought leads to a decline in milk production	0.5	0.7	0.35	0.6	0.5	0.3	0.4	0.6	0.24	0.3	0.9	0.27	0.4	0.3	0.12	0.6	0.6	0.36	1.64	0.27
39	Accidents of transport vehicle	0.7	0.9	0.63	0.3	0.8	0.24	0.6	0.7	0.42	0.5	0.5	0.25	0.3	0.8	0.24	0.6	0.6	0.36	2.14	0.36
40	Existence of middlemen/ too many middlemen	0.5	0.6	0.3	0.6	0.9	0.54	0.4	0.5	0.2	0.7	0.9	0.63	0.7	0.7	0.49	0.6	0.6	0.36	2.52	0.42
41	Too long chain cause delay in product movement	0.3	0.5	0.15	0.7	0.7	0.49	0.3	0.5	0.15	0.8	0.5	0.4	0.5	0.5	0.25	0.6	0.6	0.36	1.8	0.30
42	Poor conditioned road for moving product (delay & spoilage)	0.5	0.7	0.35	0.4	0.5	0.2	0.9	0.9	0.81	0.5	0.9	0.45	0.7	0.8	0.56	0.7	0.7	0.49	2.86	0.48
43	Inadequate transport facilities to move products frequently	0.5	0.6	0.3	0.6	0.8	0.48	0.9	0.9	0.81	0.5	0.5	0.25	0.8	0.7	0.56	0.7	0.7	0.49	2.89	0.48
44	Lack of milk tanker (refrigerated)	0.6	0.7	0.42	0.7	0.6	0.42	0.6	0.7	0.42	0.9	0.9	0.81	0.9	0.8	0.72	0.6	0.6	0.36	3.15	0.53
45	Unethical behavior of middle men (adulteration, added price, deprivation)	0.5	0.5	0.25	0.6	0.5	0.3	0.6	0.8	0.48	0.9	0.9	0.81	0.6	0.5	0.3	0.7	0.7	0.49	2.63	0.44

SL	P7			P8			P9					P10			P11				
	P	I	DI	P	I	DI	P	I	DI	Total	DI Av.	P	I	DI	P	I	DI	Total	DI Av.
1	0.4	0.6	0.24	0.5	0.5	0.25	0.9	0.9	0.81	1.3	0.43	0.7	0.5	0.35	0.8	0.6	0.48	0.83	0.42
2	0.6	0.5	0.3	0.5	0.8	0.4	0.9	0.8	0.72	1.42	0.47	0.7	0.5	0.35	0.6	0.4	0.24	0.59	0.30
3	0.8	0.7	0.56	0.9	0.9	0.81	0.7	0.9	0.63	2	**0.67**	0.8	0.6	0.48	0.8	0.4	0.32	0.8	0.40
4	0.9	0.4	0.36	0.5	0.7	0.35	0.8	0.9	0.72	1.43	0.48	0.9	0.7	0.63	0.9	0.3	0.27	0.9	0.45
5	0.9	0.5	0.45	0.7	0.8	0.56	0.9	0.9	0.81	1.82	0.61	0.6	0.6	0.36	0.5	0.4	0.2	0.56	0.28
6	0.9	0.4	0.36	0.7	0.6	0.42	0.6	0.5	0.3	1.08	0.36	0.8	0.8	0.64	0.9	0.6	0.54	1.18	0.59
7	0.7	0.5	0.35	0.7	0.7	0.49	0.7	0.5	0.35	1.19	0.40	0.3	0.4	0.12	0.2	0.2	0.04	0.16	0.08
8	0.7	0.6	0.42	0.8	0.7	0.56	0.6	0.9	0.54	1.52	0.51	0.5	0.3	0.15	0.6	0.1	0.06	0.21	0.11
9	0.9	0.5	0.45	0.7	0.6	0.42	0.5	0.9	0.45	1.32	0.44	0.7	0.4	0.28	0.6	0.3	0.18	0.46	0.23
10	0.8	0.6	0.48	0.7	0.7	0.49	0.7	0.7	0.49	1.46	0.49	0.6	0.6	0.36	0.4	0.3	0.12	0.48	0.24
11	0.9	0.5	0.45	0.9	0.8	0.72	0.9	0.7	0.63	1.8	0.60	0.8	0.8	0.64	0.8	0.6	0.48	1.12	0.56
12	0.9	0.5	0.45	0.9	0.9	0.81	0.8	0.9	0.72	1.98	**0.66**	0.8	0.9	0.72	0.7	0.8	0.56	1.28	0.64
13	0.9	0.9	0.81	0.9	0.9	0.81	0.9	0.9	0.81	2.43	**0.81**	0.9	0.9	0.81	0.9	0.9	0.81	1.62	**0.81**
14	0.8	0.7	0.56	0.7	0.6	0.42	0.9	0.9	0.81	1.79	0.60	0.9	0.9	0.81	0.9	0.9	0.81	1.62	**0.81**
15	0	0.2	0	0.4	0.5	0.2	0.2	0.3	0.06	0.26	0.09	0	0.2	0	0	0.3	0	0	0.00
16	0.6	0.4	0.24	0.6	0.7	0.42	0.4	0.9	0.36	1.02	0.34	0.3	0.4	0.12	0.3	0.4	0.12	0.24	0.12
17	0.7	0.4	0.28	0.2	0.2	0.04	0.3	0.2	0.06	0.38	0.13	0.3	0.2	0.06	0.4	0.1	0.04	0.1	0.05
18	0.7	0.4	0.28	0.2	0.2	0.04	0.4	0.7	0.28	0.6	0.20	0.4	0.7	0.28	0.3	0.7	0.21	0.49	0.25
19	0.4	0.2	0.08	0.6	0.2	0.12	0.2	0.4	0.08	0.28	0.09	0.7	0.5	0.35	0.7	0.5	0.35	0.7	0.35
20	0.3	0.3	0.09	0.1	0.1	0.01	0.2	0.9	0.18	0.28	0.09	0.5	0.5	0.25	0.7	0.5	0.35	0.6	0.30
21	0	0.1	0	0.7	0.7	0.49	0.6	0.6	0.36	0.85	0.28	0.7	0.7	0.49	0.7	0.7	0.49	0.98	0.49
22	0.2	0.2	0.04	0.7	0.7	0.49	0.6	0.5	0.3	0.83	0.28	0.8	0.7	0.56	0.8	0.7	0.56	1.12	0.56
23	0.1	0.1	0.01	0.1	0.1	0.01	0.3	0.7	0.21	0.23	0.08	0.8	0.4	0.32	0.4	0.5	0.2	0.52	0.26
24	0.7	0.5	0.35	0.1	0.1	0.01	0.4	0.9	0.36	0.72	0.24	0.8	0.5	0.4	0.8	0.4	0.32	0.72	0.36
25	0.5	0.5	0.25	0.3	0.3	0.09	0.5	0.9	0.45	0.79	0.26	0.9	0.4	0.36	0.5	0.4	0.2	0.56	0.28
26	0.8	0.6	0.48	0.3	0.8	0.24	0.5	0.9	0.45	1.17	0.39	0.5	0.8	0.4	0.3	0.9	0.27	0.67	0.34
27	0.2	0.2	0.04	0.1	0.6	0.06	0.2	0.9	0.18	0.28	0.09	0.5	0.6	0.3	0.3	0.8	0.24	0.54	0.27
28	0.1	0.1	0.01	0.1	0.7	0.07	0.1	0.9	0.09	0.17	0.06	0.2	0.8	0.16	0.1	0.9	0.09	0.25	0.13
29	0.1	0.1	0.01	0.1	0.1	0.01	0.5	0.6	0.3	0.32	0.11	0.4	0.4	0.16	0.2	0.2	0.04	0.2	0.10
30	0.7	0.5	0.35	0.2	0.5	0.1	0.4	0.7	0.28	0.73	0.24	0.7	0.6	0.42	0.8	0.6	0.48	0.9	0.45
31	0.9	0.9	0.81	0.7	0.7	0.49	0.7	0.8	0.56	1.86	0.62	0.8	0.8	0.64	0.7	0.6	0.42	1.06	0.53
32	0.8	0.6	0.48	0.9	0.9	0.81	0.6	0.7	0.42	1.71	0.57	0.7	0.8	0.56	0.8	0.7	0.56	1.12	0.56
33	0.9	0.8	0.72	0.7	0.7	0.49	0.8	0.7	0.56	1.77	0.59	0.7	0.8	0.56	0.5	0.8	0.4	0.96	0.48
34	0.9	0.7	0.63	0.9	0.7	0.63	0.9	0.7	0.63	1.89	0.63	0.4	0.4	0.16	0.8	0.6	0.48	0.64	0.32
35	0.6	0.5	0.3	0.9	0.7	0.63	0.9	0.7	0.63	1.56	0.52	0.4	0.6	0.24	0.5	0.7	0.35	0.59	0.30
36	0.5	0.7	0.35	0.5	0.5	0.25	0.8	0.5	0.4	1	0.33	0.3	0.4	0.12	0.4	0.5	0.2	0.32	0.16
37	0.6	0.4	0.24	0.4	0.6	0.24	0.8	0.9	0.72	1.2	0.40	0.2	0.3	0.06	0.2	0.2	0.04	0.1	0.05
38	0.6	0.4	0.24	0.6	0.8	0.48	0.5	0.6	0.3	1.02	0.34	0.2	0.2	0.04	0.2	0.6	0.12	0.16	0.08
39	0.6	0.4	0.24	0.1	0.8	0.08	0.9	0.9	0.81	1.13	0.38	0.5	0.3	0.15	0.2	0.4	0.08	0.23	0.12
40	0.4	0.2	0.08	0.4	0.4	0.16	0.9	0.6	0.54	0.78	0.26	0.8	0.7	0.56	0.8	0.8	0.64	1.2	0.60
41	0.3	0.1	0.03	0.2	0.2	0.04	0.7	0.8	0.56	0.63	0.21	0.8	0.8	0.64	0.8	0.8	0.64	1.28	0.64
42	0.3	0.1	0.03	0.2	0.5	0.1	0.6	0.9	0.54	0.67	0.22	0.8	0.6	0.48	0.9	0.7	0.63	1.11	0.56
43	0.9	0.5	0.45	0.3	0.5	0.15	0.6	0.7	0.42	1.02	0.34	0.8	0.8	0.64	0.9	0.8	0.72	1.36	**0.68**
44	0.9	0.5	0.45	0.8	0.5	0.4	0.1	0.6	0.06	0.91	0.30	0.9	0.8	0.72	0.8	0.8	0.64	1.36	**0.68**
45	0.5	0.3	0.15	0.1	0.3	0.03	0.6	0.6	0.36	0.54	0.18	0.9	0.9	0.81	0.9	0.9	0.81	1.62	**0.81**

Appendix 5D: Value of Relationship Matrix for QFD Analysis (Paharika)

	P1	P2	P3	P4	P5	P6	Total	WA	P7	P8	P9	Total	WA	P10	P11	Total	WA
R1S1							0	0.00	5			5	1.67			0	0.00
R1S2	1				1		2	0.33	1			1	0.33			0	0.00
R1S3			1	5			6	1.00	5			5	1.67			0	0.00
R1S4							0	0.00	5			5	1.67			0	0.00
R1S5							0	0.00				0	0.00			0	0.00
R1S6	9	5				1	15	2.50		5		5	1.67	5		5	2.50
R1S7	5	9	9	9	9	9	50	8.33	9	9	9	27	9.00	9	9	18	9.00
R1S8		5	5	5	5	5	25	4.17	5	5	5	15	5.00		5	5	2.50
R1S9							0	0.00			9	9	3.00			0	0.00
R1S10	1		5				6	1.00		1		1	0.33		1	1	0.50
R1S11							0	0.00			5	5	1.67			0	0.00
R1S12							0	0.00				0	0.00			0	0.00
R1S13							0	0.00				0	0.00			0	0.00
R1S14							0	0.00				0	0.00			0	0.00
R1S15							0	0.00				0	0.00			0	0.00
R1S16							0	0.00				0	0.00			0	0.00
R1S17							0	0.00				0	0.00			0	0.00
R1S18							0	0.00				0	0.00			0	0.00
R1S19							0	0.00				0	0.00			0	0.00
R1S20							0	0.00				0	0.00			0	0.00
R1S21							0	0.00				0	0.00			0	0.00
R1S22							0	0.00				0	0.00			0	0.00
R1S23							0	0.00				0	0.00			0	0.00
R1S24							0	0.00				0	0.00			0	0.00
R1S25							0	0.00				0	0.00			0	0.00
R1S26							0	0.00				0	0.00			0	0.00
R1S27							0	0.00				0	0.00			0	0.00
R1S28							0	0.00				0	0.00			0	0.00
R1S29							0	0.00				0	0.00			0	0.00
R1S30							0	0.00				0	0.00			0	0.00
R1S31							0	0.00				0	0.00			0	0.00
R1S32							0	0.00				0	0.00			0	0.00

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Adoption of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	Buying insurance against production loss.	Hiring skilled staff	Motivational and incentives facilities for staff	Initiative to remove political uncertainty	Implementation of a fixed policy for dairy sector	Assurance of adequate institutional credit support with low rate of interest.	Introducing off-farm activities	Focus on value addition and product diversification	Promote sound business practices by cooperation, better coordination and information sharing	Reduction of risks through merger, acquisition and integration.	Arrangement of proper training to the staff regarding temperature control	Adoption of alternative supply of power for cold storage (powerful generator)	Arrangement of proper training to the staff regarding processing and hygiene management	Attempts to create various cross breeds by adopting AI services.	Lease abandoned land to the farmers for dairy farming	Strengthen the regular supply of vaccine	Initiative to reduce the cost of feed	Support to develop technology	Focus on certified feed supplier to get quality feed.	Arrangement of adequate grassland for producing Napier grass	Arrangement of regular vaccination for the cattle	Arrangement of improved and upgraded veterinary services	Building multi-storeyed complex for farm extension	Building monitoring team	Initiative to develop roads and highways	Arrangement of adequate number of transport	Arrangement of refrigerated transport facilities	Development of roads and highway	Value addition and product diversification	Removal of unnecessary influence of middlemen	Direct marketing

Appendix 5E : Roof Matrix (Paharika)

Appendix 5F: QFD – Nahar Executives

Risk Number	Strategy Number / Risk / Mitigation Strategy	Degree of Importance	1 Adoption of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	2 Buying insurance against production loss.	3 Hiring skilled staff	4 Motivational and incentives facilities for staff	5 Initiative to remove political uncertainty	6 Implementation of a fixed policy for dairy sector	7 Assurance of adequate institutional credit support with low rate of interest.	8 Introducing off-farm activities	9 Focus on value addition	10 Promote sound business practices by cooperation, better coordination and information sharing	11 Reduction of risks through merger, acquisition and integration.	12 Arrangement of proper training to the staff regarding temperature control	13 Adoption of alternative supply of power for cold storage (powerful generator)	14 Arrangement of proper training to the staff regarding processing and hygiene management	15 Attempts to create various cross breeds by adopting AI services.	16 Lease abandoned land to the farmers for dairy farming	17 Strengthen the regular supply of vaccine	18 Initiative to reduce the cost of feed	19 Support to develop technology	20 Focus on certified feed supplier to get quality feed.	21 Arrangement of adequate grassland for producing Napier grass	22 Arrangement of regular vaccination for the cattle	23 Arrangement of improved and upgraded veterinary services	24 Building multi-storeyed complex for farm extension	25 Building monitoring team	26 Initiative to develop roads and highways	27 Arrangement of adequate number of transport	28 Arrangement of refrigerated transport facilities	29 Development of roads and highway	30 Focus on product diversification	31 Removal of unnecessary influence of middlemen	32 Direct marketing	
1	Inadequate loan facilities	0.22	3.33	0.00	3.00	1.67	3.33	4.67	1.67	6.00	1.67	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	Complex loan procedures	0.33	0.00	0.00	3.00	1.67	0.00	2.00	7.67	0.00	3.00	1.67	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	High rate of interest	0.54	1.67	0.00	1.67	0.00	0.00	3.00	6.33	0.67	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
4	Inadequate finance	0.41	0.33	0.00	0.00	0.00	0.00	0.00	7.67	2.00	0.00	4.67	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Absence of insurance or compensation coverage	0.64	0.00	6.33	0.00	0.00	0.00	6.00	3.00	2.00	0.00	0.33	4.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Shortage of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	0.44	9.00	0.00	6.33	2.00	0.00	0.00	0.00	0.00	0.00	1.67	0.00	0.33	1.67	1.67	0.00	0.00	0.00	3.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	Labour disputes	0.47	1.67	3.00	6.00	4.67	0.00	0.00	0.00	0.00	1.67	3.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	Illiteracy and inefficiency of worker	0.54	3.00	0.00	6.33	3.00	0.00	3.00	0.00	0.00	0.00	0.33	0.00	5.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Shortage of skilled staff	0.56	6.00	3.00	3.00	4.67	0.00	0.00	0.00	0.00	0.00	0.33	0.00	5.00	0.00	9.00	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	Switching of staff frequently	0.47	0.00	0.00	5.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	Lack of fixed government policy in dairy sector	0.70	0.00	0.00	0.00	0.00	0.00	7.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.67	3.33	0.33	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	Poor law and order situation (terrorism, musclemen ship)	0.48	0.00	0.00	0.00	0.00	0.33	7.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	Hartal and strike cause delay in work process	0.78	0.00	0.00	0.00	0.00	6.00	6.00	1.67	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	Political Unrest and interference	0.44	0.00	0.00	0.00	0.33	6.33	3.33	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	Corruption (adulteration by mixing water)	0.33	0.00	1.67	0.33	1.67	0.00	1.67	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.67	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.33	0.00	0.00	0.00	2.00	3.33	
16	Damage of farm's assets	0.47	0.00	3.00	5.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	6.00	7.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
17	Theft	0.36	3.00	0.33	1.67	6.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.33	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
18	Natural disaster (flood, excessive rain, storm)	0.28	0.00	9.00	0.00	0.00	0.00	1.67	2.00	0.00	0.00	0.00	1.67	0.00	6.00	0.00	0.00	0.00	0.00	0.00	4.67	0.00	0.00	0.00	0.00	7.67	0.00	5.00	0.00	0.00	3.33	0.00	0.00	0.00	
19	Quick perishability of Milk	0.23	6.00	3.33	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	7.67	6.33	3.00	0.00	0.00	0.00	0.00	4.67	0.00	0.00	0.00	0.00	0.00	0.00	7.67	9.00	7.67	6.33	0.00	0.67	3.33	
20	Machine damage/breakdown at cold storage	0.13	1.67	4.67	1.67	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	6.00	3.00	0.00	0.00	0.00	0.00	4.67	0.00	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
21	Inadequate chilling facilities	0.30	9.00	0.00	0.00	0.00	0.00	0.00	3.33	0.00	0.00	3.67	2.00	0.33	1.67	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	0.00	6.00	0.00	0.33	1.67	4.67	
22	Inadequate cold storage	0.21	7.67	0.00	0.00	0.00	0.00	1.67	3.00	0.00	0.00	3.33	0.67	0.00	3.00	1.67	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	7.67	0.00	0.33	0.00	3.33	
23	Spoilage of milk through improper handling	0.14	6.00	0.00	7.67	6.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.67	6.33	6.33	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	6.33	0.00	0.00	6.00	0.00	0.33	5.00	6.00	
24	Bacterial contamination for improper temperature	0.26	7.67	0.33	9.00	0.33	0.00	0.00	0.00	0.00	1.67	0.00	0.00	7.67	1.67	9.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	1.67	0.00	0.33	0.00	0.00	
25	Pollution and Unhygienic environment	0.15	3.00	0.00	6.00	3.33	0.00	4.67	0.00	0.00	0.00	0.00	0.67	0.00	0.00	9.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	3.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
26	Cattle diseases	0.46	1.67	3.33	3.67	3.00	0.00	4.67	0.00	1.67	0.00	0.00	0.33	0.00	0.00	6.00	2.00	0.00	6.33	0.00	6.00	0.00	0.00	6.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
27	Machine damage/breakdown at processing unit	0.39	0.00	6.33	3.67	0.33	0.00	0.00	1.67	0.00	0.00	3.00	3.00	2.00	3.00	1.67	0.00	0.00	0.00	3.00	1.67	0.00	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
28	Fire at farm shed	0.11	0.00	7.67	1.67	0.00	0.00	1.67	3.00	0.00	0.00	0.00	0.67	0.00	0.00	4.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
29	Accident (Staff injury)	0.08	0.00	7.67	3.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
30	Inadequate supply of quality feed	0.39	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.33	0.67	0.00	0.00	0.00	0.00	0.00	0.00	6.33	4.67	6.00	1.67	0.00	0.00	0.00	0.00	3.33	6.00	0.00	3.00	3.00	0.00	0.00	
31	High cost of feed and medicine	0.68	0.00	0.00	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	4.67	0.00	0.00	0.00	3.00	1.67	4.67	6.33	3.00	0.33	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
32	Scarcity of feed	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.67	0.00	3.33	6.00	5.00	4.67	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
33	Lack of upgrade vaccination and veterinary services	0.52	0.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.33	6.33	0.00	0.00	0.00	0.00	4.67	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
34	Shortage of land for expanding farm	0.41	3.00	0.00	0.00	0.00	0.00	3.33	0.00	0.00	0.00	3.00	0.67	0.00	0.00	0.00	0.00	5.00	0.00	0.00	6.00	0.00	3.00	1.67	2.00	6.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
35	Irregular supply of vaccine from government	0.50	0.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	9.00	0.00	4.67	0.00	0.00	4.67	3.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
36	Competition among the farms	0.16	2.00	0.00	0.00	0.00	0.00	0.33	3.00	1.67	3.00	4.67	3.33	0.00	0.00	1.67	3.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.33	0.00	6.00	0.00	6.00	3.67	0.00	4.67	0.33	7.67	
37	Bureaucratic complexity on maintaining various formalities	0.29	0.00	0.00	2.00	6.00	0.00	5.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.67	6.00	
38	Drought leads to a decline in milk production	0.12	0.00	3.33	0.00	0.00	0.00	0.00	0.00	9.00	0.33	0.00	2.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
39	Accidents of transport vehicle	0.37	0.00	4.67	3.33	4.67	0.00	0.00	0.00	0.00	0.00	3.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	5.00	5.00	9.00	0.00	3.00	0.00	
40	Existence of middlemen/too many middlemen	0.70	0.00	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	3.33	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	7.67	9.00	
41	Too long chain cause delay in product movement	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	2.00	1.67	0.00	4.67	4.67	
42	Poor conditioned road for moving product (delay & spoilage)	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	6.33	1.67	9.00	0.00	0.00	0.00	
43	Inadequate transport facilities to move products frequently	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.67	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.33	3.33	9.00	1.67	0.33	0.00	6.00	6.00	
44	Lack of milk tanker (refrigerated)	0.22	6.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	5.00	3.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	3.67	0.00	0.00	1.67	
45	Unethical behaviour of middle men (adulteration, added price, deprivation)	0.63	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.67	0.00	3.00	3.00	0.00	0.00	7.67	7.67	
	Absolute Importance (AI)		25.00	20.74	29.16	25.74	8.36	38.48	19.29	5.87	3.09	19.87	20.80	12.13	8.29	21.51	4.52	3.94	15.00	13.69	34.06	4.37	5.55	8.63	12.35	12.21	26.54	10.30	16.19	15.01	11.72	2.24	19.50	24.09	498.24
	Relative Cost		93.33	40.00	70.00	56.67	13.33	63.33	36.67	30.00	40.00	13.33	43.33	33.33	63.33	36.67	23.33	16.67	20.00	23.33	66.67	13.33	16.67	30.00	30.00	60.00	50.00	50.00	50.00	63.33	40.00	43.33	10.00	46.67	1286.67
	Relative Importance		0.05	0.04	0.06	0.05	0.02	0.08	0.04	0.01	0.01	0.04	0.04	0.02	0.02	0.04	0.01	0.01	0.03	0.03	0.07	0.01	0.01	0.02	0.02	0.02	0.05	0.02	0.03	0.03	0.02	0.00	0.04	0.05	100

Appendix 5G: QFD – Nahar Supply Chain

	Strategy Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	
Risk Number	Risk / Mitigation Strategy	Degree of Importance	Adoption of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	Buying insurance against production loss.	Hiring skilled staff	Motivational and inventives facilities for staff	Initiative to remove political uncertainty	Implementation of a fixed policy for dairy sector	Assurance of adequate institutional credit support with low rate of interest.	Introducing off-farm activities	Focus on value addition	Promote sound business practices by cooperation, better coordination and information sharing	Reduction of risks through merger, acquisition and integration.	Arrangement of proper training to the staff regarding temperature control	Adoption of alternative supply of power for cold storage (powerful generator)	Arrangement of proper training to the staff regarding processing and hygiene management.	Attempts to create various cross breeds by adopting AI services.	Lease abandoned land to the farmers for dairy farming	Strengthen the regular supply of vaccine	Initiative to reduce the cost of feed	Support to develop technology	Focus on certified feed supplier to get quality feed.	Arrangement of adequate grassland for producing Napier grass	Arrangement of regular vaccination for the cattle	Arrangement of improved and upgraded veterinary services	Building multi-storeyed complex for farm extension	Building monitoring team	Initiative to develop roads and highways	Arrangement of adequate number of transport	Arrangement of refrigerated transport facilities	Development of roads and highway	Focus on product diversification	Removal of unnecessary influence of middlemen	Direct marketing	
1	Inadequate loan facilities	0.40	0.00	0.00	0.00	0.00	0.00	2.50	9.00	2.50	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
2	Complex loan procedures	0.34	0.00	0.00	3.00	0.00	0.00	0.50	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
3	High rate of interest	0.38	0.00	0.00	0.00	0.00	0.00	5.00	9.00	0.00	0.00	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
4	Inadequate finance	0.36	0.00	0.00	0.00	0.00	0.00	2.50	4.50	9.00	0.00	2.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
5	Absence of insurance or compensation coverage	0.34	0.00	9.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.50	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
6	Shortage of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	0.54	9.00	0.00	0.50	0.00	0.00	0.00	2.50	0.00	0.00	0.50	0.50	0.00	2.50	0.00	0.00	0.00	0.00	0.00	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
7	Labour disputes	0.18	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
8	Illiteracy and inefficiency of worker	0.39	0.00	0.00	7.00	2.50	0.00	0.00	0.00	0.00	0.00	0.50	0.00	2.50	0.00	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
9	Shortage of skilled staff	0.45	0.00	0.00	9.00	0.00	0.00	2.50	0.00	0.00	0.00	2.50	0.50	2.50	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
10	Switching of staff frequently	0.26	0.00	0.00	0.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
11	Lack of fixed government policy in dairy sector	0.35	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	2.50	2.50	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
12	Poor law and order situation (terrorism, musclemen ship)	0.60	0.00	0.00	0.00	0.50	9.00	2.50	0.00	0.00	0.00	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
13	Hartal and strike cause delay in work process	0.77	0.00	0.00	0.00	0.50	7.00	2.50	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
14	Political Unrest and interference	0.72	0.00	0.00	0.00	0.00	9.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
15	Corruption (adulteration by mixing water)	0.05	2.50	0.00	2.50	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	
16	Damage of farm's assets	0.11	0.00	0.00	4.50	4.50	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.50	
17	Theft	0.06	4.50	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
18	Natural disaster (flood, excessive rain, storm)	0.26	0.00	4.50	0.00	0.00	0.00	0.00	2.50	2.50	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	4.50	0.00	0.00	0.00	
19	Quick perishability of Milk	0.42	9.00	0.00	5.00	0.50	0.00	0.00	0.00	0.00	3.00	0.00	0.00	9.00	7.00	7.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
20	Machine damage/breakdown at cold storage	0.39	0.00	0.00	9.00	3.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
21	Inadequate chilling facilities	0.46	9.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	2.50	0.00	2.50	7.00	0.00	0.00	0.00	0.00	0.00	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
22	Inadequate cold storage	0.56	4.50	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
23	Spoilage of milk through improper handling	0.33	4.67	0.00	4.00	2.00	0.83	0.00	0.00	0.00	0.83	0.00	0.00	6.33	2.67	4.67	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	6.83	0.00	0.00	3.00	0.00	0.00	3.33	5.50	
24	Bacterial contamination for improper temperature	0.25	7.00	0.00	7.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00	7.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.50	0.00	0.00	0.00	
25	Pollution and Unhygienic environment	0.30	2.50	0.00	2.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
26	Cattle diseases	0.64	0.00	9.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	5.00	0.00	5.00	0.00	0.00	0.00	0.00	9.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
27	Machine damage/breakdown at processing unit	0.21	0.00	4.50	7.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
28	Fire at farm shed	0.20	2.50	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
29	Accident (Staff injury)	0.06	0.00	4.50	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	4.50	0.00	0.00		
30	Inadequate supply of quality feed	0.40	0.00	0.00	0.00	0.00	0.00	7.00	2.50	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
31	High cost of feed and medicine	0.53	0.00	0.00	0.00	0.00	0.00	2.50	4.50	3.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	4.50	4.50	0.50	3.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
32	Scarcity of feed	0.48	0.00	0.00	0.00	0.00	0.00	2.50	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.50	0.00	0.50	2.50	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
33	Lack of upgrade vaccination and veterinary services	0.31	0.00	0.00	0.00	0.00	0.00	9.00	2.50	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
34	Shortage of land for expanding farm	0.29	0.00	0.00	0.00	0.00	0.00	2.50	2.50	0.00	0.00	2.50	0.50	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
35	Irregular supply of vaccine from government	0.43	0.00	0.00	0.00	0.00	0.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	5.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
36	Competition among the farms	0.18	2.50	0.00	2.50	0.50	0.00	0.00	0.00	0.50	5.00	5.00	3.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.50	0.00	0.00	
37	Bureaucratic complexity on maintaining various formalities	0.17	0.00	0.00	5.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
38	Drought leads to a decline in milk production	0.27	0.00	2.50	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
39	Accidents of transport vehicle	0.29	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	9.00	0.00	0.00	0.00	
40	Existence of middlemen/ too many middlemen	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	7.00	
41	Too long chain cause delay in product movement	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	9.00	
42	Poor conditioned road for moving product (delay & spoilage)	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00	7.00	9.00	0.00	0.00	0.00	
43	Inadequate transport facilities to move products frequently	0.48	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	2.50	2.50	0.00	0.00	0.00	
44	Lack of milk tanker (refrigerated)	0.68	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	
45	Unethical behaviour of middle men (adulteration, added price, deprivation)	0.64	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	9.00	9.00	
	Absolute Importance (AI)		18.03	13.61	21.90	7.81	17.51	29.15	27.49	7.42	2.42	11.41	4.43	10.78	10.06	18.50	4.10	2.79	12.49	3.26	12.48	5.68	6.29	10.70	7.49	1.96	3.82	0.00	8.55	13.17	8.75	0.81	13.32	13.45	329.59
	Relative Cost		100.00	50.00	50.00	30.00	10.00	25.00	45.00	30.00	20.00	25.00	30.00	10.00	30.00	15.00	30.00	40.00	10.00	10.00	10.00	35.00	35.00	20.00	20.00	50.00	20.00	20.00	45.00	60.00	45.00	25.00	15.00	25.00	985.00
	Relative Importance		0.05	0.04	0.07	0.02	0.05	0.09	0.08	0.02	0.01	0.03	0.01	0.03	0.03	0.06	0.01	0.01	0.04	0.01	0.04	0.02	0.02	0.03	0.02	0.01	0.01	0.00	0.03	0.04	0.03	0.00	0.04	0.04	100

Appendix 5H: QFD – Paharika Employees

Risk Number	Strategy Number / Mitigation Strategy / Risk	Degree of Importance	1 Adoption of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	2 Buying insurance against production loss.	3 Hiring skilled staff	4 Motivational and incentives facilities for staff	5 Initiative to remove political uncertainty	6 Implementation of a fixed policy for dairy sector	7 Assurance of adequate institutional credit support with low rate of interest.	8 Introducing off-farm activities	9 Focus on value addition	10 Promote sound business practices by cooperation, better coordination and information sharing	11 Reduction of risks through merger, acquisition and integration.	12 Arrangement of proper training to the staff regarding temperature control	13 Adoption of alternative supply of power (or cold storage (powerful generator)	14 Arrangement of proper training to the staff regarding processing and hygiene management.	15 Attempts to create various cross breeds by adopting AI services.	16 Lease abandoned land to the farmers for dairy farming	17 Strengthen the regular supply of vaccine	18 Initiative to reduce the cost of feed	19 Support to develop technology	20 Focus on certified feed supplier to get quality feed.	21 Arrangement of adequate grassland for producing Napier grass	22 Arrangement of regular vaccination for the cattle	23 Arrangement of improved and upgraded veterinary services	24 Building multi-storeyed complex for farm extension	25 Building monitoring team	26 Initiative to develop roads and highways	27 Arrangement of adequate number of transport	28 Arrangement of refrigerated transport facilities	29 Development of roads and highway	30 Focus on product diversification	31 Removal of unnecessary influence of middlemen	32 Direct marketing
1	Inadequate loan facilities	0.31	0.00	0.33	100	0.00	0.00	2.50	8.33	4.17	0.00	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	Complex loan procedures	0.44	0.17	0.83	3.33	0.00	0.00	100	7.00	100	0.00	150	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	High rate of interest	0.58	0.00	0.00	0.00	0.00	0.17	183	9.00	3.50	100	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	Inadequate finance	0.54	0.00	0.00	0.00	0.00	0.00	0.33	7.67	7.00	0.83	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Absence of insurance or compensation coverage	0.65	150	7.50	0.00	0.00	0.00	0.83	2.33	0.83	0.00	0.17	4.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Shortage of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	0.46	9.00	0.00	3.33	0.17	0.00	0.17	3.33	0.00	0.00	167	167	0.00	0.83	0.00	0.00	0.00	0.00	3.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	150	150	0.00	0.00	0.00	0.00
7	Labour disputes	0.35	150	0.00	2.67	7.00	0.17	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	150	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	Illiteracy and inefficiency of worker	0.53	2.33	0.17	6.83	100	0.00	0.00	0.00	0.00	0.00	100	2.33	3.17	3.00	4.50	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Shortage of skilled staff	0.48	150	0.00	9.00	2.33	0.00	0.83	0.00	0.00	0.00	2.50	0.00	3.33	0.00	6.00	0.00	0.00	0.00	0.00	2.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	Switching of staff frequently	0.36	0.83	0.00	150	8.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	Lack of fixed government policy in dairy sector	0.53	0.00	0.00	0.00	0.00	0.83	9.00	0.83	0.00	0.00	183	0.83	0.00	0.00	0.00	0.00	0.00	3.67	5.67	4.83	2.33	0.00	0.00	0.00	167	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00
12	Poor law and order situation (terrorism, muscleman ship)	0.56	0.00	0.00	0.00	0.00	7.67	5.67	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00
13	Hartal and strike cause delay in work process	0.71	0.00	150	0.00	0.00	7.00	2.67	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00
14	Political Unrest and interference	0.58	0.00	167	0.00	0.00	9.17	3.33	0.00	0.00	0.00	0.33	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	Corruption (adulteration by mixing water)	0.06	0.83	0.00	0.17	4.83	150	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	Damage of farm's assets	0.41	0.00	6.17	4.17	5.67	0.00	0.00	0.00	0.00	0.17	0.00	0.83	0.00	0.00	3.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	Theft	0.30	5.67	0.83	0.33	6.33	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	167	0.00	0.00	0.00	0.00	0.00	6.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	Natural disaster (flood, excessive rain, storm)	0.47	0.00	8.33	0.00	0.00	0.00	100	100	0.00	0.00	0.00	100	0.00	2.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.33	0.00	0.83	0.00	0.00	167	0.00	0.00	0.00
19	Quick perishability of Milk	0.35	8.33	4.00	5.00	0.67	0.00	0.00	0.00	0.00	0.83	0.00	0.83	6.83	4.83	6.83	0.00	0.00	0.00	0.00	4.83	150	0.00	0.00	0.00	0.00	3.17	0.00	7.50	7.67	3.50	0.17	0.83	4.00
20	Machine damage/breakdown at cold storage	0.39	0.83	6.83	6.17	150	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.83	3.83	8.33	0.00	0.00	0.00	0.00	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00
21	Inadequate chilling facilities	0.40	7.00	0.00	0.17	0.00	0.00	0.00	2.50	0.00	0.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	167	2.33	0.00	0.00	0.00	2.33
22	Inadequate cold storage	0.48	9.00	0.00	0.17	0.00	0.00	0.83	3.33	0.00	0.17	4.00	0.17	0.00	150	0.00	0.00	0.00	0.00	0.00	6.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	3.00	0.00	0.00	0.00	3.00
23	Spoilage of milk through improper handling	0.12	5.33	0.00	8.33	2.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	7.67	2.00	7.00	0.00	0.00	0.00	0.00	3.17	0.00	0.00	0.00	0.00	0.00	4.83	0.00	0.00	2.33	0.00	0.00	2.33	100
24	Bacterial contamination for improper temperature	0.37	7.67	0.33	5.67	0.17	0.00	0.17	0.00	0.00	2.67	0.83	0.00	7.67	4.17	4.83	0.00	0.00	0.17	0.00	2.50	0.00	0.00	0.00	0.00	0.00	5.33	0.00	0.83	6.17	0.17	0.00	0.00	100
25	Pollution and Unhygienic environment	0.26	3.33	0.00	5.50	2.50	0.00	2.17	0.00	0.00	0.00	0.00	0.17	0.00	0.00	9.00	0.00	0.00	0.83	0.00	167	0.00	0.00	1.17	2.33	0.17	4.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	Cattle diseases	0.45	0.83	4.00	3.17	0.17	0.00	150	0.17	0.00	0.00	0.00	100	0.00	0.00	167	7.00	0.00	6.33	0.00	0.00	0.00	0.17	8.33	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	Machine damage/breakdown at processing unit	0.33	100	6.83	5.67	0.67	0.00	0.83	100	0.00	0.00	0.00	0.17	0.00	0.00	7.00	0.00	0.00	0.00	0.00	167	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	Fire at farm shed	0.29	0.83	7.50	167	0.00	0.17	167	0.83	0.00	0.00	0.00	0.00	0.00	0.00	167	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	Accident (Staff injury)	0.10	0.00	6.17	3.50	2.50	0.00	167	0.00	0.00	0.00	0.00	0.83	0.00	0.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	167	0.00	0.00	
30	Inadequate supply of quality feed	0.32	0.00	150	0.83	0.17	0.00	100	0.00	0.00	0.00	183	2.33	0.00	0.00	0.00	0.00	0.00	0.00	183	0.00	8.33	7.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	High cost of feed and medicine	0.53	0.83	0.00	0.00	0.00	0.00	3.17	2.50	3.33	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	6.17	150	183	6.33	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	Scarcity of feed	0.28	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.83	167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	8.33	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	Lack of upgrade vaccination and veterinary services	0.49	0.83	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.83	0.33	0.00	0.00	0.00	0.00	0.00	100	0.00	0.00	0.00	0.00	3.17	8.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	Shortage of land for expanding farm	0.45	0.00	0.00	0.00	0.00	0.00	2.50	167	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	7.67	0.00	0.00	0.00	0.00	0.17	0.00	0.00	4.17	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	Irregular supply of vaccine from government	0.45	0.00	0.00	0.00	0.00	0.00	5.50	0.00	0.00	0.00	0.17	0.83	0.00	0.00	0.00	0.00	0.00	7.67	0.00	0.00	0.00	0.00	4.67	167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36	Competition among the farms	0.26	5.00	0.00	5.67	167	0.00	0.00	167	0.00	8.33	4.00	0.17	0.00	0.00	3.50	7.50	0.00	0.00	0.00	167	1.17	0.00	0.00	3.33	0.00	0.00	0.00	0.00	0.83	0.00	4.50	0.50	2.50
37	Bureaucratic complexity on maintaining various formalities	0.28	0.00	0.00	6.33	100	0.00	2.33	0.00	0.00	0.00	0.17	2.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38	Drought leads to a decline in milk production	0.27	150	3.17	0.83	0.00	0.00	0.17	2.33	167	0.00	0.83	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39	Accidents of transport vehicle	0.36	0.00	5.33	4.83	0.33	0.00	0.00	0.00	0.00	0.00	100	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	150	5.00	0.33	8.33	0.00	0.00	0.00
40	Existence of middlemen/ too many middlemen	0.42	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	3.50	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.33	5.67
41	Too long chain cause delay in product movement	0.30	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.83	133	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	8.33	6.33
42	Poor conditioned road for moving product (delay & spoilage)	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.17	150	167	6.83	0.17	0.00	0.00
43	Inadequate transport facilities to move products frequently	0.48	2.33	0.00	0.00	0.00	0.00	0.00	150	0.00	0.00	4.17	2.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	6.00	3.33	2.50	0.00	0.00	0.00
44	Lack of milk tanker (refrigerated)	0.53	7.00	0.00	0.00	0.00	0.17	0.00	2.33	0.00	0.00	3.33	0.17	0.00	150	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.33	0.00	0.00	0.00	0.83
45	Unethical behaviour of middlemen (adulteration, added price, deprivation)	0.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.67	2.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	8.33	4.83
Absolute Importance (AI)			28.70	28.46	33.01	14.92	15.42	27.13	27.65	10.28	4.61	21.02	15.00	9.75	9.55	22.85	5.11	5.40	10.08	8.61	18.07	5.58	8.29	8.70	9.70	4.43	10.14	5.76	10.70	16.23	9.74	1.30	10.34	11.75	428.29
Relative Cost			88.33	63.33	45.00	36.67	21.67	26.67	31.67	33.33	25.00	26.67	21.67	11.67	23.33	16.67	41.67	15.00	15.00	11.67	33.33	30.00	18.33	16.67	18.33	58.33	33.33	13.33	33.33	48.33	31.67	38.33	13.33	16.67	958.33
Relative Importance			0.07	0.07	0.08	0.03	0.04	0.06	0.06	0.02	0.01	0.05	0.04	0.02	0.02	0.05	0.01	0.01	0.02	0.02	0.04	0.01	0.02	0.02	0.02	0.01	0.02	0.01	0.02	0.04	0.02	0.00	0.02	0.03	100

Appendix 5I: QFD – Paharika Executives

Risk Number	Risk \ Mitigation Strategy	Degree of Importance	1 Adoption of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	2 Buying insurance against production loss.	3 Hiring skilled staff	4 Motivational and incentives facilities for staff	5 Initiative to remove political uncertainty	6 Implementation of a fixed policy for dairy sector	7 Assurance of adequate institutional credit support with low rate of interest.	8 Introducing off-farm activities	9 Focus on value addition	10 Promote sound business practices by cooperation, better coordination and information sharing	11 Reduction of risks through merger, acquisition and integration.	12 Arrangement of proper training to the staff regarding temperature control	13 Adoption of alternative supply of power for cold storage (powerful generator)	14 Arrangement of proper training to the staff regarding processing and hygiene management	15 Attempts to create various cross breeds by adopting AI services.	16 Lease abandoned land to the farmers for dairy farming	17 Strengthen the regular supply of vaccine	18 Initiative to reduce the cost of feed	19 Support to develop technology	20 Focus on certified feed supplier to get quality feed.	21 Arrangement of adequate grassland for producing Napier grass	22 Arrangement of regular vaccination for the cattle	23 Arrangement of improved and upgraded veterinary services	24 Building multi-storeyed complex for farm extension	25 Building monitoring team	26 Initiative to develop roads and highways	27 Arrangement of adequate number of transport	28 Arrangement of refrigerated transport facilities	29 Development of roads and highway	30 Focus on product diversification	31 Removal of unnecessary influence of middlemen	32 Direct marketing	
1	Inadequate loan facilities	0.43	1.67	0.33	1.67	1.67	0.00	1.67	9.00	5.00	3.00	0.33	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	Complex loan procedures	0.47	0.00	0.00	1.67	0.00	0.00	0.00	5.00	0.00	0.00	3.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	High rate of interest	0.67	0.00	0.00	0.00	0.00	0.00	0.00	7.67	6.33	0.00	0.33	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	Inadequate finance	0.48	0.00	0.00	0.00	0.00	0.00	0.00	9.00	6.33	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Absence of insurance or compensation coverage	0.61	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	3.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Shortage of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	0.36	9.00	0.00	6.33	0.00	0.00	0.00	1.67	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.67
7	Labour disputes	0.40	1.67	0.00	6.00	4.67	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	Illiteracy and inefficiency of worker	0.51	1.67	0.00	9.00	5.00	0.00	1.67	0.00	0.00	0.00	1.67	0.00	5.00	0.00	6.33	0.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Shortage of skilled staff	0.44	4.67	0.00	7.67	5.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00	2.00	0.00	9.00	0.00	0.00	0.00	0.00	4.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	Switching of staff frequently	0.49	0.00	0.00	4.67	6.33	0.00	0.00	0.00	0.00	0.00	0.00	1.67	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	Lack of fixed government policy in dairy sector	0.60	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	5.00	6.33	6.33	4.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	Poor law and order situation (terrorism, musclemen ship)	0.66	0.00	1.67	0.00	0.00	7.67	4.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	Hartal and strike cause delay in work process	0.81	0.00	1.67	0.00	0.00	9.00	3.33	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	Political Unrest and interference	0.60	0.00	0.00	0.00	0.00	9.00	1.67	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	Corruption (adulteration by mixing water)	0.09	0.00	1.67	3.33	6.33	0.00	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	3.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	Damage of farm's assets	0.34	0.00	1.67	6.00	5.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.33	0.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	4.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	Theft	0.13	9.00	0.00	1.67	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	4.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	Natural disaster (flood, excessive rain, storm)	0.20	0.00	6.33	0.00	0.00	0.00	5.00	3.67	0.00	0.00	0.00	4.67	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	Quick perishability of Milk	0.09	9.00	1.67	3.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	6.33	6.00	0.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	3.00	4.67	0.00	4.67	6.00	1.67	0.00	0.33	3.33	
20	Machine damage/breakdown at cold storage	0.09	0.00	7.67	6.33	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	Inadequate chilling facilities	0.28	9.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.33	6.00	0.00	0.00	0.00	1.67	
22	Inadequate cold storage	0.28	9.00	0.00	0.00	0.00	0.00	1.67	5.00	0.00	0.00	3.33	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.33	6.00	0.00	0.00	0.00	0.00	
23	Spoilage of milk through improper handling	0.08	9.00	0.00	1.67	0.00	0.00	0.00	3.33	0.00	0.00	0.00	1.67	9.00	3.33	6.33	0.00	0.00	0.00	0.00	4.67	0.00	0.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	1.67	3.00	
24	Bacterial contamination for improper temperature	0.24	7.67	1.67	6.33	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	7.67	5.00	6.33	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	1.67	0.00	0.00	9.00	0.00	0.00	1.67	1.67	
25	Pollution and Unhygienic environment	0.26	9.00	1.67	4.67	2.00	0.00	3.33	0.00	0.00	0.00	0.00	2.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	3.33	0.00	0.00	1.67	1.67	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
26	Cattle diseases	0.39	3.00	6.00	1.67	0.00	0.00	3.33	1.67	0.00	0.00	0.00	1.67	0.00	0.00	3.00	4.67	0.00	4.67	0.00	0.00	0.00	0.00	7.67	6.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
27	Machine damage/breakdown at processing unit	0.09	0.00	9.00	1.67	0.33	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	4.67	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
28	Fire at farm shed	0.06	0.00	9.00	1.67	0.00	0.00	4.67	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
29	Accident (Staff injury)	0.11	0.00	9.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
30	Inadequate supply of quality feed	0.24	0.00	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.67	0.00	9.00	6.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
31	High cost of feed and medicine	0.62	0.00	0.00	0.00	0.00	0.00	3.33	1.67	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00	3.33	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	
32	Scarcity of feed	0.57	0.00	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00	4.67	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
33	Lack of upgrade vaccination and veterinary services	0.59	0.00	0.00	0.00	0.00	0.00	7.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	3.33	0.00	0.00	0.00	0.00	3.00	7.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
34	Shortage of land for expanding farm	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
35	Irregular supply of vaccine from government	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
36	Competition among the farms	0.33	4.67	0.00	3.33	0.00	0.00	1.67	3.33	3.33	9.00	3.67	0.00	0.00	0.00	0.00	4.67	0.00	0.00	0.00	0.00	3.33	0.00	0.00	1.67	0.00	0.00	0.00	3.00	0.00	0.00	6.33	1.67	2.00	
37	Bureaucratic complexity on maintaining various formalities	0.40	0.00	0.00	3.67	0.00	0.00	6.33	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
38	Drought leads to a decline in milk production	0.34	3.00	1.67	0.00	0.00	0.00	0.00	0.00	3.00	0.00	0.33	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
39	Accidents of transport vehicle	0.38	0.00	9.00	6.33	3.00	0.00	0.00	0.00	0.00	0.00	1.67	5.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00	6.00	0.00	0.00	0.00	
40	Existence of middlemen/ too many middlemen	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.33	3.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.67	0.00	6.00	4.67	
41	Too long chain cause delay in product movement	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.33	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.67	0.00	0.00	4.67	0.00	9.00	9.00	
42	Poor conditioned road for moving product (delay & spoilage)	0.22	0.00	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.33	0.00	1.67	7.67	0.00	0.00	0.00	
43	Inadequate transport facilities to move products frequently	0.34	3.00	0.00	1.67	0.00	0.00	0.00	1.67	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.67	9.00	1.67	0.00	0.00	0.00	0.00	
44	Lack of milk tanker (refrigerated)	0.30	9.00	0.00	0.00	0.00	0.00	0.00	3.33	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	
45	Unethical behaviour of middle men (adulteration, added price, deprivation)	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.67	6.33	
	Absolute Importance (AI)		24.45	14.89	29.12	15.15	19.93	29.23	24.71	12.57	4.38	15.05	14.09	6.41	2.68	16.66	3.38	13.35	7.59	12.45	19.01	8.03	10.39	5.20	7.99	11.83	4.97	2.68	7.49	9.75	6.57	2.11	5.94	6.92	374.98
	Relative Cost		93.33	66.67	53.33	60.00	26.67	40.00	43.33	43.33	23.33	23.33	26.67	13.33	30.00	20.00	43.33	10.00	16.67	20.00	16.67	23.33	20.00	16.67	13.33	50.00	26.67	10.00	46.67	36.67	20.00	33.33	20.00	20.00	1006.67
	Relative Importance		0.07	0.04	0.08	0.04	0.05	0.08	0.07	0.03	0.01	0.04	0.04	0.02	0.01	0.04	0.01	0.04	0.02	0.03	0.05	0.02	0.03	0.01	0.02	0.03	0.01	0.01	0.02	0.03	0.02	0.01	0.02	0.02	100

Appendix 5J: QFD – Paharika Supply Chain

Risk Number	Strategy Number / Mitigation Strategy / Risk	Degree of Importance	1 Adoption of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	2 Buying insurance against production loss.	3 Hiring skilled staff	4 Motivational and incentives facilities for staff	5 Initiative to remove political uncertainty	6 Implementation of a fixed policy for dairy sector	7 Assurance of adequate institutional credit support with low rate of interest.	8 Introducing off-farm activities	9 Focus on value addition	10 Promote sound business practices by cooperation, better coordination and information sharing	11 Reduction of risks through merger, acquisition and integration.	12 Arrangement of proper training to the staff regarding temperature control	13 Adoption of alternative supply or power for cold storage (powerful generator)	14 Arrangement of proper training to the staff regarding processing and hygiene management	15 Attempts to create various cross breeds by adopting AI services.	16 Lease abandoned land to the farmers for daily farming	17 Strengthen the regular supply of vaccine	18 Initiative to reduce the cost of feed	19 Support to develop technology	20 Focus on certified feed supplier to get quality feed.	21 Arrangement of adequate grassland for producing Napier grass	22 Arrangement of regular vaccination for the cattle	23 Arrangement of improved and upgraded veterinary services	24 Building multi-storeyed complex for farm extension	25 Building monitoring team	26 Initiative to develop roads and highways	27 Arrangement of adequate number of transport	28 Arrangement of refrigerated transport facilities	29 Development of roads and highway	30 Focus on product diversification	31 Removal of unnecessary influence of middlemen	32 Direct marketing	
1	Inadequate loan facilities	0.42	0.00	0.00	0.00	0.00	0.00	2.50	9.00	2.50	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
2	Complex loan procedures	0.30	0.00	0.00	7.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
3	High rate of interest	0.40	0.00	0.00	0.00	0.00	0.00	2.50	9.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
4	Inadequate finance	0.45	0.00	0.00	0.00	0.00	0.00	5.00	5.00	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
5	Absence of insurance or compensation coverage	0.28	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
6	Shortage of improved technology (Milking machine, feed mixture, grass cutting, improved processing facilities)	0.59	9.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.50	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
7	Labour disputes	0.08	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
8	Illiteracy and inefficiency of worker	0.11	0.00	0.00	9.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
9	Shortage of skilled staff	0.23	0.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
10	Switching of staff frequently	0.24	2.50	0.00	0.00	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
11	Lack of fixed government policy in dairy sector	0.56	0.00	0.00	0.00	0.00	0.50	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	5.00	2.50	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
12	Poor law and order situation (terrorism, musclemen ship)	0.64	0.00	0.00	0.00	0.00	9.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
13	Hartal and strike cause delay in work process	0.81	0.00	0.00	0.00	0.00	9.00	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
14	Political Unrest and interference	0.81	0.00	0.00	0.00	0.00	9.00	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
15	Corruption (adulteration by mixing water)	0.00	7.00	0.00	0.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.50	0.00	0.00	0.00	0.00	0.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
16	Damage of farm's assets	0.12	0.00	3.00	2.50	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
17	Theft	0.05	2.50	0.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
18	Natural disaster (flood, excessive rain, storm)	0.25	0.00	4.50	0.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	
19	Quick perishability of Milk	0.35	9.00	0.00	4.50	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00	4.50	7.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.50	0.00	0.00	4.50	2.50	0.00	0.00	0.00	0.00	
20	Machine damage/breakdown at cold storage	0.30	0.00	0.00	7.00	7.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	4.50	0.00	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
21	Inadequate chilling facilities	0.49	9.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.50	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.50	0.00	0.00	0.00	0.00	0.00	
22	Inadequate cold storage	0.56	9.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.50	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.50	0.00	0.00	0.00	0.00	0.00	
23	Spoilage of milk through improper handling	0.26	2.50	0.00	9.00	0.50	0.00	0.00	0.00	0.00	0.00	0.50	0.00	9.00	7.00	9.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
24	Bacterial contamination for improper temperature	0.36	7.00	0.00	7.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	9.00	5.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00	4.50	0.50	0.00	0.00	0.00	0.00	
25	Pollution and Unhygienic environment	0.28	0.50	0.00	2.50	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.50	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
26	Cattle diseases	0.34	0.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00	3.00	0.00	0.00	0.00	0.00	5.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
27	Machine damage/breakdown at processing unit	0.27	0.00	0.00	4.50	5.00	0.00	0.00	100	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
28	Fire at farm shed	0.13	0.00	9.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
29	Accident (Staff injury)	0.10	0.00	7.00	0.50	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
30	Inadequate supply of quality feed	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
31	High cost of feed and medicine	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.50	0.00	7.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
32	Scarcity of feed	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
33	Lack of upgrade vaccination and veterinary services	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
34	Shortage of land for expanding farm	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
35	Irregular supply of vaccine from government	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	3.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
36	Competition among the farms	0.16	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	4.50	2.50	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.50	0.00	0.00		
37	Bureaucratic complexity on maintaining various formalities	0.05	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
38	Drought leads to a decline in milk production	0.08	0.00	0.50	0.00	0.00	0.00	0.00	2.50	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
39	Accidents of transport vehicle	0.12	0.00	4.50	2.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.50	4.50	9.00	0.00	0.00	0.00		
40	Existence of middlemen/ too many middlemen	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	7.00		
41	Too long chain cause delay in product movement	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	9.00		
42	Poor conditioned road for moving product (delay & spoilage)	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	9.00	9.00	0.00	0.00	2.50		
43	Inadequate transport facilities to move products frequently	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	2.50	0.50	0.00	0.00	0.00		
44	Lack of milk tanker (refrigerated)	0.68	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	2.50	0.00	0.00	0.00		
45	Unethical behaviour of middle men (adulteration, added price, deprivation)	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	7.00		
	Absolute Importance (AI)		19.97	8.71	16.88	7.42	20.62	13.57	21.67	4.42	1.60	3.58	2.15	9.78	11.61	16.33	3.02	4.56	6.46	7.43	18.20	10.56	4.97	3.76	9.40	2.21	5.69	0.00	8.03	21.25	9.74	0.72	18.45	17.02	309.75	
	Relative Cost		100.00	25.00	40.00	20.00	10.00	10.00	45.00	30.00	20.00	20.00	20.00	25.00	50.00	25.00	20.00	25.00	10.00	20.00	20.00	40.00	45.00	35.00	50.00	65.00	35.00	10.00	45.00	55.00	40.00	20.00	15.00	25.00	1015.00	
	Relative Importance		0.06	0.03	0.05	0.02	0.07	0.04	0.07	0.01	0.01	0.01	0.01	0.03	0.04	0.05	0.01	0.01	0.02	0.02	0.06	0.03	0.02	0.01	0.03	0.01	0.02	0.00	0.03	0.07	0.03	0.00	0.06	0.05	100	

Appendix 5K: The Model for Each Group of Both Case Industries

Nahar Executives

Max $f(x)$= 25.00 X_1 + 20.74 X_2 + 29.16 X_3 + 25.74 X_4 + 8.36 X_5 + 38.48 X_6 + 19.29 X_7 + 5.87X8 + 3.09 X_9 + 19.87 X_{10} + 20.80 X_{11} + 12.13 X_{12} + 8.29 X_{13} + 21.51 X_{14} + 4.52 X_{15} + 3.94 X_{16} + 15.00 X_{17} + 13.69 X_{18} + 34.06X_{19} + 4.37 X_{20} + 5.55X_{21} + 8.63X_{22} + 12.35 X_{23} + 12.21X_{24} + 26.54 X_{25} + 10.30 X_{26} + 16.19 X_{27} + 15.01 X_{28} + 11.72 X_{29} + 2.24 X_{30} + 19.50 X_{31} + 24.09 X_{32}

s.t.93.33 X_1 + 40.00 X_2 + 70.00 X_3 + 56.67 X_4 + 13.33 X_5 + 63.33 X_6 + 36.67 X_7 + 30.00X8 + 40.00 X_9 + 13.33 X_{10} + 43.33 X_{11} + 33.33 X_{12} + 63.33 X_{13} + 36.67 X_{14} + 23.33 X_{15} + 16.67 X_{16} + 20.00 X_{17} + 23.33 X_{18} + 66.67 X_{19} + 13.33 X_{20} + 16.67 X_{21} + 30.00 X_{22} + 30.00 X_{23} + 60.00 X_{24} +50.00 X_{25} + 50.00 X_{26} + 50.00 X_{27} + 63.33 X_{28} + 40.00 X_{29} + 43.33 X_{30} + 10.00 X_{31} + 46.67 X_{32} ≤ 1286.67

Nahar SC members

Max $f(x)$= 18.03 X_1 + 13.61 X_2 + 21.90 X_3 + 7.81 X_4 + 17.51 X_5 + 29.15 X_6 + 27.49 X_7 + 7.42X8 + 2.42 X_9 + 11.41 X_{10} + 4.43 X_{11} + 10.78 X_{12} + 10.06 X_{13} + 18.50 X_{14} + 4.10 X_{15} + 2.79 X_{16} + 12.49X_{17} + 3.26 X_{18} + 12.48 X_{19} + 5.68 X_{20} + 6.29 X_{21} + 10.70 X_{22} + 7.49 X_{23} + 1.96 X_{24} + 3.82 X_{25} + 0.00 X_{26} + 8.55 X_{27} + 13.17 X_{28} + 8.75 X_{29} + 0.81 X_{30} + 13.32 X_{31} + 13.45 X_{32}

s.t.100.00 X_1 + 50.00 X_2 + 50.00 X_3 + 30.00 X_4 + 10.00 X_5 + 25.00 X_6 + 45.00 X_7 + 30.00X8 + 20.00 X_9 + 25.00 X_{10} + 30.00 X_{11} + 10.00 X_{12} + 30.00 X_{13} + 15.00 X_{14} + 30.00 X_{15} + 40.00 X_{16} + 10.00 X_{17} + 10.00 X_{18} + 10.00 X_{19} + 35.00 X_{20} + 35.00 X_{21} + 20.00 X_{22} + 20.00 X_{23} + 50.00 X_{24} +20.00 X_{25} + 20.00 X_{26} + 45.00 X_{27} + 60.00 X_{28} + 45.00 X_{29} + 25.00 X_{30} + 15.00 X_{31} + 25.00 X_{32} ≤ 1286.67

Paharika Employees

Max $f(x)$= 28.70 X_1 + 28.46 X_2 + 33.01 X_3 + 14.92 X_4 + 15.42 X_5 + 27.13 X_6 + 27.65 X_7 + 10.28X8 + 4.61 X_9 + 21.02 X_{10} + 15.00 X_{11} + 9.75 X_{12} + 9.55 X_{13} + 22.85 X_{14} + 5.11 X_{15} + 5.40 X_{16} + 10.08 X_{17} + 8.61 X_{18} + 18.07 X_{19} + 5.58 X_{20} + 8.29 X_{21} + 8.70 X_{22} + 9.70 X_{23} + 4.43 X_{24} + 10.14 X_{25} + 5.76 X_{26} + 10.70 X_{27} + 16.23 X_{28} + 9.74 X_{29} + 1.30 X_{30} + 10.34 X_{31} + 11.75 X_{32}

s.t.88.33 X_1 + 63.33 X_2 + 45.00 X_3 + 36.67 X_4 + 21.67 X_5 + 26.67 X_6 + 31.67 X_7 + 33.33X8 + 25.00 X_9 + 26.67 X_{10} + 21.67 X_{11} + 11.67 X_{12} + 23.33 X_{13} + 16.67 X_{14} + 41.67 X_{15} + 15.00 X_{16} + 15.00 X_{17} + 11.67 X_{18} + 33.33 X_{19} + 30.00 X_{20} + 18.33 X_{21} + 16.67 X_{22} + 18.33 X_{23} + 58.33 X_{24} +33.33 X_{25} + 13.33 X_{26} + 33.33 X_{27} + 48.33 X_{28} + 31.67 X_{29} + 38.33 X_{30} + 13.33 X_{31} + 16.67 X_{32} ≤ 958.33

Paharika Executives

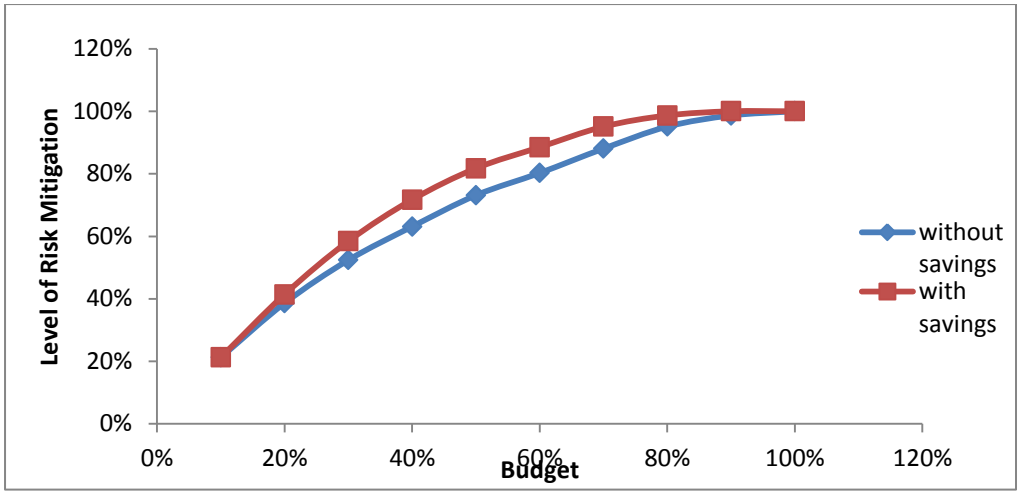
Max $f(x)$= 24.45 X_1 + 14.89 X_2 + 29.12 X_3 + 15.15 X_4 + 19.93 X_5 + 29.23 X_6 + 24.71 X_7 + 12.57X8 + 4.38 X_9 + 15.05X_{10} + 14.09 X_{11} + 6.41 X_{12} + 2.68 X_{13} + 16.66 X_{14} + 3.38 X_{15} + 13.35 X_{16} + 7.59 X_{17} + 12.45 X_{18} + 19.01 X_{19} + 8.03 X_{20} + 10.39 X_{21} + 5.20 X_{22} + 7.99 X_{23} + 11.83X_{24} + 4.97 X_{25} + 2.68 X_{26} + 7.49 X_{27} + 9.75 X_{28} + 6.57 X_{29} + 2.11 X_{30} + 5.94 X_{31} + 6.92X_{32}

s.t.93.33 X_1 + 66.67 X_2 + 53.33 X_3 + 60.00 X_4 + 26.67 X_5 + 40.00 X_6 + 43.33 X_7 + 43.33X8 + 23.33 X_9 + 23.33 X_{10} + 26.67 X_{11} + 13.33 X_{12} + 30.33 X_{13} + 20.00 X_{14} + 43.33 X_{15} + 10.00 X_{16} + 16.67 X_{17} + 20.00 X_{18} + 16.67 X_{19} + 23.33 X_{20} + 20.00 X_{21} + 16.67 X_{22} + 13.33 X_{23} + 50.00 X_{24} +26.67 X_{25} + 10.00 X_{26} + 46.67 X_{27} + 36.67 X_{28} + 20.00 X_{29} + 33.33 X_{30} + 20.00 X_{31} + 20.00X_{32} ≤ 1006.67

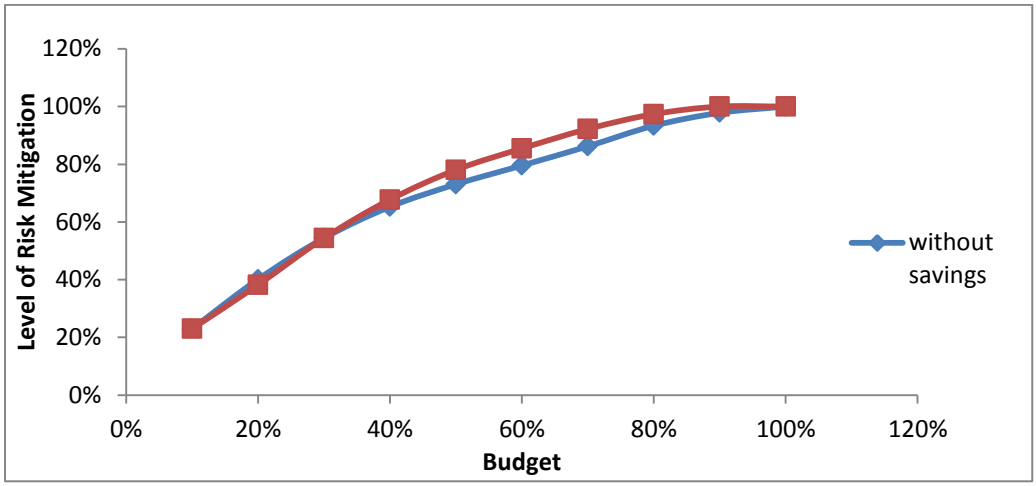
Paharika Supply chain

Max $f(x)$= 19.97 X_1 + 8.71 X_2 + 16.88 X_3 + 7.42 X_4 + 20.62X_5 + 13.57 X_6 + 21.67 X_7 + 4.42X8 + 1.60 X_9 + 3.58 X_{10} + 2.15 X_{11} + 9.78 X_{12} + 11.61 X_{13} + 16.33 X_{14} + 3.02 X_{15} + 4.56 X_{16} + 6.46 X_{17} + 7.43 X_{18} + 18.20 X_{19} + 10.56 X_{20} + 4.97 X_{21} + 3.76 X_{22} + 9.40 X_{23} + 2.21 X_{24} + 5.69 X_{25} + 0.00 X_{26} + 8.03 X_{27} + 21.25 X_{28} + 9.74 X_{29} + 0.72 X_{30} + 18.45 X_{31} + 17.02 X_{32}

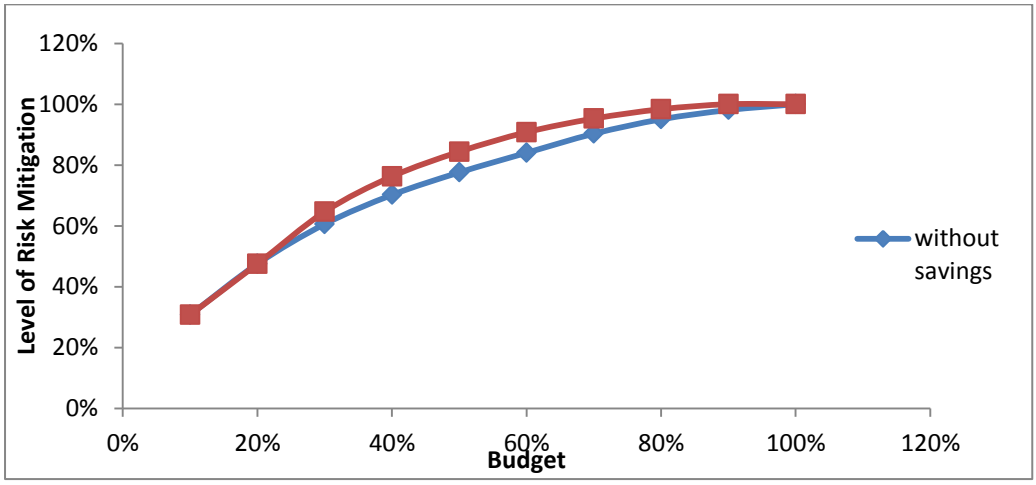
s.t.100.00 X_1 + 25.00 X_2 + 40.00 X_3 + 20.00 X_4 + 10.00 X_5 + 10.00 X_6 + 45.00 X_7 + 30.00X8 + 20.00 X_9 + 20.00 X_{10} + 20.00 X_{11} + 25.00 X_{12} + 50.00 X_{13} + 25.00 X_{14} + 20.00 X_{15} + 25.00 X_{16} + 10.00 X_{17} + 20.00 X_{18} + 20.00X_{19} + 40.00 X_{20} + 45.00 X_{21} + 35.00 X_{22} + 50.00 X_{23} + 65.00 X_{24} +35.00 X_{25} + 10.00 X_{26} + 45.00 X_{27} + 55.00 X_{28} + 40.00 X_{29} + 20.00 X_{30} + 15.00 X_{31} + 25.00 X_{32} ≤ 1015.00



Appendix 5L: Comparison of risk mitigation level with and without cost savings (Paharika Employees)



Appendix 5M: Comparison of risk mitigation level with and without cost savings (Paharika Executives)



Appendix 5N: Comparison of risk mitigation level with and without cost savings (Paharika Supply Chain)

Appendix 6A: Optimization Result for Nahar Executives

Strategies	Budgeted cost (without savings)										Budgeted cost (with savings)									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
	1286.67	1158	1029.33	900.67	772	643.33	514.67	386	257	128.67	1286.67	1158	1029.33	900.67	772	643.33	514.67	386	257	128.67
S1	✓	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓	✓	✓	✓	✓	×	×	×
S2	✓	✓	✓	✓	✓	✓	✓	×	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
S3	✓	✓	✓	✓	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	✓	✓	×	×	×
S4	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓	✓	✓	✓	✓	✓	×	×	×	×
S5	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S7	✓	✓	✓	✓	✓	✓	×	✓	✓	×	✓	✓	✓	✓	✓	×	✓	×	✓	
S8	✓	✓	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	×	×
S9	✓	×	×	×	×	×	×	×	×	×	✓	✓	✓	✓	✓	✓	✓	×	×	×
S10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S11	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓	✓	✓	✓	✓	✓	×	×	×	×
S12	✓	✓	✓	✓	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×
S13	✓	×	×	×	×	×	×	×	×	×	✓	✓	✓	✓	✓	×	✓	×	×	×
S14	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	
S15	✓	✓	×	×	×	×	×	×	×	×	✓	✓	✓	✓	×	×	×	×	×	×
S16	✓	✓	✓	×	×	×	×	×	×	×	✓	✓	✓	×	×	×	×	×	×	×
S17	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S18	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
S19	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×
S20	✓	✓	✓	✓	✓	×	×	×	×	×	✓	✓	✓	✓	×	×	×	×	×	×
S21	✓	✓	✓	✓	✓	×	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×
S22	✓	✓	✓	✓	✓	×	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×
S23	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓	✓	✓	✓	✓	✓	×	×	×	×
S24	✓	✓	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	×	×
S25	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	×	✓	×	×
S26	✓	✓	✓	×	×	×	×	×	×	×	✓	✓	✓	×	×	×	×	×	×	×
S27	✓	✓	✓	✓	✓	×	×	×	×	×	✓	✓	✓		×	×	×	×	×	×
S28	✓	✓	✓	×	×	×	×	×	×	×	✓	✓	✓	×	×	×	×	×	×	×
S29	✓	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓		×	×	×	×	×	×
S30	✓	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	×	×
S31	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S32	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×
Total selected strategies	32	29	26	23	21	16	14	11	9	5	32	29	29	26	22	17	15	11	9	5
Objective Function	498.24	484.62	462.02	432.78	396.05	352.95	300.73	240.38	176.43	101.21	498.24	477.93	477.93	448.68	411.88	357.98	300.13	241.83	176.43	101.21
Level Of risk mitigation	100.00%	97.27%	92.73%	86.86%	79.49%	70.84%	60.36%	48.25%	35.41%	20.31%	100.00%	95.92%	95.92%	90.05%	82.67%	71.85%	60.24%	48.54%	35.41%	20.31%

Appendix 6B: Optimization Result for Nahar Supply Chain

Strategies	Budgeted Cost (Without Savings)										Budgeted Cost (With Savings)									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
	985	886.5	788	689.5	591	492.5	394	295.5	197	98.5	985	886.5	788	689.5	591	492.5	394	295.5	197	98.5
S1	✓	✓	✓	✓	✓	×	×	×	×	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
S2	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓	✓	✓	✓	✓	✓	✓	×	×	×
S3	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
S4	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓	✓	✓	✓	✓	✓	✓	×	×	×
S5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S7	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×
S8	✓	✓	✓	✓	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	✓	×	×	×	×
S9	✓	✓	✓	×	×	×	×	×	×	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
S10	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×
S11	✓	✓	✓	×	×	×	×	×	×	×	✓	✓	✓	✓	×	×	×	×	×	×
S12	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S13	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
S14	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S15	✓	✓	×	×	×	×	×	×	×	×	✓	✓	✓	×	×	×	×	×	×	×
S16	✓	×	×	×	×	×	×	×	×	×	✓	✓	✓	×	×	×	×	×	×	×
S17	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S18	✓	✓	✓	✓	✓	✓	×	✓	✓	×	✓	✓	✓	×	✓	✓	×	✓	×	×
S19	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S20	✓	✓	×	×	×	×	×	×	×	×	✓	✓	✓	✓	×	×	×	×	×	×
S21	✓	✓	✓	×	×	×	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×
S22	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×
S23	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	✓	×	×	×
S24	✓	×	×	×	×	×	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×
S25	✓	✓	✓	×	×	×	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×
S26	✓	×	×	×	×	×	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×
S27	✓	✓	✓		×	×	×	×	×	×	✓	✓	✓	✓	×	×	×	×	×	×
S28	✓	✓	✓	✓	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	✓	×	×	×	×
S29	✓	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×
S30	✓	✓	×	×	×	×	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×
S31	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S32	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
Total selected strategies	32	29	26	22	20	19	16	14	11	7	32	32	29	26	24	21	18	16	12	7
Objective Function	329.59	324.85	314.26	297.31	280.02	261.99	238.14	209.93	169.13	114.23	329.59	329.59	326.83	316.68	301.29	282.44	258.59	232.94	180.08	114.23
Level Of risk mitigation	100.00%	98.56%	95.35%	90.21%	84.96%	79.49%	72.25%	63.69%	51.31%	34.66%	100.00%	100.00%	99.16%	96.08%	91.41%	85.69%	78.46%	70.67%	54.64%	34.66%

Appendix 6C: Optimization Result for Paharika Executives

Strategies	Budgeted cost (without savings)										Budgeted cost (with savings)									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
	1006.67	906	805	704.67	604	503.33	402.66	302	201.33	100.67	1006.67	906	805	704.67	604	503.33	402.66	302	201.33	100.67
S1	✓	✓	✓	✓	✓	×	×	×	×	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×
S2	✓	✓	✓	×	×	×	×	×	×	×	✓	✓	✓	✓	✓	✓	✓		×	×
S3	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×
S4	✓	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓	✓	×	×	×	×	×	×
S5	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	
S6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓
S7	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	×	✓	×
S8	✓	✓	✓	✓	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×
S9	✓	✓	×	×	×	×	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×
S10	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
S11	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
S12	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓	✓	✓	✓	✓	✓	×	×	×	×
S13	✓	×	×	×	×	×	×	×	×	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×
S14	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S15	✓	×	×	×	×	×	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×
S16	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S17	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓	✓	✓	✓	✓	✓	×	×	×	×
S18	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	
S19	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S20	✓	✓	✓	✓	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×
S21	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	✓	×	×	×
S22	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓	✓	✓	✓	×	✓	×	×	×	×
S23	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S24	✓	✓	✓	×	×	×	×	×	×	×	✓	✓	✓	×	×	×	×	×	×	×
S25	✓	✓	×	×	×	×	×	×	×	×	✓	✓	✓	✓	×	×	×	×	×	×
S26	✓	✓	✓	✓	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×
S27	✓	✓	×	×	×	×	×	×	×	×	✓	✓	✓	×		×	×	×	×	×
S28	✓	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×
S29	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓	✓	✓	✓	✓	✓	×	×	×	×
S30	✓	×	×	×	×	×	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×
S31	✓	✓	✓	✓	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	✓	×	×	×	×
S32	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓	✓	✓	✓	✓	✓	×	×	×	×
Total selected strategies	32	29	26	24	22	21	17	11	8	5	32	32	29	27	24	21	15	12	9	5
Objective Function	374.98	366.81	349.97	323.25	298.36	273.91	244.69	204	150.4	86.24	374.98	374.98	365.11	345.79	320.48	292.64	254.01	204.02	143.25	86.24
Level Of risk mitigation	100.00%	97.82%	93.33%	86.21%	79.57%	73.05%	65.25%	54.40%	40.11%	23.00%	100.00%	100.00%	97.37%	92.22%	85.46%	78.04%	67.74%	54.41%	38.20%	23.00%

Appendix 6D: Optimization Result for Paharika Supply Chain

Strategies	Budgeted cost (without savings)										Budgeted cost (with savings)									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
	1015	913.5	812	710.5	609	507.5	406	304.5	203	101.5	1015	913.5	812	710.5	609	507.5	406	304.5	203	101.5
S1	✓	✓	✓	✓	✓	×	×	×	×	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×
S2	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×
S3	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×
S4	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	×
S5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S7	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
S8	✓	✓	✓	×	×	×	×	×	×	×	✓	✓	✓	✓	×	×	×	×	×	×
S9	✓	✓	×	×	×	×	×	×	×	×	✓	✓	✓	×	×	×	×	×	×	×
S10	✓	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×
S11	✓	✓	×	×	×	×	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×
S12	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓		✓	×	×
S13	✓	✓	✓	✓	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×
S14	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
S15	✓	✓	✓	✓	×	×	✓	×	×	×	✓	✓	✓	×	×	×	×	×	×	×
S16	✓	✓	✓	×	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×
S17	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	×	✓	×
S18	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S19	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S20	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓	✓	✓	✓	✓	✓	✓	×	×	×
S21	✓	✓	×	×	×	×	×	×	×	×	✓	✓	✓	×	×	×	×	×	×	×
S22	✓	×	×	×	×	×	×	×	×	×	✓	✓	✓	✓	×	×	×	×	×	×
S23	✓	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×
S24	✓	×	×	×	×	×	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×
S25	✓	✓	✓	×	×	×	×	×	×	×	✓	✓	✓	✓	×	✓	×	×	×	×
S26	✓	×	✓	×	×	×	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×
S27	✓	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×
S28	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	✓	×	×	×
S29	✓	✓	✓	✓	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	✓	×	×	×	×
S30	✓	✓	×	×	×	×	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×
S31	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S32	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Total selected strategies	32	29	26	22	19	18	16	12	10	6	32	32	28	25	22	19	16	13	10	6
Objective Function	309.75	303.79	294.36	279.69	260.23	240.26	217.37	187.66	147.17	95.28	309.75	309.75	304.68	295.1	281.23	261.35	236.15	200.24	147.17	95.29
Level Of risk mitigation	100.00%	98.07%	95.03%	90.29%	84.01%	77.57%	70.17%	60.58%	47.51%	30.76%	100.00%	100.00%	98.36%	95.27%	90.79%	84.37%	76.24%	64.64%	47.51%	30.76%