MULTIPLE-CRITERIA DECISION MAKING TO SELECT THE BEST STRATEGY FOR REDUCING RISKS AND MAINTAINING SUSTAINABILITY IN SUPPLY CHAIN ACTIVITY BASED ON HOUSE OF RISK (HOR) FRAMEWORK: APPLICATION IN SUGAR INDUSTRY

Undergraduate Thesis

Submitted to International Program
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THESIS APPROVAL

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MULTIPLE-CRITERIA DECISION MAKING TO SELECT THE BEST STRATEGY FOR REDUCING RISKS AND MAINTAINING SUSTAINABILITY IN SUPPLY CHAIN ACTIVITY BASED ON HOR FRAMEWORK: APPLICATION IN SUGAR INDUSTRY

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EXAMINER APPROVAL OF EXAMINATION COMMITTEE

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MULTIPLE-CRITERIA DECISION MAKING TO SELECT THE BEST STRATEGY FOR REDUCING RISKS AND MAINTAINING SUSTAINABILITY IN SUPPLY CHAIN ACTIVITY BASED ON HOR FRAMEWORK: APPLICATION IN SUGAR INDUSTRY

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DEDICATION

I am grateful for the love and encouragement from Ayah, Ibu and Obik, have always provided during every endeavor in my life.

PTPN X Unit PG. Modjopanggoong

My Thesis Supervisor, Dr. Drs. Imam Djati Widodo, M.Eng.Sc.

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MOTTO

خير الناس أنفعهم للناس

“The best of people are those that bring most benefit to the rest of mankind.”

(HR. Ahmad, Thabrani, Daruqutni. Disahihkan Al Albani dalam As-Silsilah AsShahihah)

For indeed, with hardship [will be] ease, Indeed, with hardship [will be] ease

(Q.S. Al-Insyirah: 5-6)

O you who have believed, persevere and endure and remain stationed and fear Allah that you may be successful.

(QS. Ali ’Imran: 200)

PREFACE

Assalamu'alaikum Warahmatullahi Wabarakatuh

Praise be to Allah SWT. Almighty who has bestowed His mercy and grace, shalawat and greetings always poured to the Great Prophet Muhammad SAW and the all his companions who always istiqomah to practice their religion. Thanks to the help and mercy of Allah SWT so that the author be able to complete the Thesis entitled "Multiple-Criteria Decision Making to Select the Best Risk Mitigation Strategy for Reducing Risks and Maintain Sustainability in Supply Chain Activity Based on House of Risk Framework: Application in Sugar Industry".

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Author realizes that this thesis is still not perfect and still have some weaknesses so that author really expects any criticism and suggestions from readers for the perfection of this report. Hopefully this report and information included will be useful for author and give benefit to other parties who read this.

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Yogyakarta, November 2018

Muhammad Firdaus Saputra

ABSTRACT

As the main commodity in the plantation sub-sector, sugarcane plays an important role in national food seft-sufficiency. PTPN X Unit PG. Modjopanggoong is one of agro-industry unit under BUMN Ministry that produce sugarcane based white crystal sugar. In the company's supply chain, upstream department which is Bagian Tanaman plays a crucial role in the procurement activity of raw material sugarcane. Based on RKAP data of the last three milling seasons, Bagian Tanaman was unable fulfill amount of sugarcane supplied with RKAP target. Uncertainty in the supply chain that has the potential to cause disruption to achieve company goals is called risk. Therefore, supply chain risk management is needed which not only reducing risks but also maintaining the sustainability of the company. This study aims (1) To find out the risk agents that highly contribute disrupting raw materials procurement sustainability in PTPN X Unit PG. Modjopanggoong supply chain based on HOR, (2) to find out the best mitigation strategies to reduce risk and maintain sustainability in raw material sugarcane procurement activities. The HOR method is used to identify risks, determine risk priorities and design risk mitigation. The ANP method is used to determine the best risk mitigation strategies to reduce risk based on sugar industry sustainability criteria. Based on the results of risk identification found 14 risk events and 20 risk agents. The HOR1 result shows that there are 10 risk agents highly contribute disrupting procurement activity; namely, sugarcane cultivation margins are less competitive than other commodities, the price of sugar is very volatile, registered sugarcane which has been harvested are delivered to competitors (Brown Sugar & Sugarcane Shelter), narrow cultivation area, the number of indigenous sugarcane areas are limited; farmers lack financing and other production facilities (seeds, fertilizer, medicines, etc.), several farmers are reluctant to register their sugarcane with PG. (contract bound), the amount of sugarcane has not been achieved according to RKAP, credit agreements among PG, Bank and People's Sugarcane Farmers Cooperative (KPTR) are not timely, many of planting data of sugarcane variety is less accurate. Based on prioritized risks, 4 alternatives of risk mitigation strategies were composed to treat them and pairwise compared based on sustainability dimensions (economic, social, environment) as criteria. ANP method employed to select the best risk mitigation strategy. As result, Expanding the company unit sugarcane area (TS) and managed directly by PG. Modjopanggoong gradually (PA1) has the highest priority weight to be selected as the best strategy. By implementing this mitigation strategy, all activities under the Bagian Tanaman are more controlable, so that the risks are able to be reduced and sustainability maintained.

Keyword: Sugarcane, Procurement, The Best Strategy, Supply Chain Risk Management, Sustainable Supply Chain Management, Risk Mitigation Strategies, HOR, ANP

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INTRODUCTION

1.1 Background

As an agricultural country, Indonesia is blessed with abundant natural wealth. There are many types of plants can live and grow because of Indonesia's geographical location which is located in tropical regions with high rainfall. As the backbone of national development, the agricultural sector is the leading sector in national economic growth. Therefore, the needs development of agriculture and agro-industries has a critical role in the process of sustainable and comprehensive economic growth, Giving Incentives to Local Community and reduction of poverty and hunger (un.org, 2018).

Agroindustry is an industry that processes materials of plant or animal origin involving transformation and preservation through physical or chemical alteration, storage, packaging and distribution (Austin, 1992). One of the most well known agroindustry in Indonesia is sugarcane based sugar industry. Sugarcane based sugar is generally grouped into two; namely, sugar for household consumption known as white crystal sugar or Gula Kristal Putih (GKP) and sugar for industry known as refined sugar or Gula Kristal Rafinasi (GKR). As one of main commodities in plantation sub-sector, sugarcane has important role in national food self-sufficiency. Thus, Kementerian Pertanian Indonesia assigned sugarcane-based sugar as strategic commodity for national Giving Incentives to Local Community enhancement as it stated in (Indonesia/Jakarta No. 19/Permentan/HK.140/4/2015, 2015).

In order to contribute to the development of national economy in general and state revenue in particular, BUMN was established by Indonesian government as stated in (Indonesia/Jakarta No. UU RI No. 19/2003 Tentang Badan Usaha Milik Negara, 2003). One of BUMN that engaged in agroindustry sector is PTPN X. PTPN X has several business units, one of which is a sugarcane-based sugar business unit. There are 9 sugar business units scattered in East Java producing GKP. One of them is located in Tulungagung named Unit PG. Modjopanggoong.

In carrying out its business, business entities cannot be separated from supply chain. Therefore, management the of supply chain in business entities is necessary. In term of managing a supply chain, it covers several activities such as material sourcing, production scheduling, and the physical distribution system as well as supported by the necessary information flows (Felea & Albeastroiu, 2013). Material sourcing or procurement function is a crucial activity in any organization and must be conducted efficiently and effectively (Musau, 2015). Hence, procurement activity must be concerned in supply chain in order to accomplish company’s goal. Besides, procurement play a big role in the sustainability of company to fulfill the demand with high quality raw materials.

In agricultural supply chain management has special characteristics; for instance, perishable, the cultivation process depends on climate and season, yields have varied shapes and sizes and also tends to be bulk density making it difficult to handle (Marimin & Slamet, 2010). Thus, these characteristics are uncertain factors may occur and affect the performance of the company's supply chain such as the condition in Unit PG. Modjopanggoong. Uncertainty has close relationship with risk as ISO 3100 defines risk as the effect of uncertainty on an organization’s objectives (ISO Guide 73:2009, 2009).

Since the research object was Unit PG. Modjopanggoong, according to interview with the vice general manager, the main problem of the supply chain in this unit is the activity of sugarcane raw materials procurement. The amount supply of raw materials sugarcane could not fulfill minimum milling cane capacity. Therefore, the amount of sugar that produced could not achieved the target. According to the data of the last three milling seasons, activity plan and company budget (RKAP) cannot be realized. The comparative data between RKAP and realization is on the Table 1.1 below.

Table 1.1 Comparison data of RKAP and Realization period 2014/2015 - 2016/2017

Periode Musim Giling	Kategori	Luas (Ha)	Tebu (Ton)		Rend (%)	Bagi Hasil	
			Per Ha	Jumlah		Hablur Bagian PG	Gula SHS Bagian PG
2014/2015	RKAP	5,810.200	87.4	510,218.4	8.58	14,445.340	14,474.220
	Realisasi	4,855.851	75.7	369,808.5	8.58	10,270.023	9,901.798
2015/2016	RKAP	5,443.560	76.7	419,873.4	6.58	9,336.320	8,648.860
	Realisasi	3,630.469	81.1	296,139.5	6.07	3,637.424	3,308.664
2016/2017	RKAP	4,254.500	77.2	330,095.6	8.23	8,868.670	8,886.415
	Realisasi	3,473.341	78.4	273,743.6	8.52	7,534.485	6,824.953

Source: PG. Modjopanggoong

Regarding to information above, it indicates the condition in Unit PG. Modjopanggoong has problem with uncertainty factors or risks that dirupt in procurement activity to achieve RKAP. The risks that occurs on the upstream supply chain potentially have a systemic impact on the company's performance. Consequently, increase higher risks in terms of supply interruptions, productions delays etc. which ultimately result in loss of reputation, lost sales and poor financial performance (Sreedevi & Saranga, 2017). So that, the uncertainty factors affecting pontential losses and bankcruptcy in company unit categorized as the supply chain risk. So far, risks that disturb procurement activity in Unit PG. Modjopanggoong have not been identified yet. Hence, application of supply chain risk management is necessary in order to reduce risks in procurement activities by identifying the risks and respond the risks with suitable risk mitigation strategies.

Supply chain risk management (SCRM) is the management of supply chain risks by coordinating and collaborating among the supply chain echelons so as to ensure profitability and continuity (Christopher & Lee 2004; Rokou & Kirytopoulos 2014). Reseach was conducted by Giannakis & Papadopoulos (2016) stated SCRM is not perceived merely as cost saving, but rather a value creation activity to lead more sustainable supply chains. However, implementation of supply chain risk management is not just to handle the risks in company supply chain, but also to maintain the company sustainability.

Various studies about supply chain risk management have been carried out previously. House Of Risk (HOR), which is combination of House Of Quality (HOQ) of Quality Function Deployment and Failure Mode and Effect Analysis (FMEA) by selecting a set of risks agents to be treated and prioritize proactive actions in order to reduce aggregate impact of risk events caused by risk agents (Pujawan & Geraldin, 2009). Research about supply chain risk management also has been conducted by Utari & Baihaqi (2015) to devise risk mitigation strategy in PT. Atlas Copco Nusantara supply chain. The use of the HOR method proved to be the right solution to arrange mitigation strategies toward the causes of risks (Utari & Baihaqi, 2015). Another method that used for supply chain risk management is Analytic Network Process (ANP). ANP is one of multi-criteria decision making method for judgement found by Thomas Saaty. ANP is the extends the AHP to cases of dependence feedback and generalizes on the supermatix approach, it also enables interactions and feedback within clusters (inner dependence) and between clusters (outerdependence) for decision making (Adams & Saaty, 2016). Research about decision making in supply chain environment has been conducted by several researchers. Muchfirodin, et al. (2015) composed strategy by using ANP to mitigate risk on tobacco commodity supply chain in Temanggung. Poh & Liang (2017) also conducted research using ANP to select the best strategy for sustainable supply chain because ANP is suitable and represents all the interrelationships and interdependency among the elements in the problem. ANP analysis is suitable to deal with complex decision-making problems (Molinos-Senante et al., 2015) as well as raw materials procurement activity in supply chain.

Based on the background description above, the application of risk management is very important to be applied in the procurement activity in Unit PG. Modjopanggoong. The aims of this study are to identify risk events and the risk agents and provide an appropriate risk mitigation strategy based on sustainability dimensions to reduce risk agents so that the sustainability of the company can be maintained. For the methods employed in implementation of risk management is the HOR framework and ANP. This research object is Bagian Tanaman who has responsibility in raw materials sugarcane procurement, and the research was conducted based on HOR framework by combining HOR1 model for risk assessment and ANP model for the best risk mitigation strategy selection. The first phase of the HOR is used to identify risk events and source of risk events or risk agents; then the risk agents that contribute greatly in disrupting raw material procurement activities are prioritized to be responded to with appropriate risk mitigation strategies. The second phase of HOR is to compose suitable risk mitigation strategies;

then using ANP for decision making on which risk mitigation strategy is selected as the best strategy tha lead to sustainability of the company's supply chain.

1.2 Problem Formulation

Based on the background of the research, the problems that come up in the research would be formulated and they generated research questions as follows:

1. What are the risk agents that highly contribute disrupting raw materials procurement sustainability in PTPN X Unit PG. Modjopanggoong supply chain based on HOR?
2. What is the best strategy for reducing risks and maintaining sustainability in raw material sugarcane procurement activity in PTPN X Unit PG. Modjopanggoong supply chain based on proposed ANP method?

1.3 Reseach Objectives

The objective of this research is to fulfill several objectives as mentioned as below:

1. To find out the risk agents that highly contribute disrupting raw materials procurement sustainability in PTPN X Unit PG. Modjopanggoong supply chain based on HOR.
2. To find out the best strategy for reducing risks and maintaining sustainability in raw material sugarcane procurement activity in PTPN X Unit PG. Modjopanggoong supply chain based on proposed ANP method.

1.4 Scope of Problem

In order to facilitate problem solving and to focus on research objective, this research limited the problem as follows:

1. This research focuses on implementation of supply chain risk management using House of Risk (HOR) method combined with sustainable supply chain management in raw material sugarcane procurement activity using ANP.
2. This research was only conducted in raw material sugarcane procurement activity in Bagian Tanaman in PTPN X Unit PG. Modjopanggoong.

1.5 Benefits of Research

There are several benefits of this research as below:

1. Researcher can find out the risks event and sources of risk that potentially dirupt procurement activity in PTPN X Unit PG. Modjopangooong.
2. Researcher can gain deep understanding regarding to relationship between SCRM and SSCM in sugar industry.
3. The proposed method of this research can be used to identify risks in Bagian Tanaman and also facilitate manager's decision making to select proper risk mitigations strategy for reducing risks and maintain company's supply chain sustainability.
4. To be contributor in the research development supply chain risk management in the scope of sugar industry.

1.6 Systematical Writing

In order to get a well-structured research report, this research writing will be based on rules of scientific writing in accordance with the systematics as follows:

CHAPTER I INTRODUCTION

This chapter contains an introductory description of research process, the background of research, problem formulation, research objectives, and the benefits of research and systematic writing.

CHAPTER II LITERATURE REVIEW

In this chapter, there will be elaboration on the theories of reference such as journals, proceeding, books, websites as well as the results of previous researches regarding to the research problem which is used as a reference for problem solving with appropriate methods.

CHAPTER III RESEARCH METHODOLOGY

This chapter consists of the description of the framework or concept, research object and methods that used in this study with systematic way on conducting the research.

CHAPTER IV DATA COLLECTION AND DATA PROCESSING

This chapter contains data collection of research during the research and how to analyse the data. Data processing result that displayed in the form of tables and graphs. Analysis of the processed data to gain the result. In this section is a reference to the discussion of the result to be written in Chapter V.

CHAPTER V DISCUSSION

Contains discussion of the results of data processing that has been done in research. Compatibility research objectives to give recommendations.

CHAPTER VI CONCLUSION AND RECOMMENDATION

Contains the conclusion of the analysis and any recommendations or suggestions on the results attained in the problems identified during research, so it needs to be done on assessed in future research.

REFERENCES

APPENDICES

CHAPTER II

LITERATURE REVIEW

2.1 Inductive Study

Inductive study known as inductive reasoning is a literature study using previous research that has been documented into journals, books and or proceedias. Literature review is very helpful for researcher to get appropriate theory and methods as guidance to conduct research. The previous research explained as follows:

Astutik, et al. (2015) conducted research about risk management in the supply chain of organic fertilizer manufacturer. The research employed two methods; namely, House of Risk (HOR) and Fuzzy Analytical Hierarchy Process (FAHP). The aim of their research was to create robust supply chain flow against various risks that causes faulureness to achieve company's target. HOR employed to mitigate the risks occurrence in the supply chain flow by identify the risks, priotize the risk agents and construct the strategy to respond the risks. In order to construct risk rensponse strategy, FAHP was employed to prioritize and rank risk response strategies based on the weight.

Nugraheni et al. (2017) also conducted research using House of Risk (HOR) method. The objectives of their research is to analyze the risks on supply chain flow of Ready To Drink (RTD) Product in PT SGB. The research that they used is HOR that consist of two phases. The first phase is knowing the risk priority that should be mitigated and the second phase is generating some preventive strategies to mitigate the choosen priority risks. There were 63 identified risk events based on SCOR elements, 43 identified risk agents, and 15 recommended preventive strategies according to the most effective sequence of strategies that applied in the company.

Wahyudin & Santoso (2016) also conducted research about modelling of risk management for product development using HOR method. The research object is a yogurt product that produced by a dairy based product company. The aim of their research is to identify the potential appeared risks, to arrange the priority order of risk agents and to conceptualize the risk mitigation to be applied. The first phase of HOR results 20 risks with 27 identified risk agents. Those risks were lack of information regarding the competitors, Error cost analysis management, and Error of production division in yogurt drink production. There are 11 mitigation strategies were obtained to be applied in product development of yogurt drink in company among others is supervise all production activity. Based on the result, it confirmed that HOR method is quite effective to analyse risks and to formulate the mitigation strategies for any identified risks in each stage of the product development.

Anggrahini et al. (2015) also conducted research about quality risk management in a frozen shrimp supply chain using HOR framework. Their research analyse the quality problems of frozen shrimp product including supply chain activity and the Company X’s stakeholders. In HOR phase 1 all supply chain activity mapped by using Supply Chain Operations Reference (SCOR) model. There were 41 risks occurance and 52 risk agents were identified. Regarding to risk analysis based on highest Aggregate Risk Potential (ARP), it results 11 most critical risk agents. According to the selection analysis, 12 mitigation actions are proposed to be implemented in Company X.

A research about supply chain risk management was conducted by Ramadhani & Baihaqi (2018) entitled Designing Supply Chain Risk Mitigation Strategy in The Cable Support System Industry of PT. X. Their research is conducted in plate manufacturer which has currently experienced with supply chain disruptions. The disruptions in company’s supply chain has resulted delay of goods delivery ot customers. Thus, they combined two methods, namely Analytic Network Process (ANP) and House of Risk (HOR) to analyze the relationship between risks and relationship between causes of risks. The final result of both methods found that there were 30 source of risk and 13 critical risk that had 28 risks management strategies with 15 priority strategies can be carried out by company. The research concluded the method of using ANP (Analytical Network

Process) and HOR (House of Risk) is proved to be the right solution to identify and influence strategy (Ramadhani & Baihaqi, 2018).

Hosseini, et al. (2013) used ANP to select the best strategy for reducing risks in a supply chain. In their research they considered four criteria that consists supply risk, process risk, demand risk, and disruption risk. In supply risk there are three sub-criteria namely supply quality, supply cost risk, supply commitment; in process risk there are three sub criteria namely, time risk, quality risk, and capacity risk; in demand risk there is demand uncertainty; and in disruption risk there are two sub-criteira namely natural disaster and technological disaster dis five alternatives namely, total quality management (TQM), leanness, alignment, adaptability, and agility.

Poh & Liang, (2017) conducted research about sustainable supply chain. The research was conducted in fashion industry. The research presented decision support approach based on multiple-criteria-decision-making (MCDM) methodologies with purpose to help companies develop effective models for timely decision-making involving sustainable supply chain management strategies. The aim of their research was to evaluate and select the best sustainable supply chain management strategy by compared AHP and developed AHP structure into ANP. The proposed model using Analytic Network Process (ANP) that suitable and expose all the interrelationships and interdependency among the elements in the problem. There are three dimension of sustainability that considered; namely, economic, social, and environmental. According to their result, the ANP model is the more suitable and realistic than AHP by selecting socially leagile supply chain as the best strategy.

Muchfirodin, et al. (2015) conducted research about supply chain risk management on tobacco commodity in Temanggu, Central Java. The aim of their research is to identify and mitigate risks in tobacco supply chain in Temanggung Regency based on risk management principle in ISO 31000: 2009. The methods that employed in their research is Analytical Network Process (ANP) combined with Decision Making Trial and Laboratory (DAMATEL) to push more comprehensive plan in mitigating risks occurrence according to criteria. The research resulted that ANP method can minimize the risk of tobacco yielding and marketing (Muchfirodin, Guritno, & Yuliando, 2015).

Giannakis & Papadopoulos, (2016) also conducted research entitled Supply Chain Sustainability: A Risk Management Approach. Their research discussed about the relationship between sustainable supply chain and risk management. Their research try to develop of operational perspective of supply chain sustainability, by considering risk management process. They adopted mixed method approach to collect and analyze the data. First, they identified 30 risks across three main pillars of sustainability; namely, economic, social and environmental. In their research, they utilized Failure Mode and Effect Analysis (FMEA) technique for risk assessment to identify potential causes and effects between the identified risks in two textile manufacturing companies. Based on the findings, show that endogeneous environmental risks are perceived to be the most important across different industries and the interconnectedness between several sustainability-related risks is very high. The research concluded the need for integrated sustainability risk management approaches to facilitate the development of effective sustainable strategies.

Based on the previous research above, there is a relationship between supply chain risk management and sustainable supply chain management. Since the decisions taken in present have an impact in the future, it is necessary to have an appropriate strategy to reduce risks that disrupt the supply chain and maintain the sustainability of the company by considering economic, social and environmental aspects. Therefore, this research uses risk management combines with sustainable supply chain management approaches in order to reduce the risks that highly contributes dirupting procurement sustainability. The proposed methods are HOR for the risk asssessment combined with ANP to facilitate Manajer Tanaman’s decision making to select the best risk mitigations strategy. HOR framework is employed because it’s capability to identify the risks events and the risks agents; then the risk assessment is conducted by following FMEA method then combined with HOQ method to calculate ARP to find out the risk priority based on the rank of contribution of the risk disruption. After HOR stage 1 has been finished, the prioritized risk responded by composing suitable risk mitigation strategies for risk treatment. Since ANP represents interdependencies more realistically, it is employed to give pairwise comparison the composed risk mitigations strategies as alternatives by considering sub-criteria within sustainability dimensions (economic, social, environment) as criteria. The research positions is on the Table 2.1 below:

Table 2.1 Research Position

No	Researcher(s)	Title	Method(s)	Approach
1	Astutik, et al. (2015)	Risk Management Strategy in the Supply Chain of Organic Fertilizer by Using Fuzzy Analytical Hierarchy Process (FAHP) (Case Study in PT Tiara Kurnia, Malang)	HOR, Fuzzy AHP	Risk Management
2	Nugraheni et al. (2017)	The analysis of Supply Chain Risk on Ready to Drink (RTD) Product using House of Risk Method	HOR	Risk Management
3	Wahyudin & Santoso (2016)	Modelling of Risk Management for Product Development of Yogurt Drink Using House of Risk (HOR) Method	HOR	Risk Management
4	Anggrahini et al. (2015)	Managing quality risk in a frozen shrimp supply chain: a case study	HOR	Risk Management
5	Ramadhani & Baihaqi (2018)	Designing Supply Chain Risk Mitigation Strategy in the Cable Support System Industry of PT. X	ANP, HOR	Risk Management
6	Hosseini, et al. (2013)	Using the Analytical Network Process to Select the Best Strategy for Reducing Risks in a Supply Chain	ANP	Risk Management
7	Poh & Liang, (2017)	Multiple-Criteria Decision Support for a Sustainable Supply Chain: Applications to the Fashion Industry	AHP, ANP	Sustainable Supply Chain Management
8	Muchfirodin, et al. (2015)	Supply Chain Risk Management on Tobacco Commodity in Temanggung, Central Java (Case study at Farmers and Middlemen Level)	ANP, DAMATEL	Risk Management
9	Giannakis & Papadopoulos (2016)	Supply Chain Sustainability: A Risk Management Approach	FMEA, Causal Model, Correlation analyses	Risk Management, Sustainable Supply Chain Management
*	Saputra (2018)	Multiple-Criteria Decision Making to Select the Best Strategy for Reducing the Risks and Maintaining Sustainability in Supply Chain Activity Based on House of Risk Framework: Application in Sugar Industry	HOR, ANP	Risk Management, Sustainable Supply Chain Management

2.2 Deductive Study

Deductive study or deductive reasoning is testing the existing theory to develop hypothesis in this research. The basis theory of House of Risk and ANP as follows:

2.2.1 Supply Chain Management

Stock & Boyer (2009) defined supply chain as the management of a network of relationships within a firm and between interdependent organizations and business units consisting of material suppliers, purchasing, production facilities, logistics, marketing, and related systems that facilitate the forward and reverse flow of materials, services, finances and information from the original producer to final customer with the benefits of adding value, maximizing profitability through efficiencies, and achieving customer satisfaction. Mentzer, et al. (2001) also defined supply chain management as a set of many entities that directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer. So that, supply chain management is managing the chain of materials flow, information flow and finances flow from upstream to downstream in order to create valuable product for the customers.

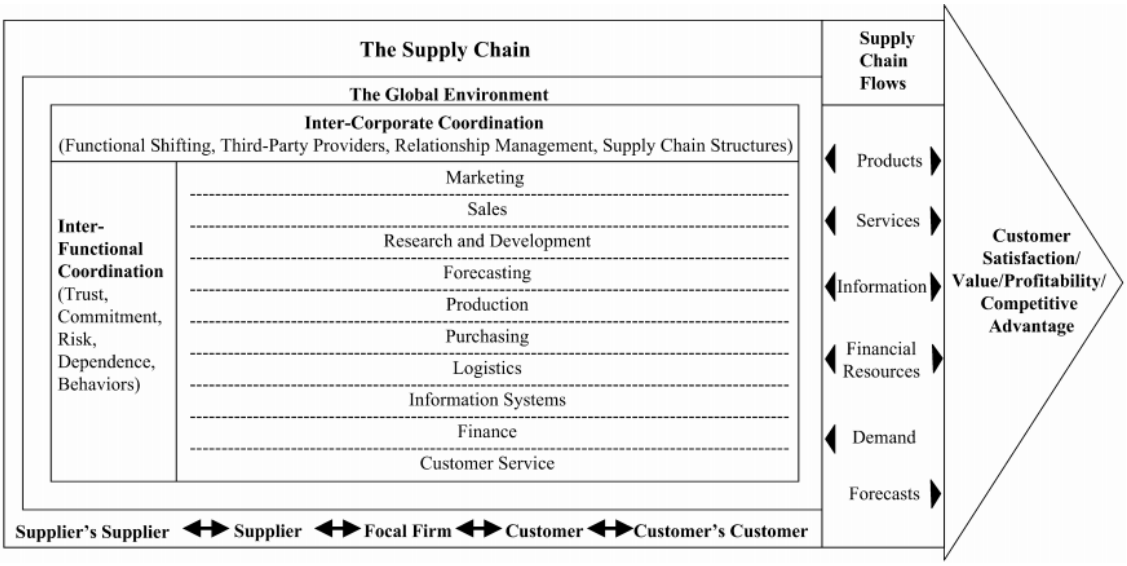

Figure 2.1 Supply chain

2.2.2 Procurement

Dobler & Burt (1996) defined procurement as the acquisition of goods and/or services at the best possible total cost of ownership, in the right quality and quantity, at the right time, in the right place and from the right source for the direct benefit or use of corporations, individuals, or even government. Procurement is the process of getting the goods and/or services your company needs to fulfill its business model and also include developing standards of quality, financing purchases, creating purchase orders, negotiating price, buying goods, inventory control, inventory management, and disposal of waste products like the packaging (Kolenko, 2018). According to information above, procurement can be defined as the activity of acquiring goods or services to fulfill company business requirements in order to produce valuable product based on customers' desire that involves quality and cost of materials, and right time materials.

2.2.3 Risk

In ISO 31000, risk is defined as effect of uncertainty on objectives (ISO Guide 73:2009, 2009). Šotić & Rajić (2015) stated risk in engineering practices is generally expressed as the product of the probability of the occurrence of an opposing event and the weight of the consequences of such an event. Other definitions of risk also has been modified. Aven (2016) stated several qualitative definitions of risk as:

1. The possibility of an unfortunate occurrence,
2. The potential for realization of unwanted, negative consequences of an event,
3. Exposure to a proposition (e.g. the occurrence of a loss) of which one is uncertain,
4. The consequences of the activity and associated uncertainties,
5. Uncertainty about and severity of the consequences of an activity with respect to something that humans' value,
6. The occurrence of some specified consequences of the activity and associated uncertainties,
7. The deviation from a reference value and associated uncertainties

2.2.4 Risk Management

Risk Management is risk related action that includes planning for the risk, identifiying risks, analyzing risks, developing risk response strategies, and monitoring and controlling risks to resolve how they have reduced. According to ISO 31000: 2009 risk management defined as a coordinated activity to direct and control an organization with regard to risk (ISO Guide 73:2009). Risk management process is summarized by ISO 31000 into seven steps as depicted in Figure 2.1 and discussed as follows: (ISO 31000, 2009ab ; Oliveira, et al. 2017).

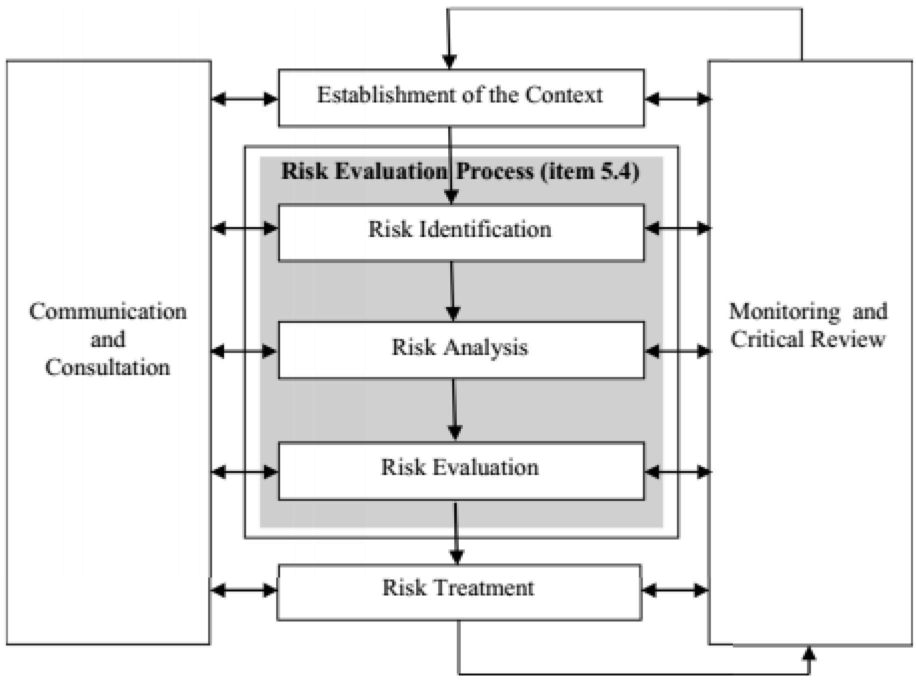

Figure 2.2 Risk Management Process ISO 31000 by ISO 31000:2009 standard

1. The process of communication and consultation covers the existence of plans for communication among the parties responsible for implementing the risk management process and the interested parties.

2. The step of establishing the context involves whether the firm articulates its objectives, defines the external and internal parameters that will be considered in managing risks and establishes the scope and risk criteria for the rest of the process.

3. Risk identification aims to generate a comprehensive list of risks from different sources, the events, their causes and potential consequences, and the areas affected.

4. Risk analysis aims to provide an understanding of risk to serve as the basis for making decisions on the best strategies and methods to deal with them, it involves consideration of the causes and sources of risks, their negative consequences and the probability these consequences will occur.

5. Risk evaluation has purpose to provide more support for making decisions, based on the results of the risk analysis, by evaluating what risks need treatment and the priority of implementing that treatment.

6. Risk Risk treatment entails the selection of one or more options to modify the risks and the implementation of these options, through a cyclical process that analyzes the treatments previously applied, residual risk levels, implementation of a new treatment for intolerable residual risks and evaluation of the efficacy of the treatment proposed.

7. Monitoring and critical review should be planned as part of the risk management process, to clearly define responsibilities among those involved, covering all aspects of the risk management process.

2.2.5 Supply Chain Risk Management

Heckmann et al. (2015) defined supply chain risk is the potential loss for a supply chain in terms of its target values of efficiency and effectiveness affected by uncertain developments of supply chain characteristics were caused by the occurrence of triggering-events. Supply Chain Risk Management (SCRM) has been defined in several ways. Supply Chain Risk Management (SCRM) is the implementation of strategies to manage both everyday and exceptional risks along the supply chain based on continuous risk assessment with the objective of reducing vulnerability and ensuring continuity (Wieland & Wallenburg, 2012). Most companies recognize the importance of risk assessment programs and use different methods, ranging from formal quantitative models to informal qualitative plans, to assess SC risks (Kirilmaz & Erol, 2016). In addition, Supply Chain Risk Management is implementation of risk management that consists of risk identification, risk analysis, risk response, monitoring and control across supply chain activities.

2.2.6 Sustainable Supply Chain Management (SSCM) in Sugar Enterprises

Sustainable supply chain management (SSCM) comprises the "management of material, information and capital flows as well as cooperation among corporations along the supply chain while achieving goals of all three dimensions of sustainable development, i.e. economic, environmental and social, into account which are derived from customer and stakeholder requirements" (Seuring & Muller, 2008; Grimm et al., 2014). According to Fish (2016) sustainable supply chain management (SSCM) can be defined as "the strategic, transparent integration and achievement of an organisation's social, environmental and economic goals in the systemic coordination of key inter-organisational business processes for improving the long term economic performance of the individual company and its supply chains". Thus, the sustainable supply chain management is the management the chain of supply that involve informations, materials and funds flows integrates with economic, environmental and social aspects to achive company's competitive advantage.

Sugar sector enterprises currently have incentives and disincentives to play their roles. Sugarcane sustainability dimensions summarized in Figure 2.3

Figure 2.3 Dimensions of Sustainability in Sugar Production
Source of Picture: (FAO, 2014; Jenkins et al., 2015)

2.2.7 House of Risk (HOR)

House of Risk (HOR) is a framework that developed by Pujawan & Geraldin (2009) which combines two basic ideas of two well-known tools: the house of quality of quality function deployement (QFD) and the failure mode and effect analysis (FMEA). The aims of HOR are to identify risk agents and respond prioritezed risks with proactive actions based on SCOR model.

In the well-known FMEA, risk assessment is done through calculation of an RPN as a product of three factors, i.e. probability of occurrence, severity of impacts, and detection. Unlike in the FMEA model where both the probability of occurrence and the degree of severity are associated with the risk events, here we assign the probability to the risk agent and the severity to the risk event. Since one risk agent could induce a number of risk events, it is necessary to quantity the aggregate risk potential of a risk. In order to perform proactive supply chain risk management this model consist of two phases; namely:

1. HOR1 is used to determined which risk agents are to be given priority for preventive actions.
2. HOR2 is to give priority to those actions considered effective but with reasonable money and resource commitments.

A. HOR Phase 1

HOR1 is a severity assessment of the risk event, risk agent occurrence assessment, and correlation between the risk event and the risk agent (Pujawan & Geraldin, 2009). Risk assessment will be conducted by spreading questionnaire to the expert respondents or risk takers. The risk variables that be assessed consist of risk occurrence and risk event severity. The results of questionnaire will be used as Aggregate Risk Potential (ARP) value, which additional be used to determine the priority of risk agents as basis for risk mitigation (Wahyudin & Santoso, 2016). The prioritized risk agents are the result from Pareto 80:20 principle. Aggregate Risk Potential (ARP) can be calculated using equation 2.1:

$$\mathrm{ARP}_j = O_j \sum_i S_i R_{ij} \qquad \text{… (2.1)}$$

Description:
ARPj: Aggregate Risk Potential on risk agent ‘j’
Oj: Probability of Risk Occurance ‘j’
Si: Severity or Impact of Risk Event ‘i’
Rij: Correlation between risk agent ‘i’ and risk event ‘j’

B. HOR Phase 2

HOR2 is conducted to conceptualise the mitigation strategy to overcome the appeared risks. The Total Effectiveness (TEk) of each strategy is calculated using Equation (2.2), aimed to explain the effectiveness level of mitigation strategy in terms of handling the risk agents.

$$\mathrm{TE}_k = \sum_j \mathrm{ARP}_j E_{jk} \quad \forall k \qquad \text{… (2.2)}$$

Description:
TEk: Total Effectiveness
ARPj: Aggregate Risk Potential on risk agent ‘j’
Ejk: Correlation level between risk agent ‘j’ and mitigation strategy ‘k’

Then give assessment to Degree of Difficulty (Dk) using likert scale with 3-5-point scale. The last step is to calculate the ration of Effectiveness to Difficulty (ETD) to determine the rank of risk mitigation priority. The ETD is calculated based on formula using equation 2.3

$$\mathrm{ETD}_k = \mathrm{TE}_k / D_k. \qquad \text{… (2.3)}$$

2.2.8 Analytic Network Process (ANP)

The Analytic Network Process (ANP) is a generalization of the Analytic Hierarchy Process (AHP), by considering the dependence between the elements of the hierarchy (Saaty, 2008). Saaty (2004) defined Analytic Network Process (ANP) is a multicriteria theory of measurement used to derive relative priority scales of absolute numbers form individual judgements (or from actual measurements normalized to relative form) that also belong to a fundamental scale of absolute numbers. This method is useful to overcome complex problem that cannot be solved using AHP and it allows to give feedback amongs the inner and outer dependence elements of network. Lin, et al. (2018) explained the ANP method consists of four steps: (1) building a hierarchical structure; (2) generating a pairwise matrix and calculating the eigenvectors; (3) creating supermatrices and calculating the weights; and (4) select the best alternatives solution (Meade & Sarkis, 1999; Cheng & Li , 2005; Lin, et al., 2018): The steps as follows:

Step 1: Build a hierarchical structure

This research set goals according to the characteristic of the problem, defines the criteria and sub-criteria and determines mutual influences among the criteria. If the criteria are influenced by each other, there is an outer dependence among them. If the sub-criteria are influenced by each other, there is an interdependence among them. The differences of AHP and ANP architecture is in on the figure 2.1

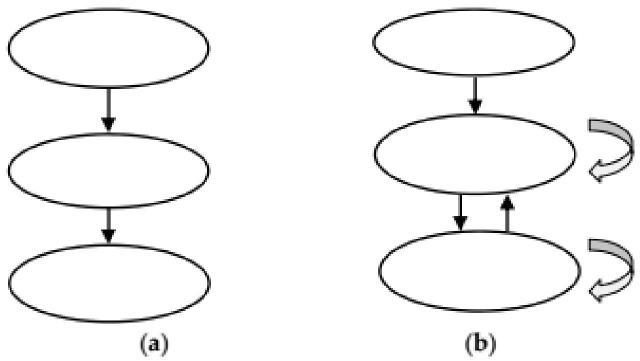

Figure 2.2 Differences the architecture of Analytic Hierarchy Process (AHP) and Analytic Network Process (ANP); (a) AHP (b) ANP (Saaty, 1996)

Step 2: Create a pairwise matrix and calculate the eigenvectors

For ANP the comparative pairwise is conducted same as AHP, following the 1-9 scale method (Saaty, 1980). For instance, the 1/9 scale indicates that the vertical criteria are much more important than horizontal criteria. The eigenvector is calculated according to each matrix comparison and used as the value of the supermatrices to indicate interdependence and relative importance.

The computational ANP involves three matrices, including the unweighted, weighted and limit supermatrices. The formula as follows:

$$\mathbf{A} \times \mathbf{w} = \lambda_{\max} \times \mathbf{w} \quad \ldots (2.3)$$

Where A indicates an *n x n* pairwise comparison matrix, w is the eigenvector and λ_{max} is the maximum eigenvalue of Matrix **A**. **A** consistency test is then conducted according to the maximum eigenvalue; in other words, it calculates the CI and CR to judge the decision-makers' consistency (as expressed in Equation 2.4 and 2.5)

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad \ldots (2.4)$$

$$CR = \frac{CI}{RI} \quad \ldots (2.5)$$

If $0 \le CR \le 0.1$, the judgement of experts is consistent (Saaty, 1996)

Step 3: Form the supermatrices

A supermatrix is conceivable, the eigenvector calculated by pairwise comparison is used as the weight value of each submatrix and value indicates the relationship between two nodes (such as criteria or groups) in decision-making system (Meade & Sarkis, 1999; Cheng & Li , 2005; Lin, et al., 2018). It is assumed that decision-making system C_i comprises (i = 1, 2, …, n) criteria and each criterion C_i comprises n_i sub-criteria. This study uses Equation (2.6) to calculate the eigenvector of each submatrix to be used as its weight value and then transforms the submatrix into a supermatrix in the permutation mode detailed by Equation (2.7) (Saaty, 1996). If matrix elements are dependent on each other, a fixed intersection extremum will be obtained after the matrix is subjected to reiterate multiplication.

$$W = \begin{array}{cc} & \\ & \\ C_1 & \begin{array}{c} e_{11} \\ e_{12} \\ \vdots \\ e_{1n1} \end{array} \\ C_2 & \begin{array}{c} e_{21} \\ e_{22} \\ \vdots \\ e_{2n2} \end{array} \\ \vdots & \vdots \\ C_i & \begin{array}{c} e_{i1} \\ e_{i2} \\ \vdots \\ e_{ini} \end{array} \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_i \\ e_{11}e_{12}\cdots e_{1n1} & \cdots & e_{i1}e_{i2}\cdots e_{ini} & \end{array} \\ \begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1i} \\ w_{21} & w_{22} & \cdots & w_{2i} \\ \vdots & \vdots & \ddots & \vdots \\ w_{i1} & w_{i2} & \cdots & w_{ii} \end{bmatrix} \end{array} \quad \ldots (2.6)$$

The computational ANP contains three matrices. Specifically, the weight of the unweighted supermatrix is the weight calculated through the original pairwise comparison, the weight of the weighted supermatrix is that of the same criterion in the unweighted supermatrix multiplied by the related group weight and the limit supermatrix squares the weighted supermatrix several times until the numbers in all columns are equal. Saaty (1996) argues that, if supermatrix $\boldsymbol{W}$ is irreducible, all column vectors in the supermatrix share the save values; in other words, the convergence effect is attained. Equation (2.7) is a supermatrix with a three-layer hierarchy, as indicated by $\boldsymbol{Wh}$

$$\boldsymbol{W_h} = \begin{bmatrix} \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{W_{21}} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{W_{32}} & \boldsymbol{I} \end{bmatrix} \quad \ldots (2.7)$$

where $\boldsymbol{W_{21}}$ is the eigenvector of a criterion under the decision-making goals, $\boldsymbol{W_{32}}$ is the pairwise comparison matrix of the alternative solution under each criterion, $\boldsymbol{I}$ is the unit matrix and $\mathbf{0}$ is the independence of the same criterion or between sub-criteria. The primary function of this matrix is to evaluate outer and inner dependence. If there is dependence between criteria, a network structure needs to be used instead of the hierarchical structure. Then, $\boldsymbol{W_{22}}$ indicates the dependence between these criteria and the supermatrix can be expressed by Saaty (1996) Equation (2.8)

$$\boldsymbol{W_n} = \begin{bmatrix} \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{W_{21}} & \mathbf{W_{22}} & \mathbf{0} \\ \mathbf{0} & \mathbf{W_{32}} & \boldsymbol{I} \end{bmatrix} \quad \ldots (2.8)$$

Any "$\mathbf{0}$" in supermatrix $\boldsymbol{Wn}$ can be replaced with a matrix based on the dependence relationship between criteria or groups. There is naturally a dependence relationship between groups in a network structure; therefore, the supermatrix usually contains the weights of multiple interdependent columns. Such a supermatrix is then referred to as an unweighted supermatrix; in other words, the weights are obtained by combining and permutating the eigenvectors of the original pairwise comparison matrix. To meet the mathematical reasoning logic, the supermatrix must first be normalized so that the sum of the weight values of each column is equal to 1. Such a supermatrix is then referred to as a weighted supermatrix. If the sum of the weight values in each column of an unweighted supermatrix is equal to 1, it becomes a weighted supermatrix. This study uses the ANP method to calculate the weight of main and sub-criteria. Therefore, the unweighted supermatrix $\boldsymbol{Wn}$ needs to be modified into a weighted supermatrix $\boldsymbol{W'n}$ as expressed by Saaty (1996) Equation (2.8)

$$\boldsymbol{W'_n} = \begin{bmatrix} \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \boldsymbol{W_{21}} & \boldsymbol{W_{22}} & \mathbf{0} \\ \mathbf{0} & \boldsymbol{W_{32}} & \boldsymbol{W_{33}} \end{bmatrix} \qquad \dots (2.8)$$

Where $\boldsymbol{W_{22}}$ and $\boldsymbol{W_{33}}$ indicate the weight of dependence between criteria and sub-criteria, respectively. To attain convergence, the weighted supermatrix $\boldsymbol{Wn}$ is multiplied to the power of $\mathbf{2}\boldsymbol{k} + \mathbf{1}$ $(\boldsymbol{k} \longrightarrow \infty)$, as expressed in Equation (2.8). Finally, this study obtains a new limit supermatrix $\boldsymbol{W_{ANP}}$ (Saaty, 1996).

$$\boldsymbol{W_{ANP}} = \lim_{k \to \infty} \left(\boldsymbol{W'_n}\right)^{2k+1} \qquad \dots (2.8)$$

Step 4: Select the best alternatives solution

The weights of the limit supermatrix $\boldsymbol{W_{ANP}}$ obtained in Step 3 can be used as the basis for ranking the alternative solutions.

CHAPTER III

RESEARCH METHODOLOGY

3.1 Research Object and Location

This research was conducted in PTPN X, Sugar Industry Unit PG. Modjopanggoong under BUMN ownership located in Tulungagung, East Java. The company focuses on producing white crystal sugar (GKP) as the main product, and molases as the by-product.

3.2 Problem Identification

Problem identification is the initial step of this research. Problem identification was obtained from the observation, interview with the Assistant Manajer & Manajer Tanaman in the PTPN X Unit PG. Modjopanggoong and comparative data of RKAP and realization from period 2014/2015 - 2016/2017 that represent the conditions of the company.

3.3 Problem Formulation

Problem formulation is being used to construct solution of the problem and as the basis to make conclusion and recommendation. Focus of this research is the implementation of risk management in supply chain of GKP using HOR in the activity of sugarcane raw material procurement in Bagian Tanaman; then using ANP to facilitate manager to make decision by considering sustainability dimensions to select the best strategy for reducing risks and maintain company sustainability. The method that adopted in this research are HOR as the risk assessment to find out the risks priority and also to compose risk mitigation strategy; then use ANP to select the best risk mitigations strategy by considering the sustainability dimension.

3.4 Data Collection

This research uses two types of data; namely:

1. Primary Data

   Primary data is the data that directly obtained from the sources. Primary data of this research was obtained from the Manajer Tanaman as the expert in the procurement activity in PTPN X Unit PG. Modjopanggoong. The data that used in is from the questionnaire about the risk events, risk agents, HOR1 and pairwise comparison of the alternatives and criteria to select the best risk mitigations strategy.

2. Secondary Data

   Secondary data is the data obtained from appropriate literature review, such as journals, proceedings, books. In this research, the secondary data were used to support research hypothesis and statement in this research. This research performed both deductive and inductive study as literature review. Deductive study was carried out to gain relevant basis theory and to test theory whether suitable or not. Then it followed by conducting inductive study to gain related information in previous research in order to positioning this research to show the uniqueness of this research.

3.5 Data Collection Method

The method of data collection in this research are observation, interview and questionnaire. Thus, the data collection in this research categorize both qualitative and quantitative approach. Qualitative indicated by carried out interview and observation that concern with the quality of information gathered; while quantitative concern on the numerical analysis by giving questionnaire to the expert as respondent to fulfill required data in HOR and ANP. Data collection method was conducted in order to identify the risks that potentially disrupt the procurement activity both risk events and risk agents for risk assessment; risk analysis and evaluation; and pairwise comparison of the composed risk mitigation strategies to select the most suitable for the conditions by considering the sustainable dimensions. The methods as follows:

1. Observation and Interview

Observation is used to observe the business process in PTPN X Unit PG. Modjopanggoong. In particular, the observation focuses in the procurement activity. Observation was carried out for mapping the activity of procurement based on the SCOR model.

Interview was carried out in order to identify and make sure whether the risks potentially disrupt the procurement activity and also to compose the risk mitigations strategy by considering the sustainability criteria.

2. Questionnaire

To fulfill the risk assessment calculation input, researcher needs to collect the data regarding to the risk events' severity level and also risk agents' occurrence level based on FMEA method. Then the next questionnaire is to give assessment the relationship between the risk events and risk agents based on HOQ model. These assessments were used as the input of HOR phase 1 to find out the ARP value to prioritize the risks which has big contribution in disrupting the procurement activity. Furthermore, the prioritized risk responded with risk mitigations strategies; then data collection using questionnaire also carried out in ANP phase for pairwise comparison, both criteria and alternatives.

3.6 Data Processing

In this research, there were two data processing that performed to get the result in supply chain risk management process; namely, HOR phase 1 as the risk assessment stage by combining FMEA and HOQ to get the rank of risk agents which contribute greatly based on ARP value. Moreover, composed risk mitigation strategies to respond the ranked risks. In order to maintain company sustainability, the ANP were adopted to perform pairwise comparison both criteria and risk mitigations strategy as the alternatives by considering environment, economic, and social.

3.6.1 House of Risk

A. HOR1

Based on the method that mentioned in chapter 2, data collection was processed in the chapter 4 using HOR phase 1. HOR phase 1 focus on processing data of risk events and causes of risk or risk agents to gain the risks priority based on the weight of ARP. The scale that used for risk assessment is adopted from FMEA using scale 1-5 as in the Table 3.1 and Table 3.2. Furthermore, the result risk events' severity and risk agents' occurrence inputted in HOR1 model in Table 3.4 to be evaluated whether there are correlations between the risk agents and the risk events as the procedure mentioned in the chapter 2 using correlations scale as in Table 3.3. To calculate the ANP value, the formula is mentioned in chapter 2 in Equation 2.1.

Table 3.1 Risk Agent's occurrence level

Rank	Level of Occurrence	Criteria of Occurrence
1	Very Low	Likelihood of Occurrence is 0-25% (The Risk Almost is Never Occurs)
2	Low	Likelihood of Occurrence is 26-50% (The Risk is Rarely Occurs)
3	Moderate	Likelihood of Occurrence is 51-60% (The Risk is Likely Occurs)
4	High	Likelihood of Occurrence is 61-75% (The Risk is Often Occurs)
5	Very High	Likelihood of Occurrence is 76-100% (The Risk is Very Often Occurs)

Table 3.2 Risk Event's severity level

Rank	Level of Severity	Criteria of Severity
1	No Effect	The Risk has no impact on the activity of sugarcane procurement
2	Minor Disruption	The Risk has small impact on the activity of sugarcane procurement
3	Moderate Disruption	The Risk has moderate impact on the activity of sugarcane procurement
4	Major Disruption	The Risk has serious impact on the activity of sugarcane procurement
5	Catastrophic	The Risk has extreme impact on the activity of sugarcane procurement

Table 3.3 Correlations scale between risk events and risk agents

Relationship scale between the risk events and risk agents	
Scale	**Description**
0	There is no relationship between the risk events and risk agents (no correlation)
1	There is relationship between the risk events and risk agents is low (low correlation)
3	There is relationship between the risk events and risk agents is moderate (low correlation)
9	There is relationship between the risk events and risk agents is high (high correlation)

Table 3.4 HOR1 model

Business Process	Risk Event (Ei)	Risk Agents (Aj)							Severity of Risk event i (Si)
		A_1	A_2	A_3	A_4	A_5	A_6	A_7	
Plan	E_1	R_{11}	R_{12}						S_1
	E_2	R_{21}	R_{22}						S_2
Source	E_3	R_{31}							S_3
	E_4	R_{41}							S_4
Make	E_5								S_5
	E_6								S_6
Deliver	E_7								S_7
	E_8								S_8
Return	E_9								S_9
Occurrence of agent j		O_1	O_2	O_3	O_4	O_5	O_6	Oi	
Aggregate risk potential j		ARP_1	ARP_2	ARP_3	ARP_4	ARP_5	ARP_6	ARPj	
Priority rank of agent j									

B. HOR2

In this research, HOR2 were just performed to compose risk mitigation strategies based on the result of HOR1 to find out risks priority that has highest ARP. Risk mitigation strategies composed by discussing with the Manajer Tanaman to respond and treat the prioritized risk agents. The composed risk mitigations strategy will become the alternatives in for multicriteria decision making using ANP that can lead company sustainability by considering sustainability dimensions as criteria.

3.6.2 Analytic Network Process

Analytic Network Process is adopted to select the best risk mitigation strategy for reducing risks and to maintain company supply chain sustainability. The composed risk mitigations strategy gathered from the brainstorming with the Assistant Manajer and Manajer Tanaman were used as the alternatives in ANP model and the sustainable dimensions; namely economic, environement, and social aspects were used as the criteria. The steps of creating ANP in this research as follows:

1. Building a linkage model as hierarchical structure
   In this stage the researcher determines the objectives to be achieved, which is determine the best risk mitigation strategy to reduce risk and maintain sustainability; then determine the relevant criteria based on sustainability dimensions (economic, environment, social); and determine the alternatives based on risk mitigations stragies that have been approved by expert.

2. Generating pairwise comparison questionnaire and calculate the eigenvectors
   In this stage, the researcher give questionnaire to the Manajer Tanaman as the expert or decision maker and the policy maker to fulfill the questionnaire based on the importance level of the nodes in each cluster and the alternatives. The scale that used in pairwise comparison is 1-9 same as AHP, the defition of scale is as shown in Table 3.5. The weight of the priority vector calculated using equation 2.3 in chapter 2.

Table 3.5 The Fundamental Scale of Making Judgement

Priority Scale	Definition
1	Equal
2	Between Equal and Moderate
3	Moderate
4	Between Moderate and Strong
5	Strong
6	Between Strong and Very Strong
7	Very Strong
8	Between Very Strong and Extreme
9	Extreme

Source: adopted from (Adams & Saaty, 2016)

3. Check the consistency ratio is less than 0.1

   If the result is more than 0.1, it means the data is not consistent and need to repeat the data collection process in choosing the best mitigations strategy selection. The equation to check the consistency is mentioned in equation 2.4 and 2.5 in chapter 2.

4. Create supermatrix

   In this step the weights of each node in cluster synthesize into supermatrix that consist of unweighted supermatrix; weighted supermatrix; limit supermatrix to find out the weight of the alternatives.

5. Select the best alternative solution with the highest weight

   The highest weight of the alternative is the best solution to overcome the risk problem and to maintain the sustainability company.

3.6.3 Tools

In this researcher need tools to help researcher processing data by using Microsoft Excel 2016 to process the data that required in HOR phase, and using Superdecisions v2.8 to help researcher build ANP model and process the data; create supermatrix; up to synthesized to gain the best alternative solution. The sequence of stages of research systematically starting from problem identification to conclusion and recommendations can be seen on the Flow Chart shows in Figure 3.1.

3.7 Research Flowchart

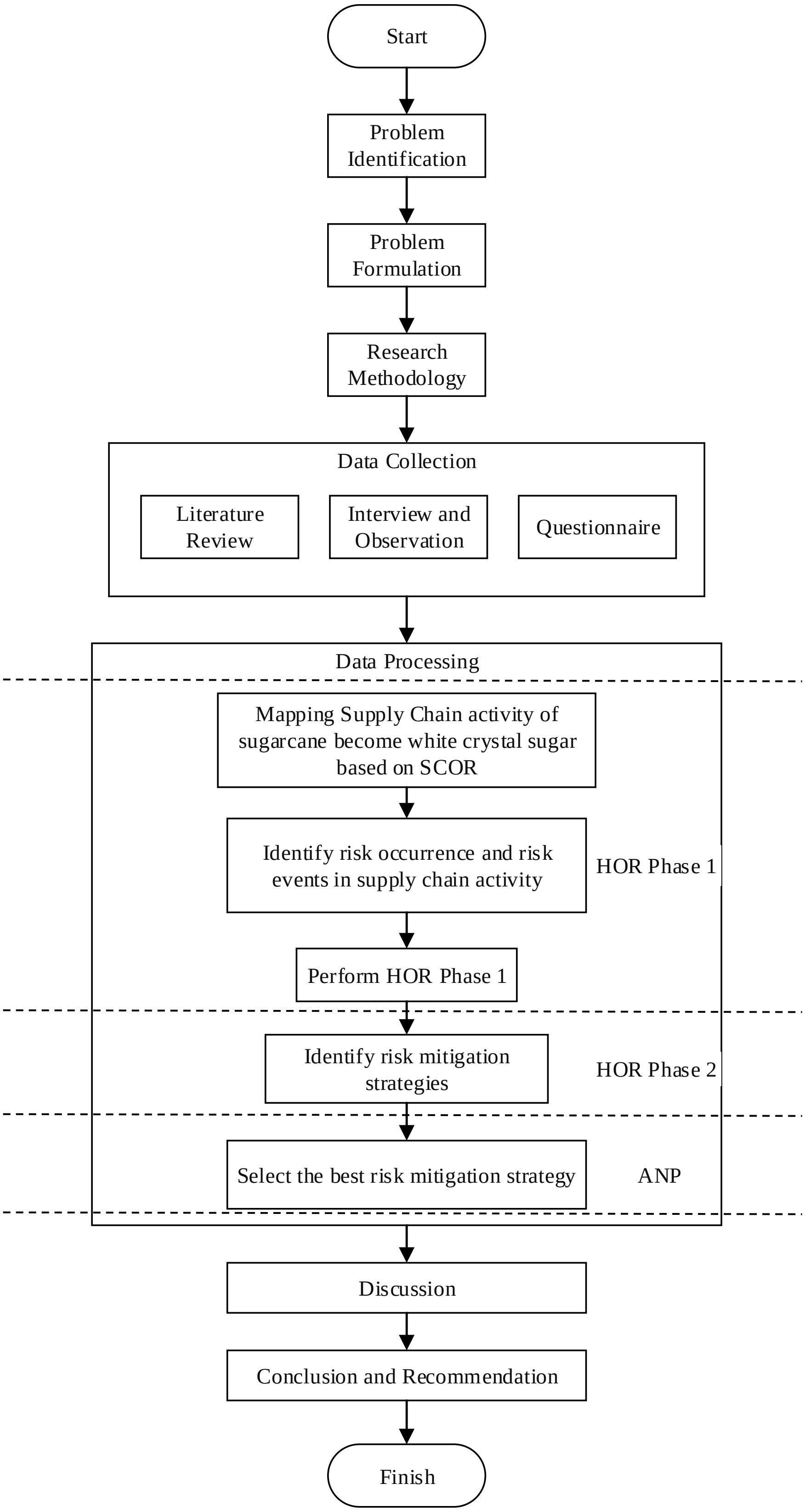

Figure 3.1 Research flowchart

3.8 Discussion

After data processing finished, the next step is analysis and discussion from the result of the calculation that performed using HOR and ANP. In this section explain in detail how the the result of the theory that applied in the selected object. Besides, this section is the basis suggestion in the conclusion and recommendation section.

3.9 Conclusion and Recommendation

This section would provide the answers of all the problem formulations that have been formulated in the beginning of the research, Moreover, there are several suggestions from the researcher to the company and future research.

CHAPTER IV

DATA COLLECTION AND PROCESSING

4.1 Risks Identification

4.1.1 Brief history of Company

PG. Modjopanggoong is one of the sugar business units under the auspices of PTPN X (Persero) under the ministry of State-Owned Enterprises (BUMN). PG. Modjopanggoong was firstly established in 1852 by a Dutchman named Mr. Dinger. In 1957 ownership of PG. Modjopanggoong turned to the Government of Indonesia with a State-Owned Enterprise called PPN until 1968. In 1968 Act No. 23 of 1978 issued the transfer of PPN to PT. Perkebunan (Persero), for the working area of Surabaya and Kediri into one, namely PT. Perkebunan XXI-XXII (Persero). In 1996 after the issuance of PP No. 5 of 1996 merged under PT Perkebunan Nusantara X (Persero). PG Unit Location. Modjopanggoong is in Tulungagung Regency, Kauman District, Sidorejo Village. The main product of the PG unit. Modjopanggoong is white crystal sugar, in Bahasa called as Gula Kristal Putih (GKP). Besides PG's main products. Modjopanggoong is also a byproduct of dregs and drops. The main raw material used to produce GKP is sugar cane. PG Modjopanggoong production system can be seen in Figure 4.1 as follows:

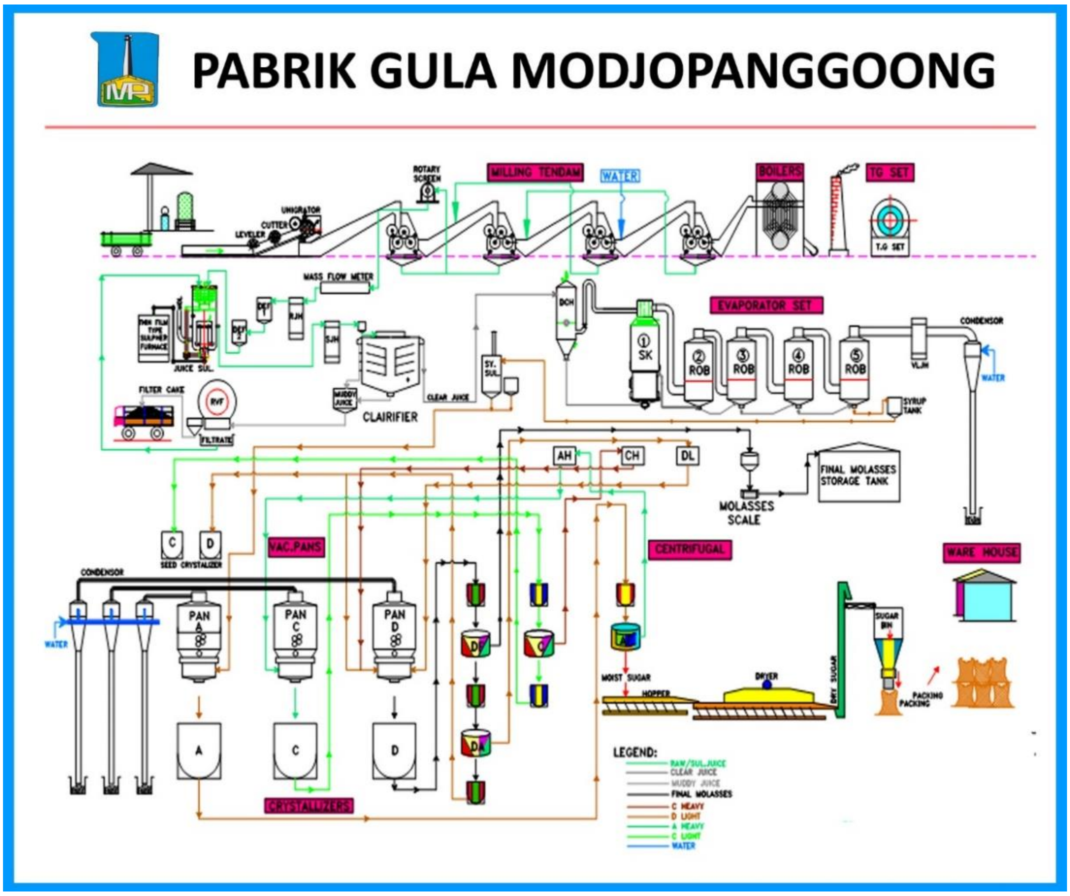

Figure 4.1 PG. Modjopanggoong Production System
Source: PG. Modjopanggoong

4.1.2 Organizational Structure in Unit PG. Modjopanggoong

The implementation of whie crystal sugar production, there are several departments involved in the successful running of milling operations in Unit PG. Modjopanggoong, the picture is shown on Figure 4.2.

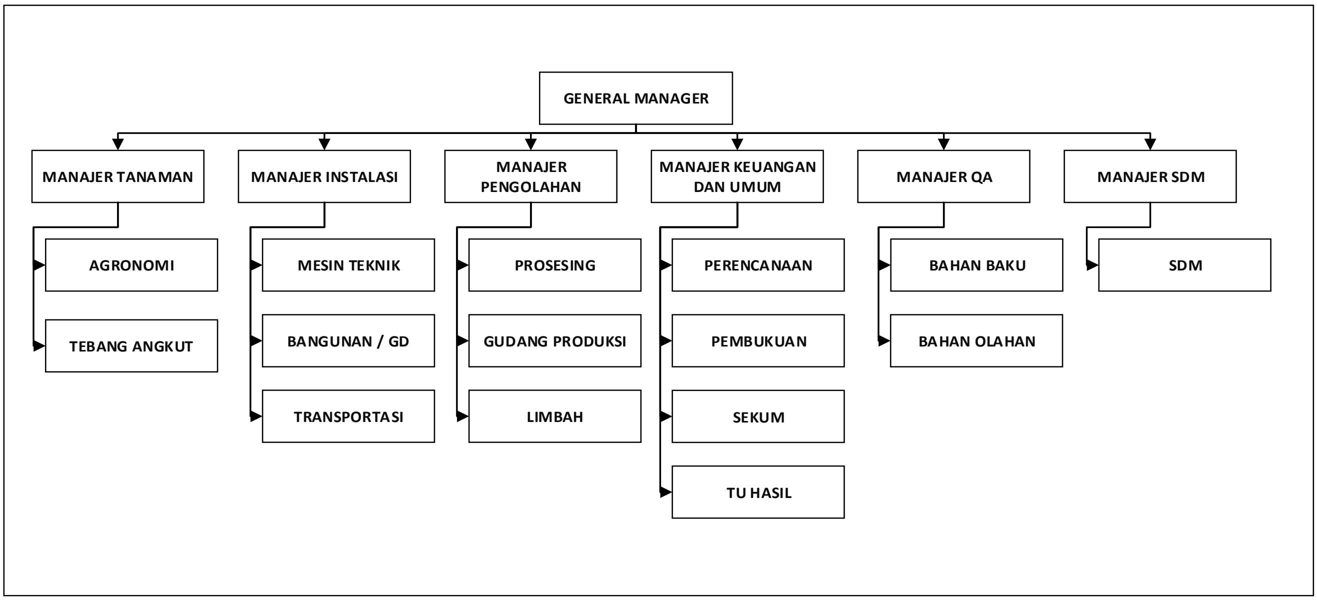

Figure 4.2 Organizational Management in PG. Modjopanggong

Job description of each department in unit PG. Modjopanggoong explained as follows:

1. Bagian Tanaman

   Bagian Tanaman is one department in unit PG. Modjopanggoong that responsible with all related to the raw material sugarcane (BBT) procurement activity. Procurement of raw material sugarcane starts from the process of sugarcane cultivation to harvesting and transporting sugar cane which meets the criteria to be supplied to sugarcane milling machines at PG. Modjopanggoong. Good quality standard of sugar cane raw material, sweet, fresh and clean (MSB).

2. Bagian Instalasi

   Bagian Instalasi is responsible for the operations of milling activities at PG. Modjopanggoong such as electricity in the production process, milling machines, production schedule of the machine, kettle and maintenance of the machines used in grinding operations.

3. Bagian Pengolahan

   Bagian Pengolahan is responsible for the process of processing raw material sugarcane (BBT) which is taken as a white sugar crystal. In addition to the process of processing sap into GKP, this part is also responsible for waste processing.

4. Bagian Administrasi, Keuangan, dan Umum (AKU)
   Bagian AKU responsible for the flow of funds and work at PG. Modjopanggoong. There are four sub-sections that have their respective responsibilities such as Planning and Control (PP), Accounting, Secretariat & General, and Administration of Results and Warehouses.

5. Bagian Quality Control and Assurance (QA)
   Bagian QA responsible for On Farm and Off Farm activities. On Farm activities are activities carried out starting from the procurement of raw material sugarcane such as mapping in sugarcane cultivation areas, while Off Farm is a milling operation where this part is responsible for the quality and standard of sugar that is suitable for sale based on Indonesian National Standard (SNI).

6. Bagian Sumber Daya Manusia (SDM)
   Bagian SDM responsible for managing the emphasis on employee salaries, coordination between sections, providing training, and employee performance evaluation at PG. Modjopanggoong.

4.1.3 Supply Chain mapping in PG. Modjopanggoong

In the process of producing sugar in unit PG. Modjopanggoong, the Sugarcane that supplied into milling cane is imported from three sources, including the Public's Sugar Cane (TR), Company unit Sugar Cane (TS), and Sugar Cane Outside the Region. In order to maintain the quality of raw material sugarcane, there is always coordination with working partner or stakeholders between internal parts and stakeholders, one of which is a sugar cane farmer.

In the supply chain of GKP in PTPN X, there are three actors that involve in the supply chain scope; namely, sugarcane farmers, industry, and the investor. Sugarcane that produced in each unit in PTPN X such as PG. Modjopanggoong in the cane growing process is carried out by sugarcane farmer then it is supplied in milling machine to produce white crystal sugar, then marketed in the office center to the broker. In general, the supply chain activity in sugar industry is the same, the flow sugarcane supply chain from sourcing the sugarcane until it is produced into sugar and sold in market can be seen on figure 4.3:

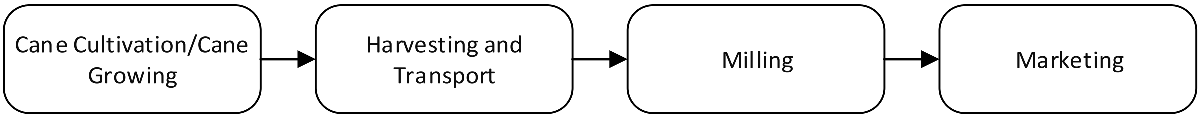

Figure 4.3 Supply Chain activity in PG. Mojopanggong until marketed by Office Center
Source: adapted from (Everingham, et al., 2002)

In the milling operations of sugarcane, unit PG. Modjopanggoong conducted production based on the capability of sugarcane supplied in the Tulungagung area, but sometimes depends on the Director decision from the office center. Unit Modjopanggong just have responsibility to produce sugar as much as it can in order to fulfil GKP demand in Indonesia.

4.1.4 Mapping Business Process of Procurement Activity

Mapping of business processes in raw material procurement activities was carried out through interviews and discussions with Assistant Manajer Tanaman. The SCOR model was adopted for mapping the business process of raw material sugarcane procurement activity start from Plan, Make, Source, Deliver, and Return. The purpose of business process process mapping is to make it easier to identify risks in procurement activities raw material sugarcane in the scope of supply chain in Bagian Tanaman, so that the emergence of risks in each activity of procurement can be known. Based on the results of interview with Assistant Manajer Tanaman, business processes are obtained in the procurement of goods in Table 4.1 as follows.

Table 4.1 Procurment activity in unit PG. Modjopanggoong based on SCOR

Business Process	Sub Process	Detail Activity
Plan	Making Base Number/ Work Plans and Corporate Budgets (RKAP)	Planning Activity in scope of Bagian Tanaman
		Prognose/ Forcast the Cultivation Area
		Prognose/ Forcast total amount of sugarcane
Source	Regional Orientation	Survey to the cultivation region
		Find out the situations and conditions in the region about community activity, occupation, and crops that are often cultivated
	Regional Partnership Meeting Forum (FTK) / Counseling	Counseling with the farmers in order to convey the objectives

Business Process	Sub Process	Detail Activity
		such as to ask community to cultivate sugarcane
Make	Candidates of Area and Farmer (CPCL) Data Collection	Collecting the data of the farmers that interested and agreed to register their field to collaborate with PG. Modjopanggoong
	Registration of Area	Area registration, and check the properness areal (usually work with QA deparment to make map of registered area using GPS)
	Dropping Production Facilities	PG. Modjopanggoong give credits or loan for working costs to the proper farmers (ex: fertilizer, medicine for sugarcane, etc.)
	Realization of Working Costs	Realization or implementation of sugarcane cultivation and using the production facilities such as fertilizer
	Plant Maintenance	Growing the sugarcane in cultivation phase until maturity phase
	Training and Visits	Training and visits the sugarcane areal and give training wheter the sugarcane has fulfill the standard
	Business Valuation in December (Taksasi Desember)	Business Valuation conducted in every December
	Business Valuation in March (Taksasi Maret)	Business Valuation conducted in every March
	Preliminary Analysis	Take the samples of sugarcane to check the maturity of the cane and appropriate to be harvested or crop
		Create schedule for cutting schedule
Deliver	Sugarcane Harvesting Schedule	Harvesting realization
	Sugarcane Transportation to the Factory	Transport and supply the standard sugarcane to PG. Modjopanggoong and ready to mill

4.1.5 Risk Identification

Identification of risk events in this study was carried out by observation and interview with the Assistant Manajer Tanaman based on the risk events that occur on procurement activities.

Then, identification of risk agents from each risk event is conducted. The risk events and risk agents that have been mapped then were consulted to the Manager Tanaman who authorized to make policies on the scope of raw material cane procurement for confirmation whether the identified risks relevant or need to be added based on Manajer Tanaman opinion as the expert. After being confirmed by Manajer Tanaman, the results of the classification of risk agents and risk events in the PG. Modjopanggoong is 14 risk events and 20 risk agents. The list of risk events as shown in Table 4.2.

Table 4.2 Identify Risk Events in procurement acitivity

SCOR	Risk Events
Source	Farmers are not interested in growing sugarcane
	The total area registered is less than the target
Make	The risk of gardening costs payment is disrupted
	The operational cost of gardening is high
	The maturity of sugarcane is uneven
	Some stages of cultivation are not carried out, and usage of alternative fertilizers are not suitable
	The potential of sugarcane pol is reduced, slow maturity phase
	Mechanization system cannot be applied in cultivation & low productivity
	The harvesting schedule does not match with maturity of sugarcane
Deliver	Raw material sugarcane supplied is insufficient with milling cane demand (Jam berhenti A)
	The quality of raw material sugarcane is not as expected
	Cannot apply mechanization in harvesting process
	Potential of non-performing loans
	Sugar that belongs to Manufacturer (GMPG) cannot achieve target (RKAP)

After identifying the risk events in the procurement activity, then assess to the risk events that disrupt procurement activities. Assessment of risk events was carried out to measure the severity level of the risks' impact on procurement activities in unit PG. Modjopanggoong. By adopting the FMEA method, assessment process was conducted by giving a scale of 1-5 to the severity level of risks' impact on procurement activities in Bagian Tanaman, where scale 1 is very small (insignificant) while the scale 5 is very large (catasthropic) so that it is potentially harmful or has big contribution in disturbing procurement activity.

Table 4.3 Risk Assesment on Risk Events

SCOR	Risk Events	Code	Severity
Source	Farmers are not interested in growing sugarcane	**E1**	**5**
	The total area registered is less than the target	**E2**	**5**
Make	The risk of gardening costs payment is disrupted	**E3**	**4**
	The operational cost of gardening is high	**E4**	**4**
	The maturity of sugarcane is uneven	**E5**	**4**
	Several stages of cultivation are not carried out, and usage of alternative fertilizers are not suitable	**E6**	**4**
	The potential of sugarcane pol is reduced, slow maturity phase	**E7**	**4**
	Mechanization system cannot be applied in cultivation & low productivity	**E8**	**3**
	The harvesting schedule does not match with maturity of sugarcane	**E9**	**4**
Deliver	Raw material sugarcane supplied is insufficient with milling cane demand (Jam berhenti A)	**E10**	**5**
	The quality of raw material sugarcane is not as expected	**E11**	**4**
	Cannot apply mechanization in cutting process	**E12**	**2**
	Potential of non-performing loans	**E13**	**4**
	Sugar that belongs to Manufacturer (GMPG) cannot achieve the target (RKAP)	**E14**	**5**

After identifying risk events, the next step is to find out the sources of risk or risk agents that cause risk events. Based on the results of observations and interviews with experts, there were 20 risk agents that triggered risk event were approved by the expert. Assessment of risk agents is also carried out based on the FMEA method by experts with a scale of 1-5 for risk agents, where scale 1 rarely to occur and 5 is almost certain to occur. The Risk Agents list can be seen in the Table 4.3 The questionnaire given to the expert can be seen in the attachment.

Table 4.4 Risk Agents

Code	Risk Agents	Occurrence (Oi)
A1	Sugarcane cultivation margins is less competitive than other commodities	**4**
A2	Many areas of sugarcane crops have shifted to schools, houses, industries, etc.	**2**
A3	The price of sugar is very volatile	**4**
A4	Long Bureaucracy	**3**
A5	Several farmers are reluctant to register their sugarcane with PG. (contract bound)	**4**

Code	Risk Agents	Occurrence (Oi)
A6	Credit agreements among PG, Bank and Sugarcane Farmers Community Cooperative (KPTR) is not repaid timely	**3**
A7	The Banking party is requested PG. as availst	**5**
A8	Credit submission is not in accordance with works on field	**3**
A9	Narrow cultivation area	**4**
A10	Gardening labors are less skillled and limited	**4**
A11	Farmers lack financing and other production facilities (seeds, fertilizer, medicines, etc.)	**4**
A12	Technical irrigation is not available in the most of cultivation area	**4**
A13	Several farmers are reluctant to allow preliminary analysis	**4**
A14	Many of planting data of sugarcane variety are less accurate	**3**
A15	Stem lengthening phase and maturity phase are inhibited	**2**
A16	The number of indigenous sugarcane areas is limited	**5**
A17	The location of sugarcane areas is farm from PG. and scattered	**5**
A18	Registered sugarcane which has been harvested is delivered to competitors (Brown Sugar & Sugarcane shelter)	**5**
A19	The amount of sugarcane supplied has not been achieved according to RKAP	**5**
A20	The sugarcane yield has not been achieved according to RKAP	**2**

4.2 Data Processing using House of Risk

In the data processing step, there are 2 methods that are employed, namely the House of Risk phase 1 to determine the priority of the cause of risks (risk agents) and compose the risk mitigation strategy in the HOR phase 2. Researcher using ANP to select the best alternatives of risk mitigations strategy by considering sustainability dimensions criteria. In processing data on the HOR phase 1, the data involved is risk agents and risk events, while in HOR2 phase is to compose risk mitigation strategy. Furthermore, by using ANP the data involved is risk mitigation strategies as the alternatives with sustainability dimensions (social, economic and environment) as criteria that be considered based on appropriate journal and expert suggestions to select the best strategy for reducing risk and maintain company sustainability.

4.2.1 Data Processing using HOR1

After assessing the Risk Events and Risk Agents, the next step is processing data in the House of Risk phase 1. At the HOR1 stage, an assessment of the correlation between the Risk Agents and Risk Events is based on the level of correlation between risk agents or sources of the risk and causes of the risk agents which is risk events. The correlation values was carried out the same as the HOQ process with a scale of 0, 1, 3, 9. A value of 0 is given if there is no relationship between risk agent and risk events; a value of 1 is given if there is a small correlation, a value of 3 is given if there is a moderate correlation; and a value of 9 is given if the relationship between the source of risk and the incidence of risk is very high. By applying equation 2.1, the ARP calculation results can be seen as ARP calculation 1-9 below. For processing HOR1 as shown in the Table 4.5

1. ARP 1 = 4 x [(9 x (5 + 5 + 5)) + (3 x (3 + 4)) + (1 x (4 + 4 + 4 + 2))] = 740

2. ARP 2 = 2 x [(3 x 5) + (1 x (5 + 5 + 4 + 3 + 4 + 4 + 2 + 4 + 5))] = 134

3. ARP 3 = 4 x [(9 x (5 + 5 + 5)) + (3 x (4 + 5 + 5)) + (1 x (3 + 4 + 2 + 4))] = 724

4. ARP 4 = 3 x [(3 x (5 + 5 + 4)) + (1 x (5 + 4 + 4 + 5))] = 180

5. ARP 5 = 4 x [(9 x 5) + (3 x (5 + 4 + 5)) + (1 x (5 + 4))] = 384

6. ARP 6 = 3 x [(9 x 4) + (3 x (5 + 5)) + (1 x (3 + 4 + 4))] = 231

7. ARP 7 = 5 x [(9 x 4) + (1 x (5 + 4))] = 225

8. ARP 8 = 3 x [(3 x (4 + 4)) + (1 x (3 + 5))] = 96

9. ARP 9 = 4 x [(9 x (5 + 3 + 2)) + (3 x (5 + 5)) + (1 x (4 + 4 + 4 + 5))] = 548

Table 4.5 House of Risk Phase 1

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	Si
E1	9	1	9	3	3	3	0	0	3	0	1	1	0	0	0	0	0	0	0	1	5
E2	9	1	9	3	9	3	1	0	9	1	1	0	0	0	0	0	0	0	0	1	5
E3	1	1	9	3	3	9	9	3	1	0	3	0	0	0	0	0	0	0	0	0	4
E4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	4
E5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	4
E6	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	4
E7	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	4
E8	3	1	1	0	0	1	0	1	9	3	3	3	0	0	0	0	0	0	0	0	3
E9	1	1	3	0	0	0	0	0	1	0	0	0	3	9	0	0	0	0	0	0	4
E10	3	1	3	1	1	0	0	0	3	0	3	0	0	0	0	9	3	9	3	1	5
E11	1	1	1	1	0	1	1	0	1	3	1	0	3	9	3	0	3	1	1	0	4
E12	1	1	1	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	2
E13	3	1	1	1	1	1	0	3	0	0	0	0	0	0	0	0	0	3	0	0	4
E14	9	3	3	1	3	0	0	1	1	0	0	0	0	1	1	9	0	9	9	9	5
Oj	4	2	4	3	4	3	5	3	4	4	4	4	4	3	2	5	5	5	5	2	
ARPj	740	134	724	180	384	231	225	96	548	104	392	56	96	231	58	450	135	590	320	120	
Rank	1	14	2	12	7	9	11	17	4	16	6	20	18	10	19	5	13	3	8	15	

4.2.2 Pareto Chart

In this research, the pareto principle was adopted to find out the 80% of the entire identified risk agents which potentially disrupting in Bagian Tanaman. The pareto principle is used to find which risks that categorized as prioritezed risk that need to be treated or mitigated. In order to categorized which prioritized risk and non-prioritized, the ARP value of each risk agents need to be ranked based on the weight or ARP value. The higher ARP value of risk agent, the higher rank will be. The result of HOR phase 1 is sorted from the highest ARP to the smallest ARP in Table 4.6 below. The 80% of risk agents with the highest ARP value are categorized as prioritized risk that need to be treated.

Table 4.6 Result of HOR1 sorted from highest ARP

Code	Risk Agents	ARPj	Cummulative	Cummulative Percentage
A1	Sugarcane cultivation margins are less competitive than other commodities	**740**	**740**	**12.73**
A3	The price of sugar is very volatile	**724**	**1464**	**25.18**
A18	Registered sugarcane which is cut down is sent to competitors (Brown Sugar & Sugarcane shelter)	**590**	**2054**	**35.33**
A9	Narrow cultivation area	**548**	**2602**	**44.75**
A16	The number of indigenous sugarcane areas are limited	**450**	**3052**	**52.49**
A11	Farmers lack financing and other production facilities (seeds, fertilizer, medicines, etc.)	**392**	**3444**	**59.24**
A5	Several farmers are reluctant to register their sugarcane with PG. (contract bound)	**384**	**3828**	**65.84**
A19	The amount of sugarcane has not been achieved according to RKAP	**320**	**4148**	**71.35**
A6	Credit agreements between PG, Bank and People's Sugarcane Farmers Cooperative (KPTR) are not timely	**231**	**4379**	**75.32**
A14	Many of planting data of sugarcane variety are less accurate	**231**	**4610**	**79.29**
A7	The Banking party is requested PG. as avails	**225**	**4835**	**83.16**
A4	Long Bureaucracy	**180**	**5015**	**86.26**
A17	The location of sugarcane areas is farm from PG. and scattered	**135**	**5150**	**88.58**
A2	Many areas of sugarcane crops have shifted to schools, housing, industries, etc.	**134**	**5284**	**90.88**

Code	Risk Agents	ARPj	Cummulative	Cummulative Percentage
A20	The sugarcane yield has not been achieved accoring to RKAP	**120**	**5404**	**92.95**
A10	Garden labors are less skillled and limited	**104**	**5508**	**94.74**
A8	Credit submission is not in accordance with works on field	**96**	**5604**	**96.39**
A13	Some farmers are reluctant to allow preliminary analysis	**96**	**5700**	**98.04**
A15	Stem lengthening phase and maturity phase are inhibited	**58**	**5758**	**99.04**
A12	The most of located land is not technically irrigated	**56**	**5814**	**100.00**

Based on the Table 4.6 above, there are 10 risk agents which categorized as prioritized risk and 10 risks agent categorized as non-prioritized risk. The result of HOR1 in Table 4.6 then visualized into Pareto chart in Figure 4.4 below.

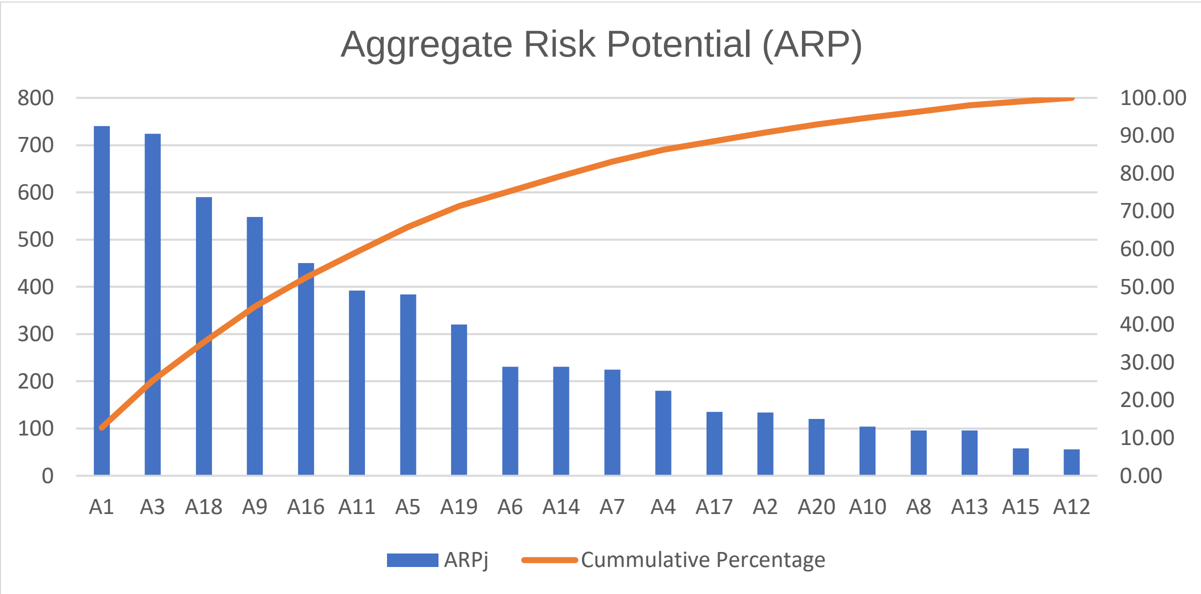

Figure 4.4 Pareto Chart of ARP

The pareto chart above represents the degree of importance to reduce the likelihood of risk agents' occurrence. Certainly, the company have to prioritize those with highest ARP value. Determination of risk priorities was carried out using the Pareto 80:20 rule in which resulted 10 risk agents which have big impact in the activities of raw material sugarcane procurement activity need more attention to be responded.

4.2.3 HOR2 Composing Risk Mitigation Strategies

Since the Risk Agents with high priority has been found, researcher dicussed with the Manajer Tanaman to determine which options are suitable to respond the prioritized risk which contribute greatly disrupt the procurement activity in company supply chain. The list of risks response is on Table 4.7.

Table 4.7 Preventive Action for Risk Response

Response	Code	Preventive Action
Risk Reduction	PA1	Expanding the company unit's sugarcane area (TS) and managed directly by PG. Modjopanggoong gradually
	PA2	Provide sufficient costs for the costs of working on, production facilities, medicines, etc.
	PA3	Increase the amount of sugarcane outside rigion
	PA4	Increasing partnership with local sugarcane farmers
Acceptance	PA5	Accept the risk

The chosen options to respond the risks in this case study are risk reduction and risk acceptance. Since the risk treatment for risk agent A3 and risk agent A5 are not available, the company has to accept the risk as mentioned in Table 4.7 with code PA5. For the rest of prioritized risk agents, risk mitigations strategies (PA1, PA2, PA3, PA4) were composed to reduce the risk agents and lead to maintain company supply chain sustainability. In order to select the best strategy for reducing risk and maintain company SC sustainability, ANP method was employed to make decision in multicriteria environement based on available risk mitigation strategies.

4.3 The Best Strategy Selection using ANP

4.3.1 Build the ANP model

The ANP model designed in this research consists of three levels which is the same as AHP model namely, the goal which is to select the best risk mitigations strategy; criteria that consists of three bottom line of sustainability; namely, social, economic, environmental; then followed by creating sub-criteria of each criteria and the selected alternatives (PA1, PA2, PA3, PA4) obtained from HOR2 stage. The sub-criteria of each sustainability dimensions adopted from (Neven, 2014; Jenkins et al., 2015) as mentioned in Chapter II and combined with subcriteria expected by the Manajer Tanaman to select the best risk mitigation strategy for reducing risk and maintain sustainability. The network model as shown in Figure 4.5 below.

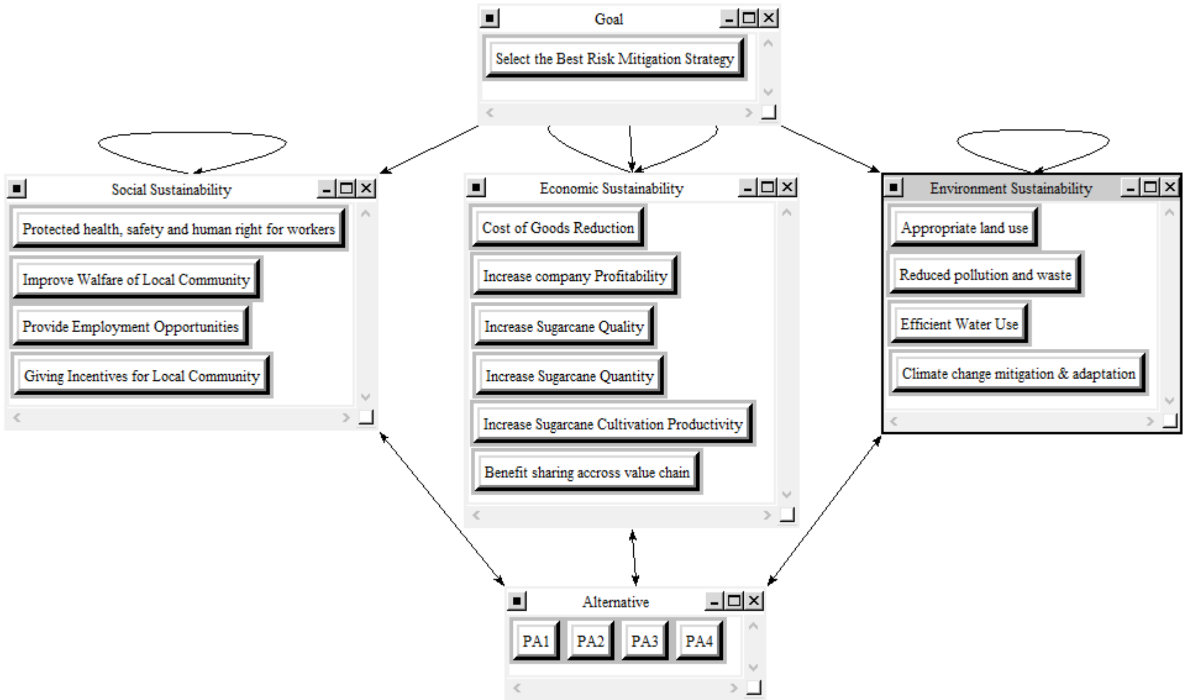

Figure 4.5 Network Model of Best Risk Mitigation Strategy Selection

Based on the Figure 4.5, each cluster consists of set of nodes and arc. The nodes represent sub-criterion of each criteria formed as clusters and arcs represents directed causal influences between connection nodes. Each sub-criteria leaf is given code to adjust the size fit with this research paper as follows in the Table 4.8 and Table 4.9 and Table 4.10 below.

Table 4.8 Economic Sustainability Sub-Criteria

Code	Sub-Criteria Economic
C1	Benefit Sharing Across Value Chain
C2	Cost of Goods Reduction
C3	Increase Company Profitability
C4	Increase Sugarcane Cultivation Productivity
C5	Increase Sugarcane Quality
C6	Increase Sugarcane Quantity

Table 4.9 Environmental Sustainability Criteria

Code	Sub-Criteria Environment
N1	Appropriate Land Use
N2	Climate Change Mitigation & Adaptation
N3	Efficient Water Use
N4	Reduce Pollution and Waste

Table 4.10 Social Sustainability Criteria

Code	Sub-Criteria Social
S1	Giving Incentives to Local Community
S2	Improve Walfare of Local Community
S3	Protected health, safety, and human right for workers
S4	Provide Employment Opportunity

4.3.2 Pairwise comparison and Consistency Test

The second step after construct the the ANP model is carried out pairwise comparison. In this research, pairwise comparison was carried out based on the standard of Saaty's 9-point scale. Then the criteria which have been pairwise compared need to check the consistency value. As mentioned in chapter two the value of inconsistency has to be less than 10% or 0.1 that represents the data is consistent. Yet, if collected data has been pairwise compared but the the result of inconsistency test is more than 0.1, researcher need to repeat data collection stage until the result of inconsistency test is less than 0.1.

A. Prioritization of the main criteria

The second stage after construct the ANP model, it is necessary to conduct pairwise comparison among the main criteria to find out which criteria of sustainability dimensions need to be prioritized. Table 4.11 represents the pairwise comparison matrix of the three main criteria of sustainability dimensions, and also the inconsistency test to ensure the data collection is acceptable with value less than 0.1. Based on the result in Table 4.11, it can be interpreted that economic sustainability is considered equally to moderately more important than the environmental, and is moderately more important than social sustainability. Moreover, the environemental sustainability is equally as important as social sustainability.

Table 4.11 Pairwise Comparison of the three main criteria w.r.t. Goal

	Economic Sustainability	Enviromental Sustainability	Social Sustainability	Priority Weight	Inconsistency
Economic Sustainability	1	2	3	0.5499	0.0176
Enviromental Sustainability	1/2	1	1	0.2402	
Social Sustainability	1/3	1	1	0.2098	

B. The Economic Sustainability Criteria and Sub-Criteria

According to literature review shown on Figure 2.3 in Chapter II, Economic outcomes within sustainability dimensions in sugar production consists of profitability and equitable benefit sharing all along the supply chain (FAO, 2014; Jenkins et al., 2015). Besides, the Manajer Tanaman as the expert accepted them as sub-criteria and added several sub-criteria to reduce the risks in procurement and lead company to sustainability by considering cost of goods reduction, increase productivity of sugarcane, increase quality of cane supplied and increase quantity of cane supplied. Therefore, the sub-criteria in the cluster of Economic sutainability within ANP model consists of benefit sharing across the supply chain, cost of goods reduction, company profitability, sugarcane quality, sugarcane quantity and sugarcane cultivation productivity. Pairwise comparison of each nodes/sub-criteria within Economic Sustainability Cluster shown in the Table 4.12.

Table 4.12 Pairwise Comparison of Sub-Criteria within Economic Sustainability

	C1	C2	C3	C4	C5	C6	Priority Weight	Inconsistency
C1	1	1/4	1/4	1/5	1/4	1/4	0.0418	0.06463
C2	4	1	1	1/2	2	3	0.2029	
C3	4	1	1	2	3	3	0.2813	
C4	5	2	1/2	1	3	4	0.2720	
C5	4	1/2	1/3	1/3	1	1/2	0.0939	
C6	4	1/3	1/3	1/4	2	1	0.1081	

Furthermore, since each sub-criterion in the cluster has interdependence with other sub-criteria, the curved arc in Figure 4.5 represents connections among the nodes within the Economic Sustainability Cluster or called as inner dependent. The collected data from questionnaire can be called consistent or no correction in judgements if the value of inconsistency index is less than 0.1. The result of pairwise comparison of Economic Sustainability in summary sub-criteria are shown in Table 4.13. The the matrix of pariwise comparison and the inconsistency index test in detail are shown in detail Appendix A.

Table 4.13 Result of Pairwise Comparison within Economic Sustainability Cluster

Code	Sub-Criterion	Inconsistency Index	Consistency Check
C1	Benefit Sharing Across Value Chain	0.047	Consistent
C2	Cost of Goods Reduction	0.075	Consistent
C3	Increase Company Profitability	0.060	Consistent
C4	Increase Sugarcane Cultivation Productivity	0.032	Consistent
C5	Increase Sugarcane Quality	0.017	Consistent
C6	Increase Sugarcane Quantity	0.042	Consistent

C. Environmental Sustainability

According to literature review shown on the Figure 2.3 in Chapter II, the Environmental outcomes in sugar production sustainability dimensions consists of, efficient water use, reduce pollution and waste, appropriate land use and climate change mitigation and adaptation. Based on discussion with Manajer Tanaman, this research adopts them as sub criteria within Environmental Sustainability Cluster. Pairwise comparison of each nodes/sub-criteria within Environmental Sustainability Cluster shown in the Table 4.13.

Table 4.14 Pairwise Comparison for sub-criteria within Environmental Sustainability

	N1	N2	N3	N4	Priority Weight	Inconsistency
N1	1	1/3	2	3	0.2597	0.06175
N2	3	1	2	3	0.4576	
N3	1/2	1/2	1	2	0.1789	
N4	1/3	1/3	1/2	1	0.1038	

Furthermore, since each sub-criterion in the cluster has interdependence with other sub-criteria, the curved arc in Figure 4.5 represents connections among the nodes within the Environemental Sustainability Cluster or called as inner dependent. The collected data from questionnaire can be called consistent or no correction in judgements if the value of inconsistency index is less than 0.1. The result of pairwise comparison of Environment Sustainability in summary sub-criteria are shown in Table 4.15. The the matrix of pariwise comparison and the inconsistency index test in detail are shown in detail Appendix B.

Table 4.15 Result of Pairwise Comparison within Environmental Sustainability Cluster

Code	Sub-Criterion	Inconsistency Index	Consistency Check
N1	Appropriate Land Use	0.052	Consistent
N2	Climate Change Mitigation & Adaptation	0.052	Consistent
N3	Efficient Water Use	0.009	Consistent
N4	Reduce Pollution and Waste	0.000	Consistent

D. Social Sustainability

According to literature review shown on the Figure 2.3 in Chapter II, the social outcomes in sugar production sustainability dimensions consists of, secure land rights, protected health, safety and human rights for workers, no child or forced labor, Giving Incentives to Local Community and gender equity. After discussed with Manajer Tanaman, this research adopted protected health, safety, and human rights for workers and Giving Incentives to Local Community as sub criteria within Social Sustainability Cluster. Furthermore, the other sub-criteria added into Social Sustainability based on Manajer Tanaman consideration are Improve Walfare of Local Community and Provide Employment Opportunity. Pairwise comparison of each sub-criteria within Social Sustainability Cluster shown in the Table 4.14.

Table 4.16 Pairwise Comparison for sub-criteria within Social

	S1	S2	S3	S4	Priority Weight	Inconsistency
S1	1	1/3	2	4	0.4912	0.06395
S2	3	1	1	1	0.1612	
S3	½	1/2	1	1/2	0.1582	
S4	1/3	1/3	1/2	1	0.1894	

Furthermore, since each sub-criterion in the cluster has interdependence with other sub-criteria, the curved arrow in Figure 4.5 represents connections among the nodes within the Social Sustainability Cluster or called as inner dependent. The collected data from questionnaire can be called consistent or no correction in judgements if the value of inconsistency index is less than 0.1. The result of pairwise comparison of Social Sustainability in summary sub-criteria are shown in Table 4.17. The the matrix of pariwise comparison and the inconsistency index test in detail are shown in detail Appendix C.

Table 4.17 Result of Pairwise Comparison within Social Sustainability Cluster

Code	Sub-Criterion	Inconsistency Index	Consistency Check
S1	Giving Incentives to Local Community	0.000	Consistent
S2	Improve Walfare of Local Community	0.052	Consistent
S3	Protected health, safety, and human right for workers	0.000	Consistent
S4	Provide Employment Opportunity	0.052	Consistent

E. Pairwise Comparison of Alternatives

As mentioned in the Table 4.7, the preventive actions to respond the risks are used to mitigate risks and used as the alternatives in ANP model. In this stage the alternatives are pairwise compared w.r.t. all leaf of sub-criteria in each criteria cluster of sustainability dimensions. Since the structure is the same as AHP, the alternatives are pairwise compared to find out the priority weight based on sub-criteria within each sustainability clusters. The result of pairwise comparison of alternatives w.r.t. the entire leaf of sub-criteria is shown in Table 4.18. For the pairwise comparison matrix, the priority weight and inconsistency index test are shown in Appendix D in detail.

Table 4.18 Pairwise Comparison Alternatives w.r.t Sub-Criteria

Code	Sub-Criterion	Inconsistency Index	Consistency Check
C1	Benefit Sharing Across Value Chain	0.044	Consistent
C2	Cost of Goods Reduction	0.079	Consistent
C3	Increase Company Profitability	0.042	Consistent
C4	Increase Sugarcane Cultivation Productivity	0.066	Consistent
C5	Increase Sugarcane Quality	0.058	Consistent
C6	Increase Sugarcane Quantity	0.074	Consistent
N1	Appropriate Land Use	0.060	Consistent
N2	Climate Change Mitigation & Adoption	0.060	Consistent
N3	Efficient Water Use	0.033	Consistent
N4	Reduce Pollution and Waste	0.030	Consistent
S1	Giving Incentives to Local Community	0.033	Consistent
S2	Improve Walfare of Local Community	0.033	Consistent
S3	Protected health, safety, and human right for workers	0.054	Consistent
S4	Provide Employment Opportunity	0.060	Consistent

F. Pairwise Comparison of Sub-Criteria w.r.t. Alternatives

In order to complete the super matrix, it is required to conduct pairwise comparison the sub-criteria in cluster with respect to alternatives cluster. The arcs from four nodes in alternatives cluster toward all of leaf of sub-criteria within each sustainability cluster shown in Figure 4.5 represents there are feedback which can be conducted using ANP instead of AHP. The summarized pairwise comparison and priority weight of fifteen subcriteria w.r.t. the four alternatives respectively are shown in Table 4.16 and the calculation are shown in Appendix E in detail.

Table 4.19 Pairiwise Comparison Criteria w.r.t. Alternatives

Alternatives	Cluster	Inconsistency Index	Consistency Check
PA1	Economic	0.033	Consistent
	Environment	0.069	Consistent
	Social	0.058	Consistent
PA2	Economic	0.074	Consistent
	Environment	0.045	Consistent
	Social	0.062	Consistent
PA3	Economic	0.059	Consistent
	Environment	0.062	Consistent
	Social	0.030	Consistent
PA4	Economic	0.062	Consistent
	Environment	0.066	Consistent
	Social	0.054	Consistent

4.3.3 Create Supermatrix

After each sub-criteria and alternatives have been pairwise compared and the inconsistency value is acceptable which is less than 0.1, the next stage is to create supermatrix. Supermatrix consists of three stage; namely, unweighted supermatrix, weighted supermatrix and limit super matrix. Supermatrices consists of the nodes inside clusters that sorted in alphabetical order across the top and down the left side formed as matrix.

In general, the first step in super matrix is unweighted supermatrix. The initial supermatrix or unweighted supermatrix is shown in Table 4.20. For instance, the priorities of the elements in Economic Sustainability Criteria represents with Code C w.r.t. Goal are shown in the first row first coloumn from left. The result shown that C3 has the highest value which is 0.281 over other sub-criteria within Economic Cluster. The value itself is obtained from the pairwise comparison on the nodes within the Economic Sustainability Cluster. This may be interpreted with statement, “C3 is slightly preferable than C4; moderately preferable than C2 and it is also dominant preferred than C1, C5 and C6.

The next supermatrix is weighted supermatrix. The unweighted supermatrix which composed of several eigenvectors are summed up to 1.0 then must be weighted and transformed to a matrix in which each of its columns sums to unity. To distinguish the difference, unweighted supermatrix is shown in Table 4.20 and weighted supermatrix is shown in Table 4.21.

The last step in of supermatrix is Limit Matrix. The weighted supermatrix is raised to limiting power to get global priority vectors. In order to find the value in limit suparmatrix, the equation 2.8 in Chapter II is adopted. The limit supermatrix is shown in Table 4.22

4.3.4 Synthesize

After supermatrix stage has finished, the next step is to synthesize the model. The computations synthesize command displays the final results in three ways as shown in Figure 4.6. Raw coloumn represents level of priority from limit supermatrix in Table 4.22, Normals coloumn represents the normalized results from cluster coloumn and Ideals coloumn results obtained from deviding the values either the normalized or limiting columns by the largest value in the column (Adams & Saaty, 2016). Based on this result, the highest priority value of Risk Mitigations Strategies in Alternatives Cluster will be selected to treat the priority risks from data processing using HOR1 in the scope of procurement activity. The overall synthesized shown in Figure 4.6 below.

Name	Graphic	Ideals	Normals	Raw
PA1		1.000000	0.480214	0.160071
PA2		0.385950	0.185339	0.061780
PA3		0.199786	0.095940	0.031980
PA4		0.496669	0.238508	0.079503

Figure 4.6 Overall synthesized priorities for the Alternatives

Table 4.20 Unweighted Super Matrix of Risk Mitigation Strategies

		Goal	Criteria														Alternatives			
		Best	C1	C2	C3	C4	C5	C6	N1	N2	N3	N4	S1	S2	S3	S4	PA1	PA2	PA3	PA4
Goal	Best	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Criteria	C1	0.042	0.000	0.085	0.079	0.064	0.085	0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.050	0.355	0.359	0.333
	C2	0.203	0.077	0.000	0.188	0.122	0.127	0.147	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.083	0.058	0.131	0.126
	C3	0.281	0.261	0.133	0.000	0.324	0.330	0.300	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.204	0.208	0.071	0.087
	C4	0.272	0.344	0.302	0.336	0.000	0.330	0.223	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.266	0.194	0.075	0.210
	C5	0.094	0.217	0.178	0.212	0.255	0.000	0.251	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.184	0.092	0.152	0.078
	C6	0.108	0.102	0.302	0.185	0.235	0.127	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.212	0.095	0.213	0.166
	N1	0.260	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.249	0.540	0.600	0.000	0.000	0.000	0.000	0.203	0.439	0.410	0.461
	N2	0.458	0.000	0.000	0.000	0.000	0.000	0.000	0.594	0.000	0.297	0.200	0.000	0.000	0.000	0.000	0.485	0.146	0.301	0.262
	N3	0.179	0.000	0.000	0.000	0.000	0.000	0.000	0.249	0.594	0.000	0.200	0.000	0.000	0.000	0.000	0.171	0.311	0.171	0.124
	N4	0.104	0.000	0.000	0.000	0.000	0.000	0.000	0.157	0.157	0.163	0.000	0.000	0.000	0.000	0.000	0.141	0.104	0.118	0.153
	S1	0.491	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.249	0.143	0.249	0.487	0.123	0.534	0.458
	S2	0.161	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.429	0.000	0.429	0.594	0.208	0.289	0.102	0.240
	S3	0.158	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.143	0.157	0.000	0.157	0.096	0.420	0.218	0.116
	S3	0.189	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.429	0.594	0.429	0.000	0.208	0.168	0.145	0.185
Alternatives	PA1	0.000	0.235	0.323	0.541	0.502	0.559	0.533	0.502	0.469	0.511	0.454	0.508	0.508	0.443	0.502	0.000	0.000	0.000	0.000
	PA2	0.000	0.217	0.159	0.154	0.252	0.238	0.181	0.138	0.252	0.131	0.197	0.154	0.154	0.183	0.138	0.000	0.000	0.000	0.000
	PA3	0.000	0.097	0.086	0.076	0.102	0.102	0.124	0.090	0.084	0.111	0.107	0.093	0.093	0.096	0.090	0.000	0.000	0.000	0.000
	PA4	0.000	0.452	0.431	0.230	0.143	0.102	0.161	0.270	0.194	0.247	0.242	0.245	0.245	0.278	0.270	0.000	0.000	0.000	0.000

Table 4.21 Weighted Super Matrix of Risk Mitigation Strategies

		Goal	Criteria														Alternatives			
		Best	C1	C2	C3	C4	C5	C6	N1	N2	N3	N4	S1	S2	S3	S4	PA1	PA2	PA3	PA4
Goal	Best	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Criteria	C1	0.023	0.000	0.042	0.040	0.032	0.043	0.040	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.027	0.191	0.193	0.180
	C2	0.112	0.039	0.000	0.094	0.061	0.063	0.073	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.045	0.031	0.070	0.068
	C3	0.155	0.130	0.066	0.000	0.162	0.165	0.150	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.110	0.112	0.038	0.047
	C4	0.150	0.172	0.151	0.168	0.000	0.165	0.112	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.144	0.105	0.040	0.113
	C5	0.052	0.108	0.089	0.106	0.128	0.000	0.125	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.099	0.050	0.082	0.042
	C6	0.059	0.051	0.151	0.092	0.117	0.063	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.115	0.051	0.115	0.090
	N1	0.062	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.125	0.270	0.300	0.000	0.000	0.000	0.000	0.033	0.072	0.067	0.075
	N2	0.110	0.000	0.000	0.000	0.000	0.000	0.000	0.297	0.000	0.148	0.100	0.000	0.000	0.000	0.000	0.079	0.024	0.049	0.043
	N3	0.043	0.000	0.000	0.000	0.000	0.000	0.000	0.125	0.297	0.000	0.100	0.000	0.000	0.000	0.000	0.028	0.051	0.028	0.020
	N4	0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.079	0.079	0.082	0.000	0.000	0.000	0.000	0.000	0.023	0.017	0.019	0.025
	S1	0.103	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.125	0.071	0.125	0.145	0.037	0.159	0.136
	S2	0.034	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.214	0.000	0.214	0.297	0.062	0.086	0.030	0.071
	S3	0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.071	0.079	0.000	0.079	0.028	0.125	0.065	0.035
	S4	0.040	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.214	0.297	0.214	0.000	0.062	0.050	0.043	0.055
Alternatives	PA1	0.000	0.117	0.162	0.270	0.251	0.280	0.267	0.251	0.235	0.255	0.227	0.254	0.254	0.222	0.251	0.000	0.000	0.000	0.000
	PA2	0.000	0.108	0.080	0.077	0.126	0.119	0.091	0.069	0.126	0.066	0.099	0.077	0.077	0.091	0.069	0.000	0.000	0.000	0.000
	PA3	0.000	0.048	0.043	0.038	0.051	0.051	0.062	0.045	0.042	0.055	0.054	0.046	0.046	0.048	0.045	0.000	0.000	0.000	0.000
	PA4	0.000	0.226	0.215	0.115	0.072	0.051	0.081	0.135	0.097	0.124	0.121	0.122	0.122	0.139	0.135	0.000	0.000	0.000	0.000

Table 4.22 Limit Matrix of Risk Mitigation Strategies

		Goal					**Criteria**											**Alternatives**		
		Best	C1	C2	C3	C4	C5	C6	N1	N2	N3	N4	S1	S2	S3	S4	PA1	PA2	PA3	PA4
Goal	Best	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Criteria	C1	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
	C2	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
	C3	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071
	C4	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082
	C5	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059
	C6	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061
	N1	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
	N2	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
	N3	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026
	N4	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
	S1	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057
	S2	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057
	S3	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
	S4	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054
Alternatives	PA1	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160
	PA2	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062
	PA3	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
	PA4	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080

CHAPTER V

ANALYSIS AND DISCUSSION

5.1 Identified Risks in Procurement Activity

Regarding to the research that has been conducted, there are 14 risk events with the level of severity caused by each risk events itself and 20 sources of the risk or risk agents with the level of occurrence or likelihood that causes risk events that shown in Table 4.3 and Table 4.4. Risks that have been identified within the scope in Bagian Tanaman, potentially disrupting procurement activity of raw material sugarcane possibly affect the amount of raw material sugarcane that supplied into sugarcane milling machine in Unit PG. Modjopanggoong.

Based on the SCOR model that adopted in this study, there are 2 risk events in the source process business, then there are 7 risk events in the make business process, and the last there are 5 risk events in the deliver business process. The mapping of risk events using SCOR model was limited to the scope of procurement activity, so that identified risks are limited ranging from finding land for sugarcane cultivation, sugar cane production or cultivation until transport sugarcane from the cultivation site to the manufacturer to be supplied in the sugarcane milling.

Based on the results, the risk events identified in each business process were then assessed to be grouped into category based on the level of impact caused. In the process of risk assessment that has been carried out in Chapter IV, there are 4 risk events that have a severity level 5, 8 risk events with severity 4, 1 risk with severity 3 and 1 risk with severity 2, for more details, see table 5.1. Furthermore, the source of risk or risk agents that have been identified were also assessed to be classified based on likelihood or occurrence of risks. There are 5 risk agents that have level of occurrence with value 5, there are 8 risk agents with level of occurrence with value 4, there are 3 risk agents with level of occurrence with value 3 and 3 risk agents with level of occureence with value 2. For more details, see table 5.2

Table 5.1 Category of Risk Events based on Level of Severity

Rank	Severity Level	Risk Events
1	Insignificant	
2	Minor	E12
3	Moderate	E8
4	Major	E3, E4, E5, E6, E7, E9
5	Catastrophic	E1, E2, E10, E14

Table 5.2 Category of Risk Agents based on Level of Occurrence

Rank	Occurrence	Risk Agents
1	Rare	-
2	Unlikely	A2, A15, A20
3	Possible	A4, A6, A8, A14
4	Likely	A1, A3, A5, A9, A10, A11, A12, A13
5	Almost certain	A7, A16, A17, A18, A19

5.2 Risk Prioritization using HOR

In order to find out the prioritized risks in the raw material sugarcane procurement activity in Unit PG. Modjopanggoong, data processing of HOR phase 1 was conducted. Both of risk events and risk agents were used as input in HOR framework phase 1. The assessment which conducted in HOR phase 1 is based on combination of FMEA and HOQ. In FMEA phase, the risk events and risk agents assessed using FMEA scale to find out the severity level of risk events and occurrence level of risk agents. Furthermore, the risk agents and risk events are assessed based on their correlation using HOQ scale. Since one risk agent could lead more than one risk events, reducing risk agents' occurrence would typically prevent several risk events to occur (Pujawan & Geraldin, 2009). Risk Agents' priority need to be responded in HOR phase 1 is ranked based on the score of Aggregate Risk Potential (ARP). The higher ARP value of Risk Agents; the higher rank the risk to be prioritized. After ARP value of each Risk Agents has been obtained from data processing, it visualized into Pareto Chart to determine the risk that has dominant impact in the raw material sugarcane procurement activity. By using pareto rule 80:20, 80% of total ARP which contributes in disrupting procurement activity were picked to be prioritized to be responded. The list of prioritized risk agents is on the table 5.3 below:

Table 5.3 Rank of Prioritized Risk based on ARP value

Code	Risk Agents	ARPj	Cummulative Percentage	
A1	Sugarcane cultivation margins are less competitive than other commodities	**740**	**12.73**	**Prioritized Risk**
A3	The price of sugar is very volatile	**724**	**25.18**	
A18	Registered sugarcane which is cut down is sent to competitors (Brown Sugar & Sugarcane shelter)	**590**	**35.33**	
A9	Narrow cultivation area	**548**	**44.75**	
A16	The number of indigenous sugarcane areas are limited	**450**	**52.49**	
A11	Farmers lack financing and other production facilities (seeds, fertilizer, medicines, etc.)	**392**	**59.24**	
A5	Several farmers are reluctant to register their sugarcane with PG. (contract bound)	**384**	**65.84**	
A19	The amount of sugarcane has not been achieved according to RKAP	**320**	**71.35**	
A6	Credit agreements between PG, Bank and People's Sugarcane Farmers Cooperative (KPTR) is not repaid timely	**231**	**75.32**	
A14	Many of planting data of sugarcane variety are less accurate	**231**	**79.29**	

Based on the calculation of HOR phase 1 in Chapter IV, the ARP value of each risk agent obtained. The priority rank of risk agents is based on the magnitude of the ARP value of each risk agent in Table 5.3. The result shows that there are two risk agents with ARP more than 700, two risk agents with ARP value between 700 and 500, four risk agents with ARP value between 500 and 300 and the rests have ARP value below 300. Further analysis shows that there are ten risk agents contribute about 80% of total ARP. Description of prioritized risk agent in Table 5.3 as follows:

1. Sugarcane cultivation margins are less competitive than other commodities (A1)
   Risk Agent A1 has the highest ARP score which is 740 and also contributes 12.73% affecting procurement activity of the entire risk agents, therefore it becomes the 1st rank

of risk agents that need to be prioritized. Risk Agent A1 has high correlations with several risk events namely; farmers are not interested in growing sugarcane (E1), the total area registered is less than the target (E2), Sugar that belongs to Manufacturer (GMPG) cannot achieve target (RKAP) (E14). The risk events that identified are mostly caused and affected by sugarcane cultivation margins are less competitive than other commodities. When the margins of sugarcane cultivation reduce and cannot compete with other commodities, farmer's interest level in growing sugarcane also reduces. Besides, the less sugarcane cultivation margins also the less the target of total area that registered, then the sugar that produces in PG. Modjopanggoong also reduces and cannot achieve RKAP target. Risk agent A1 also has moderate correlations with several risk agents; namely, mechaization system cannot be applied in cultivation & low productivity (E8), raw material sugarcane supplied is insufficient with milling cane demand (Jam berhenti A) (E10). Risk agent A1 also influences application of mechanization and insufficient cutting capacity but the impact in risk event is not big. Risk Agents A1 also has low correlations with several risk events; namely, the risk of gardening costs payment is disrupted (E3), the harvesting schedule does not match with maturity of sugarcane (E9), the quality of raw material sugarcane is not as expected (E11), cannot apply mechanization in harvesting process (E12).

2. The price of sugar is very volatile (A3)

   Risk Agent (A3) has the second highest ARP which is 724 and also contributes 12.45% with cumulative percentage 25.18% of entire risk agents that affecting procurement activity. Risk agent A3 has high correlations with several risk events; namely, farmers are not interested in growing sugarcane (E1), total area registered is less than the target (E2), the risk of gardening costs payment is disrupted (E3). When the price of sugar is easily volatile, that will affect the level of intest for farmers to cultivating or growing sugarcane, similarly with the total of registered sugarcane field also less then target, and also the gardening costs payment is disrupted because it influences the farmers' income. Risk agent A18 also has moderate correlations with several risk event that are, the harvesting schedule does not match with maturity of sugarcane (E9), raw material sugarcane supplied is insufficient with milling cane demand (Jam berhenti A) (E10), sugar that belongs to Manufacturer (GMPG) cannot achieve target (RKAP) (E14). Risk agent A18 also has low correlations with several risk events; namely, mechanization system cannot be applied in cultivation & low productivity (E8), the quality of raw material sugarcane is not as expected (E11), cannot apply machanization in cutting process (E12), potential of non-performing loans (E13).

3. Registered sugarcane which is cut down is sent to competitors (Brown Sugar & Sugarcane shelter) (A18)

   Risk agent A18 has the third highest ARP which is 590 and also contributes 10.15% with cumulative percentage 35.33% of entire risk agents that affecting procurement acitivity. Risk agent A18 has high correlations with raw material sugarcane supplied is insufficient with milling cane demand (Jam berhenti A) (E10) and Sugar that belongs to Manufacturer (GMPG) cannot achieve target (RKAP) (E14). Risk events that mentioned above significantly triggered by the existance of competitors Brown Sugar industry and sugar shelter. When the sugarcane farmers supply the mature cane to the competitors, the demand of cane milling machine in PG. Modjopanggoong which is 2850 TCD cannot be fulfilled and can cause idle time and cost production redundant. Risk agent A18 also has moderate correlations with the maturity of sugarcane is uneven (E5) and potential of non-performing loans (E13). Risk agent A18 also has low correlations with the quality of raw material sugarcane is not as expected (E11).

4. Narrow land area (A9)

   Risk agent A9 has the fourth highest ARP which is 392 and also contributes 9.42% with cumulative percentage 44.75% of entire risk agents that affecting procurement acitivity. Risk agent A9 has high correlations with several risk events; namely, the total area registered is less than the target (E2), Mechanization system cannot be applied in cultivation & low productivity (E8), Cannot apply machanization in harvesting process (E12). Narrow land area potentially has big impact with the total registered area less than target because the amount of cultivated sugarcane will be less than target. The narrower area, the more difficult application of mechanization in cultivation and cutting process, because the mechanization needs large field. Risk agent A9 also has moderate correlations with two risk events; namely, farmers are not intersted in growing sugarcane (E1) and raw material sugarcane supplied is insufficient with milling cane demand (Jam berhenti A) (E10). Risk agent A9 also has low correlations with several risk events; namely, the risk of gardening costs payment is disrupted (E3), The harvesting schedule does not match with maturity of sugarcane (E9), the quality of raw material sugarcane is not as expected (E11), Sugar that belongs to Manufacturer (GMPG) cannot achieve target (RKAP) (E14).

5. The number of indegeneous sugarcane areas are limited (A16)
   Risk agent A16 has the fifth highest ARP which is 450 and also contributes 7.74% with cumulative percentage 52.49% of entire risk agents that affecting procurement acitivity. Risk agent A16 has high correlations with risk events raw material sugarcane supplied is insufficient with milling cane demand (Jam berhenti A) (E10) and sugar that belongs to Manufacturer (GMPG) cannot achieve target (RKAP) (E14). When the number of indigenous sugarcane areas are limited, that would affect the fulfillment of cane milling demand. When supply of sugarcane to milling cane demand cannot be fulfilled, it also makes the idle capacity, redundant cost production and redundant energy. Moreover, the sugar that produced by PG. Modjopanggoong will be less than RKAP, and it prone of bankcruptcy of the company.

6. Farmers lack of financing and other production facilities (seeds, ferlitizer, medicines, etc.) (A11)
   Risk agent A11 has the sixth highest ARP which is 392 and also contributes 6.75% with cumulative percentage 59.24% of entire risk agents that affecting procurement acitivity. Risk agent A11 has high correlations with risk event several stages of cultivation are not carried out, and usage of alternative fertilizers are not suitable (E6). Farmers lack of financing and production facilities causes several stages of cultivation are not carried out or delayed and also the usage of alternative fertilizers is not suitable because of lack of budgets in order to cultivate the sugarcane. Risk agent A11 also has moderate correlations with several risk event that are, the risk of gardening costs payment is disrupted (E3), the potential of sugarcane pol is reduced, slow maturity phase (E7), mechanization system cannot be applied in cultivation & low productivity (E8) and raw material sugarcane supplied is insufficient with milling cane demand (Jam berhenti A) (E10). Risk agent A11 also has low correlations with farmers are not intersted in growing sugarcane (E1), the total area registered is less than the target (E2), the quality of raw material sugarcane is not as expected (E11).

7. Several farmers are reluctant to register their sugarcane with PG. (contract bound) (A5)
   Risk agent A5 has the seventh highest ARP which is 384 and also contributes 6.60% with cumulative percentage 65.84% of entire risk agents that affecting procurement acitivity. Risk agent A5 has high correlations with the total area registered is less than the target (E2). Reluctance of farmers to register their sugarcane with PG. Modjopanggoong directly affecting the total area that must be registered less than target. If the farmers are reluctant to make a contract bound with PG. Modjopanggoong that will reduce total area of sugarcane field that must be supplied to PG. Modjopanggoong. Risk agent A5 also has moderate correlations with farmers are not intersted in growing sugarcane (E1), the risk of gardening costs payment is disrupted (E3) and sugar that belongs to Manufacturer (GMPG) is not in accordance with RKAP (E14). Risk agent A5 has low correlations with raw material sugarcane supplied is insufficient with milling cane demand (Jam berhenti A) (E10) and potential of non-performing loans (E13).

8. The amount of sugarcane has not been achieved according to RKAP (A19)
   Risk agent A19 has the eighth highest ARP which is 320 and also contributes 5.51% with cumulative percentage 71.35% of entire risk agents that affecting procurement acitivity. Risk agent A19 has high correlations with sugar that belongs to Manufacturer (GMPG) is not in accordance with RKAP (E14). The amount of sugarcane has not been achieved according to RKAP directly causes sugar production decrease then sugar that belongs to PG. Modjopanggoong automatically cannot achieve RKAP as targeted. Risk agent A19 also has moderate correlations with raw material sugarcane supplied is insufficient with milling cane demand (Jam berhenti A) (E10) and low corralations with the quality of raw material sugarcane is not as expected (E11).

9. Credit agreement between PG, Bank and Sugarcane Farmer Community Cooperative (KPTR) are not timely (A6)
   Risk agent A6 has the ninth highest ARP which is 231 and also contributes 3.97% with cumulative percentage 75.32% of entire risk agents that affecting procurement acitivity. Risk agent A6 has high correlations with the risk of cultivation costs payment is disrupted (E3). When the credit agreement among company and stakeholders are not paid timely that would affecting cultivation cost payment is disrupted, such as the delay in several cultivation processes. Risk agent A6 also has moderate correlations with farmers are not intersted in growing sugarcane (E1) and the total area registered is less than the target

(E2). Besides, risk agent A6 has low correlations with several risk events that are mechanization system cannot be applied in cultivation & low productivity (E8), the quality of raw material sugarcane is not as expected (E11) and potential of non-performing loans (E13).

10. Many of planting data of sugarcane variety is less accurate (A14)
    The risk agent A14 also has the ninth highest ARP same with A6 which is 231 and also contributes 3.97% of entire risk agents that affecting procurement acitivity. Risk Agent A14 has high correlation with risk events of the harvesting schedule does not match with maturity of sugarcane (E9) and the quality of raw material sugarcane is not as expected (E11). If the sample of sugarcane that used in the business process of Analisa Pendahuluan is not correct, that would impact the the harvesting schedule which taking the optimal maturity of sugar and also the quality of sugarcane cannot be maximized. Risk agent A14 also has low correlation with risk event of sugar that belongs to Manufacturer (GMPG) cannot achieve target (RKAP) (E14), which influence the amount of raw material sugarcane to achieve RKAP by supplying with low yield.

After data processing using HOR phase 1, it results 10 prioritized risk agents to be responded in the risk treatment stage. In this study, there are two risk agents with the same ARP value which is 231; namely, Risk Agent A6 and Risk Agent A14. However, after discussed with Manajer Tanaman, Risk Agent A6 placed in the higher rank which is 9 and A14 placed in rank 10 because A6 potentially causes bigger impact than A14.

5.3 Analysis of The Best Strategy Selection using ANP

In this stage, after obtained Risk Agents that are given priority to be responded, researcher determine response how to give treatment to the prioritized risk. According to study conducted by Curkovic et al. (2013), there are several options included in risk treatment in SCRM based on ISO 31000:2009 framework, such as acceptance of risk to realize competitive advantage; avoidance of risk by not engaging in the activity; reduction or removal of the impact or probability of the risk; distribution of risk by sharing or transferring the risk. In order to respond the prioritized risk, there are two options that adopted; namely, acceptance the risk as mentioned in Table 4.7 with code PA5 and risk reduction by composing suitable risk mitigation strategies mentioned in Table 4.7 with core PA1, PA2, PA3, PA4. There are two risks responded by acceptance risk because of company limitation to respond it; namely, volatility of sugar's price depending on the market and the economic condition of the country and also narrow cultivation are which represent the availability area for cultivation. Supply chain risks involve external risks, such as logistical difficulties, supplier problems, and those sourcing from governmental actions, and internal risks (operations and primarily policies); these characteristics are typically categorized as sustainability, therefore collaborate supply chain risk and sustainability is reasonable to make supply chains more resilient (Rostamzadeh et al., 2018).

In order to select the proper risk mitigation strategies from four mitigation strategy, it has to fulfill several criteria that can lead sustainability for the company. Therefore, technical response is needed in the context of managerial level decision making in the activity of raw material sugarcane procurement in the company's supply chain. Analytic Network Process is employed to select the risk mitigation strategy by considering sustainability dimensions based on value of priority weights, which one is the most suitable to reduce the risk and maintain company's supply chain sustainability.

5.3.1 Analysis of Main Criteria

Based on the result on Table 4.11 in Chapter IV, the Economic Sustainability Cluster has the highest value of prority weight over other main criteria. The result indicates that economic sustainability needs to be prioritized first over the social and environmental sustainability. Since Economic sustainability refers to the company business sustainability, the establishement this company is to utilize agricultural products, especially sugar cane to be processed into sugar so that the value of the benefits and selling is higher in the market in order to generate profit. Besides, the pairwise comparison result of Social and Environmental Sustainabilities has the same priorities as well as the mission and vision of government-owned companies in order to participate in improving people's welfare and protecting the environment for the good of future generations.

5.3.2 Analysis of Economic Sustainability Cluster

Within Economic Sustainability Cluster, there are six sub-criteria; namely, Cost of Goods Reduction, Increase Company Profitablity, Increase Sugarcane Quality, Increase Sugarcane Quantity, Increase Sugarcane Cultivation Productivity, Benefit Sharing. Each sub-criterion has its own function, for instance:

Sub-Criterion Increase Sugarcane Quantity means that the higher amount of raw material sugarcane supplied, the higher capability to fulfil the milling cane machine demand to produce electricity as energy for milling operation. Besides, demand fulfilment of the milling cane machine demand can reduce idle activity of machine to be more productive. So that, this sub-criterion is needed to be considered as economic aspect to concern with company business to generate maximum profit. Different from Increase Company Profitability, company profitability has could be maximized if the amount of sugar production could fulfill demand from the brokers as customers.

Based on the data processing on Table 4.12 in Chapter IV, sub-criteria Increase Company Profitability (C3) has the highest value of priority weight which is 0.2813. The second highest sub-criteria Increase Sugarcane Cultivation Productivity (C4) with priority weight 0.2720 and followed by Cost of Goods Reduction (C2) with priority weight 0.2029. The inconsistency test is 0.06463 which is less than 0.1 that indicates the assessment is consistent. However, the objective of organization or enterprise concern with profit oriented, therefore the criteria that must be focused on Increasing Company Profitability.

Since the nodes within Economic Sustainability Cluster influence each other, so the connection is depicted as loop arc which indicates the inner dependence among cluster as shown in Figure 4.5. Within the Economic Sustainability Cluster, the entire set of criteria is first compared with respect to their influence on Benefit Sharing Accross Value Chain. Next, the entire set of criteria are compared with respect to their influence on Cost of Goods Reduction; their influence on Increase Company Profitability; until their influence on Increase Sugarcane Quantity. For instance, the pairwise comparison of influence sub-criteria w.r.t. Increase Company Profitability (C3) resulted Increase Sugarcane Cultivation Productivity (C4) as the highest priority weight over other criteria as shown in Table A3 in Appendix A. Therefore, this can be concluded that increasing sugarcane cultivation Productivity would lead to increase the yield that increase the amount sugarcane supplied to produce more sugar to be sold; then it leads to increase the profitability. For the rest of pairwise comparison of nodes within Economic Sustainability Cluster are shown in Appendix A.

5.3.3 Analysis of Environmental Sustainability Cluster

Based on the data processing on Table 4.13 in Chapter IV, sub-criteria Climate Change Mitigation & Adaptation (N2) has the highest value of priority weight which is 0.4576. The second highest sub-criteria Appropriate Land Use (N1) with priority weight 0.2720, followed by Efficient Water Use (N3) with priority weight 0.1789 and the lowest priority weight is Reduce Pollution and Waste (N4). The inconsistency test is 0.06175 which is less than 0.1 that indicates the assessment is consistent. In order to keep sugarcane cultivation sustainable, climate change mitigation & adoptation is necessary due to climate risk which potentially disrupt cultivation activity.

Since the nodes within Environmental Sustainability Cluster influence each other, so the connection is depicted as loop arc which indicates the inner dependence among cluster as shown in Figure 4.5. Within the Environmental Sustainability Cluster, the entire set of criteria is first compared with respect to their influence on Appropriate Land Use. Next, the entire set of criteria are compared with respect to their influence on Climate Change Mitigation & Adapatation; their influence on Efficient Water Use; and their influence on Reduced pollution and waste. For instance, the pairwise comparison of sub-criteria w.r.t. Climate Change Mitigation & Adaptation (N2) resulted Efficient Water Use (N3) as the highest priority weight over other sub-criteria as shown in Table B2 in Appendix B. Based on the result, it can be concluded that Efficient Water Use in cultivation activity has big effect to deal with climate change to be more adaptable. For the rest of pairwise comparison of nodes within Environmental Sustainability Cluster are shown in Appendix B.

5.3.4 Analysis of Social Sustainability Cluster

Based on the data processing on Table 4.14 in Chapter IV, sub-criterion Giving Incentives to Local Community (S1) has the highest value of priority weight which is 0.4912. The second highest sub-criterion Provide Employment Opportunity (S4) with priority weight 0.1894, followed by Improve Walfare Community (S2) with priority weight 0.1612 and the lowest priority weight is Protected Health, Safety, and Human Rights for Worker (S3). The inconsistency test is 0.06395 which is less than 0.1 that indicates the assessment is consistent. Social sustainability refers to make a good connection with the stakeholders who involves in the business process, both internal of company such as employee and external of company such as sugarcane farmers. Besides, social aspect also considers how to maintain Giving Incentives to Local Community, especially sugar based on market demand.

Since the nodes within Social Sustainability Cluster influence each other, so the connection is depicted as loop arc which indicates the inner dependence among cluster as shown in Figure 4.5. Within the Social Sustainability Cluster, the entire set of criteria is first compared with respect to their influence on Giving Incentives to Local Community. Next, the entire set of criteria are compared with respect to their influence on Improve Walfare of Local Community; their influence on Protected Health, Safety and Human Right for Workers; and their influence in Provide Employment Opportunity. For instance, the pairwise comparison of sub-criterion w.r.t. Improve Walfare of Local Community (S2) resulted Provide Employment Opportunity (S4) as the highest priority weight over other criteria as shown in Table C2 in Appendix C. Based on the result, it can be concluded that providing employment opportunity to the community has strong influence to improve walfare of local community over other sub-criteria. For the rest of pairwise comparison of nodes within Social Sustainability Cluster are shown in Appendix C.

5.3.5 Analysis of Sub-Criteria w.r.t. Alternatives

In order to serve our understanding of the complexity around us, we must learn to break down these judgments through more elaborate structures and organize our reasoning and calculations in advanced but simple ways. Saaty & Vargas (2006) states, although it takes more time and effort, we must use feedback networks to arrive at the kind of decisions needed to deal with the future. The ANP is able to take into consideration the impacts of the alternatives on the importance of criteria and vise versa; moreover, ANP also allows the grouping of similarly-related elements into clusters which cannot be carried out using AHP. Therefore, the arcs that connect from risk mitigations strategies in Alternatives nodes to each node within each Clusters represents as feedback that alternatives are not always influence by the criteria to make judgement.

5.3.6 Analysis of Supermatrix

To carry out synthesis, ANP uses a super matrix to represent the influences, relations, weights, priorities among the elements and clusters in the network model. Each row and column of the matrix links to an element in the ANP model. This model contains the goal, the criteria or clusters and their sub criteria or nodes within each cluster, an also the alternatives. Each coloumn in the super matrix represents the weight of an element from the columns-header with respect to an element from the row-header (Poh & Liang, 2017). There are three supermatrix associated with each network; namely, unweighted supermatrix; weighted supermatrix and limit supermatrix.

The unweighted supermatrix composed of coloumn which consists of several eigenvectors obtained from pairwise comparison of the nodes within the cluster with respect to a parent node. A parent node may have children in various different clusters, so the priority eigenvectors are weighted on top of each other in the parent node's column (Adams & Saaty, 2016). As a result, local priorities of pairwise comparison among the nodes through the network are used as input in unweighted supermatrix as shown in Table 4.15.

The weighted supermatrix is obtained by multiplying the entire elements in the component of unweighted supermatrix by matching cluster weight. Since in each column consists of several eigenvectors which of them sums up to 1.0 (in a column of a stochastic) and hence the whole column of the matrix may sum to an integer greater than 1.0 (Gencer & Gu¨rpinar, 2007). Therefore, the first step to get weighted supermatrix need to determine the primarily interdependence of the clusters on each cluster w.r.t. control criterion. This process generates an eigenvector of interdependence of clusters with each cluster, then unweighted supermatrix is multiplied by priority weights from the clusters, which results the weighted supermatrix.

The limit supermatrix is obtained by multiplying the weighted supermatrix itself until the result is stable which indicated by supermatrix's row values has the same value for each column of the matrix. When the supermatrix's row values is the same with each column of the matrix, the limit matrix has been reached out and the matrix multiplication process finish.

5.3.7 Analysis of Synthesized Supermatrix

Based on the overall synthesized priorities for Alternatives shown in Figure 4.6, the result shows there are three coloumns that consist of Raw coloumn which gives priorities from limiting supermatrix; Normals Coloumn shows the results after each component has normalized; Ideals coloumn shows results obtained by deviding the values in either normalized or limiting coloumns by the largest value in coloumn (Adams & Saaty, 2016). In this research the value of Ideals coloumn is picked and the result of each Alternatives (PA1, PA2, PA3, PA4) respectively is around 1.00, 0.386, 0.200 and 0.500. The result shows that PA1 has the highest value of global weight over other Alternatives. Hence, it can be concluded that strategy of Expanding the company unit's sugarcane area (TS) and managed directly by PG. Modjopanggoong gradually (PA1) is selected to be the best strategy for reducing risks and lead to maintain company supply chain sustainability.

5.4 Limitations and Future Research

Basically, the framework that built in this study is the same as HOR framework introduced by Pujawan and Geraldin; namely HOR phase 1 is used for risk identification and determine the risk priority based on the weight of ARP value to be mitigated, while HOR phase 2 is used to determine the risk mitigation priorities based on the ease to be implemented and correlation with the prioritized risk form HOR1. The difference in this study is HOR phase 2 adopts sustainability criteria due to risk management and sustainability have relationship to make supply chain more resilience. In order to choose the best alternative strategy for reducing risks and maintaing sustainability, this study proposed ANP to Manajer Tanaman as the expert to make technical response based on multi-criteria decision making because there are connections among the sub-criteria inside each cluster that consists of sustainability dimensions and its capability to give feedback among risk mitigations strategies as alternatives and sub-criteria.

Since the time of the study was limited, this study ignores the analysis of costs, opportunities and risks for consideration of the feasibility of implementing the risk mitigation strategies made. Therefore, it would be nice if there were a BOCR analysis applied for future studies.

CHAPTER VI

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Based on the analysis and discussion in Chapter V, a conclusion can be formulated to answer the problem that occur in the procurement activity that mentioned in Chapter I. It is stated in the following statement:

1. Based on the result, there are ten risk agents that highly contribute disrupting raw material procurement sustainability in PG. Modjopanggoong; namely, sugarcane cultivation margins are less competitive than other commodities, the price of sugar is very volatile, registered sugarcane which has been harvested are delivered to competitors (Brown Sugar & Sugarcane Shelter), narrow cultivation area, the number of indigenous sugarcane areas are limited; farmers lack financing and other production facilities (seeds, fertilizer, medicines, etc.), several farmers are reluctant to register their sugarcane with PG. (contract bound), the amount of sugarcane has not been achieved according to RKAP, credit agreements among PG, Bank and People's Sugarcane Farmers Cooperative (KPTR) are not timely, many of planting data of sugarcane variety is less accurate.

2. Based on the proposed ANP method to facilitate Manajer Tanaman's decision making in procurement activity in PTPN X Unit PG. Modjopanggoong supply chain, "Expanding the company unit's sugarcane area (TS) and managed directly by PG. Modjopanggoong gradually" (PA1) has the highest global weight value over other risk mitigation strategies, therefore this alternative is selected as the best strategy for reducing the risks and maintaining company's supply chain sustainability.

6.2 Recommendation

By applying risk mitigation strategy of Expanding the company unit's sugarcane area (TS) and managed directly by PG. Modjopanggoong gradually (PA1), activity of raw material sugarcane procurement tends to be more controllable. Thus, the entire activity in the sugarcane activity can be monitored and controlled directly by company, such as maximize the sugarcane cultivation productivity and reducing the risk of supply sugarcane to competitors by contracted farmers. Bagian Tanaman as department that plays crucial role in the upstream supply chain could maintain economic sustainability namely; maximize the amount of supply of raw material sugarcane to milling cane, maximize quality of sugarcane, increase cultivation productivity so that the target of RKAP can be achieved by Bagian Tanaman. Besides, the strategy can help to gain more profit and reduce cost of goods based on economic sustainability criteria.

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APPENDICES

Appendix A: Pairwise Comparison of nodes in Economic Sustainability Cluster

Table A.1. Pairwise Comparison of Sub-Criteria w.r.t. Benefit Sharing

	C2	C3	C4	C5	C6	Priority Weight	Inconsistency
C2	1	1/3	1/3	1/3	1/2	0.0771	
C3	3	1	1	1	3	0.2607	
C4	3	1	1	3	3	0.3439	0.04651
C5	3	1	1/3	1	3	0.2167	
C6	2	1/3	1/3	1/3	1	0.1017	

Table A2. Pairwise Comparison of Sub-Criteria w.r.t. Cost of Goods Reduction

	C1	C3	C4	C5	C6	Priority Weight	Inconsistency
C1	1	1	1/4	1/3	1/3	0.0849	
C3	1	1	1	1/2	1/3	0.1329	
C4	4	1	1	3	1	0.3018	0.07544
C5	3	2	1/3	1	1/2	0.1781	
C6	3	3	1	2	1	0.3023	

Table A3. Pairwise Comparison of Sub-Criteria w.r.t. Increase Company Profitability

	C1	C2	C4	C5	C6	Priority Weight	Inconsistency
C1	1	1/3	1/3	1/3	1/2	0.0791	
C2	3	1	1/2	1	1	0.1879	
C4	3	2	1	3	1	0.3360	0.06017
C5	3	1	1/3	1	2	0.2123	
C6	2	1	1	1/2	1	0.1846	

Table A4. Pairwise Comparison of Sub-Criteria w.r.t. Increase Sugarcane Productivity

	C1	C2	C3	C5	C6	Priority Weight	Inconsistency
C1	1	1/3	1/4	1/4	1/3	0.0636	
C2	3	1	1/3	1/2	1/3	0.1218	
C3	4	3	1	1	2	0.3245	0.03241
C5	4	2	1	1	1	0.2551	
C6	3	3	1/2	1	1	0.2349	

Table A5. Pairwise Comparison of Sub-Criteria w.r.t. Increase Sugarcane Quality

	C1	C2	C3	C5	C6	Priority Weight	Inconsistency
C1	1	1/2	1/3	1/3	½	0.0852	
C2	2	1	1/3	1/3	1	0.1269	
C3	3	3	1	1	3	0.3305	0.01732
C4	3	3	1	1	3	0.3305	
C6	2	1	1/3	1/3	1	0.1269	

Table A6. Pairwise Comparison of Sub-Criteria w.r.t. Increase Sugarcane Quantity

	C1	C2	C3	C4	C5	Priority Weight	Inconsistency
C1	1	1/2	1/3	1/3	1/3	0.0791	
C2	2	1	1/2	1	1/3	0.1468	
C3	3	2	1	1	2	0.2999	0.04212
C4	3	1	1	1	1	0.2232	
C5	3	3	1/2	1	1	0.2509	

Appendix B: Pairwise Comparison of nodes in Environment Sustainability Cluster

Table B1. Pairwise Comparison of Sub-Criteria w.r.t. Appropriate Land Use

	N2	N3	N4	Priority Weight	Inconsistency
N2	1	3	3	0.5936	
N3	1/3	1	2	0.2493	0.0516
N4	1/3	1/2	1	0.1571	

Table B2. Pairwise Comparison of Sub-Criteria w.r.t. Climate Change Mitigation

	N1	N3	N4	Priority Weight	Inconsistency
N1	1	1/3	2	0.2493	
N3	3	1	3	0.5936	0.0516
N4	1/2	1/3	1	0.1571	

Table B3. Pairwise Comparison of Sub-Criteria w.r.t. Efficient Use Water

	N1	N2	N4	Priority Weight	Inconsistency
N1	1	2	3	0.5396	
N2	1/2	1	2	0.2970	0.0089
N4	1/3	½	1	0.1634	

Table B4. Pairwise Comparison of Sub-Criteria w.r.t. Reduce Pollution and Waste

	N1	N2	N3	Priority Weight	Inconsistency
N1	1	3	3	0.6	
N2	1/3	1	1	0.2	0.0000
N3	1/3	1	1	0.2	

Appendix C: Pairwise Comparison of nodes in Social Sustainability Cluster

Table C1. Pairwise Comparison of Sub-Criteria w.r.t. Giving Incentives to Local Community

	S2	S3	S4	Priority Weight	Inconsistency
S2	1	3	1	0.4286	
S3	1/3	1	1/3	0.1429	0.0000
S4	1	3	1	0.4286	

Table C2. Pairwise Comparison of Sub-Criteria w.r.t. Improve Walfare of Local Community

	S1	S3	S4	Priority Weight	Inconsistency
S1	1	2	1/3	0.2493	
S3	1/2	1	1/3	0.1571	0.05156
S4	3	3	1	0.5936	

Table C3. Pairwise Comparison of Sub-Criteria w.r.t. Protected Health, Safety and Human Right for Workers

	S1	S2	S4	Priority Weight	Inconsistency
S1	1	1/3	1/3	0.1529	
S2	3	1	1	0.2620	0.0000
S4	3	1	1	0.4611	

Table C4. Pairwise Comparison of Sub-Criteria w.r.t. Provide Employment Opportunity

	S1	S2	S3	Priority Weight	Inconsistency
S1	1	1/3	2	0.2493	
S2	3	1	3	0.5936	0.05156
S3	1/2	1/3	1	0.1571	

Appendix D: Pairwise Comparison of Alternatives

Table D1. Pairwise Comparison of Alternatives w.r.t sub-criteria Benefit Sharing

	PA1	PA2	PA3	PA4	Priority Weight	Inconsistency
PA1	1	1	3	1/2	0.2349	0.04417
PA2	1	1	3	1/3	0.2166	
PA3	1/3	1/3	1	1/3	0.0966	
PA4	2	3	3	1	0.4520	

Table D2. Pairwise Comparison of Alternatives w.r.t sub-criteria Cost of Goods Reduction

	PA1	PA2	PA3	PA4	Priority Weight	Inconsistency
PA1	1	3	4	1/2	0.3235	0.07889
PA2	1/3	1	3	1/3	0.1591	
PA3	1/4	1/3	1	1/3	0.0865	
PA4	2	3	3	1	0.4310	

Table D3. Pairwise Comparison of Alternatives w.r.t sub-criteria Increase Company Profitability

	PA1	PA2	PA3	PA4	Priority Weight	Inconsistency
PA1	1	4	5	3	0.5409	0.04159
PA2	1/4	1	3	1/2	0.1535	
PA3	1/5	1/3	1	1/3	0.0758	
PA4	1/3	2	3	1	0.2298	

Table D4. Pairwise Comparison of Alternatives w.r.t sub-criteria Increase Sugarcane Cultivation Productivity

	PA1	PA2	PA3	PA4	Priority Weight	Inconsistency
PA1	1	3	4	3	0.5023	0.0656
PA2	1/4	1	2	3	0.2524	
PA3	1/5	1/3	1	1/2	0.1019	
PA4	1/3	2	3	1	0.1434	

Table D5. Pairwise Comparison of Alternatives w.r.t sub-criteria Increase Sugarcane Quality

	PA1	**PA2**	**PA3**	**PA4**	**Priority Weight**	**Inconsistency**
PA1	1	4	4	4	0.5591	0.05787
PA2	1/4	1	3	3	0.2376	
PA3	1/4	1/3	1	1	0.1016	
PA4	1/4	1/3	1	1	0.1016	

Table D6. Pairwise Comparison of Alternatives w.r.t sub-criteria Increase Sugarcane Quantity

	PA1	**PA2**	**PA3**	**PA4**	**Priority Weight**	**Inconsistency**
PA1	1	4	4	3	0.5334	0.07355
PA2	1/4	1	1	2	0.1814	
PA3	1/4	1	1	1/2	0.1237	
PA4	1/3	2	2	1	0.1614	

Table D7. Pairwise Comparison of Alternatives w.r.t sub-criteria Appropriate Land Use

	PA1	**PA2**	**PA3**	**PA4**	**Priority Weight**	**Inconsistency**
PA1	1	3	4	3	0.5017	0.05977
PA2	1/3	1	2	1/3	0.1384	
PA3	1/4	½	1	1/3	0.0901	
PA4	1/3	3	3	1	0.2699	

Table D8. Pairwise Comparison of Alternatives w.r.t sub-criteria Climate Change Mitigation and Adaptation

	PA1	**PA2**	**PA3**	**PA4**	**Priority Weight**	**Inconsistency**
PA1	1	3	4	2	0.4692	0.05977
PA2	1/3	1	3	2	0.2524	
PA3	1/4	1/3	1	1/3	0.0842	
PA4	1/2	½	3	1	0.1942	

Table D9. Pairwise Comparison of Alternatives w.r.t sub-criteria Efficient Water Use

	PA1	**PA2**	**PA3**	**PA4**	**Priority Weight**	**Inconsistency**
PA1	1	3	4	3	0.5110	0.03276
PA2	1/3	1	1	1/2	0.1310	
PA3	1/4	1	1	1/3	0.1105	
PA4	1/3	2	3	1	0.2475	

Table D10. Pairwise Comparison of Alternatives w.r.t sub-criteria Reduced Pollution and Waste

	PA1	PA2	PA3	PA4	Priority Weight	Inconsistency
PA1	1	3	3	2	0.4535	0.03044
PA2	1/3	1	2	1	0.1972	
PA3	1/3	½	1	1/3	0.1072	
PA4	1/2	1	3	1	0.2420	

Table D11. Pairwise Comparison of Alternatives w.r.t sub-criteria Giving Incentives to Local Community

	PA1	PA2	PA3	PA4	Priority Weight	Inconsistency
PA1	1	3	4	3	0.5080	0.03276
PA2	1/3	1	2	1/2	0.1545	
PA3	1/4	½	1	1/3	0.0926	
PA4	1/3	2	3	1	0.2449	

Table D12. Pairwise Comparison of Alternatives w.r.t sub-criteria Improve Walfare of Local Community

	PA1	PA2	PA3	PA4	Priority Weight	Inconsistency
PA1	1	3	4	3	0.5080	0.03276
PA2	1/3	1	2	1/2	0.1545	
PA3	1/4	½	1	1/3	0.0926	
PA4	1/3	2	3	1	0.2449	

Table D13. Pairwise Comparison of Alternatives w.r.t sub-criteria Protected Health, Safety and Human Right Workers

	PA1	PA2	PA3	PA4	Priority Weight	Inconsistency
PA1	1	3	3	2	0.4430	0.05361
PA2	1/3	1	3	1/2	0.1828	
PA3	1/3	1/3	1	1/3	0.0959	
PA4	½	2	3	1	0.2783	

Table D14. Pairwise Comparison of Alternatives w.r.t sub-criteria Provide Employment Opportunity

	PA1	PA2	PA3	PA4	Priority Weight	Inconsistency
PA1	1	3	4	3	0.5017	0.05977
PA2	1/3	1	2	1/3	0.1384	
PA3	¼	1/2	1	1/3	0.0901	
PA4	1/3	3	3	1	0.2699	

Appendix E: Pairwise Comparison of Sub-Criteria w.r.t. Alternatives

Table E1. Pairwise Comparison of Economic Sustainability w.r.t. PA1

	C1	C2	C3	C4	C5	C6	Weight	Inconsistency
C1	1	1/2	1/3	1/5	1/4	1/4	0.0503	0.03301
C2	2	1	1/3	1/2	1/3	1/3	0.0833	
C3	3	3	1	1	1	1	0.2042	
C4	5	2	1	1	3	1	0.2662	
C5	4	3	1	1/3	1	1	0.1837	
C6	4	3	1	1	1	1	0.2123	

Table E2. Pairwise Comparison of Environmental Sustainability w.r.t. PA1

	N1	N2	N3	N4	Priority Weight	Inconsistency
N1	1	1/3	2	1	0.2026	0.06948
N2	3	1	3	3	0.4850	
N3	1/2	1/3	1	2	0.1712	
N4	1	1/3	1/2	1	0.1412	

Table E3. Pairwise Comparison of Social Sustainability w.r.t. PA1

	S1	S2	S3	S4	Priority Weight	Inconsistency
S1	1	3	3	3	0.4874	0.05787
S2	1/3	1	3	1	0.2085	
S3	1/3	1/3	1	1/3	0.0956	
S4	1/3	1	3	1	0.2085	

Table E4. Pairwise Comparison of Economic Sustainability w.r.t. PA2

	C1	C2	C3	C4	C5	C6	Priority Weight	Inconsistency
C1	1	3	3	3	3	3	0.3545	0.07395
C2	1/3	1	1/3	1/3	1/3	1/3	0.0575	
C3	1/3	3	1	1	4	3	0.2079	
C4	1/3	3	1	1	3	3	0.1937	
C5	1/3	3	1/4	1/3	1	1	0.0919	
C6	1/3	3	1/3	1/3	1	1	0.0945	

Table E5. Pairwise Comparison of Environmental Sustainability w.r.t. PA2

	N1	N2	N3	N4	Priority Weight	Inconsistency
N1	1	3	2	3	0.4393	0.04544
N2	1/3	1	1/3	2	0.1464	
N3	1/2	3	1	3	0.3107	
N4	1/3	1/2	1/3	1	0.1036	

Table E6. Pairwise Comparison of Social Sustainability w.r.t. PA2

	S1	S2	S3	S4	Priority Weight	Inconsistency
S1	1	1/3	1/2	1/2	0.1233	0.06175
S2	3	1	1/2	2	0.2892	
S3	2	2	1	3	0.4197	
S4	2	1/2	1/3	1	0.1678	

Table E7. Pairwise Comparison of Economic Sustainability w.r.t. PA3

	C1	C2	C3	C4	C5	C6	Priority Weight	Inconsistency
C1	1	3	3	3	3	3	0.3585	0.05885
C2	1/3	1	2	2	1/2	1	0.1305	
C3	1/3	1/2	1	1	1/3	1/3	0.0711	
C4	1/3	1/2	1	1	1/2	1/3	0.0750	
C5	1/3	2	3	2	1	1/3	0.1518	
C6	1/3	1	3	3	3	1	0.2131	

Table E8. Paiwise Comparison of Environmental Sustainability w.r.t. PA3

	N1	N2	N3	N4	Priority Weight	Inconsistency
N1	1	2	2	3	0.4100	0.06175
N2	1/2	1	3	2	0.3012	
N3	1/2	1/3	1	2	0.1709	
N4	1/3	1/2	1/2	1	0.1178	

Table E9. Pairwise Comparison of Social Sustainability w.r.t. PA3

	S1	S2	S3	S4	Priority Weight	Inconsistency
S1	1	4	3	4	0.5340	0.03044
S2	1/4	1	1/2	1/2	0.1023	
S3	1/3	2	1	2	0.2184	
S4	1/4	2	1/2	1	0.1452	

Table E10. Pairwise Comparison of Economic Sustainability w.r.t. PA4

	C1	C2	C3	C4	C5	C6	Priority Weight	Inconsistency
C1	1	3	3	2	3	3	0.3328	0.06153
C2	1/3	1	3	1/3	2	1/2	0.1264	
C3	1/3	1/3	1	1/3	1	1	0.0868	
C4	½	3	3	1	2	1	0.2096	
C5	1/3	1/2	1	1/2	1	1/3	0.0782	
C6	1/3	2	1	1	3	1	0.1662	

Table E11. Pairwise Comparison of Environmental Sustainability w.r.t. PA4

	N1	N2	N3	N4	Priority Weight	Inconsistency
N1	1	3	3	2	0.4611	0.0656
N2	1/3	1	3	2	0.2620	
N3	1/3	1/3	1	1	0.1241	
N4	1/2	1/2	1	1	0.1529	

Table E12. Pairwise Comparison of Social Sustainability w.r.t. PA4

	S1	S2	S3	S4	Priority Weight	Inconsistency
S1	1	3	3	2	0.4582	0.05361
S2	1/3	1	2	2	0.2404	
S3	1/3	1/2	1	½	0.1163	
S4	1/2	1/2	2	1	0.1851	