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System Analysis and Design of Fishery Supply Chain Risk in Aceh: A Case Study

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ABSTRACT
The fishery sector has become one the most influential aspect in the development of the economic sector in Aceh. However, the complexity and rapidly changing requirements and regulations on agri-food products pose risks in its business processes. Consequently, it is increasingly mandatory for business organizations to make a transition toward integrating risk analysis to cope with the challenge. This study aims to analyze the level of risk priority in the fishery supply chain in Aceh through a business process approach. The data analysis methods used in this paper includes 1) BPMN which was used to map and structure the link between internal and external actors of the logistics and the processing network of the company; 2) SCOR model to define and identify the associated risks and 3) House risk to assess and analyze risks within the supply chain system in the fishery industry in Aceh. The results showed that 4 main actors are working collaboratively in the fishery network of the supply chain. Based on the identification result, it was found that there are 19 risks and 20 risk agents associated with the whole business process of the firm with firm ability to maintain high standard (weakness in controlling) in a processing system is rated as the critical risk in the network.

Keywords: *Fishery Supply Chain, Mining Project, Survey and Mapping, Drones*

1. INTRODUCTION

The fishery industries present an important role in the development of the economic sector in Aceh through income generation, livelihoods diversification, and foreign export and import activities. The sector contributed 2.85% to the total of Aceh's gross domestic product (GDP) with an estimated value of 1.3 million dollars and generated employment for over 80.000 people in the process [1].

The fishery sector in Aceh is mostly dominated by Small Medium Enterprises (SMEs). These enterprises have contributed exponentially to the economic growth of Aceh especially after the recovery and rehabilitation initiatives after the Tsunami in 2004. The initiatives have raised the total production and demand of the fish products from Aceh and have provided more opportunities for the SMEs to expand their presence in the global market. [2]. However, this increase in demand and production will likely put more pressure and escalate the whole complexity of the fishery supply chain for the SMEs to manage. In general, SMEs are constrained to a certain degree of limitation to cope with a good strategy to respond promptly to the internal and external risks that can potentially threaten the survival of the business [3]. As a sector that is currently dominated by SMEs, the fishery ecosystems in Aceh are still lacking in proper resources to manage risk and uncertainty in their supply chain system. While in the other hand, as the business becoming more active in the global market, their ability to manage risks are becoming more important [4]. Nevertheless, it is necessary to integrate an operational system that can identify risks and deficiencies to optimize the supply chain process within the supply chain fishery firm in Aceh. Thus, this paper therefore focuses on promoting the development of Supply Chain Risk Management (SCRM) processes that should be adopted in small businesses in Aceh region.

In this approach, this paper considers SCRM process for SMEs in Aceh. First, this paper illustrates the business model activity of the supply chain system by using Business Process Modelling and Notation 2.0 (BPMN 2.0) model to analyze how each stakeholder in the supply chain system integrates. Business activity-management system focuses on supporting the modeling the automation of business system, this modeling helps decision makers to understand business process from multiple perspectives in order to track and locate area for a strategic decision and improvement of business process [5]. Second, Supply Chain Operation Reference (SCOR) model is applied to categorize and identify risks associated with supply chain line. In its approach SCOR is based on five priority concepts that include plan, resource, make, deliver, and return of all associated stakeholders among the fisheries supply chain. Third, House of Risk (HOR) is used to assess risks and their roots as well as analyzing the relationship between risks and root causes produced by different sources.

SMEs has many opportunities to growth and one of the assets are if the owner able to discover a strategy to balance out of the strengths and the weaknesses in the supply chain command. The ways SMEs are operated quite different between normal companies that have executives board to make decisions. Commonly, it is owned, managed, and controlled by the owner. The trait of flat organizational structure making SMEs are flexible to adapt with the market environment and propagate the change in management to compete in the market. It is clear that one of the strengths of SMEs is their ability to recognize strategic challenges and opportunities particularly in supply chain within their businesses ecosystem [6].

BPMN is a tool that describes the flow of business process by providing visual notations to represent actual events or processes. BPMN was developed as a tool to describe a process, system, or an activity by using a graphical notation. BPMN is mainly used to monitor and manage business process by using a flowcharts visualization function [7].

In its approach, BPMN is typically choreographed to apply an illustration of the processing system by analyzing the relationship between stakeholders. The steps necessary to construct a BPMN diagram are as follow: 1) identify the services involved in the models as well as their stakeholders and their list of roles, 2) represent for the flow of processes to be performed, 3) apply the available symbols then reorganize the orchestration, 4) complete the diagram with explanations and data, connect the behaviors in the interaction between the stakeholders then build a choreographic collaboration diagram and finally, recheck the model if it contains errors or warnings until the intended output is error-free. The articles, journals and reports cited selected the same variables to observe how each affected the outcome of the process. Previously, it was shown that the impact of the deterministic variables selected on the product is significant by statistical experimental design [8].

SCOR model is a model to design, define, and organize the whole activities that interconnected with business activities. The SCOR model defines the business activities including Plan, Source, Make, Deliver, and Return processes [9]. SCOR model is used to analyze and cluster the current state of a company’s business activities, as well as quantifying operational of an organization by using a set of standard metrics. One of the perks of SCOR is the flexibility on usage that can adjust the productivity to meet the demand consumer [8]. The model integrates three main elements in management including but not limited to business process re-engineering, benchmarking, and process measurement into the cross-functional framework in the supply chain. One of the main advantage of SCOR is a strong hierarchy of the supply chain metrics, allowing users to diagnose performance issues and identify process-level improvement actions[10], this process can be used as the basis for defining risk identification process in supply chain risk management.

HOR is combination House of Quality and Failure Modes and Effects Analysis (FMEA) method that is often used in the process of risk assessment [11]. The model of FMEA used to identify potential failure in products or services with the purpose of to eliminate or minimize the risk of failure [12]. HOR model determine the number of risk probability occurs that linked to risked agent and the impact of severity related to risk event. The approach of HOR compute by defining the value Aggregate Risk Potential (ARP) that classified decision making process to execute. The output of HOR is categorized into several steps as follow [11]:

- Stage 1, Identify supply chain activities based on the SCOR model, in order to facilitate the detection process in which risks may arise.
- Stage 2, Identify the total risk of failure that could occur in any activity in the supply chain.
- Stage 3 Identify Severity (S) and Occurrence (O) Level or degree of impact of each risk event using a scale of 1-5.
- Stage 4 identify the risk of the agent (risk agent), detect any occurring factor identified in the step.
- Stage 5 Determine the correlation between an event to trigger the risk of the agent. If an organ is at risk, we can say that there is a correlation. If the correlation is strong, the weight is 9; the weighted correlations 3 and 1 for the value of the correlation are low.

2. METHODS

This research employs a case study analysis to study situations, processes, or events in depth. Data observation and case study analysis were conducted in Lampulo fishing port, Banda Aceh, which was one of the primary fishing ports in Aceh province. Qualitative and quantitative data is employed in this study, and which was collected from direct observation, open-ended interviews with the main stakeholder in a leading fishery industry in Aceh together with related literature to define supply chain processes and associated risk in the system.

The data analysis in this study is analyzed by using several steps: first, Business process activity was structured and mapped by using BPMN 2.0 and SCOR model. In this step, the SCOR model (Plan, source, make, deliver and return) is used as a reference to determine the activity of each stakeholder, while BPMN 2.0 is used as a modeling tool to give a visual representation of the actual business activity of the case study company. Secondly, risk identification analysis on the system is organized. To meet this objective, direct observation and interview were conducted directly to the case study company. The interview was administered by referring to the proposed information presented on the BPMN model. Furthermore, each identified risk and risk agent are rated by using a scale of 1-5. The final step of the analysis was to conduct a risk assessment of the identified risk and risk agent found in the system. In this stage, HOR method was employed to determine the potential risk agent that has the most significant impact on the overall performance of the supply chain network. Furthermore, the Pareto chart diagram is employed to determine the rank of priority risk agent in the supply chain system.

3. RESULTS AND DISCUSSION

3.1. Business process mapping

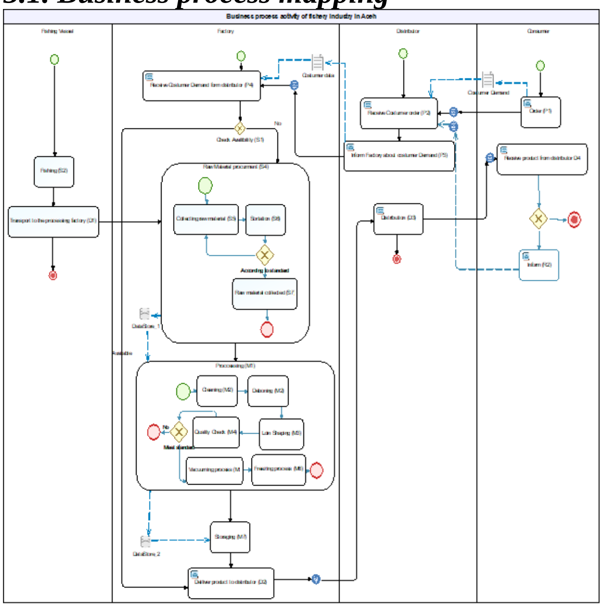

Figure 1. The business process activity model of the fishery supply chain in Aceh.

The first stage of this paper is to map the activities of the fishery industry. Literature suggests that the combination of the BPMN and SCOR model (plan, source, make. delivery, and return) provide a better and clearer perspective in identifying risk and performance indicators in a modeled system [13][14]. In this regard, this paper demonstrates the visual representation of the overall business process activity of the fishery supply chain in Aceh based on the SCOR model. Whereas the visual model is differentiated by its main stakeholder, with each stakeholder acts vertically in the system. The business process of the fishery supply chain line in Aceh is illustrated in Figure 1.

Based on the business process activity, the case study company applied a vertical integrated supply chain system in the overall business process. This vertical integrated system aims to help fishery company ensure its fish product supply from its fishing fleet, obtaining better yield and to ensure inventory and quality control that are now becoming more demanding and stricter from the exporting destination [15] [16]. The mapping of each business activities based on the SCOR model is presented in Table 1

Table 1. Supply chain business activities.

SCOR process	Fishery supply chain stakeholder's activities code			
	Fishing Vessel	Processing Factory	Distributor	Buying company
Plan		P4	P2, P3	P1
Source	S2	S1, S4, S5, S6, S7		
Make		M1, M2, M3, M4, M5, M6, M7		
Deliver	D1	D2	D3	D4
Return				R1

3.2. Risk identification

Risk identification is the initial process in designing a risk management system. This process aims to cluster and identify associated risks that could potentially appear in the logistic and production activities within the supply chain system [17]. Risk identification in this paper is carried out by using direct observation, open-ended interviews, and brainstorming directly to the relevant owner in the fishery industry in Aceh. The identified risks are then classified into five stages of the SCOR model. Based on the identification result, it was found that there are 19

Table 2. Risk identification.

SCOR model	Code	Risk	SCOR Model	Code	Risk
Plan	P1	Contract Cancelation	Make	M5	Error in marking components
	P2	Dependency of supplier		M6	Productions are contaminated
Source	S1	Volatility in cost	Delivery	D1	Means of transportation are out of order regularly
	S2	Quality of material does not meet the consumer standard		D2	Error in delivery
	S3	Lack of high skilled workers		D3	Reserved products/ materials are spoiled or contaminated
	S4	Lack of capital		D4	The risks of trade or negotiation failure with international ports
Make	M1	Production process is delayed		D5	Exchange rate risks
	M2	Machines are unavailable	Return	R1	Fail to meet costumer's standard
	M3	Regularly increasing production time (overtime)		R2	Product are refunded
	M4	Lack of material			

potential risks recognized within the supply chain activities. In this study, risks are mapped and classified by using the SCOR model in four categories: plan, source, make and deliver. Each identified risk is coded according to the source of risk. Thus, all identified risks are listed in Table 2. Thus, all identified risks are listed in Table 2.

To fully recognize the holistic view of the supply chain risk, the agent of risk is needed to be identified. Risk agent is referred as a cause of risk that may disrupt the safety of the supply chain. The causes of risks or risk agents that occurs in fishery supply chain line in Aceh is presented in Table 3.

3.3. Risk Assessment

Aggregate Risk Potential (ARP) is used to determine the priority of risk that required immediate preventive action. The ARP is obtained by calculating the aggregate of severity (S) and occurrence (O) value which are obtained from experts' judgement. Thus, the result of ARP calculation is presented in Table 4.

Table 3. Cause of Risk.

Code	Risk Agent	Code	Risk Agent
A01	Do not have long- term plan	A11	Shift in processing plan
A02	Ineffective financial management plan	A12	Weakness maintains system standard (quality of material and product)
A03	Weakness in supplier's selection	A13	Strict requirements and regulation
A04	Natural disaster	A14	Minimum workers salary
A05	Environmental Pollution	A15	Improper maintenance of machinery
A06	Economic crisis	A16	Late arrival of the product
A07	Quantity Crisis	A17	Long-term shortage of products in stock
A08	Quantity Limitation from supplier	A18	Lack of collaboration with outside organizations
A09	Difficult to compare the suppliers	A19	Do not note the orders in detail (wrong date, amount, type of product)
A10	Processing methods are limited	A20	Quality of products does not match requirements

Table 4. ARP calculation result.

SCOR model	Code	S	O	ARP	SCOR Model	Code	S	O	ARP
Plan	P1	1	5	5	Make	M5	1	2	2
	P2	3	5	15		M6	2	5	10
Sources	S1	2	3	6	Delivery	D1	1	3	3
	S2	3	5	15		D2	1	5	5
	S3	2	2	4		D3	1	5	5
	S4	1	3	3		D4	3	4	12
Make	M1	3	3	9		D5	2	4	8
	M2	1	3	3	Return	R1	4	5	20
	M3	2	3	6		R2	2	5	10
	M4	3	5	15					

Based on the severity and occurrence values on table 3, risks are mapped to the Risk Map to identify the action to be performed. Risk Map divided into 3 areas, green area indicates no to low corrective action is needed, yellow areas indicate corrective action needs to be considered, and red areas indicating immediate corrective action should be taken. Result of risk map is described in Figure 2.

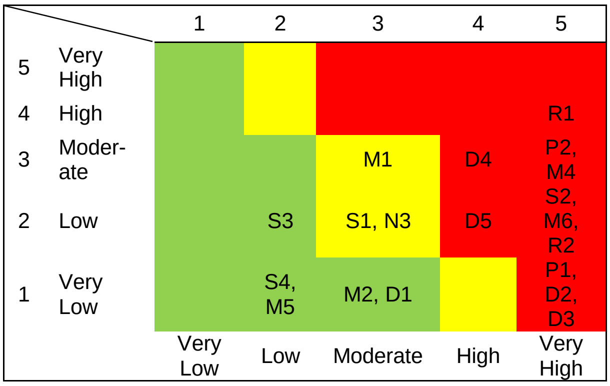

Figure 2. Risk Map.

The following step is to determine the correlation of value (CR) between risks and risk agent. CR is determined by comparing ARP value of between risks and risk agents in the supply chain system. The value of each risk and risk agent was determined by expert opinion on the subject matter, where value 1 symbolize low correlation while value 9 symbolize highest correlation between each risk and risk agent. Thus, based on the calculation, the correlation value of the fishery supply chain system can be seen in table 5. Table 5 explains that risk Event A12, A16, A3, A4, A13 present the highest correlation value in the overall supply chain process of the fish in Aceh. Furthermore, once the rank of each risk agents and the value of each agent was determined, the following step is analyzing Pareto chart to obtain critical risk agent by using a concept of 20:80, Pareto Chart aimed to determine the priority risk agent to be handled for the occurrence of the risk caused. The following is Pareto Chart of correlation value ranking that shown in Figure 3.

From the result of Pareto analysis, there are 12 dominant risk agents found in the supply chain system. Whereas weakness in controlling system (A12) has the biggest impact on the overall performance of the supply chain line in Aceh with CR value of 417. The risk contributed to 80% of total potential risk that could potentially disrupt the overall fishery logistic services. As a result, further analysis and planning is needed to mitigate the risk in the fishery supply chain line in Aceh.

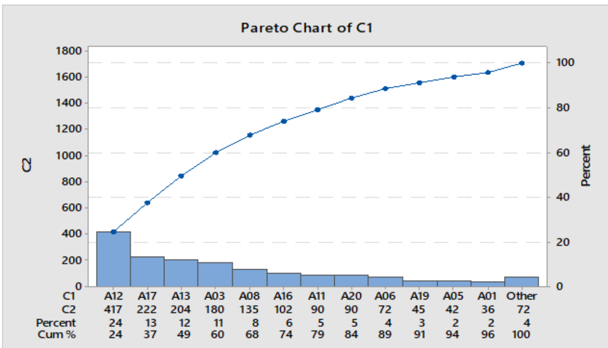

Figure 3. Pareto diagram result.

Table 5. Correlation value (CR) matrix.

	ARP	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17 A18	A19	A20	
R1	20													9							
S2	15			9		1							9								
M4	15																				
P2	15			3					9				9								
D4	12	1																	3		
M6	10										9		9								
R2	10																3			9	9
M1	9		1		9	3						3	3								
P1	8	3			9			3						3			9				
D5	8				3		9														
D2	5												3							9	
D3	5												3					9			
CR		36	9	180	177	42	72	24	135	0	90	27	417	204	0	0	102	45	36	45	90
Rank		11	13	3	4	10	8	12	5	14	7	12	1	2	14	14	6	9	11	9	7

4. CONCLUSION

This paper focuses on the fishery supply chain risk analysis based on the business process approach. The fishery sector has become one of the biggest con-tributors to the economic sector in Aceh. However, the fishery industries are challenged with high complexity and multiple issues which require them to implement proper management in the whole business network. Based on the business process activity mapping, it was found that the fishery industry in Aceh adopts a short supply chain system with four main actors inside the supply chain: processing factory, distributor, and con-sumer, with each entity in the system, is working cooperatively to make a profit. From the business model perspective, the fishery supply chain industry in Aceh is vertically integrated, with most of the supply chain functions are being dominated by a single company. The result of risk identification found 19 potential risks and 20 risk agents associated with the fishery supply chain line in Aceh. Each identified risk and risk agent is categorized into five operational stages of the SCOR model (Plan, Source, Make, Deliver and Return). Based on the risk assessment result, it was found that risk A12 (weakness in the controlling system; quality of material and product) has the biggest CR value (417) from the overall risk found in the system. This indicates that risk A12 has the biggest impact on the overall effectiveness and performance of the fishery supply chain line in Aceh, and an immediate mitigation plan should be the primary objective to improve the overall performance of the industry.

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