Macro Ergonomics Studies as a Process to Minimize Potential Seaweed Production Risks

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Abstract

Bulukumba as one of the world's largest wet seaweed producing areas, has an influence on the socio-economic improvement of the people. As many as 80% of the population of Babana Hamlet, Bulukumba Regency, works mainly as seaweed farmers. The supply chain network in seaweed commodities starts from farmers, then seaweed is sold to large traders, and finally sent to Makassar City for export abroad. Collaboration between supply chain players is important to be able to meet market needs. However, the quality of the seaweed produced is often not in line with what was expected. This study aims to minimize potential risk events in the seaweed commodity supply chain with Macro Ergonomics Analysis and Design (MEAD). This method is commonly used to design, analyze and evaluate systems involving the roles and functions of the organization. In this study, the method was developed to design a model to minimize the risks that occur in the supply chain of seaweed commodities. The risks here are divided into two, namely risks from internal and external factors. Data processing results in a potential risk on internal factors is high rainfall over a long period of time, and potential risks on external factors are in high rainfall.

Keywords : Macro Ergonomics Analysis and Design, Seaweed, Supply Chain, Risk

1. Introduction

Bulukumba is one of the world's largest wet seaweed producing areas, with a percentage of 85% (Ministry of Industry, 2018). The potential possessed by Bulukumba regency affects the socio-economic improvement of the community (Ilmi, 2020). The government targets that seaweed production will continue to grow to 12-13 million tons in 2024 (Marine and Fishery Resources Research Agency, 2021). Based on the observation results, one of the hamlets whose people work as seaweed farmers is Babana Hamlet with a presentation of 80%. The supply chain network in seaweed commodities starts from farmers, then sold to large traders, and finally sent to Makassar City for export abroad (Farmers – Wholesalers – Exporters).

Collaboration between supply chain players is very important to be able to meet market needs. However, the expected conditions do not correspond to the resulting reality. The quality of the seaweed produced is often not in line with what is expected. Finally, farmers suffered a lot of losses. The losses suffered by farmers will affect the sustainability of the seaweed commodity supply chain. The decline in the quality of the grass is caused by the risk of internal factors(human) that are used to determine potential risks that affect the quality of the crop (Darise & Bagou, 2019). and external (environmental) factors. Some of them are sudden extreme weather, increasingly abundant moss growth, prolonged extreme weather, so that the work motivation of farmers also decreases because the harvest cannot be sold due to quality that is not in accordance with standards. Seaweed quality specification standards that can be accepted at prices that meet market standards are fat seaweed (large), long seaweed (without signs of sea animal bites), as well as dry and clean seaweed (without moss, sand and plastic waste), not damaged, and a large amount of production capacity (Mohamad & Yulawati, 2021). These risks must be managed in order to reduce the occurrence of greater losses (Indahsari & Rosdiana, 2018)

Based on the above problems, this research is important to carry out considering that risk management is carried out so that the expected seaweed quality standards in accordance with market needs can be achieved. Ergonomics approach is implemented as a multidisciplinary science (Setiawan, 2017) which aims to create an effective, efficient, healthy, safe and comfortable work system (Pradini et al., 2019). Macro Ergonomics Analysis and Design (MEAD) study acts as a method of solving problems by designing, analyzing and evaluating work systems in an organization to be more effective and efficient (Purnomo et al., 2017). Macro Ergonomics Analysis and Design has 10 stages that can be arranged in a hierarchical system (Nugroho et al., 2019). This study also uses the Analytical Hierarchy Process (AHP) method as a tool for decision making in determining the weight of criteria and sub criteria through paired comparisons (Wulan & Hendrawan, 2018). This will greatly help the sustainability of the seaweed commodity supply chain.

2. Literature Review

According to Iriastadi and Yassirli (2014), Macro Ergonomics Analysis and Design (MEAD) is one of the methods that plays a role in solving problems contained in the macro ergonomics approach. MEAD is a method related to designing, analyzing, and evaluating work systems in organizations so that they become effective and efficient. This study collaborates MEAD with the Macro Ergonomicss Analysis of Structure (MAS) method. This method combines empirically the analytical model developed to determine the effects of the three main elements of the sociotechnical system, namely the technological subsystem, the personnel subsystem, and the external environment (Iriastadi & Yassirli, 2014).

Human behavior is a major determinant in improving the quality of seaweed (Darise & Bagou, 2019). This will greatly help the supply chain process so that it is not hampered. Based on the MAS method the elements affecting the quality of seaweed are personnel subsystems and the external environment. The results of the MAS model become a direction in determining what improvements need to be made to obtain a more optimal work system function (Iriastadi & Yassirli, 2014). Risk Reduction focuses on minimizing the risks that are likely to occur. Risk reduction in the supply chain is important to do in order to reduce the possibility of losses (Kasidi, 2010).

3. Methods

The framework to minimize the potential incidence of risk events in this study uses the Macroergonomi Analysis and Design method. This method develops a structured framework in designing, analyzing and evaluating a work system of an organization. This research was conducted in Babana Hamlet, Bulukumba Regency with seaweed farmers as the target. The following in Figure 1 are the stages of completing the research that follow the ten stages of MEAD as carried out by (Purnomo et al., 2017).

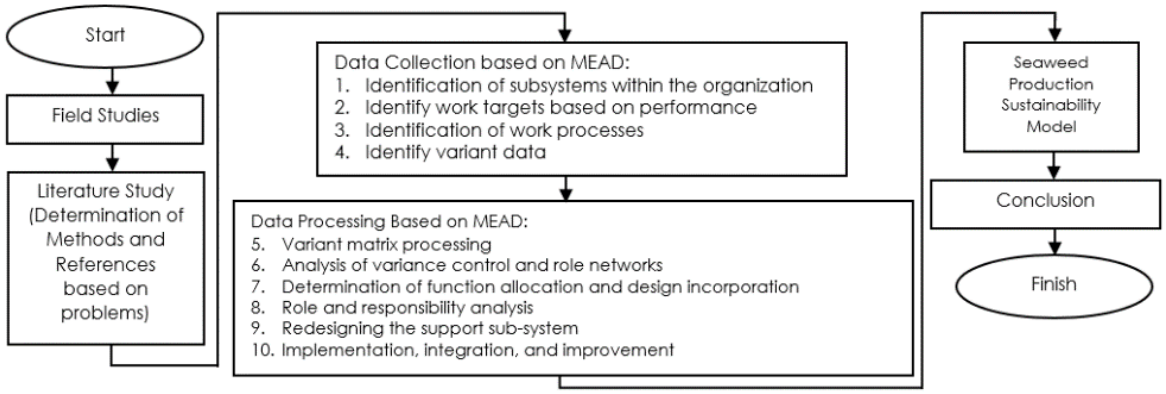

Figure 1. Stages of research completion

4. Data Collection

- **First Stage : Identification of Subsystems within the Organization**

  Babana Hamlet is one of the seaweed producing areas located in Danuang Village, Ujung Loe District, Bulukumba Regency. In its implementation, seaweed cultivation in Babana Hamlet is monitored directly by the Head of the Environment with direct coordination to the Marine and Fisheries Service. Based on the vision of the local government, namely "Realizing a Productive Society with the character of Local Wisdom towards Advanced and Prosperous Bulukumba", as well as the fourth mission, namely "Increasing the productivity of marine and fisheries resources to meet regional, national and international needs", the Marine and Fisheries Service of Bulukumba Regency described it in the Strategic Plan. The following in Table 1 is an explanation of the problems related to the fourth mission of the Bulukumba Regency Regional Government.

Table 1. Strategic plan of the Bulukumba Regency Fisheries Service

Service Problems of the Bulukumba Regency Fisheries Service	Factor	
	Barrier	**Driving**
- Low productivity of capture and aquaculture fisheries - European Union rejection of shrimp commodities due to antibiotic use - Many competing countries that are also producers of shrimp and seaweed. - Tendency to damage coastal areas such as mangrove and coral ecosystems and land use change. - Lack of technical knowledge for cultivators - Lack of application of cultivation techniques in accordance with cultivation standards by the community - Fluctuations in fishery products - Fisheries and marine businesses have not been integrated with banks, making it difficult for banks to disburse loans. - Weak institutionalization of fishermen farmers and other fisheries business actors. - Food safety of fish processing products that have not met the quality requirements and the presence of extension workers who are not a fisheries education background. - Officials and technical staff in the Fisheries Service also have inappropriate educational backgrounds. - Fishery products are generally sold raw (without processing) so that people cannot get added value from their production. - Insufficient budget allocation.	- Limited facilities and infrastructure - Revamping the System and management of institutional enterprises - Revamping the system and management of institutional enterprises - Lack of market data and information in business development - Business Capital and access to capital - Marine authority is not a district authority. - Quality of Human Resources.	- Considerable resource potential. - Application of technology and building business networks. - Control of the utilization of Marine Ecosystems, Public Waters and Fish Resources - -Restructuring of infrastructure, facilities and development of fishing technology. - Revitalization of Production Systems - Financing and Commitment Support - Quality Improvement and Food Safety Assurance.

Source : Bulukumba Regency Fisheries Service, 2022.

- **Second Stage : Identify work targets based on Performance**

  At this stage, the work target of the Marine and Fisheries Service is stated based on the barrier and driving factors contained in the Strategic Plan. Here is the resulting strategy of the SWOT Analysis:

  Strength-Opportunity Strategy

  - Optimizing the potential to increase seaweed production in order to meet market demand and increase foreign exchange by implementing semi-intensive methods.
  - Maximize the technical assistants of cultivation to intensely conduct direct counseling in the field in an effort to increase production (both quantity and quality).
  - Carry out programs and activities that function to boost production such as rehabilitation of ponds, provision of superior seeds and so on.
  - Carry out extensification of seaweed cultivation in water areas that have not been used as cultivation areas by inputting applied technology.

Strength-Threats Strategy

- Provide breadth to cultivation assistants to be intense in conducting research and experiments in an effort to overcome the disease.
- Providing stimulus to cultivators by providing assistance that can reduce production costs so as to further increase the competitiveness of our cultivators.
- Carry out technical training for cultivators.
- Development of cultivation with the application of cultivation techniques in accordance with the form of commodity adaptation
- Development of fishery product processing to diversify products and improve post-harvest infrastructure to maintain quality and market search to avoid the games of collectors and cut the marketing chain.
- Carry out group coaching through trainings and group competitions to measure group professionalism

Weakness-Opportunity Strategy

Implementation of fisheries technical training to extension workers for support increased production.

Weakness-Threats Strategy

- Improved surveillance facilities
- Tackling seaweed disease by intensifying extension workers to socialize good technical culture (CBIB).
- Providing training to extension workers and the community
- Intensify counseling on the importance of maintaining the quality of fishery products.
- In addition to technical abilities, extension workers must also be given entrepreneurial knowledge so that it can be transmitted to the community.

Seeking other sources of financing other than SAF (Special Allocation Fund) and GAF (General Allocation Fund)

- **Third Stage : Defining the Work Process**

  This stage defines the work process, namely the steps for planting seaweed seedlings to the harvest process. The process begins with seeding, then planting, inspection, harvesting, and removal of the net. After that, along with the process of resisting and removing the tarpaulin that has been carried out first, seaweed transfer is carried out to drying. After drying, cleaning is carried out. Finally, before the process of moving to the warehouse, an inspection is carried out. Based on the analysis with the operation process chart, the completion time of the entire process was obtained by 2,788 minutes.

- **Fourth Stage : Variant Identification and Fifth Stage : Variant Matrix Processing**

  Phases (4) and (5) focus on two things, that are identifying variants that occur, for example related to: quality, cost, schedule, health and safety as well as non-value added activities, as well as analysis of identified variants until key variants are found that have a significant impact on system performance. At this stage, seaweed production risk identification will be carried out using the Macro Ergonomicss Analysis of Structure. The results of risk mapping with the perspective of personnel subsystems, technology and the external environment (Vargas et al., 2018). Macroergonomy suitability consists of 3 levels that areMacro Ergonomicsal elements, Macro Ergonomicsal factors, and working systems. Improvements based on macroergonomy can help in improving the quality of work based on factors that are the cause of disruption of a work system. This macroergonomy factor is then categorized into two, internal and external. Data processing begins with creating a hierarchical structure for criteria and sub-criteria according to the Analytical Hierarchy Process method.The criteria and sub-criteria are prepared based on the risks of internal factors (target time that is ahead of the harvest schedule, prioritizing other work, late cultivation process because the farmer's physical condition decreases, erratic prices result in decreased farmer morale, and high rainfall results in decreased morale) and external factors (growth of moss on seaweed, high rainfall for a long time, long droughts, sudden

extreme weather, and high sea waves. Figure 2 shows the structure of the hierarchy for the determination of weights for each risk.

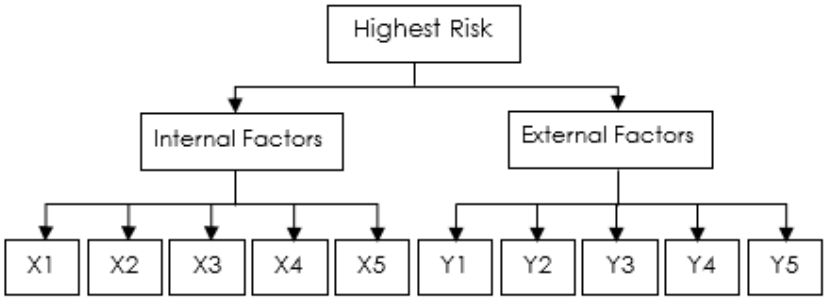

Figure 2. Hierarchy structure

Analytical Hierarchy Process data processing is carried out using Expert Choice software. The results of weighting in the sub-criteria of each factor can be seen in Tables 2 and 3.

Table 2. Weight values sub criteria internal factors

X1	X2	X3	X4	X5
0.09	0.08	0.28	0.23	0.32
		1.00		

Table 3. Weight Values Sub Criteria External Factors

Y1	Y2	Y3	Y4	Y5
0.11	0.33	0.24	0.20	0.12
		1.00		

Based on Table 2, the highest weight value for the internal factor sub-criteria is X5 with a weight of 0.32, which is high rainfall results in decreased morale. While in the external factor the highest weight is Y2 with a weight of 0.33, which is high rainfall for a long time.

5. Results and Discussion

5.1 Analysis Step of MEAD

- **Sixth Stage : Analysis of Variant Control and Role Networks**

  Macro Ergonomics Analysis and Design is a method used to design, analyze and evaluate the systems of an organization. To facilitate the preparation of analysis according to the stages of MEAD, it is necessary to involve the role of the entire system[12].In addition to seaweed farmers, the local government is also responsible for the improvements that will be made. Based on the vision of Bulukumba Regency, the Fisheries and Marine Service takes part in efforts to implement local district goals related to Fisheries and Marine Affairs, one of which is seaweed. The field of Brackish Water Aquaculture is a field that is given the responsibility to compile a program of activities, carry out the provision of seeds, carry out a study of the supply of brackish water for cultivation, carry out the management of infrastructure and cultivation facilities, convey implementation instructions, monitor and evaluate results related to cultivation in brackish water.

  At the Fisheries and Marine Service of Bulukumba Regency, there is no expert who specifically studies brackish water cultivation. So that the control measures carried out at this time are still not optimal, therefore other solutions are needed that can help grass farmers in Babana Hamlet, Bulukumba Regency. So it is necessary to find experts from outside the region to discuss related to solutions to the potential risks identified. The selected expert is an expert related to seaweed approved by the local government.

- **Seventh Stage : Determination of Function Allocation and Design Incorporation**
  The allocation of task implementation cannot be separated from coordination with the villages and hamlets, this is done so that the Fisheries and Marine Service can carry out tasks directly in the field. The following in Figure 3 is the coordination structure from the Head of brackish water aquaculture to go to seaweed farmers.

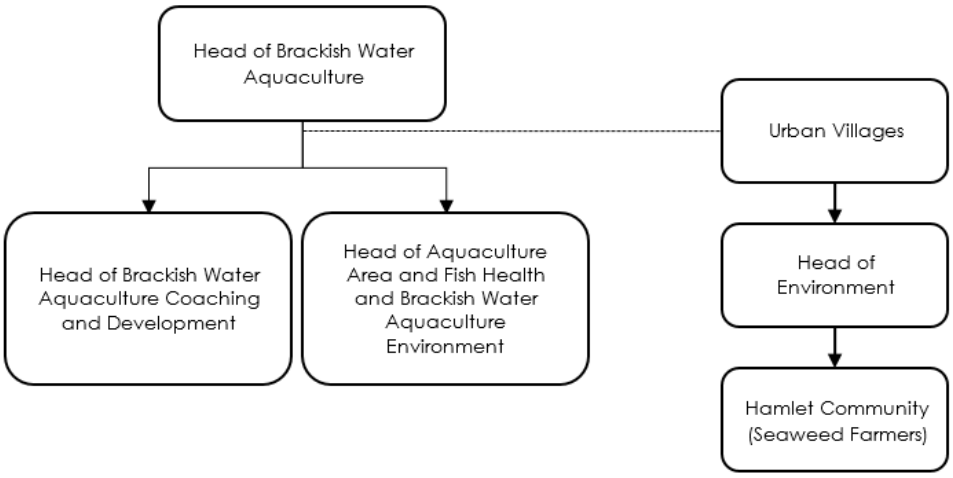

Figure 3. Coordination line of the fisheries and hamlet service

Considering the research conducted by Mohamad & Yuliawati (2018), about the good quality standards of seaweed that are in accordance with the wishes of the market are[4]: fat (large), long (without signs of bites of marine animals), clean (without moss, sand and plastic waste), as well as potential risks from internal and external factors are related to high rainfall (rainy season), so the solution obtained from the results of interviews with seaweed experts who are also engineers at the Takalar Brackish Water Cultivation Center of the Ministry of Marine Affairs and Fisheries are :

1. Selection on seaweed seedlings based on production results
2. If the seedlings are damaged, then the farmer can buy seedlings in the seedling garden for re-cultivation.
3. Spore production techniques and tissue cultures to obtain quality seedlings carried out by experts in the Laboratory.
4. Cultivating in the landbase in order to minimize seaweed damage during high rainfall.

- **Eight Stage : Role and Responsibility Analysis**
  The analysis of roles and responsibilities is to describe the person responsible for the resulting problem and solution, to achieve the expected goals. The resolution of the problem is coordinated directly with the Head of Babana Hamlet in order to minimize risks and losses to seaweed farmers. Based on discussions with seaweed experts, that the use of existing karamba can only be used in non-extreme weather. Meanwhile, the potential risk is seaweed production in the rainy season (extreme weather).
  Here is an explanation of the solution given by the seaweed expert:
  1) Short Term Planning
     Conducting Seedling Selection
     The seeds that have been harvested are then selected, taken as much as 10% for the seedlings. The trick is to look at the best seedlings, then cut and store them for personal seedlings so that they can be planted again. This is to prevent the occurrence of damage to seedlings in the future.
  2) Medium Term Planning
     Procurement of Seedling Gardens

Attempts to hold a seedling garden, with the selling price of seaweed seedlings are cheaper. This will be very helpful for the community because most people do not store seeds for re-cultivation. The reason is that the needs continue to grow (economy) so that the community or farmers must immediately sell the harvest and leave seeds of unknown quality.

3) Long Term Planning

Laboratory Procurement

Laboratories in Bulukumba Regency are not yet available. The laboratory is very important for the sustainability of seaweed farmers. Continuous research is very much needed because seaweed cultivation depends on the external environment. The laboratory can also help to hold new seedlings by means of tissue culture or spores. So that the laboratory can also provide new seeds if the seeds in the community are damaged or exposed to bacteria.

Landbase Creation

Create a landbase on certain lands for seaweed stocks during extreme weather. The landbase in question is on a special land in brackish water, then equipped with a special machine to produce vibrations or waves under light with the appropriate intensity in order to support the growth of seaweed.

- **Ninth Stage : Redesigning the Support Sub-System**

Once a solution to minimize risk has been obtained, the next step is to redesign the support sub-system. In this section, the problem will be combined with the solution that has been obtained. Here in Figure 4 is a description of the design of the new system of solutions to the risks in seaweed production.

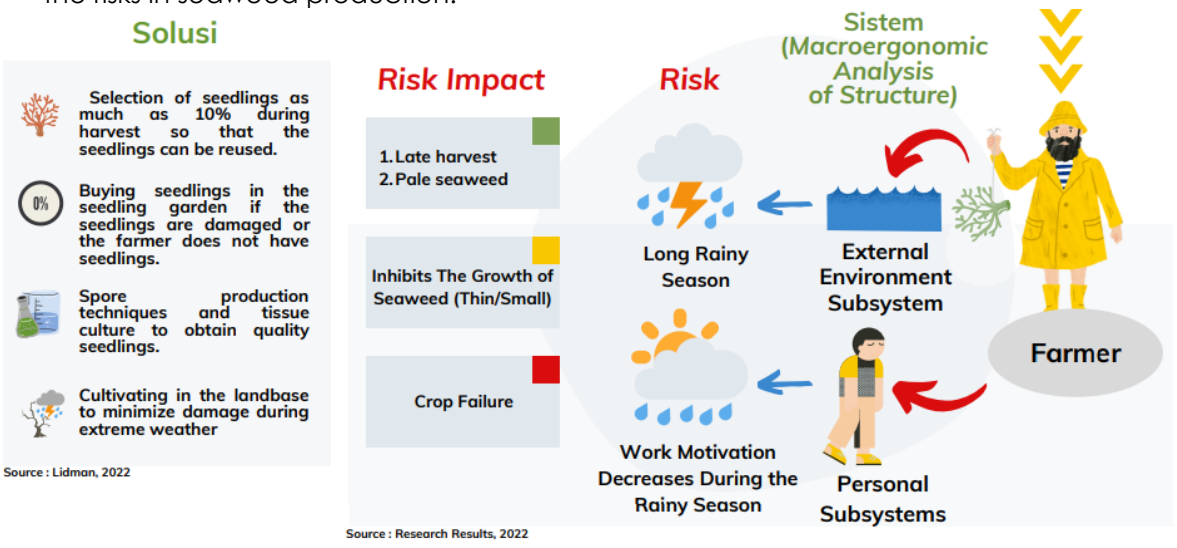

Figure 4. Design of a solution system against seaweed production risks

- **Tenth Stage : Implementation, Integration, and Improvement**

Based on the solutions above, a model is then depicted (Figure 5) that aims to maintain the stability of production results and increase the profitability of seaweed commodity supply chain actors. So it is hoped that the supply chain network for this commodity can be maintained its sustainability.

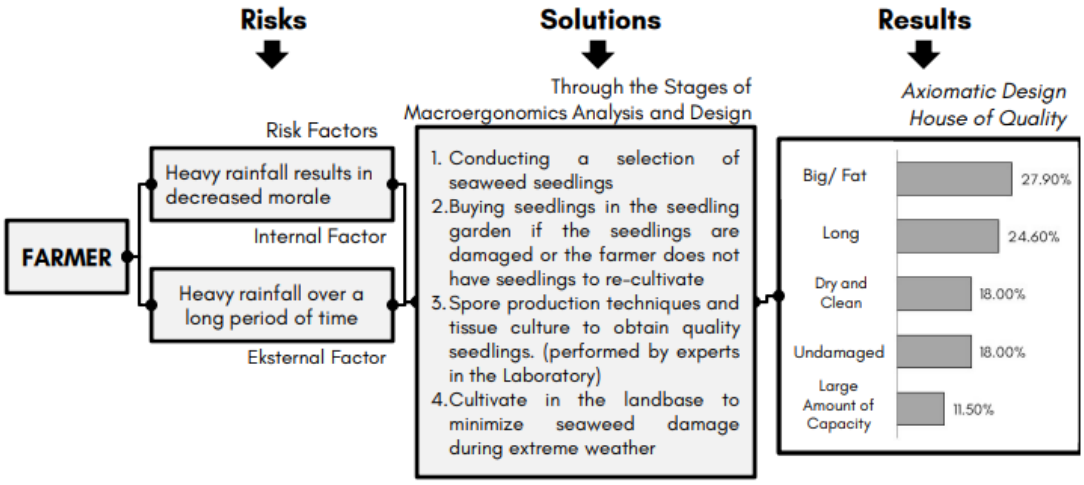

Figure 5. Sustainability model of seaweed production with macro ergonomicss analysis and design

5.2 Managerial Implications

The supply chain of seaweed commodities is still experiencing many obstacles. The rainy season is the most uncontrollable risk because it has a great impact on the cultivation process. This results in the amount of seaweed being cultivated is not the same as the harvest. In addition, this risk also affects the decline in the quality of seaweed to interfere with supply chain performance. Starting from farmers who cannot sell seaweed at the expected price because of the seaweed that is still wet or because of its declining quality, wholesalers who have to add work by carrying out the seaweed drying process independently, the amount of capacity transported to exporters is less, and delivery times are more often delayed.

Through the Macro Ergonomicss Analysis and Design stages, a model was obtained that can minimize the risks that affect seaweed production. The implementation of this model has a good impact on the smooth supply chain of seaweed commodities. If the risk can be minimized, the quality of the seaweed produced will be better. Conversely, if the risk is higher, it adversely affects the quality of the resulting one. In Figure 6 below, we can see the relationship between the identified risks that affect the supply chain network.

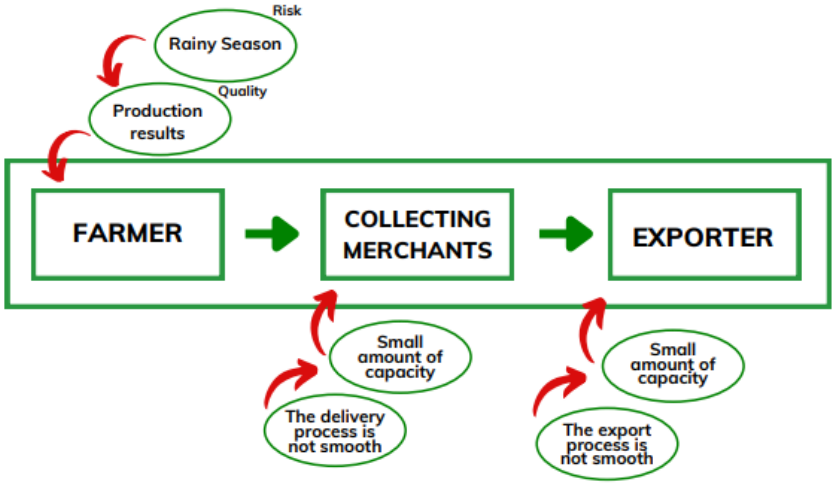

Figure 6. Risk linkages to seaweed supply chain

The picture above shows the importance of seaweed quality in the supply chain network that is dried seaweed, to support export activities. Seaweed production also affects price fluctuations, including to support the smooth running of international trade. Considering that the most exports are made to China, the price of seaweed is determined by the countries that receive seaweed exports from Indonesia, including China. The production of dried seaweed in Indonesia and the export price of seaweed have a significant effect on the export volume of dried seaweed from Indonesia to China. The export of dried seaweed needs to be supported by good seaweed quality and an increasing amount of production, in order to maximize the value of export products (Dharmawan & Marhaeni, 2021).

6. Conclusion

The model obtained from the results of Macro Ergonomics Analysis and Design is in the form of stages of a sustainable seaweed supply chain process by considering risks to seaweed farmers in Babana Hamlet, Bulukumba Regency. Potential risks associated with rainfall are overcome by conducting seedling selection, planting seedling gardens and laboratories, and creating landbases. The implementation of this solution is expected to improve the quality of seaweed commodities in accordance with customer standards and wishes. If the risk can be minimized, then the quality of seaweed commodities will be better. This has an impact on increasing the yield of seaweed harvests received by collecting traders and more and more will be distributed to exporters, so that the export process of this seaweed commodity will be smoother.

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