A framework design web-based information system for sustainable fisheries supply chain in coastal communities of small islands Indonesia

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Abstract

Recent advances of development in information technology and the rapid use of decision support systems have become one of the advantages that can be utilized for use in the fisheries sector specifically in small islands. With geography conditions that caused limited access between and within the region, a need for efficient and effective tools for interconnecting supply and production includes managing the marine resources available then Web-DSS one way to choose. This study design DSS for sustainable supply chain of sectors in Southeast Maluku Regency, Indonesia (SIRIPIKAN). The DSS framework that was built consists of the first three parts, identification of fishing locations, then identification of supplier and seller locations, the second is the measurement of the level of sustainability of marine resources and the third is the managerial fisheries business carried out. SIRIPIKAN aims to increase the profitability of coastal communities in the region related to fisheries business activities and also reserving the marine resources in the region. In this system, we used data mining combining with spatial analysis and feasibility study as an approach to as the basis of the development of the system. The model is able to provide an integrated sustainable production by using input from the user to optimize the decision making related to optimize the profitability and sustainable existing marine resources.

Keywords: DSS, sustainable, SIRIPIKAN, supply chain, fisheries

Highlights

- We develop a conceptual web-based DSS for sustainable fisheries supply chain on coastal communities in the smalls islands Indonesia
- We used data mining and spatial analysis and feasibilities study to help smoothing the flow “input-process-output” activities in fisheries supply chain
- The Model support decision making on profitability and marine resources sustainability

Introduction

The advantages of a business that has a wide network of cooperation when compared to traditional business models that have limited connections, these businesses have more opportunities to be able to compete and survive in competition [1]. One way of cooperation and improvement of cooperation networks is the sharing of information held by each business actor at each level of the supply chain. By sharing information in a supply chain cooperation network, each party can make better decisions on the number of product requests, allocation of resources related to planning and production costs which can produce dynamic supply chain relationships and have an impact on the level of profitability generated [2]. Inequality of information held by the actors is one of the causes of the delays in the flow of the supply chain in a business [3] and [4] which fisheries related business activities included.

As [5] and [6] mentioned that one of the causes of declining productivity of seaweed yields in Southeast Maluku Regency was the uneven distribution of information held and the uneven flow of information in the supply chain of seaweed businesses in this region. [7] stated that one of the obstacles of aquaculture business in this region is the access and use of the latest relevant technology in the production process. In addition, according to [8] that socio-economic factors in this case kinship and potential conflicts also affect the sustainability of aquaculture businesses that are more efficient and have optimal benefits. [9] further shows that the capture fisheries sector in the Maluku region even though it remains in a considerable amount but is experiencing a downward trend so that its utilization process must go through an effective planning process.

This condition should be immediately addressed in order to improve the welfare of coastal communities. With the more even distribution of Information Communication Technology (ICT) facilities in Southeast Maluku Regency, a system that adopts the use of ICT and the Internet should be made more efficient and appropriate, given the geographical conditions of the region, which can greatly assist in the process of analysis and accuracy of fisheries data in the region this [6]. To be able to improve the accuracy of the contribution of the data obtained, the utilization of data mining can be used which up to now has been applied in various fields [10] including in the field of fisheries supply chain.

Thus, to optimize profits and streamline production costs, it is very necessary to have a system that makes it easy for every actor in the supply chain of fisheries in Southeast Maluku Regency. The purpose of this research is to create a web-based fishery supply chain information system with data mining and Spatial Analysis approaches. This system can help improve the performance of the fisheries sector's decision-making process in general, which is expected to increase the efficiency of production activities and improve the consistency of the profits obtained by fisheries businesses in Southeast Maluku Regency.

Important role of supply chain

The role of supply chains in business success is far greater than before, collaboration between intra and inter sectoral parties is one of the keys to the sustainability of business performance. [11] argues that every business must use its supply chain to increase product intensity to the market. Collaboration and integration in the supply chain can strengthen networks and improve services to consumers. However, collaboration between stakeholders in the supply chain is difficult to determine when these constraints exist such as willingness to share information, industry characteristics and type of business [12]. Along with the development of technology and information (IT), information exchange has become very fast so that distance and time factors are no longer a barrier. This development has a positive impact on networking, connectivity and development on intra and inter-business becomes unlimited [13]. Although, on the other hand globalization can also increase business competitiveness which makes coordination between parties involved in a business very crucial. Therefore, [14] points out that the concern of information being shared between each party in the supply chain is not what is shared but how to share information including information and that includes sensitive information such as production costs.

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In a supply chain consisting of many independent actors, there is a higher likelihood of conflict because each entity in the supply chain has a different purpose. This condition will be avoided when the flow of information circulating in the supply chain runs smoothly which will automatically form a supply chain that is more likely to be a central planner than a centralized planner [20]. In addition, previous studies have suggested factors that encourage each party to coordinate in the supply chain (seller-buyer relationship) are flexibility and discounts in product quantity [21] [22] and product payment options [23].

Web-based decision support system

Intelligent DSS or intelligent decision-making system is a DSS that is designed and built by involving several techniques and modeling methods in its development. Intelligent DSS are DSS whose design and development uses one or more artificial intelligence-based techniques, such as: Artificial Neural Networks, Evolutionary Computing, Fuzzy Systems, Case-Based Reasoning, and Agent-Based Systems [24]. Various studies have been carried out in order to build a DSS-based supply chain system, in various fields such as [25] which examined the DSS supply chain with a humanitarian approach, subsequently [26] built a supply chain DSS for aluminum mining sites in India, in addition to further research, conducted by [27] also shows the use of DSS in supply chains in shipping and port systems.

Besides the use of DSS for supply chains, it has also been carried out with various approaches [28] identifying and combining DSS for supply chains with the ARIMA approach. In addition, research conducted by [29] that applies spatial analysis in supply chain DSS. Then the research conducted by [30] also adopted fuzzy analysis in supply chain DSS and [24] by using an agent-based approach to supply chain DSS.

The development of information technology, the level of utilization is becoming more widespread in addition to being an inseparable part of the main supporters of a business or industry. The use of the internet and websites in supporting supply chain activities in the industry has become more widespread, especially in facilitating business actors in the decision-making process (decision making) as done by [31] [32]. The purpose of using the website in making a supply chain decision making support system is to facilitate various actors such as the government, farmers, distributors and importers to exporters [33] in utilizing information related to accelerating the flow of information related to the business being run so that they will jointly improve performance supply chain in related industries. The purpose of utilizing websites and the internet in the formation of a supply chain decision making support system is to facilitate besides access but also the use of related DSS [34]. Another benefit of utilizing the internet through websites in supply chain DSS is to improve the adaptability of existing DSS platforms to various operating systems and various website algorithms [35]. Thus, the use of websites and the internet as a DSS container becomes increasingly important and imperative given the speed of information that must be available and the ability of the internet and a flexible website to make a combination of web-based DSS a good solution in improving supply chain performance in the industry.

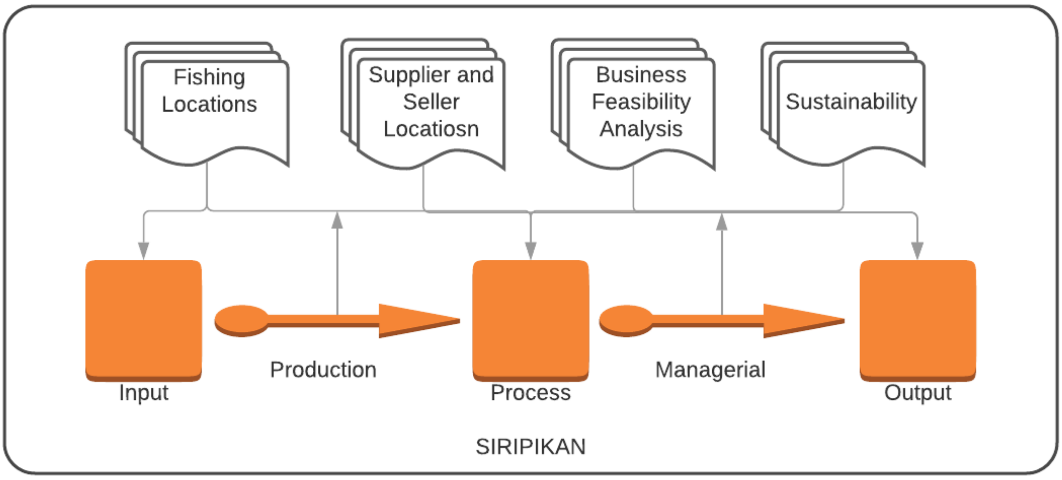
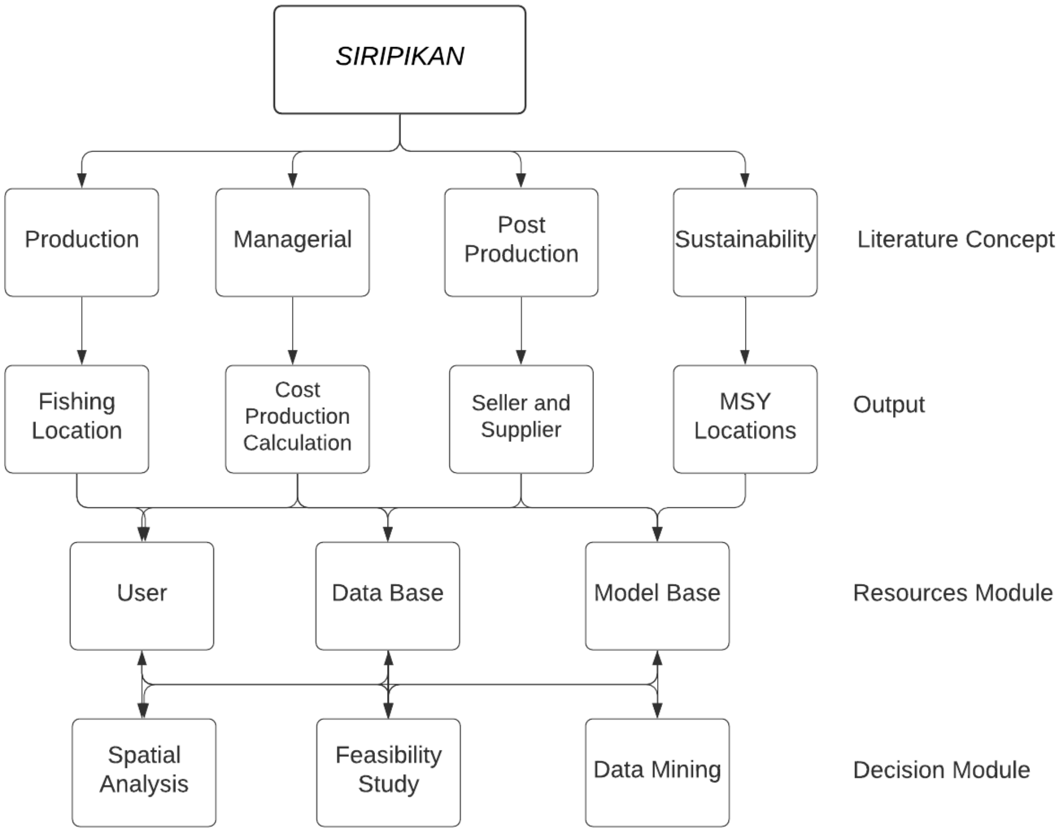


Figure 1. Proposed system based field survey

System Overview

The development of SIRIPIKAN consists of four stages. First was a field survey on the existing condition of fisheries supply chain weakness in Southeast Maluku Regency, from the results of preliminary studies conducted it was found that, the main weakness of fisheries supply chain of fisheries related business in this region is the inconsistency of product availability due to two main factors namely first, managerial related to production management, marketing, and buyers, then the second factor is technical related to the location of fishing and cultivation (Figure 1). The second stage is the literature review on the fishery supply chain system to further identify the system that is in line with the needs of fisheries business operators in this region, especially related to infrastructure conditions. This stage aims to identify the concepts and models of DSS that are applicable to fisheries supply chains in areas with archipelagic characteristics, including types of data input, user and data combinations. Based on the results of this second stage, it was found that a suitable system to cope with the need for production, managerial, post-production and marine resources sustainability (Figure 2).

The third stage focuses on the collection of data needed by the system. Spatial data is obtained and processed using data mining in order to cluster producers, suppliers and sellers of



capture fisheries and aquaculture in this region, which are then processed with GIS to obtain location map output. For managerial, data collection is carried out by surveying needs and items for production and post-production to marketing for the next process with a feasibility study concept to get a calculation of the cost of production, marketing, to projecting the benefits that can be obtained with the conditions of the origin, production, path and means of distribution to the market. For the sustainability of marine resources, we use field sufficiency to calculate the MSY (Maximum Sustainable Yield) concept. For fishing locations, we use spatial analysis using a temperature and chlorophyll-a approach.

Figure 2. System component and hierarchy architecture

The fourth stage is to build a decision support system. DSS SIRIPIKAN was created using a MySQL database, HTML, CSS, JavaScript, and PHP, The SIRIPI-KAN DSS is available in beta at http://siripikan.com/public. MySQL was chosen to store basic data such as sub-districts and villages, equipment used, data on production, distribution and location costs. The web interface is built and managed using HTML and CSS. Furthermore, JavaScript and sub-modules process user input and data from the MySQL database and then carry the output to the server. Data is processed in PHP to be stored again in MySQL.

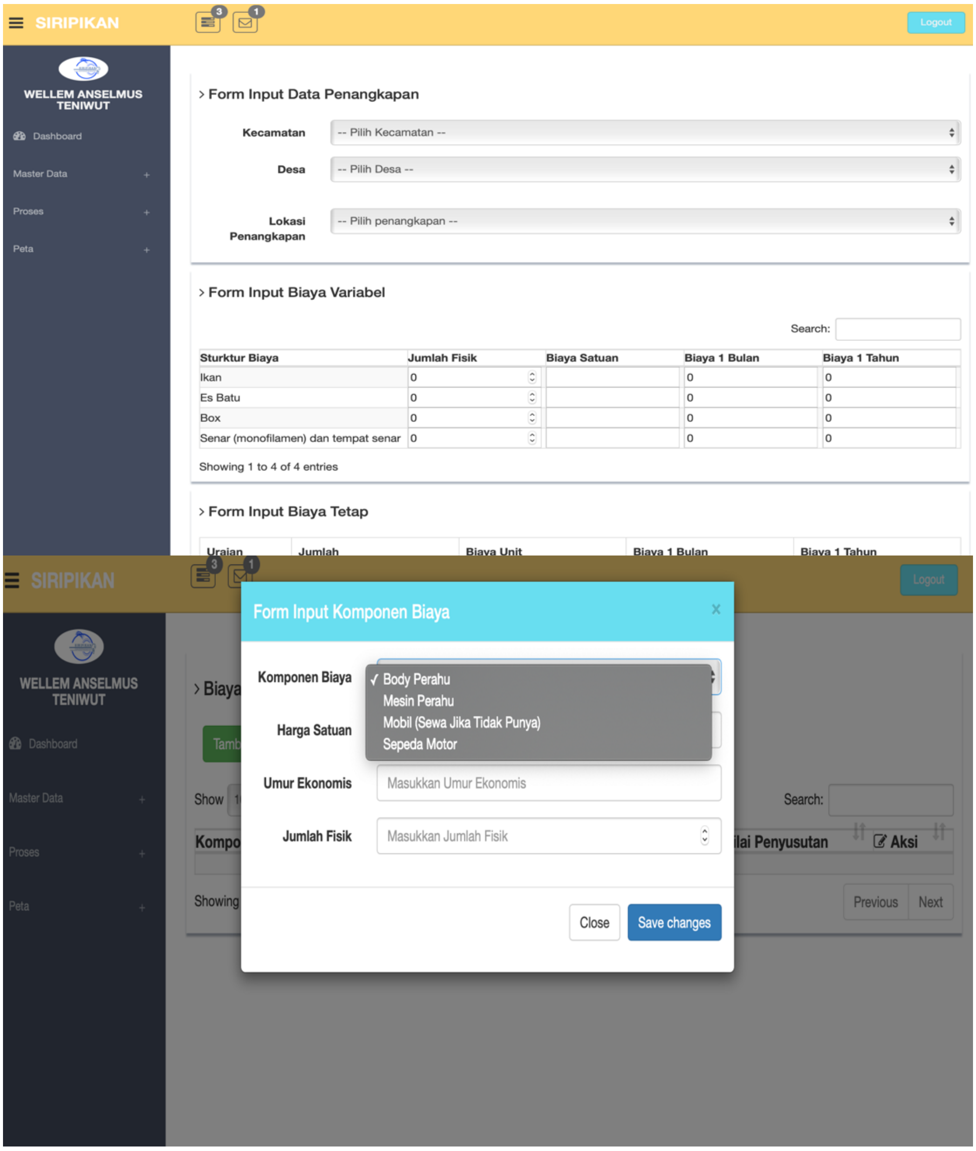


Figure 3. User interface

User Interface

The user interface can be seen in Figure 3. Users are asked to input their original location, after which they will be asked to choose which fisheries sector to do, there are two choices, namely the capture fisheries and aquaculture sectors. Furthermore, users can also have an estimate of production costs by entering the type of equipment, the amount and price. Furthermore, the user also enters distribution costs, production costs consisting of equipment and material costs; and distribution and marketing costs. For the types of production equipment and transportation equipment sales until the production items are filled can be selected from the dropdown menu that comes from the master data that can be updated by the admin, making it easier for the user, because the choice of data items is auto-fill.

Fishing Location

For the selection of fishing locations, we used a sea surface temperature distribution (SST) and chlorophyll-a approach. For image data processing, the MODIS algorithm for our chlorophyll-a calculation based on Algorithm Theoretical Basic Document Modis 19 (ATBD 19) by [36] as showed on equation 1.

$$\log chl\ a_{emp} = {}_{c_o} + {}_{c1} log_{(r35)} + {}_{c2}\left[log_{(r35)}\right]^2 + {}_{c3}\left[log_{(r35)}\right]^3 \qquad (1)$$

Where

$$r_{35} = \frac{R_{rs}(488)}{R_{rs}(451}$$

For SST we use an algorithm that refers to Algorithm Theoretical Basic Document Modis 25 (ATBD 25) study by [37] as seen on equation 2.

$$SST = c_1 + c_2 * (T_{31} + 273) + c_3 * (T_{31} - T_{32}) * (T_{20} - 273) + C_4 * (T_{31} - T_{32}) * \left(\frac{1}{\cos\theta - 1}\right)$$

(2)

Where

T_{20} is the brightness level of the temperature band 20 (BT)

T_{31} is the brightness level of the temperature band 31 (BT)

T_{32} is the brightness level of the temperature band 32 (BT)

c_1, c_2, c_3 and c_4 are the coefficient of sea surface temperature θ is the zenith angle of the satellite.

Table 1.

Coefficients for the MODIS Band 31 and 32 SST retrieval algorithm, derived using radiosondes to define atmospheric properties and variability.

Coefficient	T_{31} - T_{32} <= 0.7	T_{31} - T_{32} > 0.7
c_1	1,228552	1,692521
c_2	0,9576555	0,9558419
c_3	0,1182196	0,0873754
c_4	1,774631	1,199584

Then converted to water brightness temperature by using the Planck inverse function equation (equation 3).

$$T_b\lambda = \frac{C_2}{\left[\lambda \ln\left(\frac{C_1}{\lambda^5\, \pi L_\lambda} + 1\right)\right]} \tag{3}$$

Where Tb is water brightness temperature (^{0}K). C_1, C_2 is constant number, where C_1 1,1910659*10^8 $[W\ m^2\ sr^{-1} (\mu m^{-1})^{-4}]$, and C_2 is 1,438833x10^4 $[K\ \mu m]$. γ wavelength (m), and L is spectral radians $(W\ m^{-2}\ m^{-1}\ str^{-1})$.

Supplier locations

For the selection of potential supplier locations, we use the X-Means clustering approach. X-Means clustering algorithm is an extended K-Means. X-Means tries to automatically determine the number of clusters based on Bayesian Information Criterion scores. X-Means algorithm begins after each time the K-Means is run, make local decisions about the subset of the current centroid which should be split itself to better fit with the data [38].

Sustainability Marine Resources

We use the Gordon-Schaefer model to measure the maximum sustainability yield of water areas in each district in this region. MSY value calculation is done using the concept of effort and yield and then used to get the value of CPUE (catch per unit effort) obtained from the results of the division of effort against yield, to then calculate the predictive value of yield. To get the MSY value, we calculate the optimal effort value to get the optimal prediction yield which is then compared to the actual effort value. If the optimal effort value is lower than the actual effort value, then the water area can still be utilized, if on the contrary, at this time the problem is overfishing.

$$CPUE = Catch/Effort$$

Business feasibility

Business feasibility study is a research of a business plan that not only analyzes whether a business is feasible or run, but also controls operational activities regularly in order to achieve goals and maximum profits. Some of the methods we use in business feasibility studies are total cost, total revenue, BEP, gross profit and net profit.

$$Profit/Loss = TR - TC \quad (5)$$

$$BEP = 1\left(\frac{\frac{FC}{VC}}{S}\right) \quad (6)$$

Where, TR is total revenue calculated by multiply price and quantity production; TC is total cost which calculated by sum variable cost (VC) and fix cost (FC); S is sales volume and BEP is breakeven point.

Results: Master data and prototype

From the results of the comparison of ground truth data (table 2) of waters in the Kei Islands with the results of mapping analysis of potential fish locations in this region based on chlorophyll-a and SST, the master data for fishing sites can be seen in Figure 4. A description of the potential for potential fishing locations in this area with the hope of facilitating capture fishermen in particular to be more efficient in conducting fishing activities. Knowledge on the location of fishing is also expected to increase the quantity of catches and increase the level of profits due to the increased level of effectiveness of fishing activities.

Table 2.

Ground Truth Kei Islands Sea

No	Point (location)	Latitude	Longitude	PH	Chlorophyll-a	Temperature	Total Suspended Solid
1	P1	-5,6539926	132,7126658	7,34	3.5 mg/m3	26,24°C	0,89 mg/l
2	P2	-5,7176285	132,5875485	7,27	3 mg/m3	26°C	0,72 mg/l
3	P3	-5,9522214	132,7132619	8,08	5 mg/m3	26,24°C.	0,69 mg/l
4	P4	-5,9158441	132,8658481	7,97	3.2 mg/m3	26,38 °C	0,34 mg/l
5	P5	-5,7667692	132,9235937	7,84	3.1 mg/m3	26,8 °C	0,33 mg/l
6	P6	-5,6932916	133,0396495	7,61	3 mg/m3	29,82 °C	0,33 mg/l
7	P7	-5,5985805	132,4687159	8,19	2.8 mg/m3	27.1 °C	0.56mg/l
8	P8	-5.6418000	132,2299245	8,42	2.9 mg/m3	29.6 °C	0.56mg/l
9	P9	-5,7937298	132,2447199	8,16	2.5 mg/m3	26.6 °C	0.58mg/l

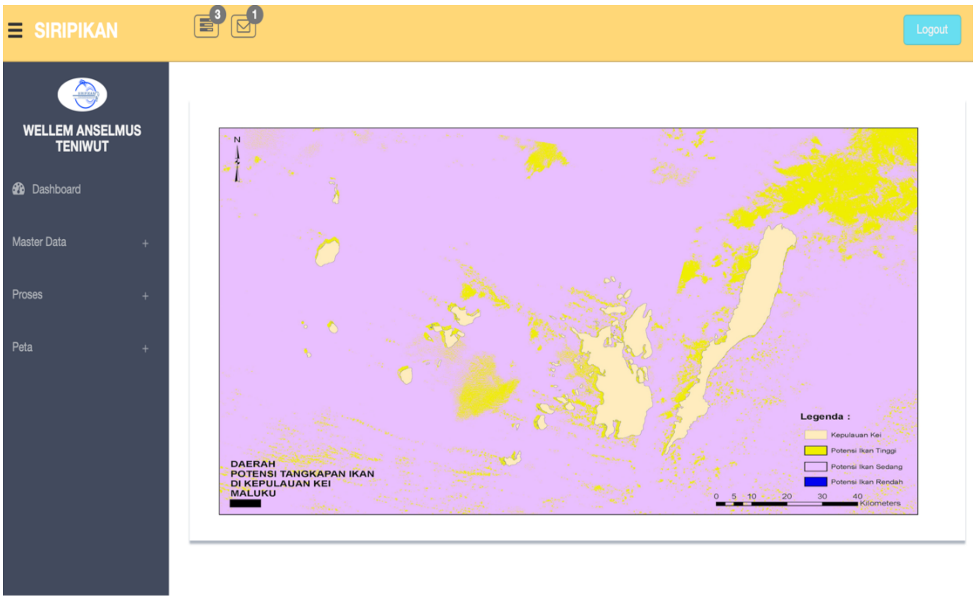


Figure 4. Potential fish locations

Furthermore, for fisheries supplier data in this region, the results of x-means clustering (table 3) show that based on the number of sellers and price criteria of fisheries commodities in this region, potential supplier locations are obtained in this region. the reason we use the criteria of number of sellers and the selling price is that fishermen and farmers in this region know locations that have a significant number of buyers and are consistent with prices that are also consistently competitive in this region (figure 5). So that it is expected to facilitate fishermen in selling their catches which can smoothly supply the upstream supply chain of fisheries commodities in this region.

Table 3.

Clustering region based on number of sellers and price

No	Clusters	Value
	Number of sellers	
1	Cluster 0	31.04% lower
2	Cluster 1	32.14 lower
3	Cluster 2	115.8% higher
4	Cluster 3	128.9% hinger
	Price	
1	Cluster 0	-
2	Cluster 1	-
3	Cluster 2	129.86%
4	Cluster 3	73.1% lower

Figure 5. Supplier locations for fisheries commodity

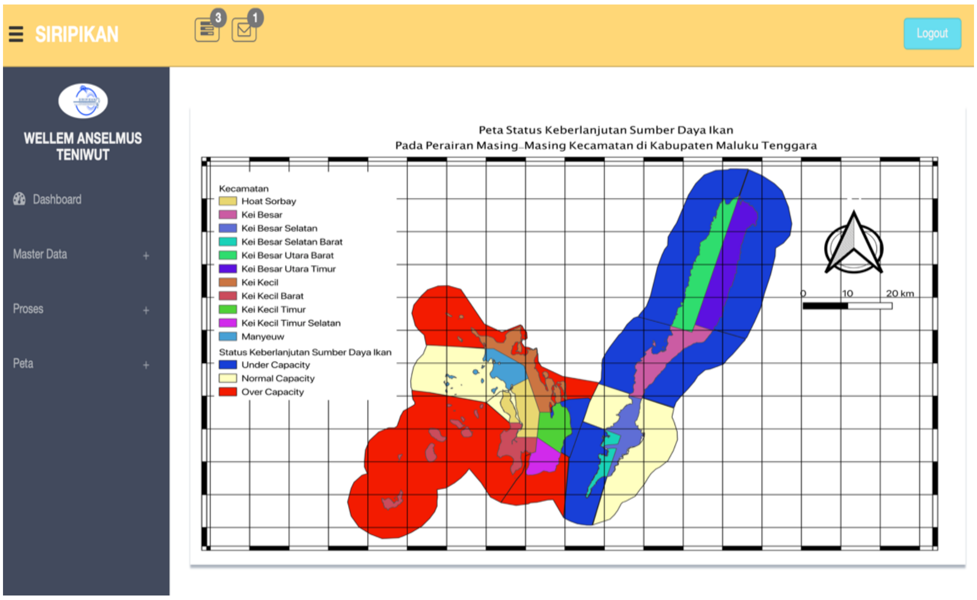


Figure 6. Sustainability location of water in Southeast Maluku Regency

Furthermore, to maintain the sustainability of marine resources in this region, based on the results of MSY with the CPUE approach (Appendix A1), it can be seen in Figure 6 the location of the waters that already have full capacity and areas that are still untouched and well utilized. Thus, it is expected that fishermen in particular can pay attention to this matter where in addition to maintaining the sustainability of marine resources but also can increase the potential income earned.

No	Uraian	Tahun 1
1	R/L Sebelum Pajak	Rp.1.200.000.000
2	Pajak (15%)	Rp. 180.000.000
3	Laba Setelah Pajak	Rp. 1.020.000.000
4	Profit on Sales	Rp. 1.020.000.000
5	BEP: Rupiah	Rp. 45.620.621
6	Ekor	57.026

Figure 7. Feasibility result

Based on the results of simulations conducted on capture fisheries activities in the village of Sathean, District of Kei Kecil with the amount of income and costs incurred also assuming a tax of 15%, the results obtained in Figure 7.

Discussions and Conclusions

The framework of the fisheries supply chain information system design in Southeast Maluku Regency was made in order to improve the smooth supply chain information system in this region. Based on the existing conditions of the region and the socio-economic and socio-cultural characteristics of coastal communities in the region also considering the condition of internet and electricity network infrastructure, the development of DSS still relies heavily on the admin in this case we are in providing and facilitating the simplicity of the existing DSS system so that coastal communities can utilize well and easily. Making an interface that is easy and simple, with easy data input as well as output that is easy to use is expected to be useful for the conduct of fisheries in this region.

The core of the output in this system boils down to three main functions in production, namely input, process and output as well as two parts in the supply chain namely upstream and downstream. On the input side we provide information on the location of capture and input of production items which also includes to the process side, on the output side the supplier data and in addition to facilitate the fisheries businesses, most of whom are coastal communities in profitable decision making processes and also to maintaining the level of sustainability of existing marine resources, we also provide information on the level of water use in the region.

The future development of this system will be carried out in two steps, namely direct field testing at a certain time period to be able to see the direct impact of this system on the fisheries business decision-making process in this region, as well as evaluating the development of this system from the outcome of the user. We strongly consider using interactive capture sites in accordance with real-time changes without having to be updated manually by us every 6 months or there are significant changes in sea weather such as El Nino and La Nina.

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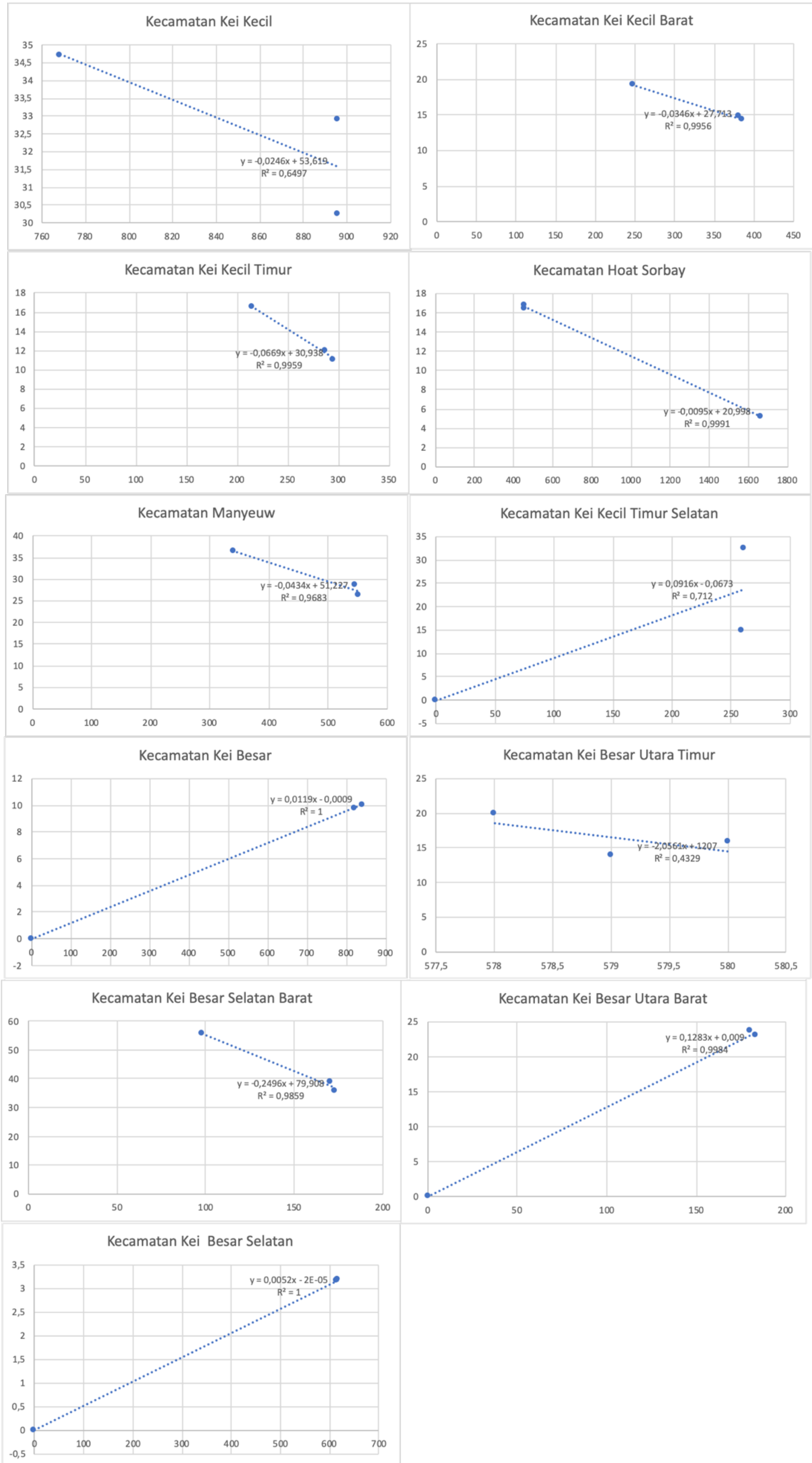
Appendix A.

1. MSY result



References

1. Shepherd, C., dan Günter, H. 2010. *Measuring supply chain performance: current research and future directions*. In Behavioral Operations in Planning and Scheduling (pp. 105-121). Springer. Berlin-Germany.
2. Cheng, J. H. 2011. Inter-organizational relationships and information sharing in supply chains. *International Journal of Information Management*, 31(4), 374-384.
3. Ozer dan Gal Raz. 2011. Supply Chain Sourcing Under Asymmetric. Information *Production and Operations Management* 20(1): 92–115
4. Wagner, M. R. 2015. Robust purchasing and information asymmetry in supply chains with a price-only contract. IIE Transactions 47: 819–840.
5. Teniwut, W. A., Betaubun, K. D., dan Djatna, T. 2017. A conceptual mitigation model for asymmetric information of supply chain in seaweed cultivation. *IOP Conference Series: Earth and Environmental Science*, Vol. 89, No. 1, p. 012022.
6. Teniwut, W., Marimin, M dan Djatna, T. 2019. GIS-Based multi-criteria decision making model for site selection of seaweed farming information centre: A lesson from small islands, Indonesia. *Decision Science Letters* , 8(2): 137-150.
7. Teniwut, W. A., dan Teniwut, R. M. 2018. Minimizing the instability of seaweed cultivation productivity on rural coastal area: a case study from Indonesia. *AACL Bioflux*, 11(1): 259-271.
8. Teniwut, W. A., Teniwut, Y. K., Teniwut, R. M., dan Hasyim, C. L. 2017. Family vs Village-Based: Intangible View on the Sustainable of Seaweed Farming. *IOP Conference Series: Earth and Environmental Science*, Vol. 89, No. 1
9. Teniwut W. A., 2016. For sustainable revenue of fisheries sector in small islands: evidence of Maluku, Indonesia. *AACL Bioflux* 9(3):722-732.
10. Han, J., Pei, J., dan Kamber, M. 2011. *Data mining: concepts and techniques*. Elsevier. Wlatham- USA

11. Puigjaner, L., dan Lainez, J. M. 2008. Capturing dynamics in integrated supply chain management. *Computers and Chemical Engineering*, 32 (11): 2582–2605.
12. Martínez-Olvera, C. 2008. Entropy as an assessment tool of supply chain information sharing. *European journal of operational research*, 185(1), 405-417.
13. Lotfi, Z., Mukhtar, M., Sahran, S., dan Zadeh. A. T. 2013 Information sharing in supply chain management, *Procedia Technology*, 11: 298-304.
14. Campuzano, F., & Mula, J. 2011. Bullwhip effect in supply chains. In Supply chain simulation (pp. 23-35). Springer, London-England.
15. Fawcett, S. E., Magnan, G. M., McCarter, dan M. W. 2008. Benefits, barriers, and bridges to effective supply chain management. *Supply Chain Management: An International Journal*, 13(1): 35-48.
16. Sarmah, S. P., D, Acharya., dan S K. Goyal. 2006. Buyer vendor coordination models in supply chain management. *European journal of operational research* 175.1: 1-15.
17. Lim CP dan Jain LC. 2010. Advances in Intelligent Decision Making. Berlin Heidelberg: Springer-Verlag.
18. Laguna-Salvadó, L., Lauras, M., Okongwu, U., dan Comes, T. 2018. A multicriteria Master Planning DSS for a sustainable humanitarian supply chain. *Annals of Operations Research*, 1-41.
19. Gupta, N., Dutta, G., dan Tiwari, M. K. 2018. An integrated decision support system for strategic supply chain optimisation in process industries: the case of a zinc company. *International Journal of Production Research*, 1-17.
20. Mar-Ortiz, J., Gracia, M. D., dan Castillo-García, N. 2018. *Challenges in the Design of Decision Support Systems for Port and Maritime Supply Chains*. In Exploring Intelligent Decision Support Systems (pp. 49-71). Springer, Cham-Swiss.

21. Dellino, G., Laudadio, T., Mari, R., Mastronardi, N., dan Meloni, C. 2018. A reliable decision support system for fresh food supply chain management. *International Journal of Production Research*, 56(4): 1458-1485.
22. Geri, F., Sacchelli, S., Bernetti, I., dan Ciolli, M. 2018. *Urban-Rural Bioenergy Planning as a Strategy for the Sustainable Development of Inner Areas: A GIS-Based Method to Chance the Forest Chain. In Smart and Sustainable Planning for Cities and Regions: Results of SSPCR* 2017 2 (pp. 539-550). Springer International Publishing.
23. Dev, M., Kaur, P., dan Sarma, K. K. 2017. Fuzzy Approach to Decision Support System Design for Inventory Control and Management. *Journal of Intelligent Systems*.
24. Othman, S. B., Zgaya, H., Dotoli, M., dan Hammadi, S. 2017. An agent-based Decision Support System for resources' scheduling in Emergency Supply Chains. Control *Engineering Practice*, 59: 27-43.
25. Laguna-Salvadó, L., Lauras, M., Okongwu, U., dan Comes, T. 2018. A multicriteria Master Planning DSS for a sustainable humanitarian supply chain. *Annals of Operations Research*, 1-41.
26. Dutta, G., Gupta, N., Mandal, J., dan Tiwari, M. K. 2018. New decision support system for strategic planning in process industries: Computational results. *Computers dan Industrial Engineering*, 124: 36-47.
27. Mar-Ortiz, J., Gracia, M. D., dan Castillo-García, N. 2018. *Challenges in the Design of Decision Support Systems for Port and Maritime Supply Chains*. In Exploring Intelligent *Decision Support Systems* (pp. 49-71). Springer, Cham-Swiss.
28. Dellino, G., Laudadio, T., Mari, R., Mastronardi, N., dan Meloni, C. 2018. A reliable decision support system for fresh food supply chain management. *International Journal of Production Research*, 56(4): 1458-1485.

29. Segura, M., Ray, D., dan Maroto, C. 2014. Decision support systems for forest management: A comparative analysis and assessment. *Computers and Electronics in Agriculture*, 101, 55-67.

30. Samvedi, A., Jain, V., dan Chan, F. T. 2013. Quantifying risks in a supply chain through integration of fuzzy AHP and fuzzy TOPSIS. *International Journal of Production Research*, 51(8), 2433-2442.

31. Ustundag, A., dan Budak, A. 2015. A web-based DSS for fuzzy distribution network optimization. *Journal of Enterprise Information Management*, 28(2): 260-274.

32. van den Eede, G., dan Plan, D. (2012). *Integration of Co-Extra Results in EU Tools for Traceabilit*y. Genetically Modified and Non-Genetically Modified Food Supply Chains: Co-Existence and Traceability, 491-520.

33. Balasubramaniam, O. A., dan Somu, A. 2012. IT-enabled supply chain management using decision support systems. *European Journal of Social Science*, 32(4): 632-643.

34. Xin, J. (2011, September). A supply chain optimization DSS Web-services-based for e-retail industry. *In Power Engineering and Automation Conference* (PEAM), 2011 IEEE Vol. 3: 229-232.

35. Repoussis, P. P., Paraskevopoulos, D. C., Zobolas, G., Tarantilis, C. D., dan Ioannou, G. 2009. A web-based decision support system for waste lube oils collection and recycling. *European Journal of Operational Research*, 195(3): 676-700.

36. Carder, K. L., Chen, F. R., Lee, Z., Hawes, S. K., & Cannizzaro, J. P. (2003). MODIS ocean science team algorithm theoretical basis document. *ATBD*, *19*(Version 7), 7-18.

37. Brown, O. B., Minnett, P. J., Evans, R., Kearns, E., Kilpatrick, K., Kumar, A., ... & Závody, A. (1999). MODIS infrared sea surface temperature algorithm algorithm theoretical basis document version 2.0. *University of Miami*, *31*, 098-33.

38. Pelleg, D., & Moore, A. W. (2000, June). X-means: Extending k-means with efficient estimation of the number of clusters. In *Icml*(Vol. 1, pp. 727-734).