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The Benefit of Decision Support System as Sustainable Environment Technology to Utilize Coastal Abundant Resources in Indonesia Hermawan, S1* 1Civil

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Indonesia. Email: shermawan **@petra.ac.id Abstract**

Being the largest archipelagic state in the world with about 81,000 km of coastline, Indonesia has a great potential for developing the aquaculture industry. But, the accomplishment of sustainable practices and management systems to preserve coastal environments is still in its infancy. Therefore, it is vital to improve aquaculture technology and to develop management tools that address the need for an eco-friendly production process. In this manuscript, the

system for the management of sustainable **floating net cage** finfish **11**

cultures **(SYSMAR)**

of the Decision Support System (DSS) software is applied. This software integrates physical, chemical, biological properties and information on coastal uses to determine site selection, production carrying capacity, ecological carrying capacity and socio economic assessment of 18 cases, focusing on the economic viability

of Tiger Grouper (Epinephelus fuscoguttatus), Humpback Grouper **1**

(Cromoliptes **altivelis)**

and Leopard Coral Grouper (Plectropomeus leopardus) at three remote areas in Indonesia, including: Talise Island, Galang Island and Ekas Bay. The outcomes of SYSMAR DSS demonstrate that only Galang Island provides suitable area of 12,940 hectares with the estimated production carrying capacity of 0.5 to 366 tons/annual/fish farm along with ecological carrying capacity are limited of 18,393 to 21,727 tons/annual and economic evaluation highlighted that all cultures development are economically viable. Keywords: Aquaculture, Decision Support System, Indonesia, Software, Sustainable Introduction According to the FAO (2007),

Indonesia is the largest aquaculture producer of marine finfish in Southeast Asia (De Silva and Philips, **2007).** 5

Being the largest archipelagic state in the world with about 81,000 km of coastline, corresponding to approximately 14% of the world's coastlines, Indonesia has a great potential for developing the aquaculture industry

(Ministry of Marine Affairs and Fisheries, 2009). **The** expansion **of the** 10

aquaculture and

fishery sector is expected to improve **the** 14

country's welfare, especially for fishermen and fish farmers that are currently living under the poverty level (BPS, 2009). On other hand, the accomplishment of sustainable practices and management systems to preserve coastal environments is still in its 1 infancy and more emphasis should be given to it. In particular, the degradation of coastal environments, overlapping and conflicting utilization of the coastal areas and enforcement of laws regarding the management of the marine and coastal environments are not being addressed properly. Therefore, it is essential to improve aquaculture technology and to expand management tools that address the need for an eco-friendly production (Hermawan et al. 2012, Hermawan and Syafrani, 2015). During the development, the extensive measurements and monitoring programs along with system application have been successfully implemented to several coastal areas in Indonesia, including: Pegametan Bay Bali, Seribu Islands in the Java Sea, Celukan bawang in Bali and Saleh Bay in Lombok (van der Wulp et al. 2010, Mayerle et al. 2011). In this manuscript, the application of SYSMAR DSS software for the sustainable environmental and socio-economic management of floating net cage finfish culture is assessed. Along with recent developments in SYSMAR DSS, we have turned our attention to the need for substantial and user-friendly software. The lack of measurement data in remote areas has been identified as a major problem for many years and is addressed in this study. This will be complemented with an evaluation of the economic viabilities. The outcomes achieved are going to support decision makers and the public with respect to the selection of best sites, assessment of the impacts and estimation of economic viabilities for the sites under investigation. Material and Methods The investigations will be carried out at three priority sites in Indonesia namely: Talise Island located in the northern most tip of

Sulawesi; Galang Island which is part of the Riau Archipelago located opposite of Singapore and Ekas Bay located south of the Lombok Island. The development focuses on the most common high value finfish species nurtured in FNC in Indonesia (Heemstra and Randal, 1993;

Sim et al. 2005; Sadovy **et al.** 1

2003, 2008). In this 2 study

Tiger grouper (Epinephelus fuscoguttatus), Humpback grouper 1
(Cromoliptes **altivelis),**

and Leopard Coral grouper (Plectropomeus leopardus) are considered. This software is integrated in a graphical user interface (GUI), which has been constructed in MATLAB by van der Wulp et al. (2010) and amended with additional features by Mayerle et al. (2011). These interfaces have several databases for quick access, and they are linked to a geographic information system (GIS) to process and visualize spatial information (Mayerle et al. 2011). In this paper, the

MATLAB version 7.11.0.584 (R2010b), 32 bit (win32) 9

was used. Data When using this system, data input or analysis types are selected by the user through the interface that controls the type of analysis to be made by the model components of the DSS. The compulsory data for the purpose of the DSS is gained from several sources. The hydrodynamic and wave models require bathymetric data along near shore areas in Indonesia which is usually obtained from nautical charts issued by the

Badan Koordinasi Survey dan Pemetaan Nasional (National 6
Coordinating Agency for Survey and Mapping).

GEBCO

(General Bathymetric Chart of the Oceans) data 4

is issued

by the British Oceanographic Data Centre, U.K **(IOC/IHO/BODC, 2003).** 4

It is usually adopted to provide information in deeper areas. For tidal variations and wind characteristics for diving, the numerical models are extracted from Total Modal Driver (see Egbert and Erofeeva, 2002). The wind data is obtained from the NCEP/NCAR reanalysis database (NOAA/OAR/ESRLPSD, 2009). Water quality information is usually obtained from agencies and measurements taken in the vicinity of the selected areas. In many cases, it is supported by analysis of satellite data. Problems resulting from conflicts of integrated coastal zone management or coastal uses and adverse natural environmental conditions are also accounted for in the selection of suitable sites, and for this purpose geographic data of National Development Planning are collected to identify the most relevant problems in the coastal zone. Opening Screen Practical information through the SYSMAR DSS is accessible by choosing buttons from the opening screen of the interface, as shown Figure 1. Under the database menu, new database entries can be added, modified or removed. The following windows are shown to illustrate the presentation of SYSMAR DSS. The next selection window is displayed for preparing a DSS input. Figure 1: The OPENING SCREEN of the SYSMAR DSS INTERFACE (Mayerle et al. 2011) Farm Properties Figure 2 shows how the window interface of farm properties allows the user to select the FNC grouper culture farm type for decision purposes. The tab allows a specification of farm type, dimensions, investment description, maintenance cost and staff along with wages of a representative FNC grouper culture unit. It contains farm size; estimated investment cost, maintenance cost, as well as staff and technician wages, and anticipated farm lifespan. Prices given are valid for the local market. Stock Properties In this study, SYSMAR DSS allowed the selection of a combination of one out of three types of grouper species with three feed types. For example: tiger grouper can be selected for species and then combined with feeding by trash fish, pellet, as well as a mix of 30% pellet and 70% trash fish. The selected combination of fish species and feed types allows the DSS to establish the production characteristics per ton of production. Site selection criteria are defined in the table shown in Figure 3. Figure 2: Farm Properties Interface Site Selection Criteria Interface Figure 4 presents the windows of site selection criteria, which allow the user to input data based on 32 parameters (e.g. physical, chemical and ICZM) related to suitability and sustainability analysis. In this module, the user can define allowable ranges or optimal ranges with respect to the information data. Figure 3: Stock Properties Interface Figure 4: Site Selection Criteria Interface GIS for Processing and Spatial Planning Data for Carrying Capacity Figure 5 shows how the carrying capacity tabs are used to determine carrying capacities with respect to particulate carbon. Locations can be selected by adding farms (manual or auto). For each farm, the suitability analysis and carrying capacity is summarized including needed farm area and economic analysis. This figure has been generated with a particulate carbon 6 deposition threshold of 1 - 2 g cm-2 d-1, as well as the settings of the tab for farm placement with the maximum number of farms being adjusted for farms located at a minimum between farm distances of 500 m. Figure 5: GIS for Carrying Capacity Economic Analysis It can be seen in Figure 6 below how an overview of the economic flow of development for a FNC tiger grouper culture fed with pellet is executed under the SYSMAR DSS interface. The capital cost of 600 cages for a five year project is shown by the annual depreciation cost. The variable cost including maintenance, seed, and feed are also presented. As can be seen from this figure, the wage costs are defined by 1 manager, 1 site manager, 2 block managers as well as 25 technicians. The manuscript presents and applies economic models which have been developed as an amendment using SYSMAR DSS in conjunction with a Microsoft Excel spreadsheet program with respect to the cost-benefit analysis technique. All biological data, production cost and profit is obtained from personal communication and literature data from the development of FNC cultures in Indonesia. Data was obtained from many institutions, including Ismi, S 7 (2012) Gondol Research Institute for Mariculture in Indonesia, Indonesian Bank, Act No. 17 in 2010 about progressive tax for domestic agency Indonesian, Ministry of Labor Indonesia, CRITC LIPI – Riau University, and Sugama (2012). This method has not been comprehensively reviewed and discussed in previous research with the application of DSS. A. Depreciation Euro/Year Floating net cage (wood) (600 holes, 16200 m³) 100,800 € -- 100,800 € B. Variable cost Maintenance Freshwater 5,760 € Boat (Gasoline)

5,280 € Boat (Technical maintenance) 2,880 € Generator (Gasoline) 3,840 € Maintenance and Medicines 14,400 € Seed Tiger Grouper (438000 pcs) 262,800 € Feed Pellet(~520 tons) 541,158 € ------------------------ --- 836,118 € C. Wages Site Manager 2,400 € Manager 4,800 € Technician 33,648 € Block Manager 3,840 € -- -------- 44,688 € D. Revenue Tiger Grouper (~197.1 tonnes) 2,207,520 € --- -- Total Revenue 2,207,520 € Profit (D - (A + B + C) 1,225,914 € Figure 6: Economic Analysis Interface of the SYSMAR DSS Results The performance of this system will be presented through the use of a geographic information system (GIS) as a spatial planning tool. Applying site selection of the SYSMAR DSS shows that Galang Island provides a bright potential for FNC finfish culture development which is indicated by a suitable area of about 12,940 hectares (see Figure 5). The results of hydrodynamic and wave numerical models show that Ekas Bay and Talise Island are not suited for FNC finfish culture projects. Regarding production carrying capacities, the marine environment in the vicinity in Galang Island obviously has large

potential for the development of FNC grouper culture. The findings of 13

this study indicate that the estimation of maximum and minimum production carrying 8 capacity of all potential farms with distances of at least 500 m between farm sites are in the range of 51 - 366 tons per farm and 0.5 - 2 tons per farm, respectively and estimated production regarding ecological carrying capacity could produce in the range of 18,393 - 21,727 tons/year/community area, respectively (see Figure 5). The

results from the present study have provided vital information 1

of about 18 cases

regarding the economic viability of tiger, humpback, and leopard coral groupers FNC farming utilizing various feed types and production scales. 1

Every prototype farm consists of 600 cages and 10 cages, respectively in Galang Island with a standard cage size of 3 x 3 x 3 m for width, length, and depth. Different types of feed are also considered, such as trash fish, pellet, as well as mixing 70% trash fish and 30 % pellet. The study shows that FNC finfish culture developments are economically viable as a whole, because

after a 5-year projection period, 1

positive cumulative cash flow and

net present value (NPV), internal rate of return (IRR) at rates above the 8

bank rates, and a payback period (PP) far below the 5 year projected lifetime of the project are evident.

Discussion In aquaculture management, the attention to DSS to utilize coastal resources abundant is relatively new along with development of such a technology

will play an increasingly important role in analyzing and **planning potential aquaculture** site selection, **production, environmental impacts, and sustainability.** 2

SYSMAR DSS intends to help decision makers in Indonesia to collect useful information from a variety of information systems (GIS, remote sensing, online data, etc) for future of sustainable aquaculture development. A possible explanation for some of our results may be the lack of adequate raw data. These results therefore need to be interpreted with caution. However with model simulations, caution must be applied, as the findings might be utilized to identify tasks and make decisions. It is also a priority to develop a management system to ensure that the environmental impact from Indonesian mariculture does not exceed acceptable levels. These results advertise

a strategy 9 **for the** incorporation **of aquaculture within the** broader **ecosystem in a way that** supports **sustainable development, equity, and** the **resilience of interlinked social and ecological systems.** 2

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