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by Sabihaini Sabihaini

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Integration of Weather Information Systems and The Potential of Fish Spread with Vessel Monitoring Systems on Fishing Vessels

Awang Hendrianto Pratomo¹, Sabihaini^{2*}, Heru Cahya Rustamaji¹, Yogaswara Wahyu Adhi¹

¹Department of Informatics, Faculty of Industrial Engineering, UPN "Veteran" Yogyakarta, Yogyakarta

²Department of Management, Faculty of Economics and Business, UPN "Veteran" Yogyakarta, Yogyakarta

*Email: sabihaini@upnyk.ac.id

ABSTRACT

Indonesian traditional fishermen generally use boat which not equipped with adequate navigation equipment. This becomes a problem when fishermen cannot get important information directly, such as location of navigation, weather, fish distribution and fuel adequacy. Vessel Monitoring System (VMS) on a fishing boat was build that to integrating all of the information. VMS consists of 2 parts, namely the ground control station (GCS) and navigation equipment. Weather data from WWS and data on chlorophyll A which correlate to fish distribution were obtained from WWS read via GCS and distributed to the navigation equipment. The results of maritime weather prediction testing based on the position of the ship and the fishing target gain 100% conformity. The results of testing of the potential fish distribution based on chlorophyll A data from API GIBS NASA gain an average accuracy of 95.24%. The results of testing the conformity of the representation of GCS coordinate points with the navigation system gain 100% conformity.

Keywords: Vessel Monitoring System, weather information system, fish distribution.

1. INTRODUCTION

Indonesia is a maritime country and the largest archipelagic country in the world [1]. The economy of the people in Indonesia is supported by fishery activities that depend on the biodiversity of its marine products. Fishery activities are divided into fish breeding activities and fishing activities carried out by fishermen. In general, fishermen determine their fishing grounds using traditional hunting methods based on repeated experiences and gathering information from fellow fishermen [2].

Fishermen in Indonesia can be categorized into large fishermen and small fishermen (traditional). Large fishermen are fishermen who use boats of more than 30 GT (Gross Tonnage) equipped with sophisticated fishing equipment including GPS devices. Fishermen in Indonesia are generally traditional fishermen who use simple fishing technology with fishing equipment operated manually by human labour, in which the boat weight is less than 30 GT with a cruising distance of about 3m from the coast and not equipped with adequate navigation devices [3]. This becomes a technical problem when important information related to their works cannot be obtained directly by the fishermen [4].

⁷ The word 'navigation' comes from the Latin word "navigare" which means "to sail". The word "navigare" itself comes from "navis" which means "ship", and "agere", which means 'to drive'. Basically, navigation is the term used with operating and ordering the passage of ships in the sea [5]. In supporting shipping navigation activities in Indonesia that are in accordance with responsible fisheries management, every catcher or transporter fishing vessel is required to install a Sistem Pemantauan Kapal Perikanan (SPKP) or Vessel Monitoring System (VMS) transmitter. The order is in accordance with Indonesian Ministry of Maritime Affairs and Fisheries Law Number 5 of 2007 concerning the implementation of a fishing vessel monitoring system, which requires the installation of a VMS transmitter for vessels over 30 GT.

VMS technology allows users to monitor the position of the ship, the path of movement or vessel movement, and even identify illegal fishing [6]. However, this technology cannot be used yet by small fishermen (traditional) due to the installation of the VMS tool and operational costs are quite expensive. Although VMS is introduced to show location and dynamics of fishing activities [7], the current VMS devices does not⁵ offer information related to changes in weather and fishing grounds. Accurate measurement of sea surface temperature obtained from⁹ remote imagery is a fundamental requirement for monitoring marine and coastal waters. Sea surface temperature has a significant influence on the distribution of fish [8], and can be obtained from the NASA's MODIS satellite imagery [9].

The VMS is made so that fishermen can find out their location while sailing and gain information related to changes in maritime weather and fishing grounds. In addition, fishermen can also calculate the estimated fuel usage and the distance calculated by the Haversine formula. Ground Control Station functions to monitor position data from fishermen and provide information related to maritime weather, taken from API World Weather Online (WWO), and fishing grounds based¹² on the distribution of *chlorophyll A* obtained from NASA's MODIS satellite imagery. VMS data are then used to indicate the location and dynamics of fish catching [10].

To support the ship's navigation system, a GPS is required.² GPS is a satellite-based navigation system consisting of a network of 24 satellites that are placed into orbit by the US Department of Defence. GPS was originally intended for military applications, but in the year 1980, the system² started to be used by civilians. GPS operated by the United States Space Force (USSF) works in any weather conditions, anywhere in the world, 24 hours a day [11]. For weather system integration, the Indonesian Agency of Meteorological, Climatological, and Geophysical (BMKG) provides weather data information regarding weather and climate data [12]. VMS is also integrated to obtain fishing area information. Fishes that live in marine waters have a temperature range for life [13]. Sea surface temperature has also been used for decades by fishermen¹¹ and researchers to determine fish habitat and sustainability [14]. Apart from temperature, the spatial distribution of fish is also positively associated with the distribution of *chlorophyll A* [15]. The presence of *chlorophyll A* distribution can also be obtained from the MODIS satellite [16].

Nevertheless, any marine technology that is made should consider the ease of use and benefits obtained by fishermen, because it will have an impact on the technology acceptance by fishermen [17].

2. METHOD

2.1 Research Stages

The research method used were divided into three stages, namely the analysis stage, the design stage, and the implementation stage. The analysis phase includes literature study as a basis for determining the background of the problem, as well as being the basis for determining the required system analysis, namely the necessary hardware to run the program and the software to support this research. The design stage includes designing the system architecture, designing the interface and designing the process. The implementation stage is the stage of system development, based on the design that has been made, along with system testing and evaluation.

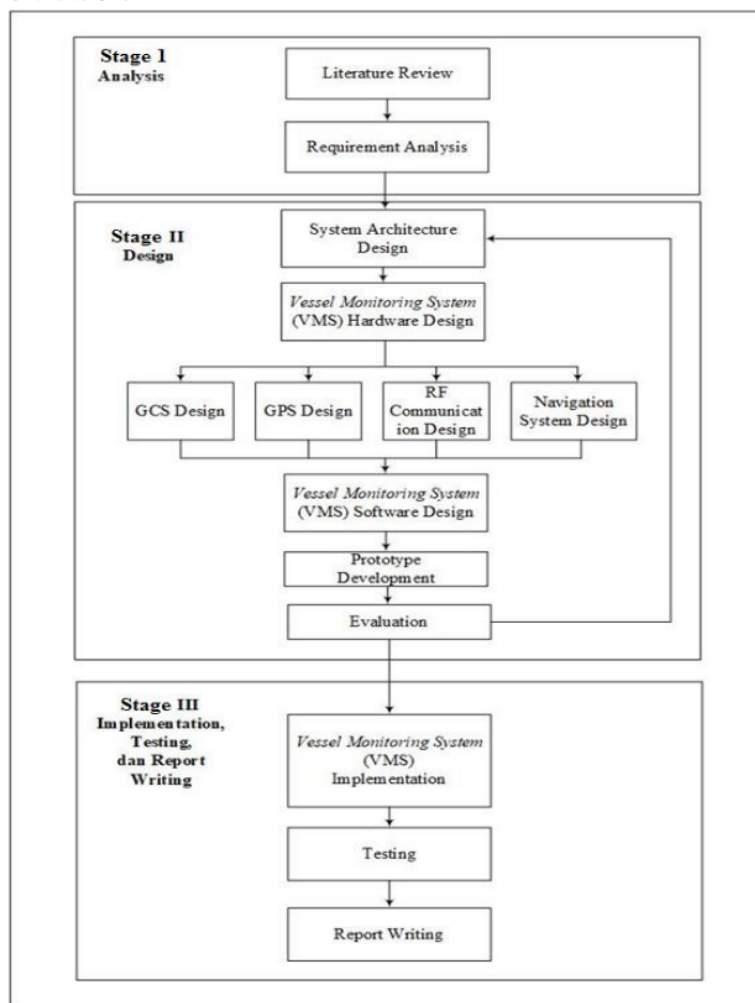


Figure 1. Research Stages

2.2 System Architecture

The VMS system architecture has two parts, namely the ground control station (GCS) and the navigation system (Figure 2). GCS functions to retrieve weather data from the World Weather Online (WVO) website through the API of each ship's position and displays fish distribution data based on *chlorophyll A* obtained from the NASA website and to monitor the position of the sailing ships. The navigation system sends data on ship positions and fishing targets based on longitude and latitude which will be used by GCS as a parameter to request weather data with WVO API and determine the chlorophyll index and potential distribution of fish at certain coordinates. The coordinates of the position and target of the capture are also used to calculate the estimated the fuel usage.

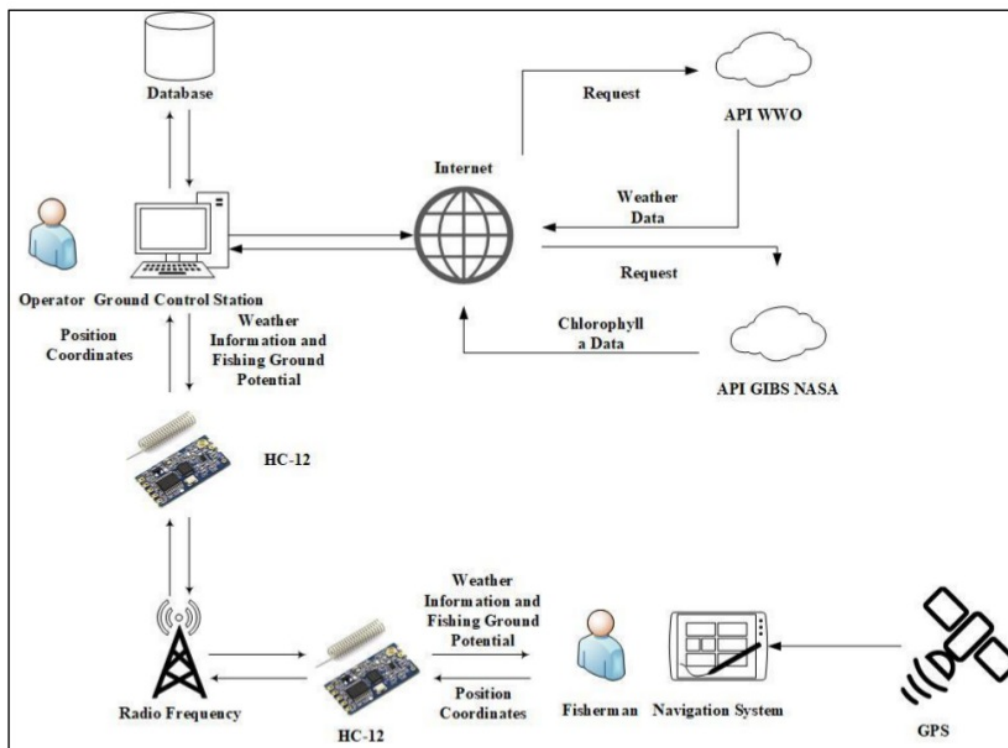


Figure 2 System Architecture

The components used in the GCS are Mini PC, HC-12, and USB-to-ESP 8266. The mini PC on the GCS is used to display a map along with the ship's position display which is

used to monitor the situation and distribution area of *chlorophyll A* from the NASA's GIBS API cloud. The *chlorophyll A* data are in PNG format and used on the map as the main parameter for detecting potential fish distribution by taking the value of *chlorophyll A* at the current location of the ship. The weather forecast information are taken from WWO's API cloud based on the ship's position on the GCS, in which the potential fish distribution and weather information will be stored in a database based on the ID of the ship. The HC-12 and USB-to-ESP 8266 modules on the GCS are used to obtain coordinate data from ships and to transmit data on potential fish dispersal and weather change information to the ships.

The on-board navigation system is operated by fishermen while sailing. Fishermen monitor the position of the vessel according to the GPS coordinates displayed on the navigation system screen. The feature for estimating fuel usage is used by fishermen to reduce the risk of running out of fuel while at sea. Information on potential fish dispersal and weather changes based on vessel position and fishing targets is received from GCS via radio frequency communication. The GY-NEO6MV3 GPS component is used to obtain location coordinates, processed by the Arduino to adjust the coordinate data format before the data is stored into the database on the Raspberry Pi via USB serial communication. Raspberry Pi is used as the main processing place in the navigation system to display maps to fishermen along with the location of the fishermen at sea, based on the coordinates obtained from GPS and Arduino. The HC-12 and USB-to-ESP 8266 module on this navigation system are used for communication with GCS via radio frequency waves to send position coordinate data and fishing targets and to receive potential fish dispersal information and weather change information.

The cloud on the VMS is used for data integration on the GCS of various shore stations so that in further development of GCS data, monitoring of ship positions can be carried out at various shore stations simultaneously. The API WWO data such as longitude, latitude, and time are stored in the cloud. Data received by WWO API is in JSON format which is stored in the 'loc' table in the database based on the ship ID. Cloud is also used in collecting *chlorophyll A* data from the NASA GIBS API with CRS parameters, layer name, and time. Tile data in PNG format are attached to the map on the GCS as the main parameter for potential fish distribution detection.

2.3 Tool Design

The HC-12 module uses pins consisting of RX and TX pins for data communication. The Broadcast and receive pins are connected to the mini pc via a USB-to-ESP 8266 converter module with VCC and GND pins for power from the HC-12 (Figure 3). The broadcast process is carried out by GCS periodically using the data provided by the API on GCS. The JSON data with encryption ASCII transmitted through radio communication channels. The receive process on GCS is obtained via HC-12 and decrypted based on ASCII and sent via API to the database based on the received ship ID. The schematic circuit is illustrated in Figure 4.

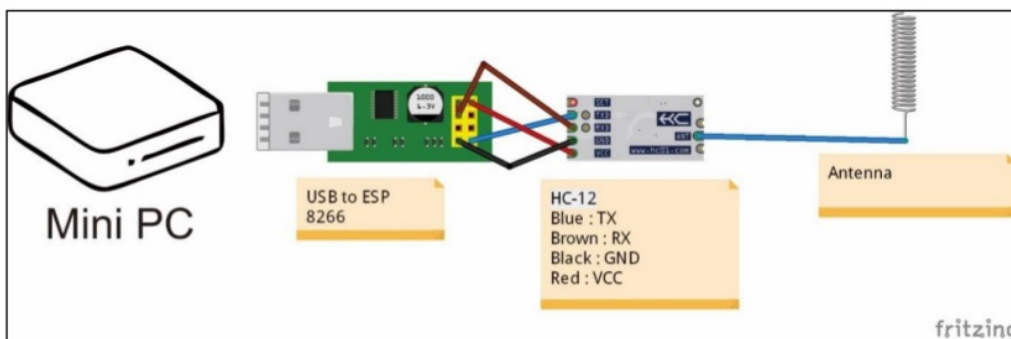


Figure 3. GCS Tool Design

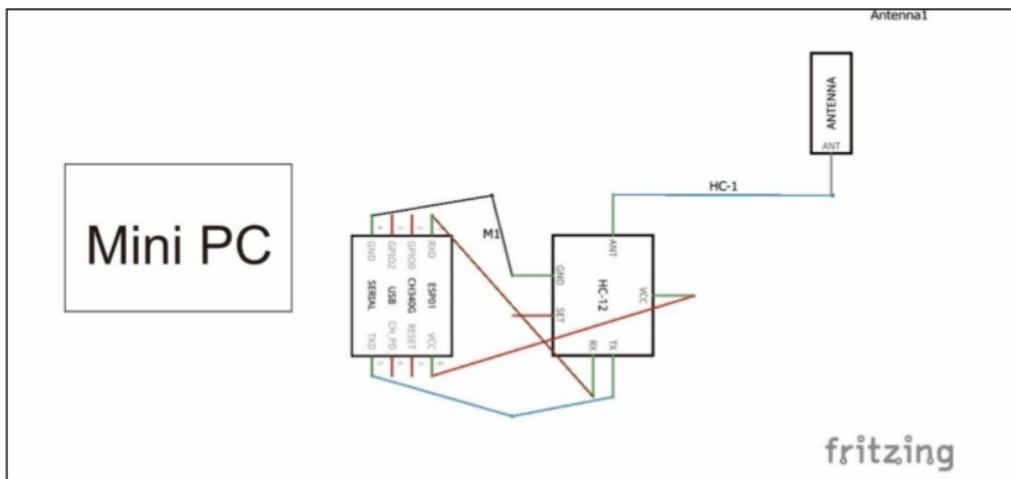


Figure 4 Schematic Design of the GCS Tool

2.4 Navigation System

The GY-NEO6MV3 GPS module is used to obtain position coordinates every one second and the data format processed on the Arduino is stored in the Raspberry Pi via serial communication. Raspberry Pi displays a map of fishermen's location based on the coordinates obtained from GPS and Arduino, as well as information on forecasting fuel use, maritime weather, and potential fish distribution. The HC-12 and USB-to-ESP 8266 modules are used for communication with GCS, via radio frequency waves, and JSON data with the encoding-decoding process (Figure 5).

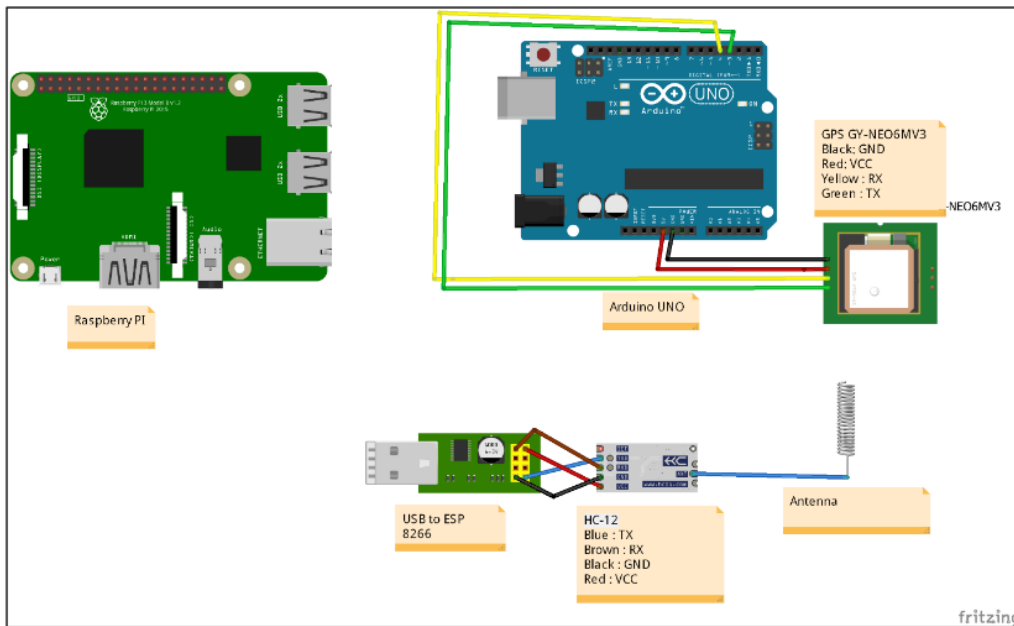


Figure 5 Design of Navigation System Tools

The GY-NEO6MV3 GPS module is connected to Arduino for processing the coordinate data using pin 5 on Arduino, which is used for TX on GPS, pin 4 for RX, pin GND for ground, and pin 5V for VCC. In Arduino, after obtaining the coordinates from the GPS, Arduino will send a serial message to the raspberry pi via serial communication connected via USB, then the raspberry pi will process the received data via serial and will be saved to the database in the loc table. The position of the ship's coordinates that have changed is then used to change the position of the ship's point on the map (on the raspberry pi). The HC-12 module

uses pins consisting of RX and TX pins for data communication, which is related to the broadcast and receive pin processes, this is then connected to the raspberry pi via the USB-to-ESP 8266 converter module with VCC and GND pins for power from the HC-12. The broadcast process is carried out by raspberry pi with data provided by the API which is obtained from coordinate data that has been stored in the database, then the data will be formed into JSON data which will then be encrypted ASCII in the form of bits and then sent via radio communication lines. Raspberry pi receives via HC-12, then the data is decrypted based on ASCII and the received JSON data will be sent via API to the database according to the ship data. The schematic design is shown in Figure 6.

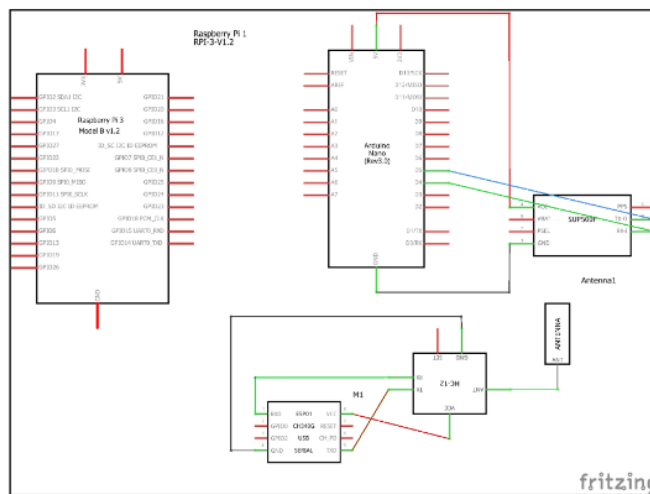


Figure 6. Schematic Design of Navigation System Tools

The process begins with displaying a map on the GCS and navigation system, and requesting *chlorophyll A* data from API GIBS. The GPS navigation system determines the position coordinates of the device and fishermen, determines the coordinates of the fishing target on the navigation system, and calculates the estimated fuel usage required which involves the Haversine formula for determining the distance. The engine type and ship speed parameters are also used in the calculation.

GCS requests weather data according to the ship's position and capture target as request parameters to get data from the WWO API. The input parameters needed to make a request include the coordinate reference system (CRS) used to project the map, the type of data to be retrieved from the NASA GIBS, the time the data will be taken, the map zoom level, tilerow,

and tilecol. In addition, coordinate data is used to determine the potential distribution of fish, taking the value of *chlorophyll A* which is used to determine the potential distribution of fish. The data is stored in the database based on the id of the navigation system. Information is sent to all navigation systems connected to GCS. The process flowchart is shown in Figure 7.

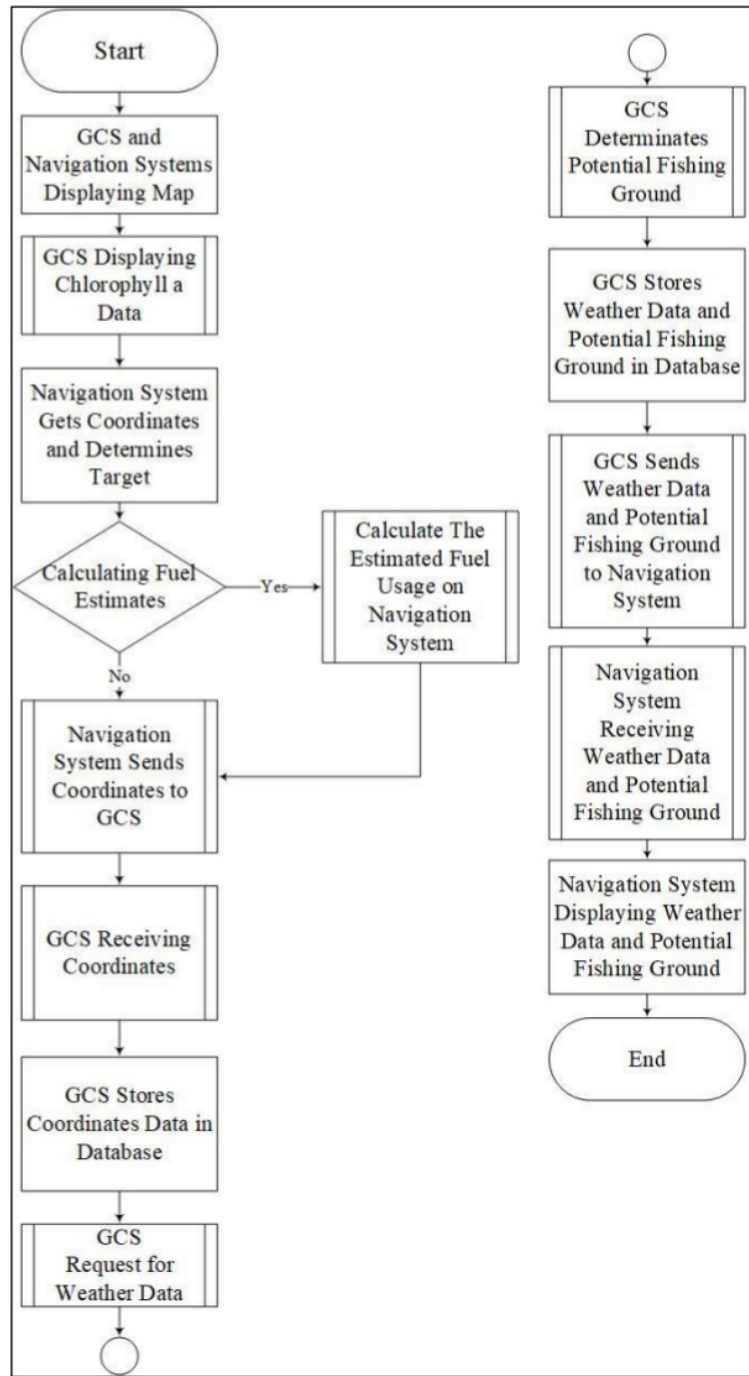


Figure 7. Flowchart

When requesting data of *chlorophyll A* from the NASA GIBS API (using CRS parameters, layer names, and time), data in the form of tiles in PNG format attached to the

map will be obtained. This tile has an RGB colour image based on the colour value of the coordinate pixel which is then converted by changing the image from RGB colour to HSV which is eventually converted to the existing *chlorophyll A* index. An example of *chlorophyll A* distribution map is presented in Figure 8.

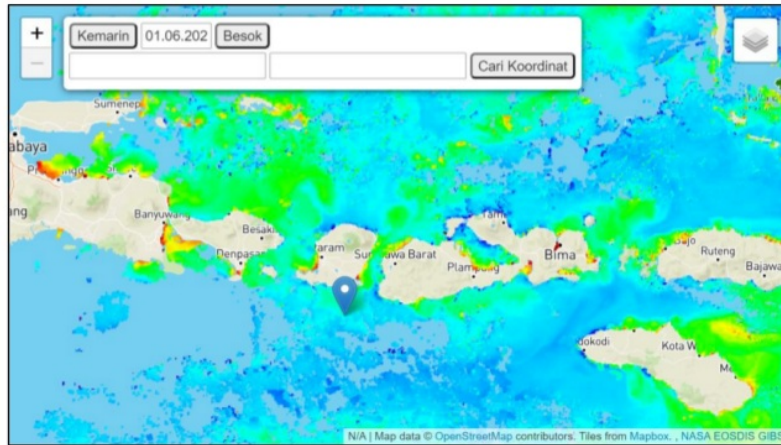


Figure 8. Map of *chlorophyll A* distribution in some of east part of Indonesia.

3. RESULT AND DISCUSSION

3.1 Result

A tool for GCS has been developed which is used to monitor and provide various information regarding the weather and potential distribution of fish. In GCS, there are several components used, namely the Mini PC as a data processing place, the HC-12 module as a tool for sending information via radio frequency and the USB to ESP 8266 converter module to use the HC-12 to USB converter (Figure 9).



Figure 9. The GCS device made in this study

The navigation system tool was made with the Raspberry Pi component as a processing centre and controller of the entire navigation system, the GY-NEO6MV3 GPS module for determining the position coordinates of the ship, the Arduino Nano for processing and controlling the GPS module, the HC-12 module which is used for data communication via radio frequency and a USB to ESP converter module 8266 for HC-12 to USB conversion (Figure 10).

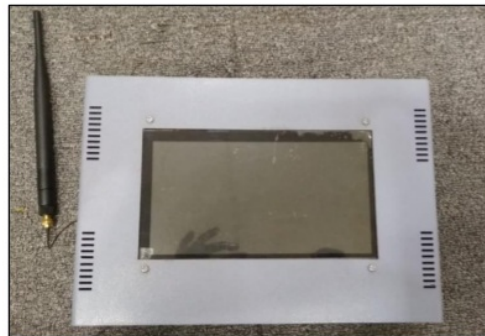


Figure 10. Navigation Tool made in this study.

3.2 Maritime Weather Prediction Testing

Testing of maritime weather prediction results is carried out to test the accuracy or suitability of the data taken from the WWO API with the new system. Testing of maritime weather prediction results is carried out using 5 ships, each of which has the coordinates of the ship's position and the target area of the fish capture. The weather data were taken based on the coordinates of the ship's position and the target area of the fish capture at different times. On the coordinates of the ship's position, the data taken were weather data based on the time taken to make data requests, while for the coordinates of the target area is weather data with allocation time of one hour ahead. The results of the system weather prediction were then compared with the prediction results from API WWO in order to check the accuracy of the weather data collection. Tables 1 and 2 are test results of weather predictions on the ship's position and the target position taken from WWO at coordinates (-8.264496, 110.707855), on March 8 - 2020 at 2:11 GMT + 7 with a 100% accuracy level.

Table 1 Testing of Maritime Weather Prediction Results at Ship Position

No.	ID	Latitude	Longitude	Hour (GMT +7)	System				WWO API				Result
					C	TG	KA	AA	C	TG	KA	AA	
1	C	-8.264496	110.707855	2:11	Moderate or heavy rain shower	1.1	16	W	Moderate or heavy rain shower	1.1	16	W	S
2	D	-8.385431	111.104736	2:11	Patchy rain possible	1.1	17	W	Patchy rain possible	1.1	17	W	S
3	A	-8.051071	110.33844	2:11	Moderate or heavy rain shower	1.1	16	W	Moderate or heavy rain shower	1.1	16	W	S
4	E	-8.483239	111.346436	2:11	Patchy rain possible	1.1	17	W	Patchy rain possible	1.1	17	W	S
5	B	-7.988518	110.11322	2:11	Moderate or heavy rain shower	1.1	16	W	Moderate or heavy rain shower	1.1	16	W	S

Table 2 Testing of Maritime Weather Prediction Results at the target position

No.	ID	Latitude	Longitude	Hour (GMT +7)	System				WWO API				Result
					C	TG	KA	AA	C	TG	KA	AA	
6	A	-8.124491	110.287628	2:11	Patchy rain possible	1.1	17	W	Patchy rain possible	1.1	17	W	S
7	B	-8.05787	110.052795	2:11	Patchy rain possible	1.1	17	W	Patchy rain possible	1.1	17	W	S
8	C	-8.341953	110.65155	2:11	Patchy rain possible	1.1	17	W	Patchy rain possible	1.1	17	W	S
9	D	-8.545714	111.036072	2:11	Partly cloudy	1.1	19	W	Partly cloudy	1.1	19	W	S
10	E	-8.657057	111.30249	2:11	Partly cloudy	1.1	19	W	Partly cloudy	1.1	19	W	S

3.3 Testing of Potential Fish Distribution

The test for potential for fish distribution was carried out by comparing the Fishing Area Forecast Map (PPDPI) data from the Marine Research and Observation Agency (BROL) to determine the accuracy of the prediction results in the system. The chlorophyll index as a reference for determining the potential area of fish distribution in the system has a *chlorophyll A* concentration in the range 0.1–0.5 mg/m³ or in a colour range with HSV images having a hue value in the range of 140–220. If *chlorophyll A* is 0 mg/m³, it means that the water area is covered by clouds at these coordinates, thus it is not used in accuracy test calculation. The results of the accuracy of testing the potential distribution of fish are:

$$Accuracy = \frac{\text{similar result}}{\text{number of test}} = \frac{100}{105} = 95.24\%.$$

Table 3 Table of Potential Test Results for Fish Distribution on 14-16 February 2020.

No	Lat	Long	Hue1 4 Feb 2020	Hue 15 Feb 2020	Hue 16 Feb 2020	Fish potency 14 Feb 2020	Fish potency 15 Feb 2020	Fish potency 16 Feb 2020	Result 14 Feb 2020	Result 15 Feb 2020	Result 16 Feb 2020
1	-10.4165	119.1665	201	210	0	H	H	U	S	S	S
2	-3.1665	117.9165	139	0	0	L	U	U	NS	S	S
3	-4.2915	111.2915	0	116	0	U	L	U	S	NS	S
4	-4.4165	111.6665	0	150	0	U	H	U	S	S	S
5	-5.0415	120.7915	0	190	0	U	H	U	S	S	S
6	-5.2915	108.9165	0	174	0	U	H	U	S	S	S
7	-5.2915	120.9165	0	0	182	U	U	H	S	S	S
8	-5.4165	108.5415	0	181	0	U	H	U	S	S	S
9	-5.4165	121.0415	0	191	0	U	H	U	S	S	S
10	-5.4165	126.7915	192	202	215	H	H	H	S	S	S
11	-5.7915	109.9165	196	0	0	H	U	U	S	S	S
12	-5.7915	110.0415	219	0	0	H	U	U	S	S	S
13	-5.7915	110.1665	181	0	0	H	U	U	S	S	S
14	-5.7915	111.4165	171	0	180	H	U	H	S	S	S
15	-5.9165	107.5415	0	125	0	U	L	U	S	NS	S
16	-5.9165	110.4165	139	0	0	L	U	U	NS	S	S
17	-5.9165	111.2998	156	0	195	H	U	H	S	S	S
18	-5.9165	111.5498	172	0	156	H	U	H	S	S	S
19	-6.0415	107.5415	0	84	0	U	L	U	S	NS	S
20	-6.0415	122.2915	0	199	204	U	H	H	S	S	S
21	-6.0415	122.4165	0	205	191	U	H	H	S	S	S
22	-6.0415	122.5415	0	204	191	U	H	H	S	S	S
23	-6.0415	122.9165	208	196	187	H	H	H	S	S	S
24	-6.0415	123.0415	0	200	191	U	H	H	S	S	S
25	-6.0415	123.1665	0	194	195	U	H	H	S	S	S
26	-6.1665	111.5415	0	0	148	U	U	H	S	S	S
27	-6.1665	122.1665	0	197	192	U	H	H	S	S	S
28	-8.6665	119.2915	172	182	0	H	H	U	S	S	S
29	-8.7915	115.4165	0	190	194	U	H	H	S	S	S
30	-8.7915	119.4165	185	182	0	H	H	U	S	S	S
31	-8.7915	119.5415	157	156	0	H	H	U	S	S	S
32	-8.9165	115.6665	0	200	186	U	H	H	S	S	S
33	-9.0415	113.0415	205	0	205	H	U	H	S	S	S
34	-9.0415	113.1665	0	0	209	U	U	H	S	S	S
35	-9.1665	113.4165	0	0	204	U	U	H	S	S	S

H : High
U : Unknown
L : Low
S : Similar
TS : Not Similar

3.4 Suitability Test on Coordinate Position Point Representations

Suitability test on coordinate position point representation was done by comparing the coordinateposition of the location on the map of the navigation system and the GCS. The coordinate points are sent from the navigation system to the GCS using RF, then the results will be compared between the position on the navigation system map and the position on the

GCS to get its suitability. Figure 11 is an example of the representation of the coordinates position on the GCS and on the navigation system at (-8.023195, 110.288315). The test results are presented in Table 4 with a 100% compliance level.

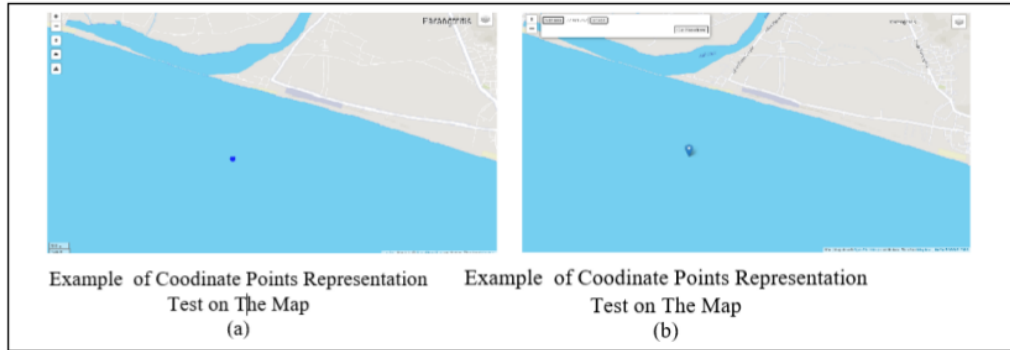


Figure 11. Example of Coordinate Points Representation Test on the Map.

Table 4. Conformity Test of Coordinate Point Representations

No.	Navigation System		GCS		Correspondence of Position Coordinate Points on GCS
	Latitude	Longitude	Latitude	Longitude	
1	-8.264496	110.707855	-8.264496	110.707855	match
2	-8.385431	111.104736	-8.385431	111.104736	match
3	-8.051071	110.33844	-8.051071	110.33844	match
4	-8.483239	111.346436	-8.483239	111.346436	match
5	-7.988518	110.11322	-7.988518	110.11322	match
6	-8.264496	110.707855	-8.264496	110.707855	match
7	-8.385431	111.104736	-8.385431	111.104736	match
8	-8.051071	110.33844	-8.051071	110.33844	match
9	-8.483239	111.346436	-8.483239	111.346436	match
10	-7.988518	110.11322	-7.988518	110.11322	match

4. CONCLUSION

The integration between the GCS and the navigation system in the VMS conducted in this study is considered to be successful for monitoring the position of fishermen while at sea and providing information regarding weather data and potential fishing areas via radio frequency based on *chlorophyll A* distribution. The results of maritime weather forecast testing based on the position of the ship and the target of fish catching gain a 100% conformity with

WVO API, based on 5 coordinates samples of ship's position and 5 coordinates samples of the fish catching target, and on 3 different times. The testing for the potency of fish distribution based on *chlorophyll A* data from the NASA GIBS API gain an average accuracy of 95.24%. The testing of coordinate point by the GCS and the navigation system gain 100% conformity based on 10 coordinates samples sent from the navigation system to GCS via radio frequency.

Acknowledgments

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