Application of GIS Technology for Determining Sea Fish Capital Potential on Mobile Apps

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Abstract

The ocean is the central source of livelihood for fishermen. Fishermen depend heavily on their sea catch. Fishermen often need more certainty because, as is often the case, the spot where they go for fishing is not necessarily the site of the fish. Remote sensing technology, such as the Aqua MODIS satellite, provides two vital advantages: the exact location of the fish and, importantly, guidance to the exact spot of the fish. This guidance can be a reassuring tool for fishermen. Using GIS technology on smartphones, fishermen can ensure the fish's position. The distribution of sea surface temperature and chlorophyll-a is analyzed to determine the coordinates. The purpose of this research is to use the React Native platform to create a mobile application that uses Geographic Information System (GIS) and Global Positioning System (GPS) technologies and is accessible through smartphones. This research adopts a prototyping model method consisting of several stages: Information Gathering, Quick Planning, Quick Design, Software Development, Testing and Deployment, and Results. The application developed can run smoothly from the log-in stage to predictive visualization of fish positions in the ocean. However, further research needs to be done to improve some features.

Keywords— GIS, Fishermen, Aqua Modis, Chlorophyll

1. INTRODUCTION

The largest archipelagic nation in the world, Indonesia occupies 70% of the land and sea area, with a coastline of 81.000 km and a sea area of 5.8 million km². The Indonesian Sea is rich in natural resources due to its vast maritime territory. Due to the wealth of natural resources in the fisheries sector, particularly in the field of fisheries [1]. Indonesia's potential for marine capture fisheries is estimated at 7.164.302 tons based on data on fisheries production. In the province of North Sulawesi, marine fish production stood at 258.976 tons, with a decrease of 109.734 tons in 2019. However, in 2020, production increased by 63.719 tons, reaching a total of 322.695 tons [2]. The North Sulawesi province's marine fisheries produced 345.529 tons in 2024, valued at Rp 9.616.478.309. This amount greatly exceeds the 5.882 tons of inland water catch production, which had a production value of Rp 234.901.888 [3]. These data showcase the high potential and richness of marine fisheries, highlighting their vital role as a major sector contributing to the economy of North Sulawesi Province.

For most people who live near the seashore, around 60% of the people work as fishermen, while the rest are engaged in various other professions besides fisheries [4]. For experienced and skilled fishers, there are four aspects to consider in their fishing activity system:

a. Utilizing technology in fishing aids and gear to boost captures without endangering current marine ecosystems.

b. Evaluating the amount of time needed to capture a specific fish based on its size and species, as well as the location and weather at the time of capture.
c. Consideration of labor and capital for efficient operation of vessels and fishing gear.
d. Maintain the quality of the fish catch to obtain a high exchange rate [5].

Fish catch has a significant impact on fishermen's incomes. The chief option to increase fish catch is to improve the quality of production factors. Factors affecting the betterment of living standards in fisheries and fishing community production are labor capital, technology used, and working hours. The utilization of fisheries biological resources in Indonesian waters contributes significantly to the well-being of fishing communities in Indonesia [6].

According to data retrieved from the Ministry of Maritime Affairs and Fisheries of the Republic of Indonesia, fish consumption increased between 2015-2018, and the achievement in fish consumption is higher than the target set by the Ministry of Maritime Affairs and Fisheries of the Republic of Indonesia. In 2018, the target for fish consumption was 50.65 kg/capita and the forecast for achievement in fish consumption in 2018 was 50.65 kg/capita, which is higher than the target set at 50 [7].

When preparing to go out to sea to conduct their fishing operations, fishermen must take capital into account. Boats, speed, fishing equipment, engines, fuel, and technology are the capital that fishermen must take into account. Capital has a significant impact on fishermen's catches, and the more capital acquired, the better the fisherman's. This capital gives the fishermen the tools they need to catch fish. Technology will perform. High fishing expenses, such as the need to buy fuel oil and the requirement that fishermen make a living while fishing, are additional factors that make it challenging for fishermen to engage in their activities at sea. The amount spent has an impact on fishermen's earnings. The amount of money that fishermen spend is also influenced by how long they fish. Fishermen make more money the longer they are at sea collecting fish, but they also have to prepare more gear and spend more money fishing [8].

The amount of time fishermen spend traveling to the fishing location and scanning the sea for the best spot to catch fish affects how long a fishery lasts. Fishermen can catch fish for longer periods and catch more fish the longer they stay at sea. However, the availability of fish is a determining factor [9].

Weather and climate also significantly impact the livelihoods of fishers living along the coast. The unpredictable climate causes issues for fishers in determining the fishing season [10]. Climate changes also alter the fishing grounds, reducing catches and affecting fishermen's income [11]. Fishermen's livelihoods depend, to a large extent, on their income from fishing. If fish catches decrease and fishermen cannot make a living from their catch, it becomes difficult for them to sustain themselves [12].

Climate change may have an impact on where fish are caught, making fishing more challenging for fishermen [13]. Sea level rise, rising sea temperatures, rising seawater acidity, altered circulation patterns, water-time reversal processes, altered precipitation, and intensified extreme weather events are all impacted by climate change [14]. Paying attention to the difficulties fishermen encounter in identifying distribution areas that may harbor a lot of fish and figuring out the distance to be traveled to maximize the use of the necessary fuel. Using the Aqua MODIS satellite, fishing positions can be ascertained by examining the distribution of sea surface temperature and chlorophyll-a. [15]. It takes specific knowledge to estimate fish locations based on sea surface temperature and chlorophyll-a; in fact, fishermen continue to use antiquated techniques that enable them to pinpoint the precise location of their catch, which results in less-than-ideal catches [16]. Conventional fishing methods require time to estimate fish distribution in the sea, giving rise to less precise possibilities [17]. Thus, fishermen may go to sea without knowing exactly where their fishing grounds are.

With the advancement of technology, smartphones have become a powerful tool in bridging the economic gap [18]. They have evolved from a luxury for the wealthy to a useful and reasonably priced tool for the middle and lower classes [19]. In Bitung City, Pasir Panjang village, South Lembeh district, where the average household income is Rp 4,184,615 per year,

manufacturers are now able to produce smartphones at low prices, making them affordable even for fishermen [20]. With a price of about Rp 1,549,000 on April 9, 2020, smartphones are no longer an expensive item and are within the means of the typical Pasir Panjang village fisherman. [21]. The development of smartphones has also been greatly influenced by technological advancements. For example, the Benefon Esc! was the first cell phone to use GPS in 1999. At the time, this was a costly feature. These days, GPS-enabled smartphones are so widely available and reasonably priced that practically all of them come with it as standard [22].

In sum, Indonesia has the potential for reliable fishing as a source of livelihood for fishermen. For this reason, knowledge is needed about which water areas have the potential to become fishing areas where fishermen will go to get fish in large quantities. Generally, fishermen who go to sea rely on knowledge obtained from generation to generation by looking at natural phenomena as navigation to find fishing destinations, so the results cannot be determined with certainty. By looking at the existence of fishermen who should have a decent living due to catching fish, this is not visible where fishermen generally live in social strata that are still classified as poor because the fish catch is inadequate for the capital spent on fishing. There are even times when fishermen who go to sea do not get anything because the area they are going to does not have any fish, while those looking for other places have limited fuel to carry. Previous research only determined the potential distribution area for fish [23], then in this research, the fishermen using this application can find out the distance they will travel, so fishermen can prepare the ship to be used to the destination. Therefore, this study creates forecast maps of fishing areas and calculates the distance between the departure point and fishing locations using Mobile Global Information System coordinates from the Indonesian Ministry of Maritime Affairs and Fisheries and chlorophyll-a predictions from the MODIS Aqua satellite.

2. RESEARCH METHODS

The application development methodology utilizes a prototyping model [24]. This approach is chosen because it allows for more accurate improvements to the application, with faster stages than other models. As a result, the application can be developed even if the requirements are insufficient or need to be modified to meet the development needs. The research stages are as follows:

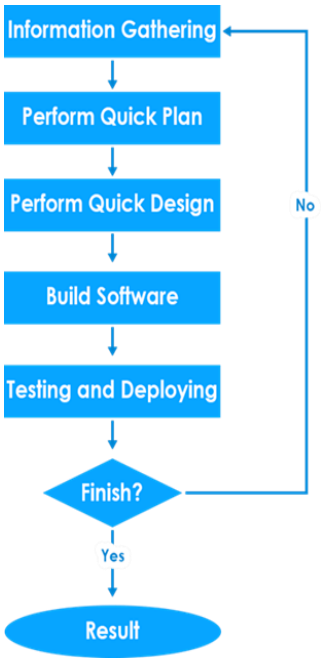

Figure 1. Conceptual Framework of the Research

Figure 1 displays the conceptual framework used in this research. The explanation of each stage is as follows:

a. Information Gathering: The Ministry of Maritime Affairs and Fisheries' official website is the source of the data needed for application development. This includes information about where fishing spots are located.
b. Quick Planning: Coordinates for the application are determined by the date the pertinent data was published.
c. Quick Design: To guarantee fishermen's practical usability, the application interface concept was created.
d. Software Development: The application is developed based on the design using software such as Photoshop and JavaScript.
e. Testing and Deployment: The developed application is tested to ensure it meets the development objectives. If discrepancies are found, the design is revised until the application achieves the desired goals.
f. Results: Applications are saved and made available to fishermen as ready-to-use resources after passing the testing and deployment phases.

3. RESULT AND DISCUSSION

This research produces an application that allows fishermen who use the application to find areas that have the potential to contain fish as fishing destination areas, as shown in Figure 2.

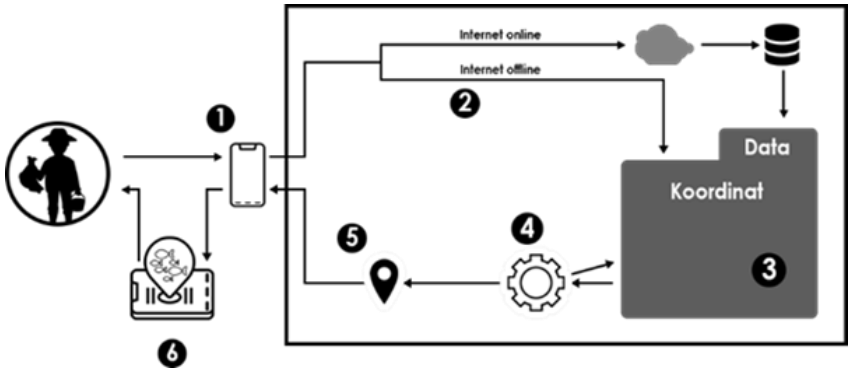

Figure 2 Application Conceptual Framework

An explanation of how the resulting application interacts with fishing users is as follows:

1. On a smartphone that meets the established minimal requirements, the user launches an application created based on research findings.
2. Features that the developer has previously developed can be accessed by the application if the smartphone has internet connectivity. The program then retrieves local data from the computer, which includes the most recent coordinate data updated for this study.
3. Logic, specifically software developed as a result of this research, is used to process the existing data. It processes coordinate data that corresponds to user input when choosing which data to display. On the other hand, logic directly shows coordinates without user input if the user does not choose which coordinates to display.
4. Coordinate points are the output of logic based on coordinate data retrieved from data storage. These points can be used in applications that have been developed in the form of geographic information systems or mapping.
5. Based on the most recent data, the application's Geographic Information System displays the coordinates that the logic produced, assisting fishermen in locating areas where they can catch fish.

6. The display form of the information produced is in visual form, which represents the potential location of fish distribution that fishermen can exploit.

The application shows the user a distribution of coordinate points, which the user must choose to calculate the distance traveled from the user's starting point to the user-selected fish catch coordinate point. Here, GPS and data from GIS processing—which comes from the Indonesian Ministry of Maritime Affairs and Fisheries—are used to set up the system. The spatial data processed and acquired from the Indonesian Ministry of Maritime Affairs and Fisheries (KKP) served as the database for this study. It is the coordinate input that will generate the GIS form in the application. This data is entered into the application database since it originates from the KKP.

3.1. Use Case Diagram

In the use case Application of GIS Technology for Determining Sea Fish Capital Potential on Mobile Apps in Figure 3, it is explained that all the functionality built into the application to obtain fish catches is assembled into a single unit consisting of:

1. Fishermen as application user actors: After activating the application, the application displays the coordinates of the distribution of potential fish catch areas so that fishermen can determine the selected potential fish catch areas. The application provides directions to fishermen users to the selected place.
2. Admin is the actor who provides data on potential fish catch areas that application users use.

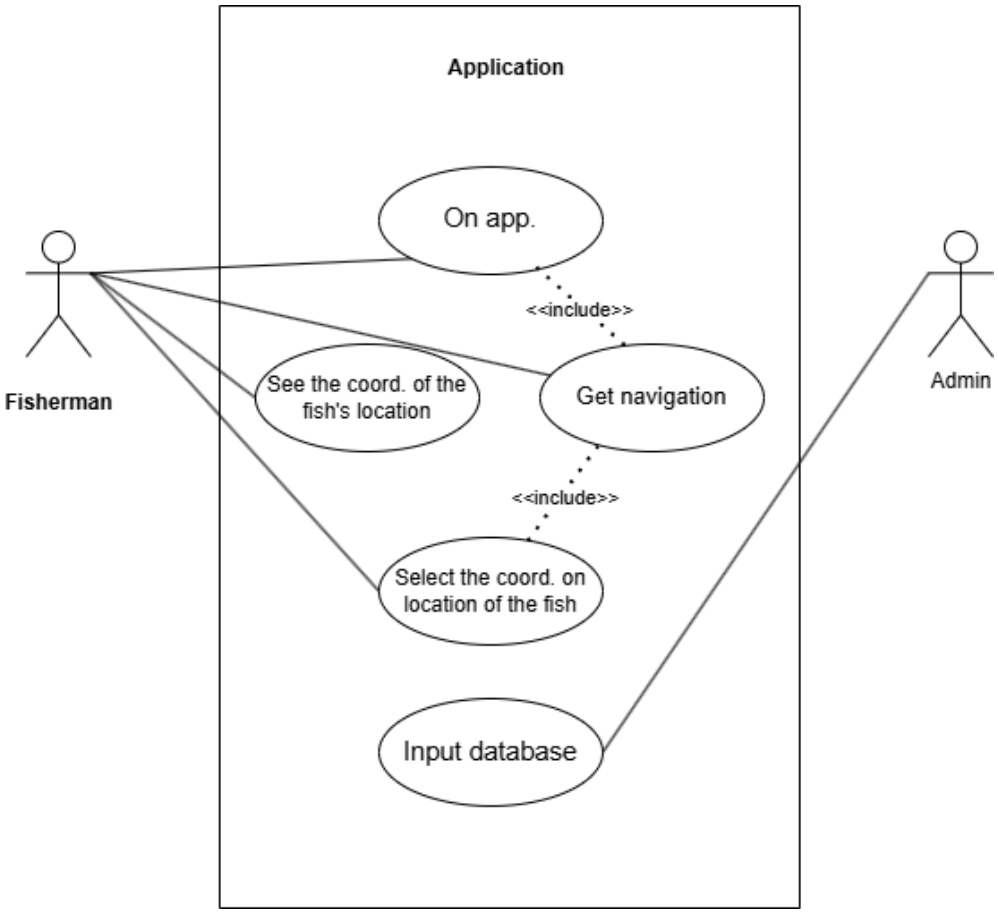

Figure 3. Use Case Diagram

3.2. Class Diagram

In each class, the attributes and operations used to create the Application of GIS Technology for Determining Sea Fish Capital Potential on Mobile Apps are created in the form of a Class Diagram, which is in Figure 4, the explanation of which is as follows:

1. **Class Map**: This class displays the map and arranges the user's location based on geographic coordinates.
2. **Geolocation class**: It estimates the user's location based on location information and latitude coordinates.
3. **Marker Class:** This class is responsible for displaying markers on the map and setting the location and description of the markers.
4. **Polyline Class:** It displays direction lines between the user's location and specific markers on the map.
5. **Database Class:** This class is responsible for storing coordinate information and explanations related to markers in the database.

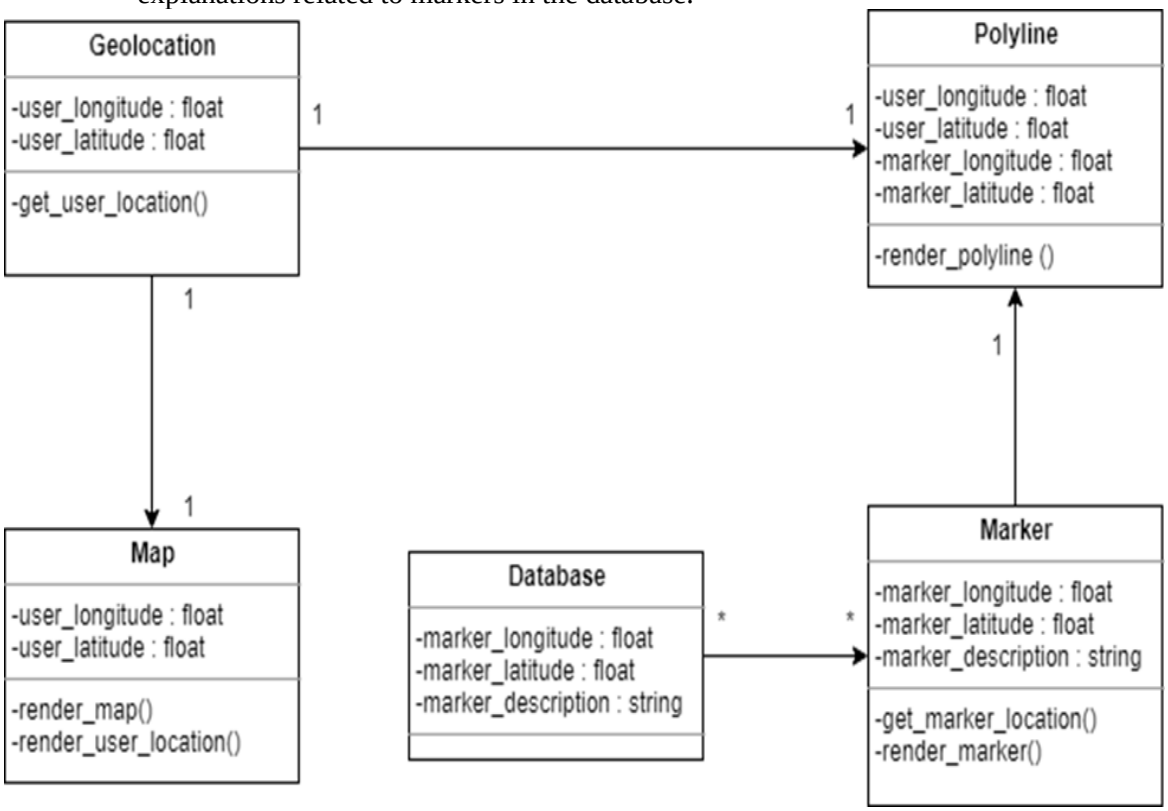

Figure 4. Class Diagram

3.3. Application Implementation

Figure 5 illustrates the marine fish mapping application interface, showcasing different sections from the log-in screen to the visualization results of predicted coordinate points. Figure 5A depicts the application login screen that users encounter upon opening the app. Figure 5B illustrates the interface for enabling location services when the application is launched. Figure 5C shows the application display when it successfully retrieves user coordinates via GPS, indicated by a blue dot. Figure 5D displays the locations of fishing spots, marked with the symbol of five fish, and the predicted locations of fishing spots, marked with the symbol of one fish. Lastly, Figure 5E shows directional lines that guide the user from their current location to the added location based on the estimated potential fish points.

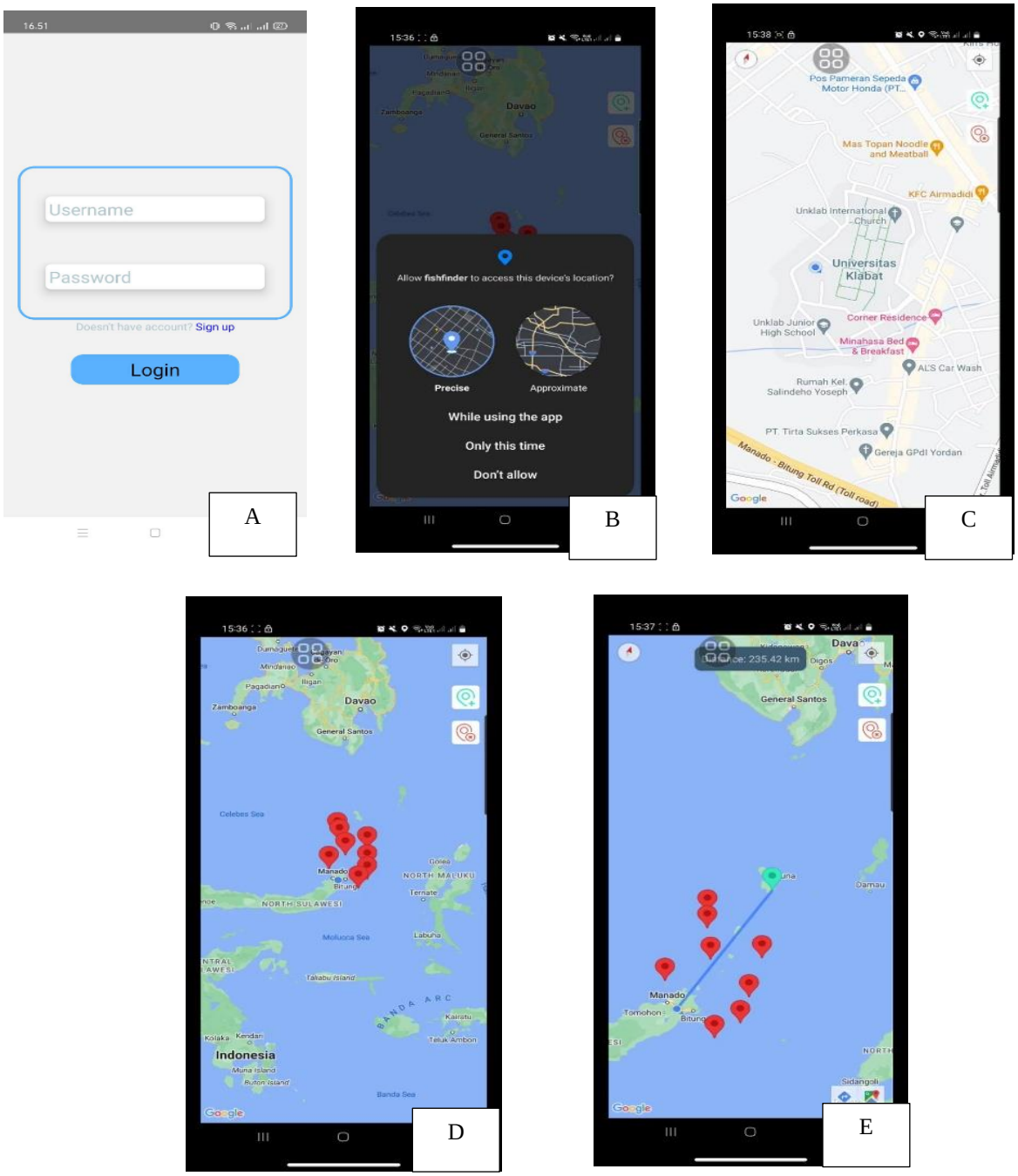

Figure 5. Display of the mapping application interface. (A) Appearance of Initial Application Interface; (B) Interface display when logged in; (C) User Location Interface Display; (D) Interface Display of Fishing Place Locations and Fishing Place Prediction Locations; (E) Feature interface display that user can use to add predicted coordinate points manually.

Tests performed on the developed applications' features are shown in Table 1. The test results indicate that the application's functionality has operated smoothly and generated the desired output. This shows that the application development has reached a sufficient level of maturity and is ready for use by users. This test is useful for testing how far the features in this application run, using a black box method so that errors and missing things can be seen. However, further improvement needs to be made in future research to fix several issues with this app.

Table 1. Application Feature Testing

Input	Expected output	Result
Obtaining latitude and longitude from the user	Displaying the user's current location	Successful
Retrieving the latitude and longitude of fish locations from the database	Displaying fish locations as markers and creating navigation by default	The marker was successfully displayed, but default navigation could not be generated.
Selecting Marker	Displaying information about the marker and creating navigation to the marker from the user's location	Successful
Selecting a point outside the Marker	Does not provide navigation to that point.	It does not provide navigation.

Further testing was conducted on smartphones with various specifications (Table 2). Testing was carried out on five types of smartphones with different specifications to evaluate the application's ability to install and run well on various devices. This testing ensures the application can operate consistently and is accessible to users on a wide range of commonly used devices. During testing, each type of smartphone will be tested by installing and running the application and then seeing whether the application can function adequately without experiencing significant problems such as crashing, lagging, or features not working as expected. Testing is carried out with various usage scenarios to determine whether the application can handle various situations well on all devices tested.

Table 2. Smartphone Feature Testing

Smartphones	Specifications	Result
A	● RAM: 2GB ● CPU: MediaTek MT6580 Quad-Core 1.3 GHz Cortex-A7 ● Android 5.1 ● GPS, A-GPS	The application works smoothly under normal conditions. However, if there are network issues, it may experience subtle delays.
B	● RAM: 6 GB ● Exynos 8895 Octa-core (4x2.3 GHz Mongoose M2 & 4x1.7 GHz Cortex-A53) - EMEA ● Android 7.1.1 (Nougat)s ● GPS, A-GPS, GLONASS, BDS, GALILEO	The application runs smoothly.
C	● RAM: 4 GB ● Qualcomm Snapdragon 820 Quad-core (2x2.15 GHz Kryo & 2x1.6 GHz Kryo) atau Exynos 8890 Octa-core (4x2.3 GHz Mongoose & 4x1.6 GHz Cortex-A53) ● Android 6.0 (Marshmallow) ● GPS, A-GPS, GLONASS, BDS	The application works, but sometimes it is laggy due to a weak internet connection
D	● RAM 4 GB ● Exynos 9610 Octa-Core ● Android 9 (Pie) ● A-GPS, GLONASS, GALILEO, BDS	The application runs smoothly.
E	● RAM 4 GB ● Mediatek MT6771 Helio P60 Octa-Core ● Android 8.1 (Oreo) ● A-GPS	The application runs smoothly

The results of this test will provide a better understanding of the application's compatibility with various types of smartphones and different specifications. Suppose the application can run well on all types of devices tested.

4. CONCLUSION

Using the React Native platform, this research sought to create a mobile application that would help fishermen by leveraging GPS and GIS technologies. The Aqua MODIS satellite, a remote sensing tool, was used to pinpoint the exact locations of the fish. The application, which was created using a prototyping model approach, runs seamlessly from login to fish position

prediction visualization. To maximize utility, some features require additional improvements in the future.

Further research is oriented towards developing an application to determine the type of vessel to catch fish in the selected area because the fishing distance determines the type of vessel that can be used. In addition, further developed applications need to estimate the use of well-controlled, subsidized fuel by ship users since different types of vessels have their regulations on subsidized fuel. Therefore, whether or not they are subsidized, fuel supplies can be effectively managed and always available. Given that fishermen do not always own the kind of boat appropriate for the fishing distance, the developed application will advise fishermen on the best boat type for their needs when they go to sea.

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