INVAFISH MY: A MOBILE APPLICATION WITH GIS INTEGRATION FOR INVASIVE FRESHWATER FISH REPORTING IN MALAYSIA

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Abstract- Freshwater ecosystems in Malaysia are increasingly threatened by invasive fish species that disrupt native biodiversity and aquatic balance. However, currently, there is a lack of a centralised real-time application for reporting and managing such species. Hence, a mobile application called InvaFish MY is developed to address the significant gap in national biodiversity management. Geographic Information System (GIS) technology is utilized in the application for real-time reporting and monitoring capabilities. The combination of mobile GIS and citizen science applications is not a new concept, but this application's novelty lies in its focus on invasive freshwater fish in Malaysia. The study employs the Agile methodology, which involves analysing problems through a literature review and developing applications. InvaFish MY is then evaluated in terms of usability using the Participatory GIS Usability Scale (PGUS), resulting in an average score of 80. This PGUS score indicates a good to excellent level of usability. Hence, it is concluded that InvaFish MY is user-friendly and all functions are working well to support spatial monitoring of invasive freshwater fish in Malaysia. This tool could empower the fisheries department to swiftly identify potential issues, fostering timely interventions that bolster the protection of the ecosystem.

Keywords— Mobile GIS, Invasive Species, Spatial Monitoring, Usability Evaluation, Geolocation Reporting

1 Introduction

The native freshwater fish of Malaysia are increasingly at risk as non-native and invasive species continue to spread across local rivers due to activities such as irresponsible fish releases, aquaculture escapes, and recreational fishing, whether intentional or accidental. The growing presence of these unwanted species poses a major threat to Malaysia's freshwater biodiversity [1]. Sometimes, species can be misidentified, or reports are incomplete, resulting in unreliable datasets that weaken ecological assessments and policy development [2].

Current practices for fish monitoring are fragmented, outdated, and mostly manual, with reports often recorded on paper or kept in separate locations. Based on the authors' knowledge, there is currently no centralised and technology-based application for monitoring invasive freshwater fish in Malaysia [3]. Without an integrated reporting platform, it is hard to perform early detection, and long-term ecological studies are more challenging to maintain, thereby reducing the effectiveness of national conservation efforts [1][4]. This is due to the absence of Geographic Information System (GIS) integration, which is essential for mapping species distribution and modelling ecological risks [5].

Existing studies related to mobile applications with GIS integration and invasive freshwater fish reporting in Malaysia are reviewed to contextualise the proposed system and align the discussion with the scope of this study. Building upon these studies, this application utilises GIS as an advanced tool specifically designed to gather, store, analyse, and manage spatial and geographical data [6]. The application aims to increase public participation, improve data accuracy, and strengthen national biodiversity protection. These improvements are supported by mobile technologies, crowdsourcing, and GIS functions, as users of location-based services form the primary audience for mobile GIS [7]. To support this study, several existing applications were reviewed, and their strengths and weaknesses are summarised in Table 1.

Table 1: Comparative analysis of existing applications

Application	**Strength**	**Weakness**
iNaturalist [8]	Widely used citizen science platform with image-based species identification.	Lacks GIS-layered invasive species tracking features.
IPM – Invasive Species Mapper [9].	Supports GIS-based mapping of invasive species pests	Slow in detecting rapid ecological changes.

Based on Table 1, the primary outputs of this research are three: first, the design and creation of a GIS-embedded mobile application specifically for invasive freshwater fish reporting in Malaysia. Subsequently, the adoption of a crowdsourced reporting process, combined with administrative validation, facilitates data credibility. And, finally, the analysis of the application's usability based on the Participatory GIS Usability Scale (PGUS).

This study contributes to the field of environmental informatics by developing a centralised, real-time, GIS-enabled mobile application tailored for monitoring invasive freshwater fish in Malaysia, integrating crowdsourced reporting, spatial analysis, and usability evaluation to enhance national biodiversity management.

2 Methodology

2.1 Agile Model

This study adopts agile methodology, which is designed to respond to the fluidity inherent in the software development process, where requirements often change, and users expect updates to be delivered as quickly as possible. Continuous integration, the ability to deliver working software rather than comprehensive documentation, customer collaboration as a primary matter of importance, and a focus on responding to change rather than following a set plan are some of the values promoted by Agile [10].

An agile approach is chosen because it best suits projects where requirements are constantly evolving, and user feedback is a top priority. This method enables potentially shippable increments to be delivered after each cycle, which are tested by stakeholders and end-users themselves, allowing for responsiveness to evolving ecological requirements. Fig. 1 illustrates the Agile development workflow adopted for this project.

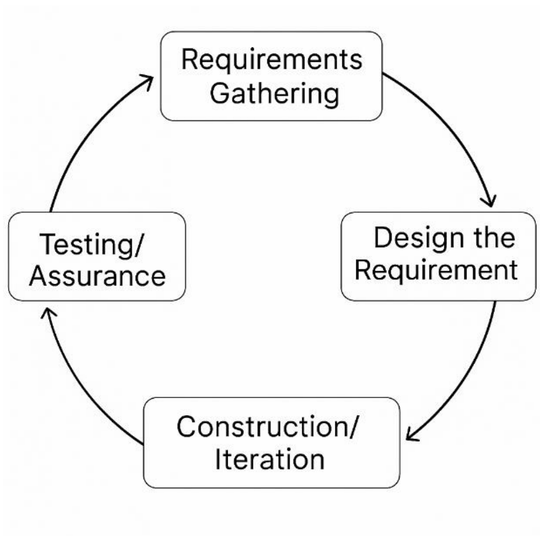

Fig. 1 Agile model

This approach supports different user roles (public users and administrators), geolocation services, image processing, and live visualisation panels, which are developed through an iterative approach. An agile approach is also compatible with the lightweight characteristics of mobile platforms [11], consists of four main stages. The first stage, which is the planning stage, involves requirement gathering and defining objectives with stakeholders. In the second stage, system architectures, user interfaces, and GIS-based functionalities are designed. Next, in the development/iteration stage, the main functions were implemented. The primary functions defined in this application are user reporting, species identification, GIS visualization, and administrative verification. In the final stage, known as Testing/Review, the application is evaluated through a usability test. These four stages ensure a systematic method is followed through while being responsive to any new requirements.

2.2 Evaluation Test

Usability testing is conducted to determine whether the application is practical and efficient, using the Participatory GIS Usability Scale (PGUS). The PGUS is the primary assessment instrument because it utilizes online mapping tools that are accessible to non-expert users. These users will provide their feedback in the form of PGUS questionnaires and rate the task completion. The PGUS questionnaire [12] is shown in Fig. 2.

(A) *User interface*
1. The terms used in the system are clear.
2. It is easy to move through different parts of the system.
3. The error messages are easy to understand.
4. The delay between operations is acceptable.
5. Returning to the homepage is easy.

(B) *Spatial interface*
1. It is easy to move to a new location on the map.
2. It is easy to zoom in and out on the map.
3. I can create new content easily.
4. I can easily access information about what is displayed in the map.
5. The visual edits on the map take effect immediately.

(C) *Learnability*
1. I am confident using the system.
2. It is easy to remember how to perform tasks.
3. Discovering new features by trial and error is easy.
4. I find the help resources useful.
5. Mistakes can be easily undone.

(D) *Effectiveness*
1. The system gives me the tools to reach my goals.
2. The system is reliable.
3. I can complete tasks that would be impossible without the system.
4. The system increases my participation in the project.
5. I would recommend this system to others.

(E) *Communication*
1. The system helps me communicate my ideas to other participants.
2. I always understand what the system is showing.
3. The maps are easy to understand.
4. I can express my opinion about other participants' ideas.
5. When I have a problem, somebody can help me.

Fig. 2 Participatory GIS Usability Scale instrument [12]

The application's usability will be assessed in five main dimensions, each consisting of five distinct statements, totalling 25 items. The users rate for each statement on a 5-point Likert scale, with Strongly Disagree (1) and Strongly Agree (5) being possible outcomes. The ratings are then transformed into an equivalent rating between 0 and 100, with higher ratings having higher levels of usability [12]. The overall raw score is thus between 25 (lowest) to 125 (highest). In this study, a total of 10 participants will complete the PGUS evaluation, following Ballatore et al. [12]. The small sample size is adequate based on several justifications: 1) the usability test is carried out to identify usability issues rather than to generalize statistically, 2) a small number of participants in enough to uncover the majority of usability issues according to the "5-user rule" [13] and 3) this application itself is still at the prototyping stage, hence any critical issues can be improved in the iterative refinement process.

The participants are selected using purposive sampling, consist of university students and general users with basic smartphone experience, reflecting the intended public user group of the application. Each participant was briefed on the purpose of the test and guided through a simulated use case that mimicked the process of reporting invasive fish sightings.

The participants were instructed to perform several main functions, including navigating and zooming on the interactive map, tagging a location to simulate a fish sighting area, uploading a sample image of an invasive fish specimen, and submitting a sighting report by inserting the species name, location details, and a short description.

Each participant must complete the PGUS survey after finishing the tasks. The raw score is then converted to a 0 to 100 scale using the equation as follows:

$$PGUS\ Score = \left(\frac{Raw\ Score - 25}{100}\right) \times 100 \qquad (1)$$

Using Equation 1, a raw score of 25 will be associated with a PGUS score of 0, and a raw score of 125 will be associated with a PGUS score of 100. This is because the normalised score enables usability findings to be compared across all participants, providing a clear understanding of the application's effectiveness and user-friendliness.

3 Results and Discussion

3.1 Interface Design

A well-designed user interface is vital in many ways, as it enhances usability, efficiency, and user satisfaction. Fig. 3 illustrates all user interfaces of InvaFish MY, including those for public users and administrators. One can utilise existing human-computer interaction

(HCI) and user-centred design (UCD) principles when developing the design to enhance features, convenience, and data security.

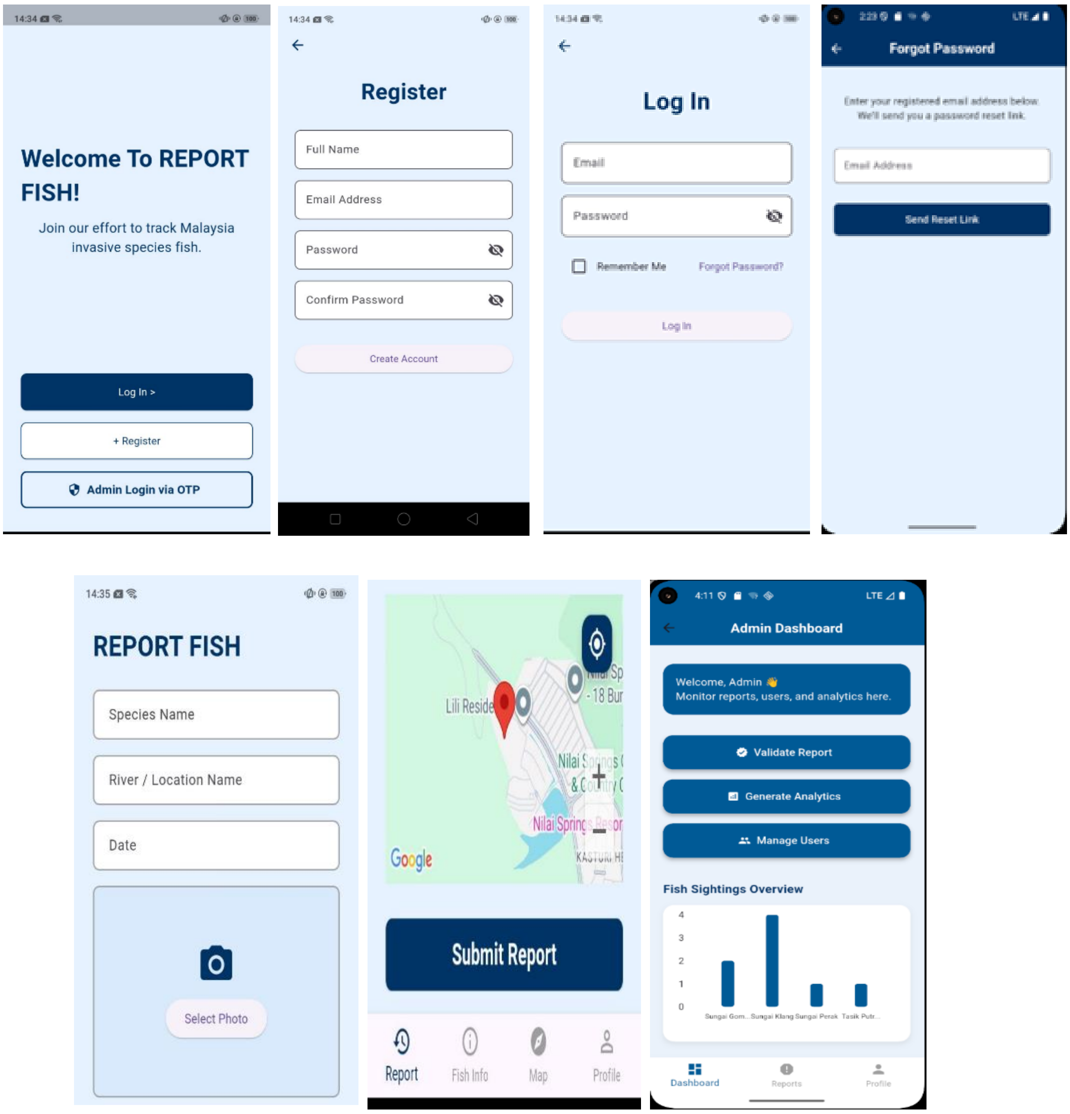

Fig. 3 User interfaces of the proposed application

As for the Initial Page, the screen introduces the application with a welcoming message to the application. The interface employs a clean, centred layout with three distinct action buttons arranged vertically for clarity and ease of selection. The Login and Register buttons are designated for standard public user citizens, anglers, environmental enthusiasts, and community members who wish to contribute to sighting reports.

New users must create an account through the registration page. During registration, users must provide the necessary information, including their Full Name, Email Address, Password, and Confirm Password. Each password field features a toggle visibility icon (an eye icon) that allows users to show or hide their password input for security and convenience. After successful registration, users are directed to the login page to access the application.

Once registered, users can log in through the secure Log In page. Users are required to enter their Email Address and Password in the corresponding input fields. Users can see the inserted hidden input by pressing the visibility toggle icon (eye icon). For users who have forgotten their credentials, they may click the" Forgot Password?" link as a password recovery mechanism. Upon successful login, users can access their profiles, submit reports, view their contribution history, and report their sighting. However, if authentication fails, users are prompted to correct their input.

Once logged in, the home page will be displayed. The user may report an invasive fish sighting. For this feature, the user needs to enter species details, upload photos, and geotag locations on a GPS-enabled map. The interface employs a vertical scrolling layout that organises input fields in logical sequence: species identification, location specification, temporal data, photographic evidence, and spatial positioning. For exact location reporting, the application provided an embedded map with real-time GPS positioning.

The application provides a secure authentication pathway for administrators, who are personnel of the Department of Fisheries Malaysia. Multi-Factor Authentication (MFA), which includes both departmental credentials (such as an official email address or employee identification number) and a time-sensitive one-time password (OTP) confirmation, is used for administrator login. The one-time password will only be transmitted to the employee's registered contact information and must be entered within a limited timeframe to complete authentication. This condition ensures that administrative access cannot be compromised solely through stolen passwords.

Based on the sighting report sent by the public users, the administrator must verify reports before they are publicly displayed. The information that needs to be verified includes the photos, the user's location on a map, the time, and the name of the bird. This action avoids the application from being spammed or receiving misinformation. The reports include "validate" and "reject" buttons to ensure that only accurate and legitimate data is included in the database. Validated fish sighting information can be displayed based on chosen species, location, or a specific period. The administrator can also manage users through the User Management menu to monitor who has access to the application, track user activity, view each user's history, and identify any suspicious actions.

For both public users and administrators to retrieve their passwords, they must enter their registered email address in the provided field on the "Forgot Password" page. The interface provides clear instructions to guide users through the password recovery process. Upon clicking the "Send Reset Link" button, the application sends a link to the specified email address. Upon following the link, users are required to create a new password and re login to the application.

3.2 Evaluation Test

Usability testing on InvaFish MY was conducted with ten participants. The evaluation results are presented in Table 2, where P1 to P10 represent each participant's responses, corresponding to one complete usability test session each.

Table 2: Evaluation Result

Part	**Raw Score**	**PGUS Score (0-100)**
P1	110.	85
P2	103	78
P3	98	73
P4	106	81
P5	112	87
P6	95	70
P7	108	83
P8	100	75
P9	114	89
P10	104	79

Based on Table 2, the score is then calculated as follows:

Average Raw Score: 105
Average PGUS Score: 80
Overall Usability Level: $\left(\frac{105-25}{100}\right) \times 100 = 80$
Result: Good to Excellent

A detailed PGUS score shows that participants rated Interface Design the highest, with an average score of 84, followed by Task Completion (82), Navigation (79), Data Entry (78), and Feedback/Help (77). Overall, the testing showed an average PGUS score of 80, which falls within the good to excellent range. This PGUS score indicates that InvaFish MY meets user expectations for the design. The user agrees that the information provided in the application is clear and user-friendly.

Several positive comments from users highlight the intuitive map navigation features and the convenience of automatic GPS tagging. Participants described the interface as user-friendly, with smooth navigation across key features such as reporting, location tagging, photo uploads, and data validation. Additionally, the option to attach photos directly from the device improved the verification and credibility of reports. Nonetheless, the application can be further improved by providing clearer instructions for first-time users, particularly for submitting reports.

4 Conclusion

The study was motivated by the growing ecological threat posed by non-native freshwater fish species in Malaysia. In the long run, this problem may disrupt native biodiversity and the balance of aquatic ecosystems. Based on the literature review, it was found that there is a lack of a centralised real-time application for reporting and managing such species. Thus, this study aimed to address these issues by developing a centralized, robust framework for ecological monitoring that includes a real-time reporting application. InvaFish MY utilizes Geographic Information Systems (GIS) functionality that allows live reporting with geotags, identifies hotspots, and performs spatial analysis.

To foster citizen and professional collaboration, InvaFish MY supports two roles: public users and administrators. Public users can share invasive fish sightings, including species details, photos, and GPS-enabled locations. On the other hand, administrators can verify, reject, or request more information through a secure dashboard.

The application went through usability testing. The PGUS usability testing yielded an average PGUS score of 80, indicating a “Good to Excellent” range. The application’s interface was visually clear and consistent, easy to learn and use, with seamless transitions for reporting, mapping, and profile management.

The application has the potential to be used in the real world for real-time monitoring of invasive fish species, enabling early detection, higher-quality ecological datasets, and more informed decisions by conservation authorities. Simultaneously, this application encourages citizen involvement while enabling the fisheries department to develop timely actions to protect freshwater ecosystems.

This study contributes to the broader field of environmental informatics by demonstrating how mobile GIS platforms can be tailored to local contexts to address biodiversity challenges. Future improvements, such as automated species identification, offline reporting, and expanded platform integration, could be implemented to further enhance the application’s scalability and long-term value.

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