Journal of Information Systems and Informatics
Vol. 7, No. 1, March 2025 e-ISSN: 2656-4882 p-ISSN: 2656-5935
DOI: 10.51519/journalisi.v7i1.1043 Published By DRPM-UBD

Deploying a GIS for Enhancing Clinic Accessibility in Indonesia: An Agile QGIS Approach

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Abstract

Health is a fundamental necessity for all living beings, and clinics represent one of the most accessible healthcare facilities for communities. The spatial distribution of clinics can be effectively analysed and visualized through a Geographic Information System (GIS). This study proposes the development of a web-based clinic GIS for Indonesia using Quantum GIS (QGIS) software, implemented through the Agile methodology. The integration of Agile practices ensures that the system is accurate, adaptable, and responsive to evolving user needs. The resulting GIS website was successfully developed and tested, achieving a usability score of 88.76%, with effectiveness, efficiency, and satisfaction ratings of 91%, 90%, and 85%, respectively. The platform aims to support policymakers and healthcare providers in gaining a deeper understanding of health service distribution, ultimately promoting more equitable, data-driven decision-making in healthcare planning and resource allocation.

Keywords: Clinic, QGIS, Geographic Information System, Website, Agile

1. INTRODUCTION

Health is a fundamental asset that enables individuals to live productively and meaningfully. It encompasses not only a healthy body and clear mind but also the capacity to engage positively within society [1]. In the context of national development, health is a cornerstone—nations with healthy populations can work more efficiently and contribute significantly to socioeconomic progress [2]. However, ensuring equitable access to healthcare services across Indonesia's vast and geographically fragmented landscape remains a persistent challenge.

This challenge became even more apparent during the COVID-19 pandemic, which laid bare systemic weaknesses but also opened doors for transformative change. Recognizing this momentum, the Indonesian Ministry of Health launched a bold initiative to accelerate digital transformation in healthcare by leveraging technology to bridge service gaps and improve public health outcomes [3]. At the

p-ISSN: 2656-5935 http://journal-isi.org/index.php/isi e-ISSN: 2656-4882

heart of this initiative is the 2024 Health Digital Transformation Strategy Blueprint, which outlines a structured roadmap for technology-driven healthcare system reforms (Figure 1) [3].

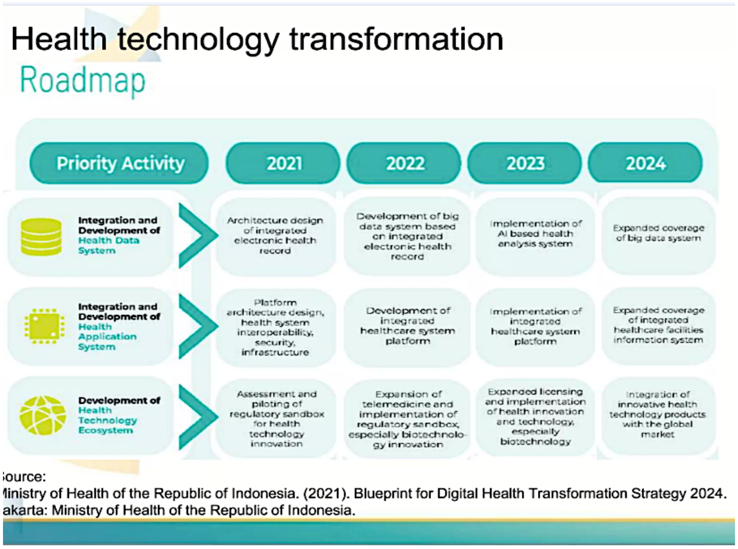

Figure 1. Health technology transformation roadmap [3]

Despite these strategic plans, one major bottleneck remains: the inequitable distribution and accessibility of clinics, which are often the first point of contact for individuals seeking medical attention. Clinics serve a crucial role as primary healthcare facilities—offering basic services and referring patients to hospitals when needed [4]. As of February 23, 2023, there were 17,953 clinics registered with the Ministry of Health based on data from BPS. However, the large number does not necessarily translate into equal geographical coverage or accessibility, especially in rural and remote areas.

To address this issue, Geographic Information Systems (GIS) offer a powerful tool for visualizing and analyzing spatial patterns. GIS enables the capture, storage, manipulation, analysis, and presentation of spatial data and associated attributes [5], [6]. It can show not only where clinics are located but also help identify service gaps based on demographic, socioeconomic, and geographic variables. Yet, there is a noticeable gap in applying GIS specifically for healthcare service optimization, particularly in the context of clinic distribution and accessibility planning.

To fill this gap, this study proposes the development of a web-based GIS platform using QGIS integrated with Agile development principles. The goal is to create a dynamic, responsive system that facilitates better planning and decision-making regarding clinic locations, ultimately enhancing public access to primary healthcare

p-ISSN: **2656-5935** http://journal-isi.org/index.php/isi e-ISSN: **2656-4882**

services. The proposed solution is rooted in Agile methodology, known for its ability to adapt to changing requirements through iterative development and close stakeholder collaboration [7], [8].

Prior studies using GIS have focused on a variety of domains, such as literacy distribution [6], population and land usage [9], cultural heritage site recommendations [10], and optimization of beekeeping schedules [11]. While these studies highlight the versatility of GIS applications, they also reveal a lack of targeted implementations in the health domain, particularly for clinic accessibility in Indonesia.

This research adopts Extreme Programming (XP), a branch of Agile methodology that emphasizes customer satisfaction, frequent releases, and adaptability—making it an ideal fit for a project with evolving user needs and public impact [12], [13]. Moreover, web-based GIS platforms built using XP can be accessed across multiple devices, unlike mobile-exclusive apps, increasing accessibility for both healthcare professionals and policymakers. Therefore, the aim of this study is to design and implement a web-based GIS for enhancing clinic accessibility in Indonesia, leveraging the QGIS platform and developed through the Agile XP methodology. The system will provide actionable insights into clinic distribution, identify underserved areas, and support informed decision-making to align with national health equity goals.

2. METHODS

This study adopts the Agile methodology, specifically utilizing the Extreme Programming (XP) model, to develop a web-based GIS that visualizes and improves the distribution of clinics across Indonesia. Agile methodologies are well-suited to complex, evolving projects like GIS development, where flexibility, rapid iteration, and stakeholder feedback are essential. The XP model an Agile variant emphasizes close communication, fast development cycles, continuous integration, and constant user feedback, making it ideal for public service systems that must adapt to real-world needs dynamically, as shown in Figure 2.

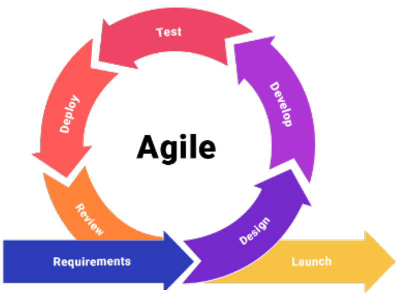

Figure 2. Agile Method

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In applying this approach, the project is structured into six key stages that align with both Agile principles and the technical requirements of developing a GIS using QGIS and related web technologies. These stages are outlined as follows:

1) Needs Analysis and Data Collection

The foundation of any successful system lies in thorough initial research. This stage begins with a comprehensive literature review, which helps identify best practices, previous implementations, and key theoretical underpinnings for GIS and web development. From a technical standpoint, this step also determines the software and hardware resources necessary to support development—including tools such as QGIS for spatial data processing and web frameworks for deployment. Simultaneously, real-world data is gathered, including clinic locations, regional health service data, and supporting demographic information. The combination of theoretical groundwork and empirical data ensures that development is both academically sound and practically relevant.

2) Planning and Design

Once the necessary background and data are secured, the next step is to lay out the system's architecture and visual structure. This phase employs the Unified Modeling Language (UML) approach to model both system behavior and user interaction [14]. Specifically, use case diagrams are used to define how users will interact with the GIS system, while activity diagrams outline the processes behind those interactions. Alongside this, the navigation structure of the web interface is planned, ensuring intuitive access to features like clinic maps, search functionality, and detailed information pages. A database schema is also designed at this stage, aligning the spatial data with relevant attributes such as clinic types, services offered, operational hours, and regional categorization.

3) System Creation

The core development phase involves creating the actual Web GIS application, using the Agile development process guided by XP principles. Development is conducted in short cycles, or iterations, with each cycle delivering a functioning piece of the system. Throughout this stage, developers integrate spatial data using QGIS and web mapping libraries such as Leaflet or OpenLayers to create interactive maps. Continuous user feedback is solicited at every stage, ensuring that changes can be made swiftly and in response to real user needs. This iterative model allows for ongoing refinements and greater alignment with project goals.

p-ISSN: **2656-5935** http://journal-isi.org/index.php/isi e-ISSN: **2656-4882**

4) Testing

After development iterations produce a workable version of the GIS, usability testing is conducted to evaluate both user interface (UI) and user experience (UX) performance. This testing phase is critical, as the effectiveness of a web GIS hinges on its accessibility and ease of use, especially for non-technical users. Usability is tested across various parameters including navigation clarity, load time, interactivity, and accessibility. As noted by [15], a high usability score is directly linked to a positive user experience, which is essential for a system intended for wide public access.

5) Implementation

With testing complete and the system stable, the next step is to deploy the Web GIS, making it accessible to stakeholders. This includes health officials, planners, and the general public, all of whom can use the platform to locate clinics, explore service coverage, and identify healthcare gaps. The implementation phase also involves integration with live datasets where applicable, ensuring that users receive up-to-date information on clinic availability and functionality.

6) Revision and Maintenance

Finally, a system built using Agile principles must remain dynamic and adaptable. This final stage focuses on system revision, incorporating feedback gathered from users during the implementation phase. Additionally, the system is updated to reflect new clinics, closures, or changes in operational details. Routine maintenance ensures performance stability, data accuracy, and ongoing relevance in supporting healthcare accessibility.

This structured, Agile-driven development process ensures that the Web GIS evolves in response to real-world needs, with QGIS at the core of spatial data handling and visualization. The result is a flexible, user-centered application aimed at enhancing clinic accessibility across Indonesia, in line with national health transformation goals.

3. RESULTS AND DISCUSSION

This section discusses the implementation of each stage in the Agile XP development cycle applied to building a Web GIS for visualizing clinic distribution in eight cities across Indonesia. The development process is designed to address the identified gap in spatially optimized healthcare facility access and aligns directly with the goal of enhancing public health accessibility through geospatial

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technology. Only key results and figures critical to the research objectives are included for clarity and focus.

3.1. Analysis Phase

The first stage involved a detailed analysis of system requirements to determine both the technical specifications and the operational scope needed to build an efficient GIS platform. The development was supported by the use of QGIS 3.30.2, a powerful open-source GIS application, and Microsoft Excel for initial data formatting. A reliable mid-tier development environment was ensured using a Windows 10-based ASUS TUF Gaming FX505DD laptop with adequate processing capabilities to support map rendering and plugin integration.

The analysis concentrated on gathering clinic-related data, including clinic names, geolocation coordinates (longitude and latitude), responsible personnel, and contact numbers. These data were collected for eight Indonesian cities with diverse geographic profiles. The data were cleaned and stored in a structured tabular format using Excel and then saved in CSV format for seamless integration with QGIS. This step was vital in preparing a clean dataset for spatial visualization and interaction.

3.2. Planning and Design Phase

In the planning and design phase, the system architecture and interaction flow were conceptualized using the Unified Modeling Language (UML) approach. A Use Case Diagram (Figure 3) was developed to depict the primary interactions between users and the system, such as viewing the clinic map, accessing clinic details, and using location-based filters. This figure illustrates the system's essential functionalities and provided a clear framework for user-centered development. The user flow was further refined using an Activity Diagram (Figure 4), which describes the step-by-step process a user would take—from entering the home page to selecting and viewing clinic information. This workflow ensured that the system supported a logical and intuitive user experience.

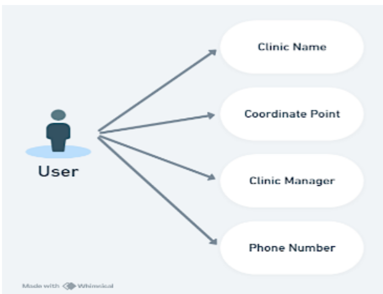

Figure 2. Use Case Diagram

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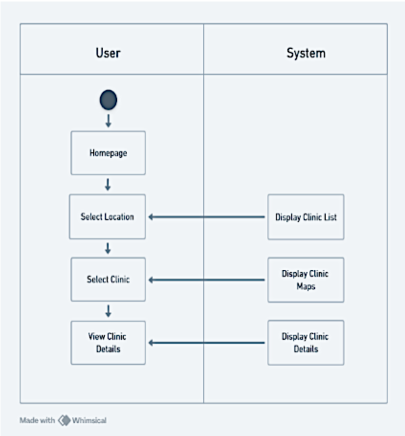

Figure 3. Activity Diagram

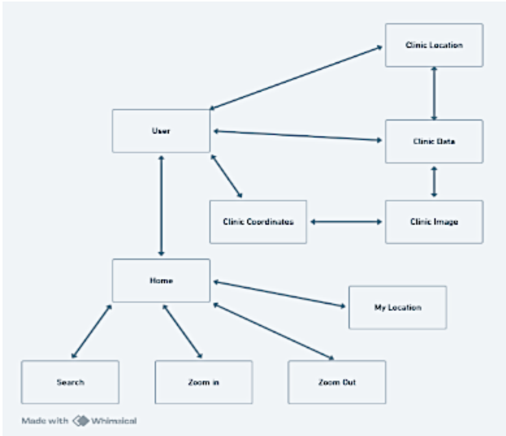

Figure 4. Navigation Structure

To enhance navigability, a non-linear website navigation structure was designed (Figure 5). This structure allows users to move fluidly between service pages, maps, and detailed clinic profiles. Visitors begin on a homepage that introduces the purpose and functions of the system. From there, they can explore the available services, access the interactive clinic map, and retrieve relevant clinic information, including estimated distances from the user's current location. This modular navigation design supports both new and returning users in quickly finding the information they need.

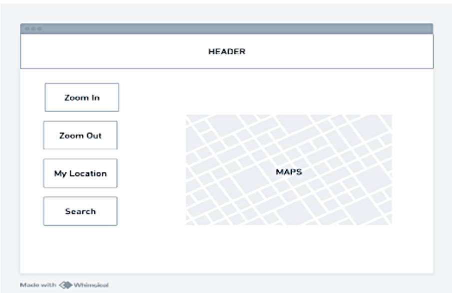

Figure 5. Home Page Layout Design

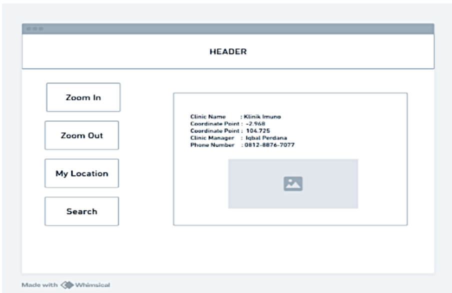

Figure 6. Clinic Information Design

A central database table "klinik_indo" was designed to store structured information about each clinic, such as name, coordinates, contact number, clinic manager, and associated image files. The database schema is presented in Table 1, which outlines the field types and data attributes used. This relational structure ensures accurate mapping of spatial and attribute data within the GIS platform. The final element of the design stage was the interface layout. A visual mockup of the homepage (Figure 6) was created, followed by the map interface showing clinic

p-ISSN: **2656-5935** http://journal-isi.org/index.php/isi e-ISSN: **2656-4882**

distributions across eight cities (Figure 7). These figures helped guide the actual front-end development and ensured that user expectations were met in terms of visual clarity and functional access.

Table 1. Clinic Variables

Field	Type of data	Length	detail
Name of Clinic	text (string)	10	Not null
Coordinate_E	decimal (double)	25	Not null
Coordinate_S	decimal (double)	25	Not null
Telp_Number	integer	15	Not null
Clinic_ manager	text (string)	50	Not null
Picture	text (string)	500	Not null

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3.3. System Development Phase

System creation began with installing QGIS and configuring necessary plugins, including qgis2web, QuickMapServer, and Qgis2threejs, to enable web compatibility and 3D visualization. After initiating a new QGIS project, the cleaned CSV dataset was imported and georeferenced. This integration step allowed for clinic locations to be precisely mapped and represented visually. A base map was added using the QuickMapServer plugin, which provided real-time map tiles, enhancing spatial context (Figure 8). Clinic data points were styled for visibility and linked to corresponding attribute data, such as names and phone numbers. These layers were then exported using qgis2web, which generated HTML, CSS, and JavaScript files for deployment on a web server.

The exported web map files were hosted using an online hosting service. The hosting process involved uploading the exported GIS web content through a file manager interface (Figure 9) and configuring the website environment. After deployment, users could access the website publicly and interact with the fully functional GIS map showing clinic distribution. The hosted system interface is shown in Figure 10.

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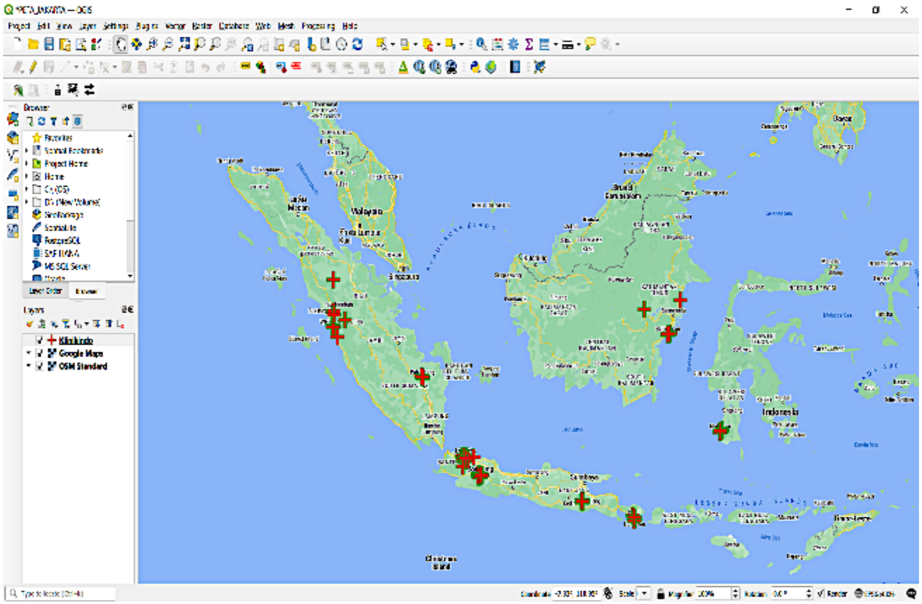

Figure 8. Display Map

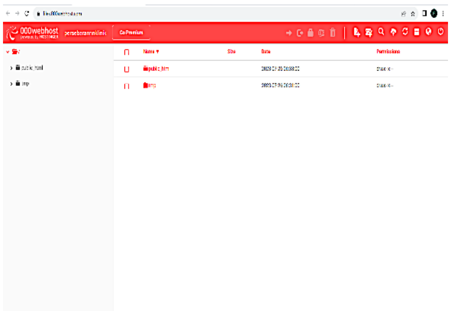

Figure 7. File Manager Hosting

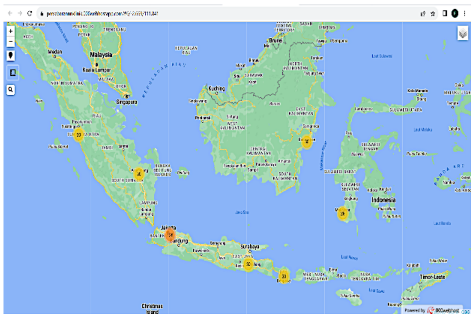

Figure 8. Website is Hosted

The resulting platform allows users to explore clinic locations, view clinic-specific information, and access health facility data through an intuitive, map-based interface. This aligns directly with the research objective of enhancing clinic accessibility and providing data-driven insights into healthcare distribution using Agile GIS development.

3.4. Testing

Usability testing was conducted to evaluate the overall performance and user experience of the developed GIS website for clinic distribution. The goal of this phase was to assess whether the system effectively meets user needs in terms of accessibility, ease of use, and satisfaction—critical indicators for determining the

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practicality and public usability of health-oriented GIS platforms. Data for this test were collected through an online questionnaire distributed via Google Forms. The questionnaire was structured around three main usability aspects: effectiveness, efficiency (or ease of use), and user satisfaction. Each category contained a set of statements that respondents rated using a five-point Likert scale, ranging from Strongly Disagree (1) to Strongly Agree (5). The scoring weights associated with these responses are presented in Table 2.

Table 2. Questionnaire Value Weight

Likert Scale	Value
SD (Strongly Disagree)	1
D (Disagree)	2
QA (Quite Agree)	3
A (Agree)	4
SA (Strongly Agree)	5

A total of 20 respondents who had interacted with the SIG website participated in the survey. To interpret the results, the usability value was calculated by averaging the scores from all three aspects. Based on Table 3, which outlines the percentage criteria for website feasibility, a system that scores between 80% and 100% is categorized as "Very Worthy".

Table 3. Eligibility Criteria

Percentage	Result
0% - 19,99%	Very Unworthy
20% - 39,99%	Unworthy
40% - 59,99%	Worthy
60% - 79,99%	Quite Worthy
80% - 100%	Very Worthy

The first usability aspect assessed was effectiveness, which relates to how well users can achieve their intended goals using the system. Respondents evaluated statements concerning user-friendliness, clarity of instructions, information accuracy, and data completeness. As shown in Table 4, the effectiveness score averaged 91%, indicating that users found the system reliable and informative.

Table 4. Effectiveness Value

No.	Measurement criteria	Value					Sum
		1	2	3	4	5	
1.	User friendly	0	0	1	6	13	92
2.	Understandable instruction	0	0	0	2	18	98
3.	Accurate information	0	0	2	7	11	89
4.	Completed information	0	0	5	5	10	85
	Effectivity Average						91

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The second aspect measured was efficiency, which focused on interface clarity and system responsiveness. Participants were asked about button placements, font readability, and the overall visual appeal of the website. The results, presented in Table 5, yielded an average efficiency score of 90%, affirming that users found the system intuitive and easy to navigate.

Table 5. Efficiency Value

No.	Measurement criteria	Value					Sum
		1	2	3	4	5	
1.	Proper button placement	0	0	2	7	11	89
2.	Clearly legible letters	0	0	1	3	16	95
3.	Display website attractive	0	1	2	6	11	87
Efficiency Value							90

The third aspect assessed was user satisfaction, focusing on whether users would recommend the website, felt that it delivered comprehensive information, and were visually satisfied with the interface. According to Table 6, the satisfaction score averaged 85%, which reflects a strong positive reception from the users.

Table 6. Satisfaction Value

No.	Measurement criteria	Value					Sum
		1	2	3	4	5	
1.	Recommended website	0	2	5	4	9	80
2.	Website provide completed information	0	1	4	6	9	83
3.	Display website attractive	0	0	1	5	14	93
Satisfaction Value							85

By aggregating the three categories effectiveness (91%), efficiency (90%), and satisfaction (85%)—the overall usability score of the GIS web application is calculated at 88.76%. This result places the system in the "Very Worthy" category as per the usability criteria in Table 3. This indicates that the GIS website for clinic distribution not only meets the technical development goals but also achieves a high level of practical usability for real-world application.

3.5. Implementation

The final stage of the development process involved the deployment of the Web GIS for public access. After thorough development and testing, the GIS website—designed to visualize and improve clinic accessibility across eight Indonesian cities—was successfully hosted and made accessible via an online platform. This phase focused on evaluating the real-world functionality and interactivity of the system from a user's perspective.

p-ISSN: 2656-5935 http://journal-isi.org/index.php/isi e-ISSN: 2656-4882

Upon accessing the site, users are greeted with a homepage featuring an interactive map of Indonesia. As shown in Figure 11, the map interface provides a visual overview of clinic distribution. Users can zoom in on specific areas by clicking on the region or city of interest, allowing them to explore localized healthcare data. A navigation button is available in the top-left corner, offering streamlined access to different features and sections of the site. This intuitive design ensures that even non-technical users can easily interact with the system, fulfilling the objective of enhancing public accessibility.

Figure 11. Homepage of the SIG Clinic Website

When a user selects a specific clinic location on the map, detailed clinic information is displayed in a pop-up interface. This includes essential data such as the clinic's name, address, phone number, and the person in charge. As depicted in Figure 12, this interactive popup is easy to navigate—users can view information and close the display by clicking the "x" button in the top-right corner. This level of interactivity ensures a user-friendly experience and allows the system to deliver spatial data in a clear and meaningful way.

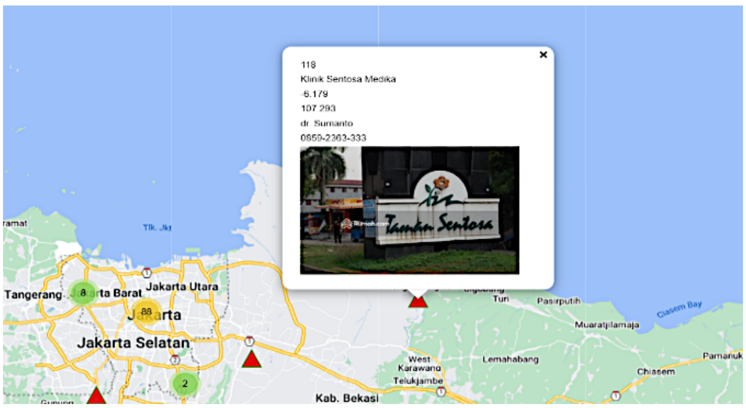

Figure 12. Display of Clinic Search Results on SIG Website

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The successful implementation of the SIG website demonstrates its readiness for public use and supports the primary research aim: to improve clinic accessibility through an efficient, web-based GIS platform developed using Agile principles. With the website now fully functional, users from various backgrounds whether health professionals, policy-makers, or the general public can access critical information about healthcare facilities quickly and efficiently.

3.6. Discussion

The development and implementation of a web-based GIS for enhancing clinic accessibility in Indonesia mark a significant contribution toward addressing spatial disparities in primary healthcare access. This study, driven by the Agile Extreme Programming (XP) approach, demonstrated that iterative, user-focused development can yield highly usable and scalable solutions in the field of health informatics.

The analysis phase laid a strong foundation for the system by focusing on essential data parameters, such as clinic names, geographic coordinates, and contact details. By employing QGIS a reliable, open-source platform—the research effectively transformed raw health facility data into spatially relevant datasets. This phase was crucial in identifying the technical scope and infrastructure needed to build a responsive and accessible GIS platform.

During the planning and design stages, the use of Unified Modeling Language (UML) tools, such as use case and activity diagrams, facilitated a clear blueprint for user interactions and system flow. The implementation of a non-linear navigation structure ensured a seamless browsing experience, allowing users to access service categories, interact with maps, and explore clinic-specific data without confusion. The structured database design (klinik_indo) further ensured that both spatial and non-spatial data were tightly integrated, which enhanced information retrieval and display accuracy.

The system development process leveraged key plugins like qgis2web and QuickMapServer, which played a pivotal role in exporting the QGIS project into a browser-compatible format. This allowed for real-time web deployment, fulfilling one of the cores aims of the research—to create a widely accessible and platform-independent GIS tool. The hosted site enabled users to locate clinics interactively, zoom into regions of interest, and retrieve essential service information, fulfilling both functional and practical requirements.

Perhaps the most telling evidence of the system's success came from the usability testing phase. With a cumulative score of 88.76%, the GIS website was categorized as "Very Worthy" according to the predetermined criteria. Effectiveness (91%)

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indicated that the system was successful in guiding users to their desired outcomes, while efficiency (90%) reflected well-planned user interface and interaction logic. Satisfaction (85%) demonstrated that the system met or exceeded user expectations, particularly in terms of visual design and content completeness. These results validate the system's applicability in real-world settings, especially among users with varying levels of technical experience.

The implementation phase further confirmed the system's operational viability. From deployment to user interaction, the platform maintained a high level of interactivity, stability, and responsiveness. Figures illustrating the homepage and search results interface show how users can easily interact with clinic markers, obtain detailed information, and navigate the system with minimal learning curve. This aligns directly with the research objective of improving public access to healthcare facility data through geospatial technology.

In comparison to prior studies that utilized GIS for purposes such as cultural heritage management, literacy distribution, or agriculture scheduling, this project fills a distinct gap in the public health domain, especially for developing nations like Indonesia. Moreover, by embracing the Agile XP method, this study addressed common pitfalls in software development—such as delayed user feedback or rigid design phases—by allowing continuous improvements throughout the lifecycle.

In conclusion, the results clearly show that deploying a Web GIS using Agile principles not only enhances clinic accessibility but also provides a replicable model for other health-related geospatial initiatives. The successful implementation in eight Indonesian cities demonstrates the system's scalability, and with further data integration, it holds the potential to serve broader national and regional healthcare planning efforts.

4. CONCLUSION

This study successfully demonstrated the design, development, and deployment of a web-based Geographic Information System (GIS) aimed at enhancing clinic accessibility in Indonesia. By leveraging the Agile Extreme Programming (XP) model and the open-source QGIS platform, the research produced a functional, scalable, and user-friendly digital health solution. From data analysis and system design to development and implementation, each phase was strategically aligned with the overarching goal of improving public access to healthcare services through spatial technology.

The project responded to a critical gap in health infrastructure visibility—particularly the spatial distribution of clinics—by creating an interactive web platform that visualizes real-time clinic data across eight major Indonesian cities.

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The system allowed users to easily locate clinics, retrieve essential information, and explore geographic patterns in health facility distribution. The use of UML for planning, structured database integration, and intuitive navigation design contributed significantly to system usability and effectiveness. The results from usability testing validated the system's success, with an overall usability score of 88.76%, classifying it as "Very Worthy" for real-world application. High scores in effectiveness, efficiency, and satisfaction revealed that users found the system practical, visually appealing, and easy to use—critical factors for digital tools in the public health domain.

Ultimately, this GIS platform not only supports healthcare planning and decision-making but also promotes digital equity by making health facility information accessible to a broad audience. The success of this project opens up pathways for future enhancements, including nationwide scaling, integration with mobile platforms, and the incorporation of live health service data. By aligning modern development practices with pressing public health needs, this study contributes to Indonesia's broader digital transformation goals and sets a foundation for future GIS-based health initiatives.

ACKNOWLEDGEMENTS

This research is funded by the 2024 Fundamental Research Grant from the Ministry of Education, Culture, Research, and Technology, Indonesia, to Gunadarma University No. in 2024.

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