JURNAL UPI

Journal of Software Engineering, Information and Communication Technology (SEICT)

Journal homepage: https://ejournal.upi.edu/index.php/SEICT

SEICT

Geographic Information System (GIS) Based Android Application for Mapping Geothermal Potential Areas

Ramaditya Firdaus[1], Thoriqul Kirom[2], Cindy Rafika Duri[3], Diwa Prasetyo[4], Muhammad Athif Fadhlurrohman[5]*

Kampus Daerah Cibiru, Universitas Pendidikan Indonesia, Indonesia

Correspondence: E-mail: ramadityafirdaus@upi.edu

ABSTRACT

Indonesia's dependency on fossil energy to meet domestic energy needs remains relatively high. This dependency is vulnerable to supply shortages as fossil fuels are non-renewable and can be depleted. As a result, fossil energy is depleting, leading to electricity energy crises like the current one. Indonesia's coal reserves are predicted to be depleted within the next 20 years. Optimizing the potential of renewable alternative energy, such as geothermal energy, can fulfill the increasing electricity demand. Indonesia possesses the world's largest geothermal reserves, approximately 40%. Geothermal energy utilization is highly efficient, economical, environmentally friendly, and relatively consistent compared to fossil energy. However, its current utilization is still less than 5%. The limited utilization of geothermal energy is attributed to the management mechanisms of geothermal areas, where construction progress in several locations has been hindered. Therefore, a Geographic Information System (GIS) is needed for mapping the areas with geothermal potential as fuel for geothermal power plants (PLTP). This research generally consists of three phases: (1) data collection, (2) designing a prototype based on an application developed using Android Studio, and (3) conducting application testing using the black box method. The research aims to identify the potential of developed and undeveloped geothermal areas. It is expected to assist and facilitate the government or energy managers in managing geothermal energy resources as fuel for Geothermal Power Plants (PLTP) to meet the electricity needs of the community.

ARTICLE INFO

Article History:
Submitted/Received 10 Nov 2022
First Revised 20 Nov 2022
Accepted 25 Nov 2022
First Available online 28 Nov 2022
Publication Date 01 Dec 2022

Keyword:
Electricity,
Geothermal,
GIS,
PLTP,
Technology.

1. INTRODUCTION

Electricity resources have become a necessity in driving the national economy (Fadika et al., 2014). Household and industrial activities heavily rely on electricity supply for their daily operations. The availability of electricity resources is crucial for supporting national economic growth. However, Indonesia's electricity availability is still significantly lower compared to most ASEAN countries. To meet the national energy needs, electricity supply in Indonesia is managed by PT. Perusahaan Listrik Negara (PLN) Persero, as well as other entities such as private companies, cooperatives, and regional government-owned enterprises (Yanto, 2019). Private companies, cooperatives, and regional government-owned enterprises have undertaken efforts to provide electricity by constructing and operating their own power plants, selling the electricity to PT PLN (Persero), commonly known as independent power producers (IPP) (Yunita, 2021). They independently build, operate, and integrate power generation, transmission, and distribution systems, selling electricity directly to consumers in specific business areas known as integrated power plants or private power utilities (PPU).

In 2010, the installed capacity of national power plants was 30,941 MW, distributed across Sumatra (4,948 MW), Java-Madura-Bali (23,009 MW), Kalimantan (1,175 MW), Sulawesi (1,195 MW), Nusa Tenggara (265 MW), Maluku (182 MW), and Papua (168 MW). Approximately 83% of the total installed capacity, equivalent to 25,752 MW, is operated by PT PLN (Persero), while 14% or 4,269 MW is operated by private power companies (IPP), and 3% or 920 MW is operated by integrated power plant companies (PPU). PT PLN predicts that Indonesia will require an additional electricity supply of 38,000 MW in the future, increasing the total capacity from around 30,000 MW in 2010 to 68,000 MW. Indonesia also aims to achieve an electrification ratio of 80% to support a 7.7% economic growth in 2014. Thus, the government plans mega power plant projects in phase III with a capacity of 15,000 MW. However, according to Minister of Economy Hatta Rajasa, the 10,000 MW power plant projects in phases I and II in 2010 were not sufficient to meet the electricity needs for driving the national economy. As economic growth continues, the demand for electricity resources will keep increasing (Sugiarso et al., 2019). The construction of 2x10,000 MW power plants, along with an additional 15,000 MW, will boost the electrification ratio to 80%. To succeed in these power plant projects, diversification of energy sources is necessary. PT PLN (Persero) aims to achieve a 100% electrification ratio by 2020.

The exploitation of fossil energy resources has been a cause of energy crises due to the depletion of natural resources (Agung et al., 2018). This poses risks to sustainable development and the unmet domestic energy needs of a population that continues to grow each year. It is crucial to find appropriate solutions to address domestic energy needs while promoting more balanced and equitable prosperity (Hamidi, 2012). Indonesia's dependency on fossil energy to meet domestic energy needs remains relatively high, with fossil energy contributing 94.3% of the total national energy consumption of 1,357 million barrels of oil equivalent (BOE), while renewable energy accounts for only 5.7% (Kusumayudha, 2022). Based on the data, petroleum contributes 49.7%, natural gas contributes 20.1%, and coal contributes 24.5%. Optimizing the potential of renewable energy, such as geothermal energy, can fulfill the increasing electricity demand in line with economic growth (AW et al., 2022).

Geothermal energy is a highly promising alternative energy resource. Indonesia has the world's largest geothermal reserves, estimated at around 40% (Marry et al., 2017). Geothermal energy is highly efficient, cost-effective, and environmentally friendly compared to fossil fuels. The potential for geothermal power generation in Indonesia is estimated to be

DOI: https://doi.org/10.17509/seict.v3i2.46899
p- ISSN 2774-1656 e- ISSN 2774-1699

around 29 gigawatts, nearly equivalent to the country's current total electricity supply. Geothermal energy development for power generation in Indonesia began in 2010 with a capacity of 1,189 MW (4.3%), according to the Geological Agency. Geothermal energy can contribute to energy self-sufficiency in remote villages, protect rural communities from high oil prices, and facilitate economic opportunities in alternative sectors like food production (Sukendar et al., 2016). Geothermal energy plays an increasingly important role in global energy supply. It offers several advantages compared to other energy sources, including traditional fossil fuels (Meilani and Wuryandani, 2010). Geothermal energy can provide a relatively constant energy supply independent of weather or seasonal considerations.

However, the utilization of geothermal energy in Indonesia is still relatively small, accounting for less than 5%. According to the Geological Agency (2010), geothermal energy for power generation in Indonesia has only reached 1,189 MW (4.3%). The limited utilization of geothermal energy is attributed to several factors, including challenges in managing geothermal areas and delays or stagnation in the development of certain locations (Sasmito, 2017). Therefore, it is necessary to establish a geothermal resource mapping system to identify potential geothermal areas for the development of geothermal power plants (PLTP) (Basid et al., 2014). With the rapid development of technology worldwide, Indonesia has entered the era of the fourth industrial revolution, which emphasizes automation in various fields, including environmental aspects. The current development of Information and Communication Technology is progressing rapidly, allowing the world to connect through computer networks, enabling interactions and information exchange (Ardimansyah et al., 2020). In this era, people are eager to stay updated and follow technological advancements, including various innovations in android-based application development and other fields.

The creation of an application for inventorying geothermal resources aims to identify potential geothermal areas across an island, indicating areas that have been developed and those that remain undeveloped (Budiyanto et al., 2012) . While geothermal energy will be highly beneficial in the future, not all regions have the potential to be utilized as geothermal energy sources. Certain geological characteristics and conditions are required for geothermal energy. This energy is typically found in high-pressure, thin-crusted zones or along fault lines in areas with many volcanic mountains, such as the Pacific Ring of Fire, which is widespread throughout Indonesia from Sumatra to Papua (Handayani and Singarimbun, 2016). Mapping geothermal resources will aid the government or energy managers in effectively managing geothermal energy as a fuel source for geothermal power plants (PLTP) to meet the energy needs of the population (Utomo et al., 2017). The application will provide information about potential PLTP locations, utilizing a geographical information system based on an Android application with visualization using the Google Maps API, enabling the embedding of maps in websites or applications with Google Maps, thereby allowing users to view the panorama (Sutejo, 2016). Furthermore, with the assistance of Google Earth, satellite image mapping with higher resolution can be incorporated (Leman and Akbar, 2018).

2. METHODS

The Geographic Information System (GIS) based Android application prototype serves as a mapping tool to identify areas with geothermal potential (Santoso and Rais, 2015). In general, the design of this prototype includes three components: data collection, application prototype design, and application testing.

DOI: https://doi.org/10.17509/seict.v3i2.46899
p- ISSN 2774-1656 e- ISSN 2774-1699

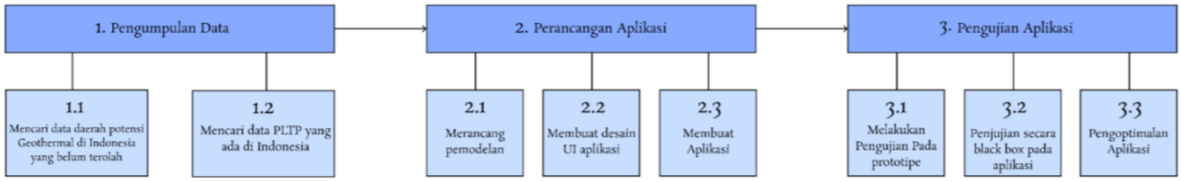

Figure 1 Prototype Design Flow

2.1 Data Collecting

In this phase, data collection is conducted for regions in Indonesia that have geothermal potential. The data is sourced from various websites on the internet, and the obtained data is divided into two categories: areas that have been developed and areas that have not been developed. Developed areas are identified by the presence of Geothermal Power Plants (GPP) in those regions.

2.2 Designing Application

The Geographic Information System (GIS) based application is developed using Android Studio, which is an Integrated Development Environment (IDE) for building Android applications based on IntelliJ IDEA. Besides being a free software, Android Studio offers numerous features that enhance productivity in creating Android applications, such as the flexible Gradle-based build system, comprehensive framework, emulator, integration with GitHub, and the ability to apply changes or builds without restarting the application.

2.3 Application Testing

The application testing is conducted using the black box method. This testing method focuses solely on the functionality aspect, particularly the input and output of the application, without inspecting the source code of the program. The testing is concentrated on the functionality of the elements within the interface for each available feature to ensure smooth operation without any bugs in the program.

3. RESULTS AND ANALYSIS

This section explains the use of writing rules, mathematical equations, the use of tables and figures.

3.1. Distribution of Geothermal Potential Areas and Geothermal Power Plants in Indonesia

Based on the information available on the internet, data has been successfully collected for 51 regions with geothermal potential and 20 operational Geothermal Power Plants (GPP) across Indonesia.

Table 1. Potential Regional Data Geothermal dan GPP

No	Region	Potential Regions	GPP Amount
1	Sumatra	12	7

DOI: https://doi.org/10.17509/seict.v3i2.46899
p- ISSN 2774-1656 e- ISSN 2774-1699

2	Java dan Bali	18	7
3	Borneo	1	0
4	Sulawesi	10	3
5	Nusa Tenggara	5	3
6	Papua and Maluku	5	0

3.2. Prototype Designing

The prototype created is a Geographical Information System (GIS) based on an Android application that maps areas with geothermal potential (Thereza et al., 2021). By using the Google Maps API, the provided information can be more accurate. In Figure 2, different colors are used to differentiate areas with geothermal potential. The Google Maps API application not only provides information about the locations with geothermal potential but also offers various view modes, allowing users to observe the geographical conditions or find routes to specific destinations.

DOI: https://doi.org/10.17509/seict.v3i2.46899
p- ISSN 2774-1656 e- ISSN 2774-1699

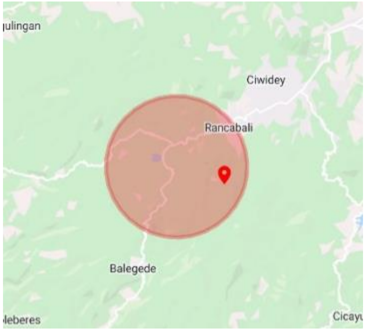

Figure 2 Normal Mode

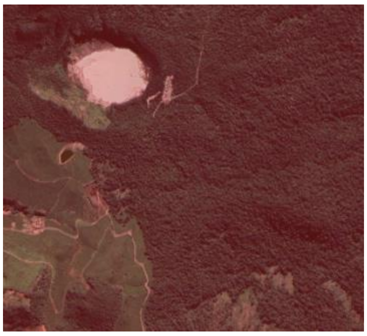

Figure 3 Satellite Mode

Figure 4 Hybrid Mode

Figure 5 Main Menu

Figure 6 Dashboard

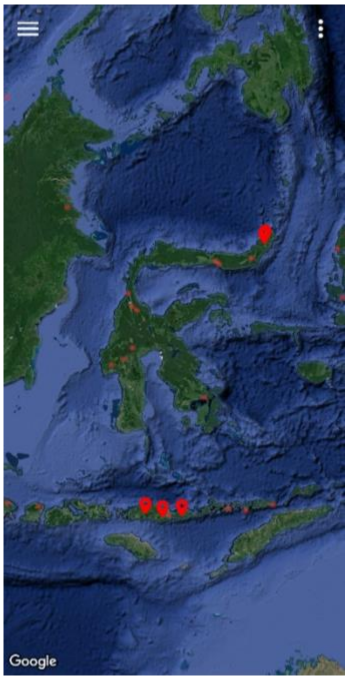

Figure 7 Mapping

For more efficient usage, there are several features available to assist users in using the application. In Figure 5, there is a main menu that serves as the initial display when users access the application. Additionally, there is a Dashboard menu that serves as the information center. All information regarding areas with geothermal potential is available in this menu. When clicked, the application will directly navigate users to the selected location within the mapping feature. Furthermore, the Dashboard is equipped with a feature to filter specific areas only.

DOI: https://doi.org/10.17509/seict.v3i2.46899
p- ISSN 2774-1656 e- ISSN 2774-1699

Figure 8 About Application

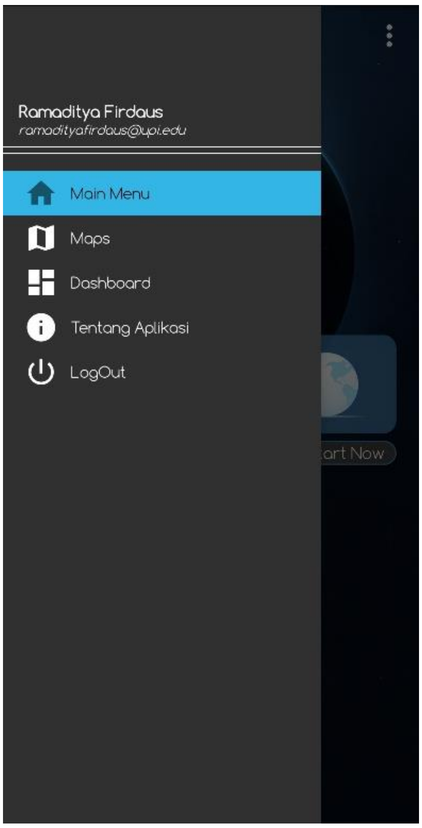

Figure 9 Navigation Drawer

DOI: https://doi.org/10.17509/seict.v3i2.46899
p- ISSN 2774-1656 e- ISSN 2774-1699

Information about the application or the administrator can be accessed through the "About the Application" menu in Figure 8. The layout shown in Figure 9 is present in all menus and features. The Navigation Drawer serves as a navigation menu that wraps and connects all the content or features within the application's activities or fragments.

3.3. Application Prototype Testing

Testing is performed by directly installing the application prototype on mobile devices. To obtain more accurate results, testing is conducted using three different mobile devices. All three devices run all the functions and features available. The results of the testing are described in the table below:

Table 2. Interface Testing Using Black Box Method

No	Case	Expected Result	Result
Main Menu			
1	Navigation Drawer Symbol	Display navigation from left side of the screen	As Expected
2	Swiping screen from left side	Display navigation from left side of the screen	As Expected
3	More Symbol	Display pop up from right side of the screen	As Expected
4	Start Now Button	Redirect user to main mapping feature	As Expected
5	Dashboard Button and Symbol	Redirecting user to Dashboard	As Expected
6	About Us Button and Symbol	Redirecting user to About Us	As Expected
Navigation Drawer			
7	Menu Button and Symbol	Redirecting user to selected Menu	As Expected
8	LogOut Button and Symbol	Display Logout Notification	As Expected
More Display On Main Menu			

DOI: https://doi.org/10.17509/seict.v3i2.46899
p- ISSN 2774-1656 e- ISSN 2774-1699

9	Rating Button	Displays a notification to the user to open another application to give a Rating	As Expected
10	Suggestion and Feedback Button	Redirect user to open Gmail application	As Expected
Logout Notification			
11	Yes Button	Close Application	As Expected
12	No Button	Close Logout notification and application still running	As Expected
Main Mapping Feature (Maps)			
13	Screen Zoom	Enlarge and minimize display and distance on Maps	As Expected
14	Marker Symbol	Display name, GPP latitude and longitude coordinat	As Expected
15	More Symbol	Display popup option to open Maps Settings, Potential List and Dashboard	As Expected
16	Google Maps Symbol	Redirect user to Google Maps	As Expected
17	GPP Symbol	Display GPP general information	Not As Expected
Settings			
18	Normal View Button	Change the map view to normal mode	As Expected
19	Normal View Button	Change the map view to satellite mode	As Expected
20	Hybrid View Button	Change the map view to hybrid mode	As Expected

DOI: https://doi.org/10.17509/seict.v3i2.46899
p- ISSN 2774-1656 e- ISSN 2774-1699

21	Terrain View Button	Change the map view to terrain mode	As Expected
Dashboard			
22	Geothermal List and Button	Redirect user on the region indicated in the mapping feature	As Expected
23	Semua Button	Display all Geothermal potential area lists	As Expected
24	Filter Button	Filter Geothermal potential areas according to the selected region	As Expected

Based on the testing results table above, the performance and functionality of the application are running well with a 96% success rate of the available functions. The functional errors are caused by program code that is not entirely suitable, but these errors do not result in errors or bugs in other functions.

DOI: https://doi.org/10.17509/seict.v3i2.46899
p- ISSN 2774-1656 e- ISSN 2774-1699

4. CONCLUSION

The prototype of the Android-based Geographic Information System (GIS) application serves as a means to store and convey information about the characteristics of a particular area. Based on the testing results, which showed a 96% performance and functional success rate, it can be concluded that the application has a good quality. With the availability of additional features and various mapping modes, it is evident that the application offers a comprehensive set of functionalities. For future development or research, it is recommended to consider adding more features and expanding the mapping capabilities to include information beyond geothermal potential areas.

5. AUTHOR'S NOTE

The authors declare that there are no conflicts of interest associated with the publication of this article. The authors also ensure that this paper is free from plagiarism.

6. REFERENCES

Agung, B. H., Faizal, A., Anggi, A., Bahri, A. S., and Utama, W. (2017). Aplikasi citra satelit landsat 8 untuk identifikasi daerah prospek panas bumi daerah songgoriti batu dan sekitarnya. *Jurnal Geosaintek, 3*(3), 149-154.

Ardimansyah, M. I., Hendriyana, H., and Muhammad, R. (2020). Rancang bangun prototipe klasifikasi sampah otomatis dengan sensor proximity dan linear rail slider box berbasis mikrokontroler arduino di lingkungan upi kampus cibiru. *Journal of Software Engineering, Information and Communication Technology (SEICT), 1*(1), 23-28.

AW, P. C., Zarkasyi, A., and Haerudin, N. (2022). Pemisahan menggunakan polynomial fitting dan analisis second vertical derivative (svd) untuk mengidentifikasi patahan pada lapangan panasbumi pulau pantar, kabupaten alor. *Jurnal Geologi dan Sumberdaya Mineral, 23*(2), 91-96.

Basid, A., Andrini, N., and Arfiyaningsih, S. (2014). Pendugaan reservoir sistem panas bumi dengan menggunakan survey geolistrik, resistivitas dan self potensial (studi kasus: daerah manifestasi panas bumi di desa lombang, kecamatan batang-batang, sumenep). *Jurnal Neutrino: Jurnal Fisika dan Aplikasinya, 7*(1), 57-70.

Budiyanto, M. N., Santosa, P. I., and Sumaryono, S. (2012). Purwarupa sistem peringatan dini awan panas gunungapi berbasis sistem informasi geografis (kasus gunung merapi di perbatasan jawa tengah dan daerah istimewa yogyakarta). *Jurnal Nasional Teknik Elektro dan Teknologi Informasi, 1*(1), 24-30.

Fadika, U., Rifai, A., and Rochaddi, B. (2014). Arah dan kecepatan angin musiman serta kaitannya dengan sebaran suhu permukaan laut di selatan pangandaran jawa barat. *Journal of Oceanography, 3*(3), 429-437.

Hamidi, H. (2012). Aplikasi sistem informasi geografis berbasis web penyebaran dana bantuan operasional sekolah. *Jurnal Masyarakat Informatika, 2*(3), 1-14.

Handayani, L., and Singarimbun, A. (2016). Pemetaan daerah rawan longsor di sekitar daerah prospek panas bumi provinsi jawa barat. *Journal Online of Physics, 2*(1), 17-22.

DOI: https://doi.org/10.17509/seict.v3i2.46899
p- ISSN 2774-1656 e- ISSN 2774-1699

Kusumayudha, S. B. (2022). Pengaruh litologi dan struktur geologi terhadap air tanah di daerah wediombo, kecamatan girisubo, kabupaten gunungkidul, provinsi daerah istimewa yogyakarta. *Jurnal Sumberdaya Bumi Berkelanjutan (SEMITAN), 1*(1), 13-24.

Leman, D., and Akbar, M. B. (2018). Sistem informasi geografis (gis) untuk penanggulangan kecelakaan berbasis android. *IT (INFORMATIC TECHNIQUE) JOURNAL, 6*(2), 217-225.

Marry, R. T., Armawi, A., Hadna, A. H., and Pitoyo, A. J. (2017). Panas bumi harta karun yang terpendam menuju ketahanan energi. *Jurnal Ketahanan Nasional, 23*(2), 217-237.

Meilani, H., and Wuryandani, D. (2010). Potensi panas bumi sebagai energi alternatif pengganti bahan bakar fosil untuk pembangkit tenaga listrik di Indonesia. *Jurnal Ekonomi and Kebijakan Publik, 1*(1), 47-74.

Santoso, K. I., and Rais, M. N. (2015). Implementasi sistem informasi geografis daerah pariwisata kabupaten temanggung berbasis android dengan global positioning system (gps). *Scientific Journal of Informatics, 2*(1), 29-40.

Sasmito, G. W. (2017). Penerapan metode Waterfall pada desain sistem informasi geografis industri kabupaten tegal. *Jurnal Informatika: Jurnal Pengembangan IT, 2*(1), 6-12.

Sugiarso, B. A., Lumenta, A. S., Narasiang, B. S., and Rumagit, A. M. (2019). Aplikasi sensor polusi udara. *Jurnal Teknik Elektro dan Komputer, 8*(3), 193-200.

Sukendar, P. M., Sasmito, B., and Wijaya, A. P. (2016). Analisis sebaran kawasan potensial panas bumi gunung salak dengan suhu permukaan, indeks vegetasi dan geomorfologi. *Jurnal Geodesi Undip, 5*(2), 66-75.

Sutejo, S. (2016). Pemodelan UML sistem informasi geografis pasar tradisional kota pekanbaru. *Digital Zone: Jurnal Teknologi Informasi dan Komunikasi, 7*(2), 89-99.

Thereza, N., Saputra, I. P. A., and Husin, Z. (2021). Rancang bangun geographic information system (GIS) sebagai pengembangan sistem monitoring area perkebunan berbasis IoT. *Jurnal Tekno Kompak, 15*(1), 40-54.

Utomo, T. A., Yuwono, B. D., and Amarrohman, F. J. (2017). Aplikasi sistem informasi geografis berbasis web dan android untuk pemilihan jalur alternatif menuju tempat pariwisata (studi kasus: kota wisata cibubur dan jungleland, kabupaten bogor). *Jurnal Geodesi Undip, 6*(2), 1-11.

Yanto, M. (2019). Sistem informasi geografis lokasi perkebunan disepanjang garis pantai pesisir selatan berbasis android. *Jurnal Ilmiah Media Sisfo, 13*(1), 28-37.

Yunita, H. D. (2021). Sistem informasi geografis (SIG) untuk identifikasi letak tower telekomunikasi operator seluler di bandar lampung. *Jurnal Cendikia, 21*(1), 513-522.

DOI: https://doi.org/10.17509/seict.v3i2.46899
p- ISSN 2774-1656 e- ISSN 2774-1699