I. J. Education and Management Engineering, **2025, 6, 53-62**
Published Online on December 8, 2025 by MECS Press (http://www.mecs-press.org/)
DOI: 10.5815/ijeme.2025.06.05

Cocoa Land Mapping Based on Geographic Information System in East Kalimantan Using Leaflet JS and GeoJSON

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Received: 12 March, 2025; Revised: 15 May, 2025; Accepted: 28 June, 2025; Published: 08 December, 2025

Abstract: East Kalimantan Province holds significant potential in developing cocoa commodities, a key sector in regional plantation development. However, there is a lack of an effective, web-based information system to visualize and manage data related to cocoa land distribution. This limitation hampers access for both the public and policymakers. To address this issue, a web-based Geographic Information System (GIS) application was developed using Leaflet JS and GeoJSON. This application aims to provide an interactive map that can display the location of cocoa plantations in the distribution of East Kalimantan Province, especially in Kutai Kartanegara, East Kutai, West Kutai, Mahakam Ulu, Penajam Paser Utara, Paser, Berau, Samarinda, Balikpapan, and Bontang, as well as providing information about the land area and cocoa production. Spatial data and cocoa production data are integrated into this application so that users, including farmers, entrepreneurs, and governments, can obtain comprehensive information about cocoa commodities in the East Kalimantan Province. By visualizing cocoa land distribution, the GIS tool is expected to support informed policymaking aimed at improving productivity and land use efficiency. It also serves to raise public awareness of cocoa potential in local communities.

Index Terms: Cocoa Mapping, Agricultural Commodities, Geographic Information System, Leaflet JS, GeoJSON

1. Introduction

Indonesia ranks as the world's third-largest cocoa producer and exporter, following Ghana and Ivory Coast. Cocoa (*Theobroma cacao* L.) is a vital plantation commodity contributing significantly to national foreign exchange earnings, alongside oil and natural gas. In 2020, the country recorded a cocoa plantation area of 1.51 million hectares and a cocoa bean output of approximately 720.66 thousand tons, marking a 1.92% increase from the previous year[1-4]. However, a major challenge in cocoa development lies in the inappropriate selection of plantation sites—often without proper consideration of soil quality and climatic conditions—resulting in suboptimal productivity and limited expansion potential.

East Kalimantan stands out as a significant cocoa-producing province, with approximately 6,833 hectares of plantations, 2,537 tons of dry bean production, and an average productivity of 611 kg/ha, supported by 3,672 registered cocoa farmers as of 2020. Among its regencies, East Kutai is notable for its high cocoa output.

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East Kutai Regency has a cocoa producer located in Busang District in the Pandan Bay area which has a land area of about 4,818 ha. Determined by East Kutai as one of the regencies in the East Kalimantan Province as a cocoa producer due to the total production of 1,410 tons with a productivity of 593 kg/ha [5-7].

Technological innovations are increasingly integrated into the plantation sector. One such advancement is the Geographic Information System (GIS), which enables the processing, storage, visualization, and analysis of geographic data related to land use and surface features [8-10]. According to Adiansyah and Kardono (2017), GIS has components covering hardware, software, data, applications, and humans [11-14].

Currently, the existing web-based cocoa information systems in East Kalimantan are inadequate in delivering accessible, accurate, and interactive content. To address this gap, the authors developed a GIS platform using Leaflet JS for dynamic mapping. This application can display geographically referenced information, one of which is location-based information. Leaflet is a javascript library (JS) designed to create interactive maps for websites [15-17]. GeoJSON is a data format that can accommodate geographical elements based on JSON (Javascript Object Notation) and compatible with many programming models on maps [18-20].

Through the integration of spatial data and cocoa result attribute data, this GIS web application can show the mapping of cocoa land in the East Kalimantan Province to facilitate the visualisation of areas that can be the centre of superior commodities that can be used to design policies to increase cocoa yield or productivity. People in East Kalimantan Province are easier to access cocoa production information thanks to web-based GIS.

Based on the above explanation, this research created a Web-based Geographic Information System (GIS) to map cocoa fields in the East Kalimantan Province. This GIS can be used to help and increase awareness of information given to the local community. It is hoped that the public who need information about the mapping of cocoa land in the East Kalimantan Province can easily access it directly. With this system, the platform aims to facilitate direct public access to mapping data, empowering communities to monitor and evaluate cocoa commodity developments. Furthermore, it serves as a strategic tool for decision-makers, particularly within the East Kalimantan Plantation Office, to guide planning and development initiatives.

2. Research Methodology

This study employed two primary methods: data collection and the Rapid Application Development (RAD) model. RAD is a linear software development framework that prioritizes a short development cycle, making it especially suitable for web-based applications [21-25]. The RAD model includes four structured phases: requirements planning, user design, construction, and cutover—each phase interlinked to ensure iterative and fast-paced development. The data diagram, as shown in Fig. 1, represents the system's data flow and highlights the interaction between the admin, users, and the GIS system for cocoa land mapping.

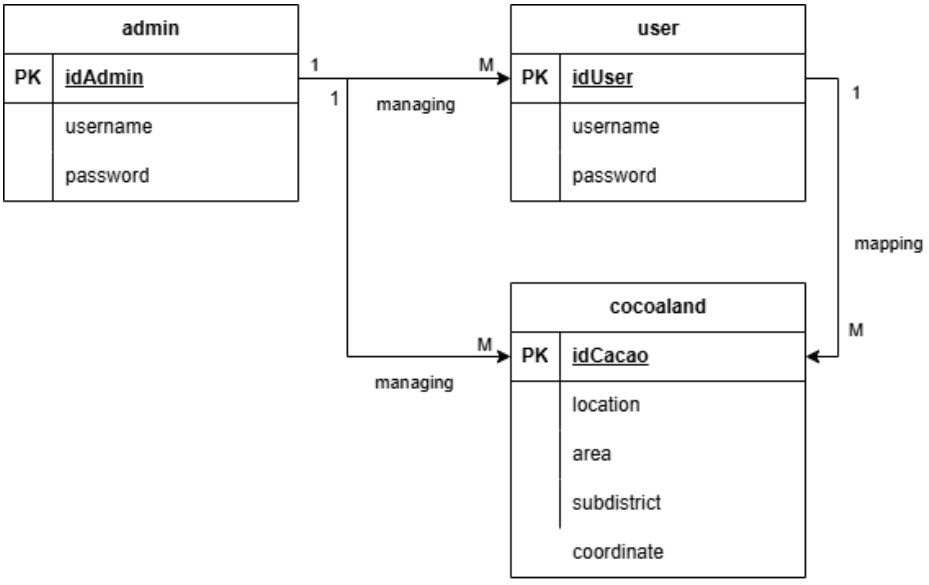

Fig. 1. Data Diagram

Figure 2 presents the Level 0 Data Flow Diagram (DFD), which provides a high-level overview of the system. It highlights the two main actors: Admin and User. Admins are responsible for data entry and management, while users primarily view cocoa land data. This diagram simplifies the internal data interactions of the application.

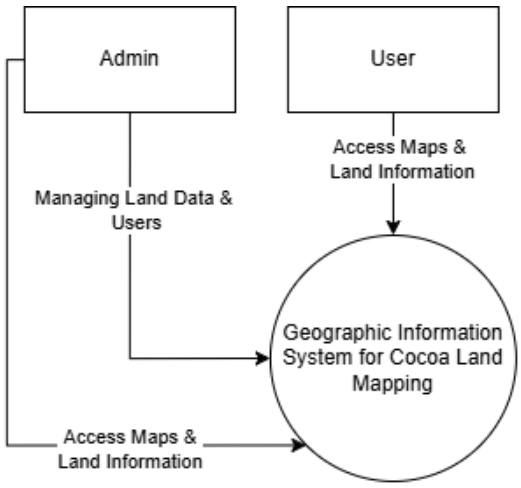

Fig. 2. Data Flow Diagram Level 0

A more detailed representation is shown in Fig. 3, the Level 1 DFD. It breaks the system into two key subsystems: cocoa data management and user account management. Admins have full control over both, while users can only access cocoa-related data. Each function is supported by specific databases to ensure proper data organization.

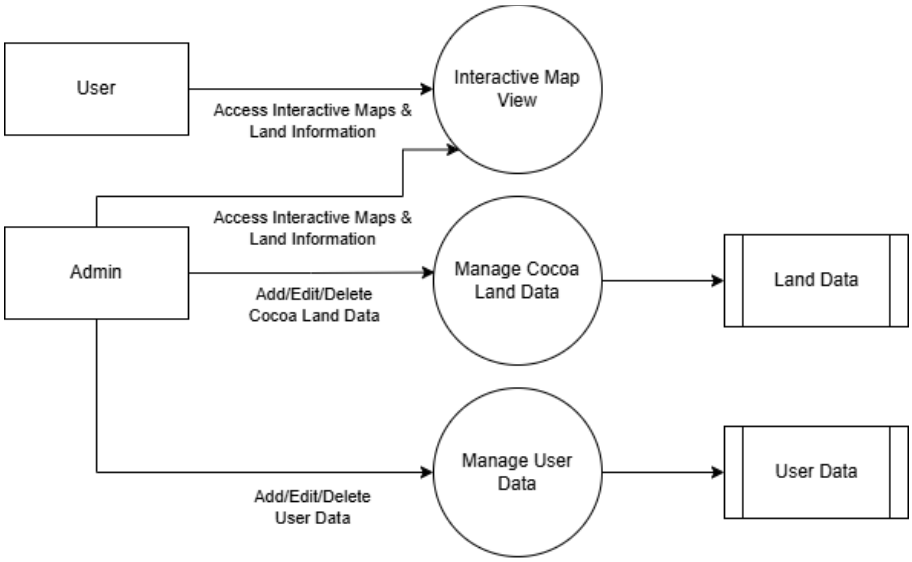

Fig. 3. Data Flow Diagram Level 1

The flowchart in Fig. 4 outlines the sequential operation of the GIS application. It starts with the login stage, where user roles (Admin or User) are verified. Admins can add, edit, and delete data, whereas users are restricted to viewing cocoa land maps. This flowchart provides a clear, step-by-step understanding of the system's logic.

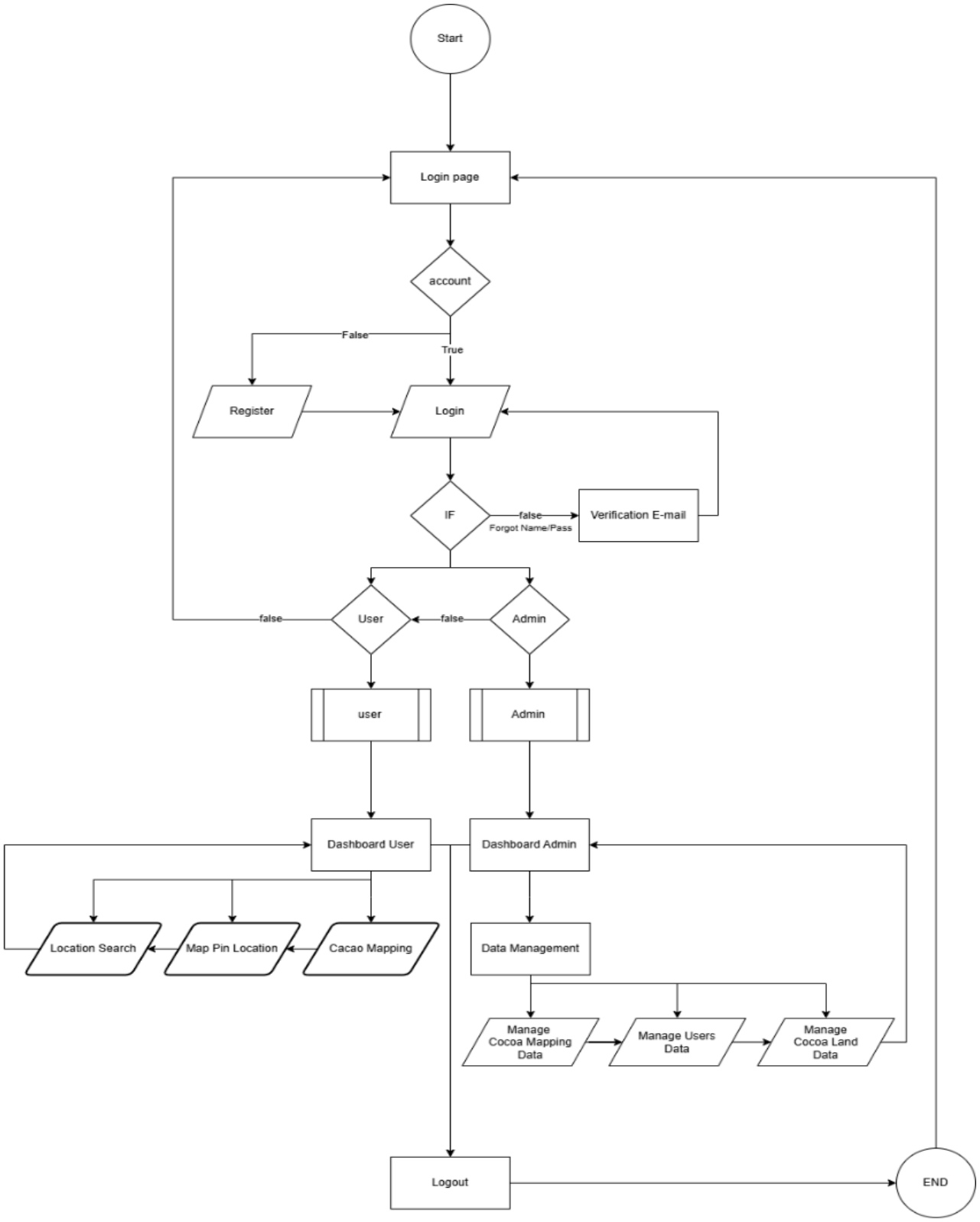

Fig. 4. Flowchart

2.1 Data Collection

Data for this research was collected using a non-participant observation method, wherein the researcher remains an external observer and does not intervene in the observed activities. The data collection process included the following steps:

1. Literature

A comprehensive review of academic journals, books, and prior studies was conducted to understand existing approaches to Geographic Information Systems and cocoa commodity management.

2. Observation

Primary data, including cocoa field coordinates and land-use documentation, was obtained through non-intrusive observation at the Sungai Langka village office.

2.2 Needs Plan

System requirements were identified by gathering relevant information and statistics from the official website of the East Kalimantan Provincial Plantation Office.

2.3 System Design Process

The system design phase involved analyzing user requirements and translating them into programming logic to create a functional prototype that was then visually presented to users.

2.4 Development

During the development phase, the system design was implemented into functional code using PHP, Leaflet JS, GeoJSON, and the CodeIgniter framework to build a responsive and dynamic web-based GIS application.

2.5 Testing

System testing was conducted using the black-box testing method to validate whether functional inputs and outputs behaved as expected [26-30]. This ensured the application met the functional specifications outlined during the needs assessment phase.

2.6 Reporting

In the final stage, the research findings were compiled, including problem identification, testing results, and conclusions, and presented in a structured research report.

3. Results and Discussion

This study successfully developed a web-based Geographic Information System (GIS) application for mapping cocoa plantations in East Kalimantan, with implementation focused on Sungai Langka Village in Pesawaran Regency. The system utilizes Leaflet JS and GeoJSON for interactive spatial representation. The application integrates Leaflet JS to render interactive maps that visualize both spatial and non-spatial data related to cocoa cultivation areas. GeoJSON is employed to encode geographic features, enabling seamless integration of location data within the web mapping interface. This ensures accurate and structured cocoa land representation on the map. The following steps outline the process of developing the web-based GIS application.

1. Importing Leaflet CSS and JavaScript libraries
2. Displaying base maps using OpenStreetMap tiles integrated via Mapbox
3. Loading and displaying GeoJSON files on the map using the Leaflet-Ajax plugin

3.1 Research Results

The developed GIS application enhances public accessibility to cocoa plantation data, facilitating location identification, monitoring, and evaluation of cocoa production across East Kalimantan. The application supports multiple access levels—admin and general user—with different privileges. The main page includes two primary menus: “Home” (which presents the main map interface) and “Info” (which provides background information about the system). While the info menu contains a brief explanation of the application. As illustrated in Fig. 5, the home page serves as the central user interface, displaying an interactive map with clickable markers. Each marker reveals specific data about cocoa land area and its related sub-district.

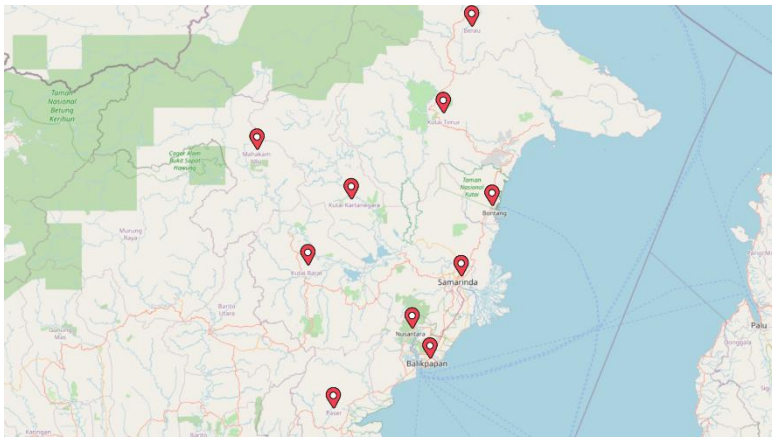

Fig. 5. Home Page Display

Users can interact with the map by clicking markers to display detailed pop-up information, including sub-district names and cocoa land areas, as shown in Fig. 6. This feature enhances user experience by delivering contextual data directly through the map interface.

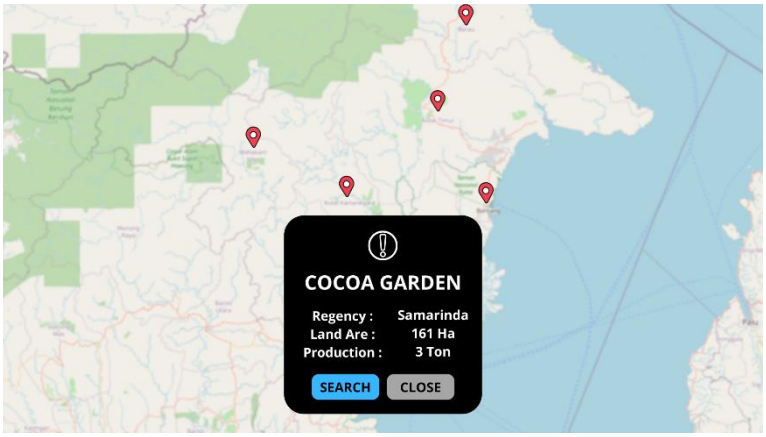

Fig. 6. Popup Info Page Display

Access to the system dashboard is granted via a login page, where users (either admin or general users) must authenticate using registered credentials. Fig. 7 displays this interface, which ensures secure system access control. This mechanism verifies user roles and grants corresponding permissions, with admins having data management access and users limited to viewing cocoa land information.

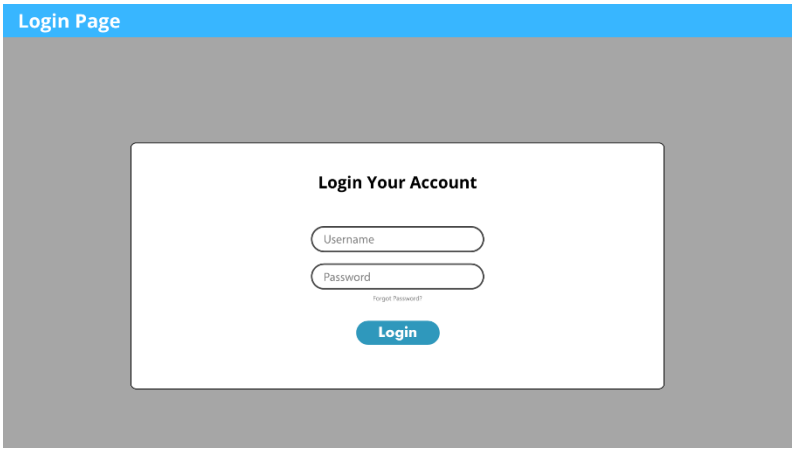

Fig. 7. Login Page Display

Upon successful login, administrators are directed to the dashboard interface (Fig. 8), which features a sidebar menu including “Home,” “Cocoa Mapping,” “Info,” and “User Management”. Upon successful login, admins are directed to the administrator dashboard, as shown in Fig. 8. This dashboard serves as the control center, providing

access to menus such as Home, Cocoa Mapping, Info, and User Management. Administrators can manage cocoa data, update records, and control user account settings.

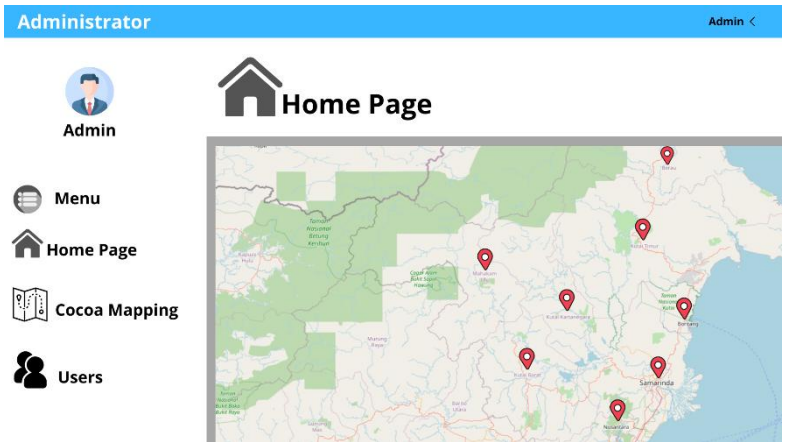

Fig. 8. Dashboard Administrator Page Display

To ensure system security, the GIS application allows users to log out after their session. Fig. 9 depicts the logout page, where admins can end their session by selecting the logout option in the upper right corner. The system then redirects them to the login page, clearing session data to prevent unauthorized access.

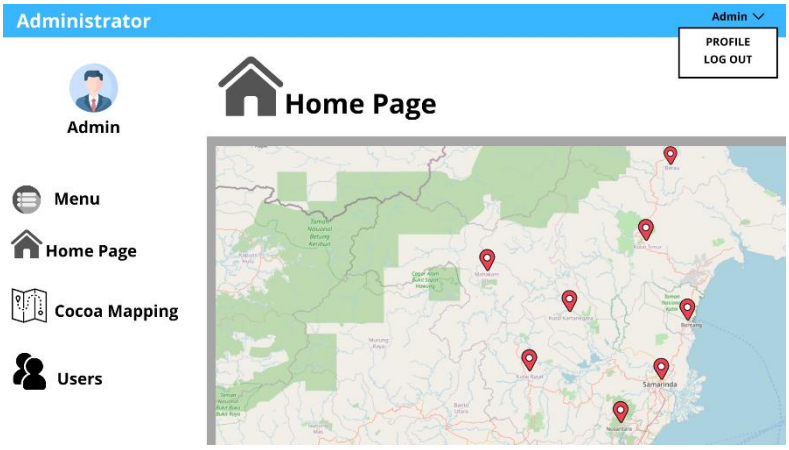

Fig. 9. Logout Page Display

The Cocoa Land Data menu is a key feature of the admin dashboard, enabling the management of cocoa plantation information. Fig. 10 shows the interface where admins can view, add, modify, or delete data about cocoa plantations across East Kalimantan Province. This functionality ensures accurate and up-to-date information is available for users.

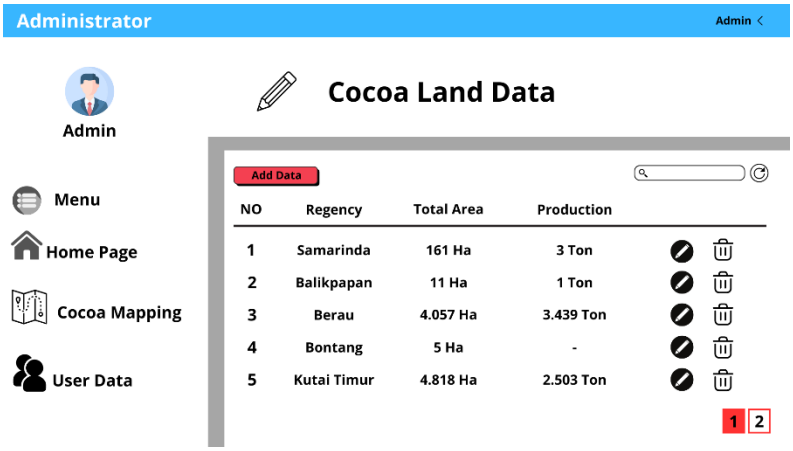

Fig. 10. Cocoa Land Data Page Display

The User Data menu, as shown in Fig. 11, allows admins to manage user accounts within the system. This includes adding new users, editing existing user details, and removing accounts when necessary. This functionality is crucial for maintaining control over system access and ensuring appropriate role assignments.

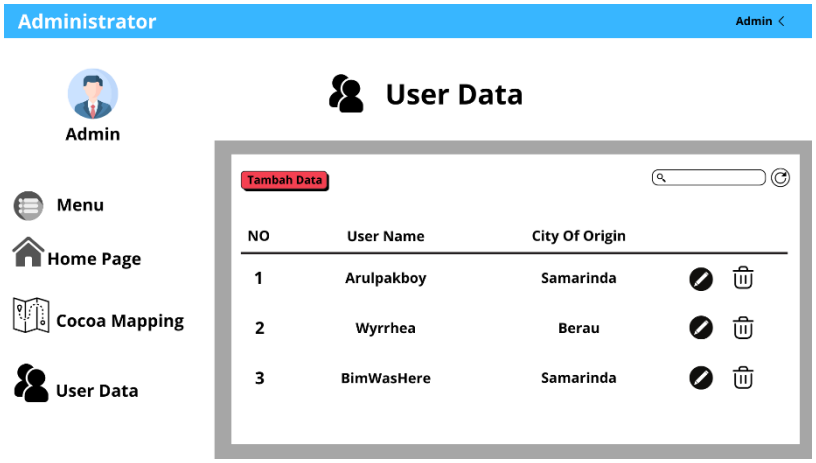

Fig. 11. Data Users Page Display

3.2 System Testing

The developed system was evaluated using the black-box testing method to verify that functional inputs and outputs align with the defined system requirements and specifications. This approach also helps identify functional errors and ensures that the application performs reliably and in accordance with its intended use. Table 1 presents the black-box test scenarios and outcomes for each core function of the GIS application.

Table 1. System Test Results Using Black Box

#	Case Test	System Testing Scheme	Expected Target	Result
1.	Home Page	Click the cocoa icon	The system successfully navigates to the main page	Succeed
2.	Location Search	Fill in the district location	The system will display cocoa plantation locations based on the search	Succeed
3.	Info	Click the info menu	The system displays a popup containing a brief description of the system	Succeed
4.	Map Pin Location	Click one of the pins on the map	The system displays a popup with district information and cocoa area coverage	Succeed
5.	Login	Fill in the username and password correctly	The system successfully logs into the administrator dashboard	Succeed
6.	Home Menu	Click the home menu	The system displays the main page	Succeed
7.	Cocoa Mapping Menu Cocoa Land Data	Click the cocoa mapping menu Admin can add data	Admin can view all data in the cocoa mapping menu Admin can add, modify, and delete data in the cocoa table	Succeed
8.	User Menu	Admin accesses the user menu	Admin can view all data in the users menu	Succeed
9.	User Data	Admin can add, modify, and delete user data	Admin can add, modify, and delete user data in the user table	Succeed
10.	*Logout*	Click the logout button on the system (top right)	Login data is deleted from the session and returns to the login page	Succeed
11.				Succeed

Table 1 includes 11 test scenarios designed to evaluate core functionalities such as login, data input, map interactivity, and user management using the black-box testing approach. The test results indicate a 100% success rate across all test cases, confirming that the system operates as intended and meets all functional requirements.

4. Conclusion

This study successfully developed a web-based Geographic Information System (GIS) to support community members and government agencies in monitoring and analyzing cocoa plantation distribution across East Kalimantan Province. The application utilizes Leaflet JS and GeoJSON technologies to provide interactive mapping capabilities that integrate geographic and attribute data into a cohesive web interface. System validation through black-box testing demonstrated full compliance with functional specifications, with a 100% success rate, confirming both system

accuracy and operational reliability. Future enhancements may include real-time data integration, advanced analytical tools for policy decision-making, and mobile responsiveness to ensure broader usability across devices and user groups.

References

[1] S. Adelina, R. Purnomo Wibowo, and H. Hasyim, "Analysis of the Export Determinants of Indonesian Cocoa with Gravity Model Approach," *Int. J. Res. Rev.*, vol. 7, no. 10, p. 10, 2020.

[2] S. Bulkis *et al.*, "Competitiveness analysis of cocoa commodities in South Sulawesi," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 343, no. 1, 2019, doi: 10.1088/1755-1315/343/1/012106.

[3] A. F. Hadi and W. A. Setyo, "Analysis of Factors Affecting the Value of Export of Indonesian Cocoa Beans in 1996-2015," *Ekuilibrium J. Ilm. Bid. Ilmu Ekon.*, vol. 14, no. 1, p. 16, 2019, doi: 10.24269/ekuilibrium.v14i1.1509.

[4] Effendy *et al.*, "Factors influencing the efficiency of cocoa farms: A study to increase income in rural Indonesia," *PLoS One*, vol. 14, no. 4, pp. 1–15, 2019, doi: 10.1371/journal.pone.0214569.

[5] N. P. Augustin, E. Prasetyo, and S. I. Santoso, "Analysis of Competitiveness and Export Trends of Indonesian Cocoa To the Five Destination Countries for 2010-2019," *Agric. Soc. Econ. J.*, vol. 21, no. 3, pp. 215–222, 2021, doi: 10.21776/ub.agrise.2021.021.3.6.

[6] T. T. Hapsari and A. F. Yuniasih, "The determinant factors of Indonesian competitiveness of cocoa exports to Germany," *J. Ekon. Pembang.*, vol. 18, no. 1, pp. 75–84, 2020, doi: 10.29259/jep.v18i1.9978.

[7] E. Ali, "Geographic Information System (GIS): Definition, Development, Applications & Components, Department of Geography Ananda Chandra College, Jalpaiguri," pp. 1–12, 2020.

[8] E. Suriaatmaja, R. M. N. Hartanto, and O. J. Djamaludin, "Policy Analysis , Geospatial And Economic Value Of Plantation Areas In The Province Of East Kalimantan , Indonesia," vol. 6, no. 9, pp. 2637–2649, 2022.

[9] G. Lü, M. Batty, J. Strobl, H. Lin, A. X. Zhu, and M. Chen, "Reflections and speculations on the progress in Geographic Information Systems (GIS): a geographic perspective," *Int. J. Geogr. Inf. Sci.*, vol. 33, no. 2, pp. 346–367, 2019, doi: 10.1080/13658816.2018.1533136.

[10] D. Putri, J. Ivo, N. Nisa, and E. Antriyandarti, "The Determinant of Indonesian Cocoa Export Growth to the Main Export Destination Countries," *J. Ilm. Tek. Elektro Komput. dan Inform.*, vol. 9, no. 4, pp. 1035–1044, 2023, doi: 10.26555/jiteki.v9i4.27232.

[11] M. S. and S.-M. C. Parima Mirshafiei , Abolghasem Sadeghi-Niaraki, "Geospatial Information System-Based Modeling," *Water*, 2019.

[12] V. Ak Seli, L. B. Zardasti, and N. Bin Md. Noor, "Risk Assessment Of Underground Gas Pipeline Leakage Incorporating Geographical Information System (GIS)," pp. 76–82, 2022, doi: 10.36647/978-93-92106-02-6.15.

[13] "Essential Gas Pipe Network Data Management in ArcGIS," no. April, 2019.

[14] S. Azunna and B. I. Anyaka, "Analysis of Groundwater Quality in Bauchi Metropolis (Nigeria) and interpretation using GIS," *Univers. J. Civ. Eng.*, vol. 2, no. 1, pp. 1–22, 2023, doi: 10.37256/ujce.2120231730.

[15] E. Falco, J. Zambrano-Verratti, and R. Kleinhans, "Web-based participatory mapping in informal settlements: The slums of Caracas, Venezuela," *Habitat Int.*, vol. 94, no. October, 2019, doi: 10.1016/j.habitatint.2019.102038.

[16] M. Ardiyansa, S. Sepriano, and F. Felawati, "WEB Based Geographic Information System For School Maping In Bungo District," *Sustain. Theory, Pract. Policy*, vol. 2, no. 2, pp. 111–125, 2023, doi: 10.30631/sdgs.v2i2.1460.

[17] N. N. Supuwiningsih and A. S. M. Malau Pase, "Geographic Information System Mapping Senior High School and Vocational High School in Bali Island Based Internet By Using Google My Maps," *Int. J. Eng. Technol. Manag. Res.*, vol. 9, no. 12, pp. 1–10, 2022, doi: 10.29121/ijetmr.v9.i12.2022.1259.

[18] R. C. Mat and G. C. Saha, "Exploring the potential of web based 3d visualization of gis data in coconut plantation management," *Int. J. Innov. Technol. Explor. Eng.*, vol. 8, no. 5s, pp. 147–153, 2019.

[19] A. Khoirunnita, F. Ramadhani, and R. Andrea, "Geographical Information System of Chocolate Plantation Locations in Berau District Using QGIS Web," *Tepian*, vol. 5, no. 1, pp. 44–49, 2024, doi: 10.51967/tepian.v5i1.3024.

[20] R. Andrea, A. Khoirunnita, andn Nuratika, "E-Commerce Information System for Marketing Agricultural Products in Kutai Kartanegara Regency", International Journal of Information Engineering and Electronic Business(IJIEEB), Vol.16, No.6, pp. 62-70, 2024. DOI:10.5815/ijieeb.2024.06.05.

[21] N. Moraiti, A. Mullissa, E. Rahn, M. Sassen, and J. Reiche, "Critical Assessment of Cocoa Classification with Limited Reference Data: A Study in Côte d'Ivoire and Ghana Using Sentinel-2 and Random Forest Model," *Remote Sens.*, vol. 16, no. 3, 2024, doi: 10.3390/rs16030598.

[22] F. O. Anyimah, E. M. Osei Jnr, and C. Nyamekye, "Detection of stress areas in cocoa farms using GIS and remote sensing: A case study of Offinso Municipal & Offinso North district, Ghana," *Environ. Challenges*, vol. 4, no. February, 2021, doi: 10.1016/j.envc.2021.100087.

[23] N. Prior, "North Dakota State University," *Grad. Study Criminol. Crim. Justice*, no. November, pp. 212–213, 2020, doi: 10.4324/9781315721606-101.

[24] P. Kumarsingh, "A Case Study to develop and test GIS/SDSS methods to assess the production capacity of a Cocoa Site in Trinidad and Tobago," no. 132, 2021.

[25] J. Halonen, "Future climate suitability of shade trees in cocoa agroforestry systems in West Africa and shade tree diversity's impact on farm microclimate: A Minor Field Study," 2023, [Online]. Available: https://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-330893

[26] Kardika, A. J., Khoirunnita, A., Salman, S., & Muliana, I. (2022). Development Web-GIS of Commodity Information System for Agriculture, Establishment and Forestry in Marangkayu District. International Journal of Education and Management Engineering (IJEME), 12(5), 1-8.5

[27] N. B. Rojas-Briceño *et al.*, "Land Suitability for Cocoa Cultivation in Peru: AHP and MaxEnt Modeling in a GIS Environment," *Agronomy*, vol. 12, no. 12, 2022, doi: 10.3390/agronomy12122930.

[28] P. Lozano-Mendoza, B. B. Gonzá lez- Osorio, N. Puente-Monar, and L. F. S. Ochoa, "Geographic distribution of cocoa cultivation: Multicriteria analysis based on agroclimatic and biophysical parameters," *NeuroQuantology*, vol. 20, no. 8, pp. 6646–6657, 2022, doi: 10.14704/nq.2022.20.8.NQ44689.
[29] K. Akpoti, M. Dembélé, G. Forkuor, E. Obuobie, T. Mabhaudhi, and O. Cofie, "Integrating GIS and remote sensing for land use/land cover mapping and groundwater potential assessment for climate-smart cocoa irrigation in Ghana," *Sci. Rep.*, vol. 13, no. 1, pp. 1–21, 2023, doi: 10.1038/s41598-023-43286-5.
[30] S. Pinardi, M. Salis, G. Sartor, and R. Meo, "EU−Africa: Digital and Social Questions in a Multicultural Agroecological Transition for the Cocoa Production in Africa," *Soc. Sci.*, vol. 12, no. 7, 2023, doi: 10.3390/socsci12070398.

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How to cite this paper: Reza Andrea, Agus Ganda Permana, Aulia Khoirunnita, "Cocoa Land Mapping Based on Geographic Information System in East Kalimantan Using Leaflet JS and GeoJSON", International Journal of Education and Management Engineering (IJEME), Vol.15, No.6, pp. 53-62, 2025. DOI:10.5815/ijeme.2025.06.05