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Development of a WEBGIS-Mapping Information System of Tuberculosis (MISS TB) for plotting tuberculosis cases: A case study in Sleman District, Yogyakarta Province, Indonesia

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Abstract. Geographic information system for health information management and public health to analyze the spatial disease distributions in surveillance has increasingly applied in the last few decades. The programming skills needed to utilize the software appropriately in contact tracing and follow up control measures for tuberculosis (TB) patients. This study aimed to develop a more user friendly application by applying XAMPP application to create WEBGIS localhost, PHP My Admin for MySQL database management, MySQL server as a database management system (DBMS), Visual Studio Code application for creating programming. The system development method uses a waterfall model. These data were collected from infectious disease prevention and control officers at the Sleman District Health Service and tuberculosis reporting programmer officers at community health centers. Data on rainfall, humidity, altitude, temperature, area, population and population density were obtained from the Central Statistics Agency of Sleman Regency. Data visualization in mapping for 17 sub-districts in Sleman Regency. The geographic menu contains information on rainfall, humidity, altitude and temperature for each month in tabular form. The demographics menu contains information on the area, population and population density of each sub-district in tabular form. The distribution location input menu is used to add data on tuberculosis cases. The distribution list menu contains a table that contains a database stored from the location input. The account menu on the administrator user contains a list of accounts created or registered in system. The website-based geographic information system (GIS) application is expected to improve case data reporting, case monitoring, support data availability, and visualize the distribution of tuberculosis cases in Sleman Regency through the mapping menu. The application developed should assist health information management and public health experts to utilize medical record data and spatial data for the surveillance purposes comprehensively.
Keywords: Medical Record, Mapping, Public Health, Spatial Analysis, Tuberculosis, WEBGIS

I. BACKGROUND

Geographic information system for health information management and public health to analyze the spatial disease distributions in surveillance has increasingly applied in the last few decades. The programming skills needed to utilize the software appropriately in contact tracing and follow up control measures for tuberculosis (TB) patients. The application developed assist public health experts to utilize spatial data for the surveillance purposes comprehensively as well as for the drafting of regulations aimed at to reducing mortality and morbidity and thus minimizing the public health impact of the disease [1].

GIS is a powerful tool in aiding TB control and prevention in developing countries and should be used for real-time surveillance and decision making [2]. Development a Geographical Information System (GIS) it can process data into maps to see high risk areas where TB disease was found. It will make it easier for health agencies to make policies in handling or preventing TB disease [3].

Stakeholders in the fight against Tuberculosis (TB) face a dilemma of the quick spreading disease that must be fought with minimal resources. The scarcity of the resources available for the fight against TB calls for creative and strategic ways if this fight is to be won. Information and Communication Technologies (ICTs), particularly cloud computing, geospatial data analysis and web technologies presents an opportunity towards the creative fight against TB. The ability of these technologies to capture and present spatial data in real-time on mapping applications makes them a good candidate for exploration in the fight against TB [4].

Based on the SITB application report, tuberculosis cases in 2018-2022 in Sleman Regency increased in 2022. The highest case data for 2018-2022 was in Depok (573 cases), Mlati (413 cases), Ngaglik (326 cases), Kalasan (312 cases), and Gamping (311 cases).

This study aimed to develop a more userfriendly application by applying XAMPP application to create WEBGIS localhost, PHP My Admin for MySQL database management, MySQL server as a database management system (DBMS), Visual Studio Code application for creating programming.

II. METHOD

The system development method uses a waterfall model. These data were collected from infectious disease prevention and control officers at the Sleman District Health Service and tuberculosis reporting programmer officers at community health centers. Data on rainfall, humidity, altitude, temperature, area, population and population density were obtained from the Central Statistics Agency of Sleman Regency.

III. RESULTS AND DISCUSSION

A. WEBGIS Design

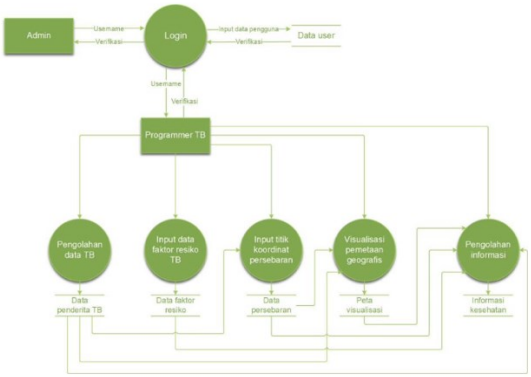

Figure 1. Data flow diagram

Data flow diagrams (entity, process, data flows, data storage) to describe how data flows through interconnected processes. These symbols describe environmental elements related to systems, process, data flows and data storage.

The WEBGIS application has two entities, namely TB administrator and programmer. User data and results of TB programmer recording process are stored in database. TB programmer login using username and password. TB programmers can manage TB data, input TB risk factor data, input coordinate points, visualize geographic mapping, and process information.

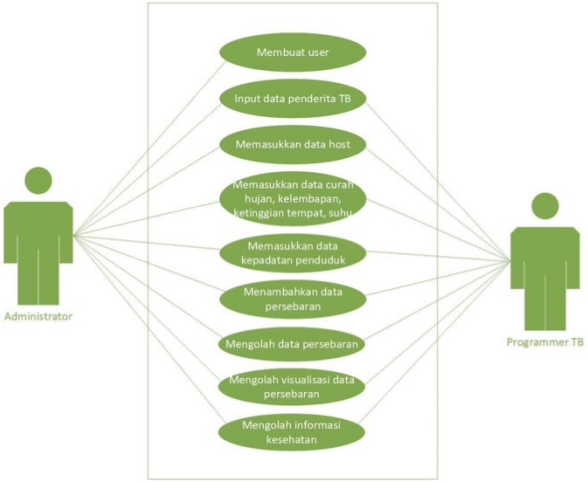

Figure 2. Use case

Use case diagrams describe the function of system from perspective of system users. Use case diagrams identify functionality of system (use cases), users who interact with system (actors) and association between users and system functionality.

Actors (system users) are all entities outside software that interact with system. WEBGIS application has 2 (two) actors involved in application process. TB administrators and programmers in WEBGIS application almost have the same features related to recording in application, however TB programmers can only operate on access (user data) that has been created by administrator.

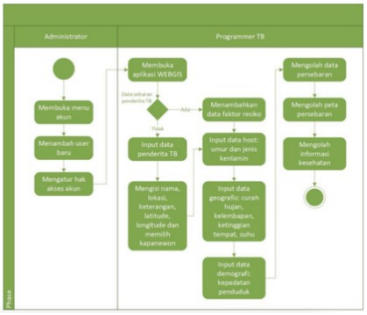

Figure 3. Activity diagram

Activity diagrams describe workflow in a system starting from business level to operational level and can support parallel behavior. Administrator starts by creating a user (TB programmer) with username and password. TB programmer login to application using registered username and password. In recording process, if there is already distribution data, then continue by filling in risk factor data. If distribution data is not yet available, TB programmer will input it first. The final result of recording is data on distribution of TB patients and a map of distribution of TB in Depok, Mlati and Kalasan Districts which are then processed into health information.

B. WEBGIS visualization of mapping tuberculosis case

a. Login page

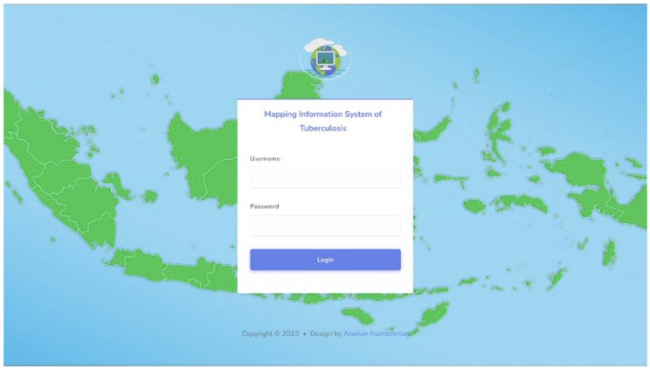

Figure 4. Login page

WEBGIS-Mapping Information System of Tuberculosis (MISS TB) application login page contains an encrypted username and password. Users log in by entering username and password registered in system. The function of login page is to enter main page (dashboard) of WEBGIS-MISS TB.

Administrator as user creator for TB programmers. Administrator creates an account (user data) for TB programmer which will be used to enter MISS TB application.

Usernames and passwords that are not recorded or registered in system cannot be used to login. Another feature of login page is that it is equipped with a protect system, unregistered users cannot enter application page even if they know domain address of htdocs file typed in browser address.

b. Dashboard

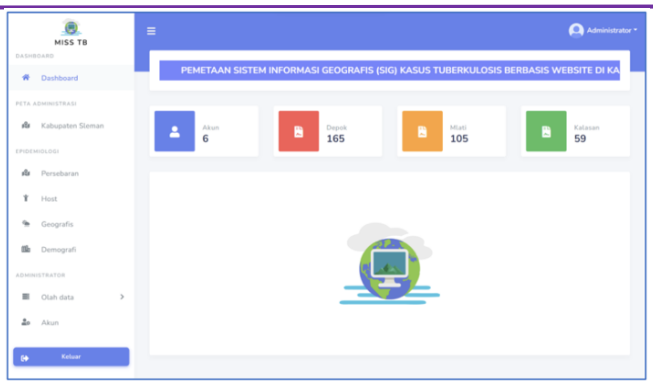

Figure 5. Dashboard admin

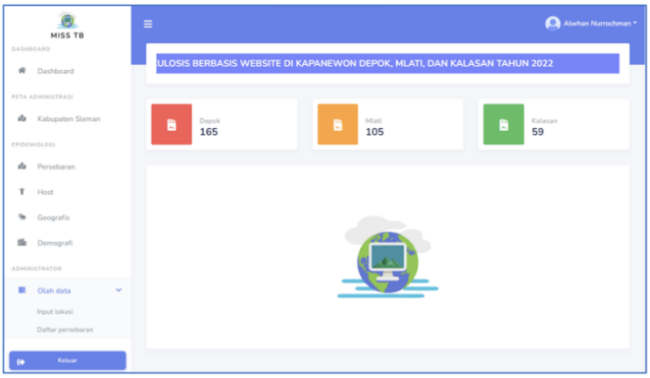

Figure 6. Dashboard TB programmer

The dashboard contains MISS TB application features from TB administrators and programmers. There are differences in features, the administrator is more full featured, has access and an account menu to create new users. On the dashboard there are registered accounts (administrators only), Depok, Mlati, and Kalasan Sub-district.

c. Administrative map of Sleman Regency

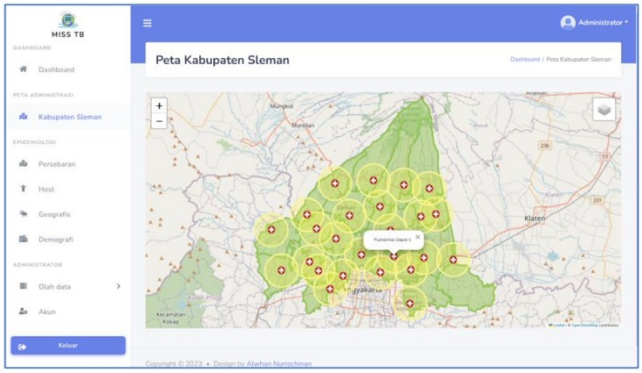

Figure 7. Administrative map of Sleman Regency

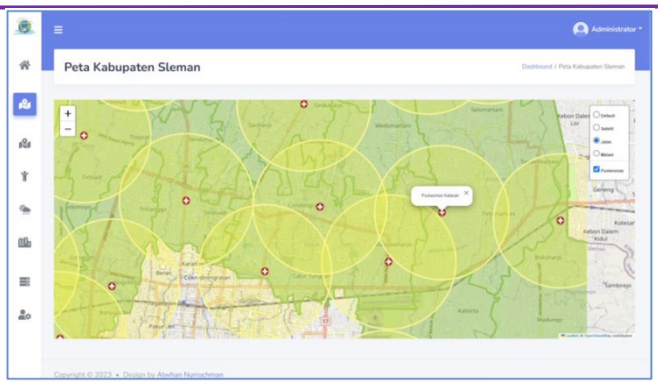

Figure 8. Administrative map of Sleman Regency – zoom

Administrative map of Sleman Regency is a visualization of Sleman Regency which consists of 17 sub-districts and uses the bind pop up feature. This feature can display information on name of sub-district when you click on map. The visualization is equipped with a layer feature that can display location of health centers in Sleman Regency and area coverage of primary health centers.

d. TB case distribution map

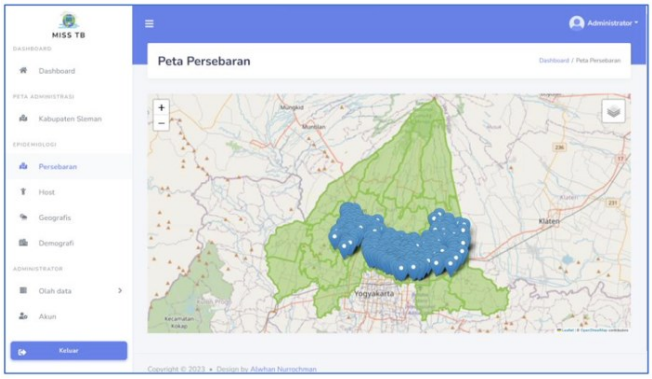

Figure 9. TB case distribution map

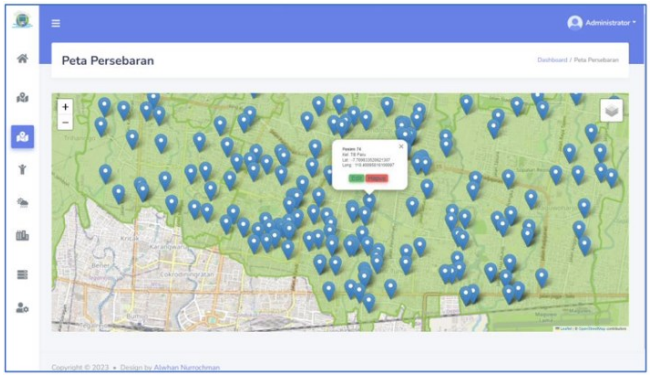

Figure 10. Tampilan peta persebaran – zoom

The distribution map contains information on the distribution points of tuberculosis patients in the Sleman Regency area, especially in Depok, Mlati and Kalasan Sub-districts. There are information features on the patient's name, TB status, latitude and longitude on each marker when clicked. Information data for each patient can be changed if there are errors or deficiencies directly in the TB case distribution map display.

e. Host

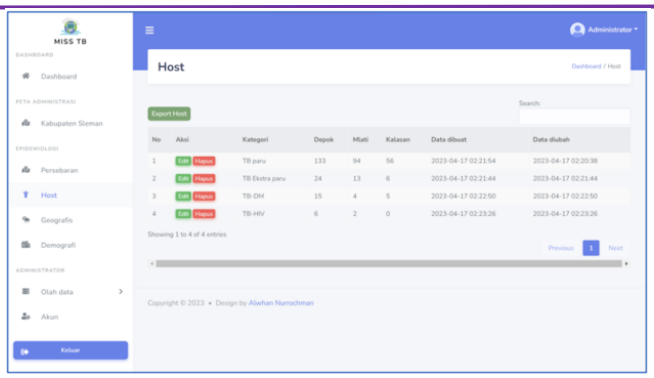

Figure 11. Host

The host contains a number of tuberculosis classification data in tabular form. Host table data can be changed by editing or deleting data. Export feature to create host reports in Excel extension file format (.xls).

f. Geographic

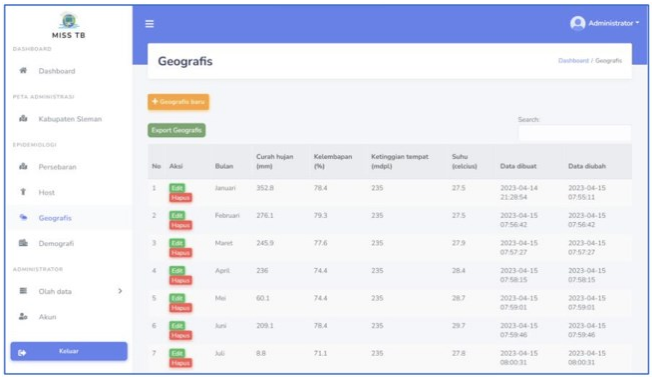

Figure 12. Geographic

Geographic contains information on rainfall, humidity, altitude and temperature for each month in tabular form. Geographic table data can be changed by editing or deleting data. Export feature for creating geographic reports with Excel extension file format (.xls).

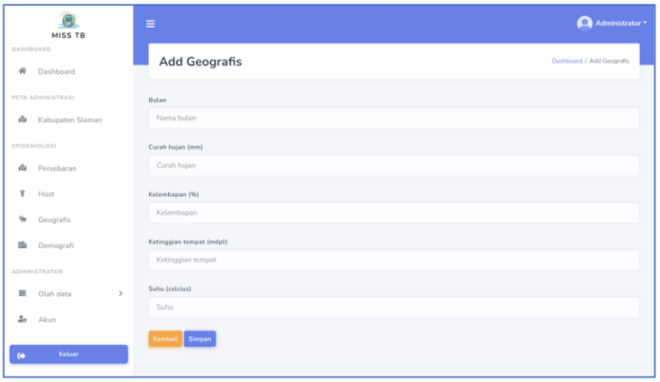

Figure 13. Add geographic

Add geographic allows users to add geographic data by filling in all components (columns) in data. The feature is equipped with a save button to ensure data is saved on system.

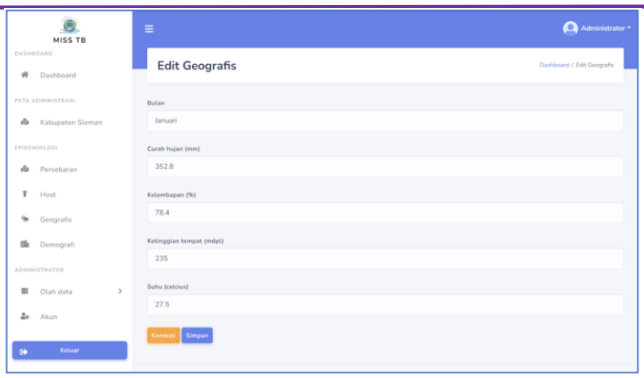

Figure 14. Edit geographic

Graphic editing is used by users when they want to change or complete inappropriate geographic data. The save button in geographic edit sub menu functions to overwrite (replace) data previously recorded on the system.

g. Demographics

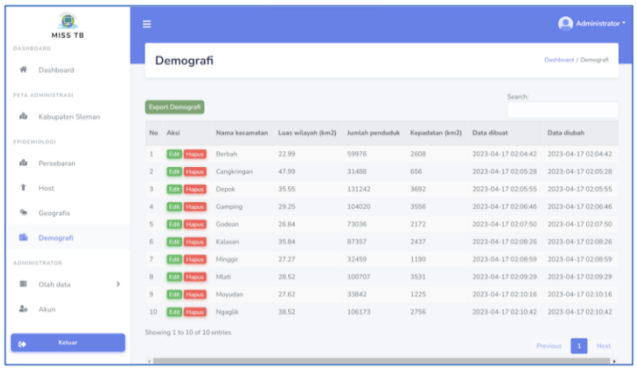

Figure 15. Demographics

Demography contains information on area, population and population density of each sub-district in tabular form. Demographic table can be changed by editing or deleting data. Export feature to create demographic reports in Excel extension file format (.xls).

h. Data processing

a) Location input

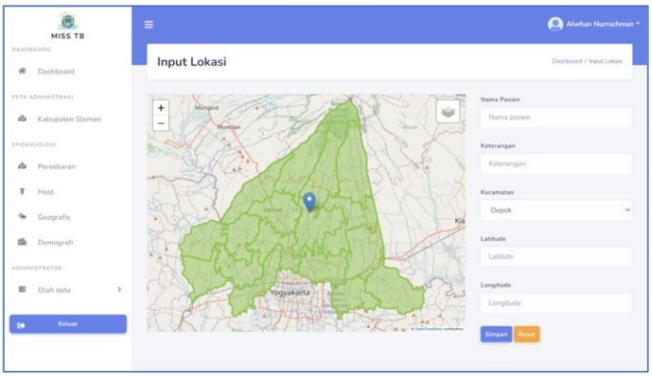

Figure 16. Location input

Location input is used to add data on tuberculosis cases. Location input feature has a marker that can be moved, it will automatically detect the latitude and longitude numbers according to location of marker.

b) List of TB case distribution

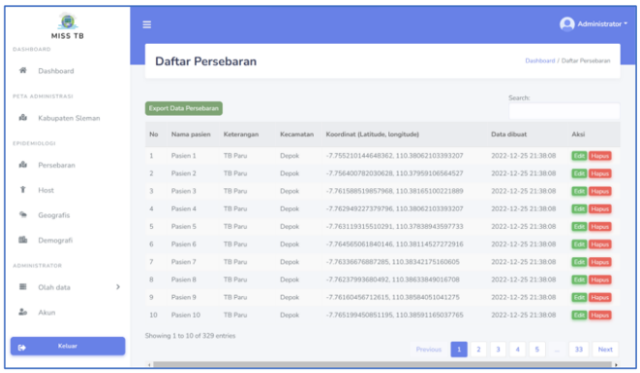

Figure 17. List of TB case distribution

List of TB case distribution is a table containing database stored from location input. There is a button that allows TB programmer to edit or delete data. Export feature is used to create a report listing distribution of TB cases in Excel extension file format (.xls).

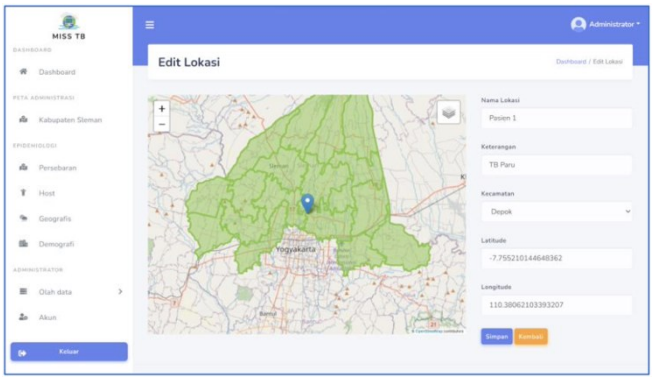

Figure 18. Edit location

Edit location allows users to change or complete distribution of TB patients. Save button in edit location menu functions to overwrite (replace) location previously recorded on system.

i. Account (administrators only)

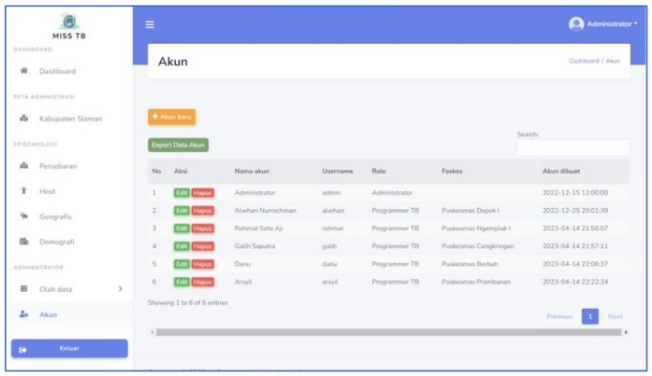

Figure 19. Account (user)

Account menu on administrator user contains a list of accounts created or registered in system. Information contained includes account name, username, role, health facilities, and information on when account was created.

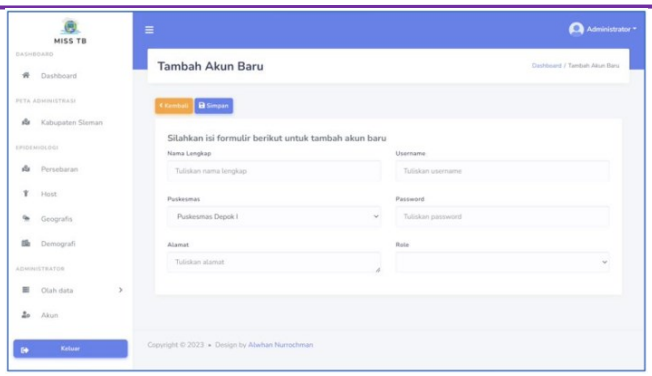

Figure 20. Add account (add user)

Add account sub menu is used to add accounts or users that can be used to access MISS TB application. In this sub menu, administrator enters full name, primary health centre, address, username, password and role to be registered and then saved. User data that has been saved makes it possible to login using username and password that was created because data is encrypted.

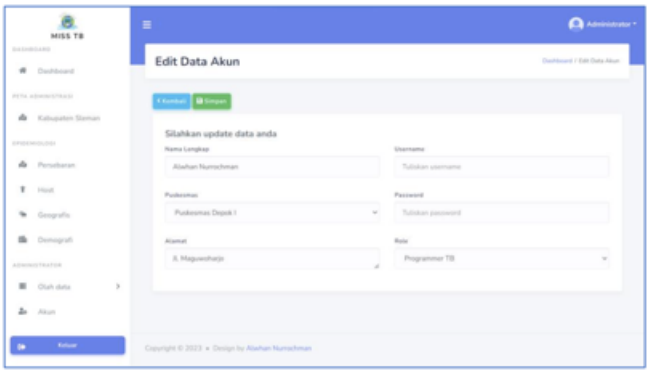

Figure 21. Edit account (edit user)

Edit account data sub menu is used by administrators to change existing user data. Edit account data will load account information that was previously recorded in system and then changed by administrator according to correct data. Administrators can make changes to form columns. For example full name, primary health centre, address, username, password and role.

Web-based applications can provide information regarding health mapping and disease outbreaks. Officers can be helped by regular monitoring as anticipation and follow-up in handling, preventing and minimizing the spread of disease. The design of a web-based geographic information system for mapping non-communicable diseases has been effective even though it is still not perfect. It is hoped that the system can be developed according to needs, especially in the multimarker disease section on the mapping page which still uses a single color marker which can be developed into a marker with many colors.

The geographic information system for mapping infectious diseases contains information on areas where infectious diseases are spreading, the number of cases of disease spreading, the frequency of occurrence of infectious diseases, and the areas where cases of infectious diseases are spreading. The system built using the area feature is colored to mark areas (sub-districts) affected by infectious diseases. The system provides data visualization in the form of diagrams or graphs to make the information easier to understand, so it can help analyze disease events.

The MISS TB application was created to make it easier for users to process distribution data into map visualization output, determine patient locations using markers accompanied by supporting information, other necessary needs will be carried out in application development. The MISS TB application is equipped with security and confidentiality features, for example application encryption (protect) and access rights for each user. The MISS TB application needs to be developed into an application that has more features and better supports the needs required in web-based mapping.

System design process by making Conceptual Data Model (CDM) serves to describe the needs of spatial data and attribute data in a database system [5]. The system would improve disease monitoring and tracking through the use of the identified

technologies, by displaying the geographical distribution of TB cases in the communities on a mapping application as well as providing reports which TB program managers can use to make decisions when planning and implementing disease control and prevention activities [6].

The application displays the location of TB cases on an interactive map based on sociodemographic factor. Portal TB allows public health officers to visualize the potential risk areas of TB cases without a trained programmer and geospatial statistician. This application will help healthcare personnel better understand TB transmission, thus improving case detection and minimize the public health impact of the disease [7].

System display on a mapping application the geographical distribution of TB cases and other reports which can be used to make decisions in the prevention of TB. Using the information provided by this system, TB program managers will be able to put the scare resources where it matters more in the fight against the disease where the cases are [8].

Using GIS analysis combined with molecular epidemiological surveillance may be an effective method for identifying instances of local transmission. These methods can be used to enhance targeted screening and control efforts, with the goal of interruption of disease transmission and ultimately incidence reduction [9].

OUT-TB Web is a valuable tool for TB case investigation. Users identified key features to implement for application enhancements, including an e-mail alert function, customizable heat maps for visualizing TB and drug-resistant cases, socioeconomic map layers, a dashboard providing TB surveillance metrics, and a feature for animating the geographic spread of strains over time [10].

OUT-TB Web has proven to be an award-winning application and a useful tool. Developed and enhanced using regular user feedback, future versions will include additional data sources, enhanced map and line-list filter capabilities, and development of a mobile app [10]. Integration of GIS can be an effective approach for analyzing the spatial patterns of geographical disease distribution. further integration of this technique with Markov modeling was found to be beneficial in describing, analyzing and projecting geographical dynamic diseases process [11].

The contribution of web-GIS in aiding the decision making process in last years is being agreed upon it by most of new applications have been developed. Is become no doubt that spatial analysis breaks down all awkward details of setting policies and taking proper decisions This project takes in hand the task of implementing a prototype web-GIS application using ArcGIS, MapGuide Open Source tools, and scripting language “PHP, ArcXML” [12]. GIS software have basic functions of disease mapping and analysis, but a better performance was expected in ArcGIS software due to enhanced statistical advancements [13].

WebGIS visualization will display cluster information for each village, visualize the data, identify patterns and trends associated with infectious diseases, ultimately aiding in better decision-making and resource allocation for disease prevention and control [14]. Features and functions of ArcGIS such as ArcGIS Pro, ArcGIS Online and Web Apps were explored for the disease mapping, data analysis and system development. By focusing on tuberculosis (TB) cases as examples, the result showed that a TB monitoring system was developed by fulfilling the user requirements. The system displays the database and mapping of the cases and spatially analyses the cases. A geospatial solution platform, mainly ArcGIS could assist the local organisations in managing the disease datasets in a systematic way [15].

An online geospatial platform was developed, which presented the prediction model providing estimates of case detection. Increased efforts should be undertaken to control tuberculosis transmission in these hotspots [16].

Environmental factors that influence trend of tuberculosis cases are rainfall, temperature, humidity, altitude, and population density. Subdistricts that have high cases have a relationship with environmental factors, which occur in Depok and Mlati sub-districts [17]. The buffer results of the distance between health facilities and the patient did show any obstacles. The areas with high rainfall was the areas that has the highest number of pulmonary tuberculosis patients [18]. Pulmonary tuberrculosis occurred over the rainy season. Spatial pattern distribution of pulmonary tuberrculosis patients in high rainfall intensity spreads and stretches from east to west areas. Active case monitoring program should be performed by tuberculosis program that concerned in areas of high rainfall intensity [19].

IV. CONCLUSIONS AND SUGGESTIONS

Data visualization in mapping for 17 sub-districts in Sleman Regency. The geographic menu contains information on rainfall, humidity, altitude and temperature for each month in tabular form. The demographics menu contains information on the area, population and population density of each sub-district in tabular form. The distribution location input menu is used

to add data on tuberculosis cases. The distribution list menu contains a table that contains a database stored from the location input. The account menu on the administrator user contains a list of accounts created or registered in system.

The website-based geographic information system (GIS) application is expected to improve case data reporting, case monitoring, support data availability, and visualize the distribution of tuberculosis cases in Sleman Regency through the mapping menu. The application developed should assist health information management and public health experts to utilize medical record data and spatial data for the surveillance purposes comprehensively.

V. ACKNOWLEDGMENT

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REFERENCES

[1] Mohidem, N. A., Osman, M., Muharam, F. M., Elias, S. M., Shaharudin, R., & Hashim, Z. (2021). Development of a web-geographical information system application for plotting tuberculosis cases. Geospatial Health, 16(2).

[2] Rosli, N. M., Shah, S. A., & Mahmood, M. I. (2018). Geographical Information System (GIS) application in tuberculosis spatial clustering studies: a systematic review. Malaysian Journal of Public Health Medicine, 18(1), 70-80.

[3] Hijriani, A., & Cahyani, A. (2021). Web GIS based assessment using SAW methods to identify high risk areas of tuberculosis transmission and incidence in Bandar Lampung City. In Journal of Physics: Conference Series (Vol. 1751, No. 1, p. 012033). IOP Publishing.

[4] Mwila, I., & Phiri, J. (2020). Geospatial, cloud and web based model for evidence-based decision-making in tuberculosis prevention. IJACSA) International Journal of Advanced Computer Science and Applications.

[5] Vitianingsih, A. V., Cahyono, D., & Choiron, A. (2017, October). Analysis and design of web-geographic information system for tropical diseases-prone areas: A case study of East Java Province, Indonesia. In 2017 4th International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE) (pp. 255-260). IEEE.

[6] Mwila, I., & Phiri, J. (2020). Tuberculosis prevention model in developing countries based on geospatial, cloud and web technologies. International Journal of Advanced Computer Science and Applications, 11(1).

[7] Mohidem, N. A., Osman, M., Muharam, F. M., Elias, S. M., Shaharudin, R., & Hashim, Z. (2021). Portal TB Gombak: Web-Based Application for Plotting of Tuberculosis Cases in Gombak, Selangor, Malaysia.

[8] Mwila, I., & Phiri, J. (2020). Geospatial, cloud and web based model for evidence-based decision-making in tuberculosis prevention. IJACSA) International Journal of Advanced Computer Science and Applications.

[9] Moonan, P. K., Bayona, M., Quitugua, T. N., Oppong, J., Dunbar, D., Jost, K. C., ... & Weis, S. E. (2004). Using GIS technology to identify areas of tuberculosis transmission and incidence. International Journal of Health Geographics, 3, 1-10.

[10] Guthrie, J. L., Alexander, D. C., Marchand-Austin, A., Lam, K., Whelan, M., Lee, B., ... & Jamieson, F. B. (2017). Technology and tuberculosis control: the OUT-TB Web experience. Journal of the American Medical Informatics Association, 24(e1), e136-e142.

[11] Zouiten, M., Harti, M., & NejjarI, C. SIG100T: A prototype for web-based health GIS application and diseases Management (Cancers and Tuberculosis in Morocco). &#', 191.

[12] Elzubair, R. M. E. A. (2009). Aiding decision making in public health domain using web gis (Doctoral dissertation, Universiti Teknologi Malaysia).

[13] Azewan, M. D. H., & Abdul Rasam, A. R. (2020). Disease mapping and health analysis using free and open source software for geospatial (FOSS4G): an exploratory qualitative study of tuberculosis. In Charting the Sustainable Future of ASEAN in Science and Technology: Proceedings from the 3rd International Conference on the Future of ASEAN (ICoFA) 2019-Volume 2 (pp. 495-506). Springer Singapore.

[14] Warni, E., Yohanes, C., Zainuddin, Z., Wardhani, T. P. M., & Rusmiati, A. (2023, October). WebGIS Visualization of Infectious Disease Clustering with a Hybrid Sequential Approach. In Asia Simulation Conference (pp. 377-389). Singapore: Springer Nature Singapore.

[15] Rasam, A. R., Zuki, N. S., Saad, N. M., & Ghazali, R. (2021). Geospatial infrastructure solutions for local government sectors: geo-enabling infectious disease monitoring system in state health departments. International Journal of Advanced Technology and Engineering Exploration, 8(78), 670-684.

[16] Dao, T. P., Hoang, X. H. T., Nguyen, D. N., Huynh, N. Q., Pham, T. T., Nguyen, D. T., ... & Bui, H. M. (2022). A geospatial platform to support visualization, analysis, and prediction of tuberculosis notification in space and time. Frontiers in Public Health, 10, 973362.

[17] Dewi Lukita Sari, A., Rohman, H., & Oktaviana, S. (2022). Analisis Informasi Kesehatan Melalui Pemetaan Penyakit Tuberkulosis Pada Masa Pandemi Covid-19. Jurnal Amanah Kesehatan, 4(1), 20-27. https://doi.org/10.55866/jak.v4i1.140

[18] Rohman, H., Jannah, H. M., & Muharry, A. (2018). Spatial Pattern Pulmonary Tuberculosis Patient: Accessibility, Environment And Lifestyle Factor In Rural Area. In International Seminar Rural Urban and Community Health (ISRUNCH) (Vol. 1, No. 1).

[19] Rohman, H. (2018). Spatial patterns of pulmonary tuberculosis analysing rainfall patterns in visual formation. International Journal of Public Health Science (IJPHS), 7(1), 13.