Web-Based Geographic Information System on the Covid-19 Vaccine in Banda Aceh City

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Abstract:
The influence of the development of information technology makes it easier for anyone to share and obtain information, one of which is information regarding the COVID-19 vaccination. The RI Ministry of Health has provided information regarding COVID-19 vaccination in the form of a WEBGIS, however, the website still has several deficiencies such as the unavailability of data on COVID-19 vaccination achievements per sub-district and village, does not provide information regarding the distribution of vaccination locations and routes to vaccination locations, and does not provide a form for registration of vaccinations. Therefore, we need a system that can overcome these deficiencies, especially for the City of Banda Aceh. This WEBGIS development uses Laravel as a Framework, Leaflet as a library and MariaDB as a database. The COVID-19 Vaccination WEBGIS for Banda Aceh City can provide information on vaccination achievements per sub-district and village in the form of graphs and thematic maps which are grouped into 3 color classes according to vaccination achievements. In addition, this WEBGIS also provides information on the distribution of vaccination locations along with routes to these locations. This WEBGIS also makes it easier for people who want to vaccinate because a form is available to register for vaccination. The Health Office also gets convenience in terms of data management and printing of vaccination data. WEBGIS has carried out usability testing on users. This usability test involved 30 respondents using 30 questions from the USE (Usefulness, Satisfaction, and ease of use) Questionnaire method which were divided into 4 sections. The results of this WebGIS test obtained an average score of 88.67%, which means that this WEBGIS is included in the very decent category.

Keywords:
WEBGIS, Vaccination, Covid-19, USE Questionnaire, Leaflet, Laravel

JEL: I10, I18

INTRODUCTION

At the end of 2019 a new virus appeared, known as Coronavirus Disease 2019 (COVID-19), which first occurred in Wuhan Province, China. After that this virus began to spread throughout the world including Indonesia. At the beginning of 2020 the COVID-19 outbreak spread widely throughout the archipelago, including Aceh Province. Various efforts for prevention have been carried out by the government, such as the obligation to wear masks, regional quarantine policies (lockdown), local Large-Scale Social Restrictions (PSBB) according to the level of severity in the province, district or city. In addition, another effort that is being carried out by the government is providing free COVID-19 vaccinations to all people.

The Banda Aceh City Government is trying to achieve a COVID-19 vaccine response for at least 190,289 residents in order to achieve herd immunity. A total of 90,084 residents have received the first dose of vaccine or 51.5 percent; 57,856 residents had vaccinated the second dose or 30.4 percent and for the third dose as many as 1,685 residents had vaccinated or 26.6 percent for health workers in Banda Aceh City (Dinkes, 2021).

Currently, the Ministry of Health has provided a WEBGIS that provides information about vaccinations (https://vacsin.kemkes.go.id/#/vaccines). Such information includes information boxes on overall and per dose vaccination results, graphs updating vaccination days per dose, information on vaccination achievements by group and maps of vaccination coverage for each

province and district/city. However, the website still has deficiencies such as the unavailability of vaccination achievement data per sub-district and village, does not provide information about vaccination locations and routes to vaccination locations, and does not provide forms for registering vaccinations.

Based on the explanation above, the authors are interested in providing an alternative regarding vaccination information carried out in Banda Aceh City in the form of a WEBGIS. WEBGIS provides a form for registration of vaccinations to make it easier for people who want to vaccinate without having to carry out a survey directly to the location of the vaccine. In this form, there are several data that must be filled in, such as: name, age, address, vaccination dose, date of vaccination, and location of vaccination . The data will then be directly stored in the database, then data from the database will display data in the form of tables, graphs and maps on the web. The map will later display village polygons with several color classes to inform the number of people who have been vaccinated. The health office will also get convenience with this WEBGIS, namely data that was previously in the form of csv data can be entered into a web database, so the data is safer and easier to process.

There are two users on the Banda Aceh city vaccination WEBGIS, the first of which is intended for the people of Banda Aceh City, where the public can see the distribution points of vaccination locations in Banda Aceh City and can register to vaccinate at the desired vaccination location. The second is the admin which is divided into two, namely the Banda Aceh City Health Office and the vaccination booth. The Banda Aceh City Health Office can manage and monitor vaccination achievements in Banda Aceh City, while the admin from the vaccination booth will receive vaccination registration data. It is hoped that by using the WEBGIS, vaccination information in Banda Aceh City which is still in the form of statistical data can be converted into WEBGIS so that it is easier to understand and use besides that it is also easier for people to find vaccination locations.

The purpose of this research are:

1. Build a WEBGIS that provides information on COVID-19 vaccination achievements for the sub-district and village levels in Banda Aceh City in the form of graphs and maps along with the distribution of COVID-19 vaccination locations and routes to these locations, as well as registration forms for carrying out COVID-19 vaccinations.
2. Provide data processing for the Banda Aceh City Health Office.
3. Analyzing the usability of the COVID-19 vaccination WEBGIS using the USE Questioner.

LITERATURE REVIEW

Vaccination

Vaccination is the act of inserting a health product containing an antigen into the human body to induce an immune response to produce antibodies. Vaccines protect not only individuals but also those who cannot be vaccinated, for example those of a certain age or who have certain diseases. Vaccines do not cause disease. According to the standards of the World Health Organization (WHO), each person will be given two injections or will need two doses of the vaccine. There are seven types of COVID-19 vaccines that can be used during vaccination in Indonesia. These seven vaccines are produced by Sinovac Biotech, Moderna, Astra Zaneca, Bio Farma, Novavax Inc, Shinopharm, Pfizer Inc and BioNtech (Iskak et al., 2021).

The purpose of administering COVID-19 vaccination to the public is to reduce morbidity and mortality caused by the COVID-19 virus, to achieve herd immunity to prevent transmission and to protect public health, to protect and strengthen the health system as a whole and to maintaining productivity and minimizing social and economic impacts. The ideal vaccine in Indonesia is an effective, safe and halal vaccine. Based on the phase 3 clinical trial of the Sinovac vaccine in Indonesia, people who are given the Sinovac vaccine have an almost 3x lower risk of experiencing symptomatic COVID-19 (Marwan, 2021).

Web-Based Geographic Information System (WEBGIS)

WEBGIS is a web mapping application that uses the internet. An example of the current WEBGIS development is the application of an information system for the distribution of COVID-19 cases in Sukoharjo Regency, which displays or publishes information on the distribution of COVID-19 cases at the village/kelurahan level on an interactive map. The development of this application offers two (2) pages, namely the case dashboard page which is updated every day, and the WEBGIS which displays an analysis map of the distribution of COVID-19 cases with quite complete functions (Tistariawan et al., 2020). WEBGIS is a web mapping which means internet mapping, not mapping but mapping using the internet, and not just displaying a map in the form of a static image, but can also display a dynamic map. WEBGIS architecture consists of three namely the user interface, database, and application server (Budisusanto et al., 2020).

WEBGIS is any GIS that uses web technologies. In general, it can be said that WEBGIS is a GIS that is implemented using web-based technology so that it can communicate between systems. WEBGIS also means a type of distributed information system. The system must at least have a server and client, where the server acts as a server application and the client can be a web browser. Servers are generally in the form of URLs that can be accessed by clients using HTTP (Fu & Sun, 2011).

METHODOLOGY

This research was conducted in Banda Aceh City and the data processing and application design were carried out at the Geospatial Laboratory of the Faculty of Mathematics and Natural Sciences building, Syiah Kuala University. As for the research time used in building this system around 6 (six) months. The tools and data that will be used in this study to build WebGIS applications are software consisting of the Windows Operating system and hardware consisting of the ASUS Vivo Book A412FL Laptop with Intel(R) Core (TM) i5-8265U CPU @ 1.60GHz processor 1,800MHz and 8GB of RAM. Data processing in this study is spatial data processing by converting district and village shp data in Banda Aceh City into GeoJSON data. As for processing non-spatial data in the form of the name of the location where the vaccination was carried out and information on vaccination achievements for each sub-district and village in Banda Aceh City.

The web-based Geographic Information System that will be designed has two users, namely the community and admin, where the admin is divided into two, namely the Health Service and vaccination outlets. This web-based geographic information system was created using an open source application. The programming framework used is Laravel using the PHP programming language, for the database it uses MariaDB while for spatial data management it uses ArcGIS and Leaflet as a library to produce a map of vaccination achievements in Banda Aceh City.

Testing and Analysis

The USE Questionnaire is a form of questionnaire that allows subjective measurement of the use of a product or service, this questionnaire consists of 30 questions that have been grouped into 4 aspects, namely: Usefulness, Ease Of Use, Ease Of Learning and Satisfaction (Gao et al., 2018). After the respondents filled out the questionnaire using a 5-point Likert scale, ranging from Strongly disagree to strongly agree, at this stage the feasibility of the questionnaire results was checked before proceeding with the usability processing process. The feasibility tests carried out are:

a. Validity test

   Validity test using Pearson product moment correlation analysis. This validity test aims to determine the level of valid or invalid correlation of the items answered by respondents (Kusuma et al., 2016). The results of the questionnaire will be said to be valid if the degree of correlation is greater than the value of the correlation coefficient. The formula for the Pearson product moment correlation can be seen in formula (1). (Hidayat, 2012).

$$r = \frac{t}{\sqrt{df+t^2}} \quad \text{..... (1)}$$

Information:
df : degree freedom
: df = n -2
n : Number of respondents
t : The function of Ms. Excel to find the two-tailed inversion value. Using the TINV formula (probability, degree freedom)
Probability: The probability value
r : r-table, Pearson Product Moment correlation coefficient

b. Reliability Test

To find out whether the measurements used based on the results of the questionnaire are consistently valid, reliability testing is carried out (Kusuma et al., 2016). The results of the reliability test are seen from the Cronbach's Alpha coefficient values. If the results are reliable, then you can proceed to the next step. Reference values can be seen in the following table.

Table 1
Reliability Level Reference

Interval Reliabilitas	Category
> 0,80 – 1,00	Very high
> 0,60 – 0,80	High
> 0,40 – 0,60	Currently
> 0,20 – 0,40	Low
> 0,00 – 0,20	Not Reliable

After valid and reliable verification, usability measurement is then carried out. This measurement is done by calculating the maximum scale score according to formula (2) and the observation score (observation score) like formula (3) for each dimension of the question with the following formula (Kusuma et al., 2016).

Score $_{max}$ = N x nbv x scale $_{\max}$ ..... (2)
Score $_{observe}$ = $\sum_{k=0}^{N} \sum_{l=0}^{30} scale$ ..... (3)

Information :
N : Number of Respondents
Nbv : The value of a valid question item
scaleMax : The maximum scale, which is 5
scoreMax : Maximum score
scale : The value of the scale filled by the respondent
scoreObserve : Score observation

Furthermore, the results of calculating the usability percentage are compared with the standard eligibility values, which can be seen in the following table.

Table 2.
Standard Value Range

Standard of Eligibility Score Range (%)	Conclusion
Score < 21	Very Unworthy
21 – 40	Not Feasible
41 – 60	Enough
61 – 80	Worthy
81 - 100	Very Worth it

RESULT & DISCUSSION

WEBGIS Design Results

System Architecture

This WEBGIS is named Banda Aceh City COVID-19 Vaccination which was built using the PHP, JavaScript, HTML, and CSS programming languages. The architectural system

consists of 3 dimensions where each dimension has its own components and tasks, namely the client dimension, support and service. The client dimension functions as a liaison between the user and the system via a web browser. In displaying the interface to the user it is supported by several components, namely JavaScript, CSS, HTML and Leaflets.

The support dimension consists of a web server, namely Apache, which includes the use of the Laravel framework. The service dimension consists of MariaDB which is a database server as a data provider. The database stores the data needed in WEBIGS. The data stored in the database is displayed in tabular form. Tables that store data on WEBGIS include data tables, sub-district boundary tables, village boundary tables, registration tables and user tables. ArcGIS Desktop is used to convert shapefile data into GeoJSON data. GeoJSON is used to store coordinate point geospatial data such as longitude or latitude, lines, points, and other spatial data. To display a map in a web browser, it requires the help of a JavaScript-based library, namely Leaflet.

Features and Functions

The design of this web-based geographic information system has 5 menus, namely Home, Route, Guide, Vaccination List and Login menus. The Home menu is the initial appearance of WEBGIS which displays information on vaccination achievements for each village and sub-district in Banda Aceh City in the form of graphs and maps. The Route menu displays the distribution points for vaccination locations and the route to that location. The Guide menu displays how to use this website. The Vaccination List menu displays the vaccination registration form and a map of location distribution along with patient capacity at each vaccination location. The Login menu functions as access to the admin layout. The admin layout is a special page for the admin where on that page the admin can add, change and delete data.

The design of this web-based geographic information system has features and functions on several menus, namely:

1. The Home menu functions to display vaccination achievements in the form of graphs, diagrams and maps. Each graph and map has 3 buttons, namely dose 1, dose 2 and dose 3 buttons, where each button will display information on vaccination achievements for each village and district per dose. On this home menu, the map that is displayed is a thematic map which on the map will display area boundaries whose colors are adjusted according to the number of vaccination achievements. On the map there is also a search feature to find the desired area, besides that there is also a pop up feature that displays information on vaccination achievement data for each dose in that area.
2. The Route menu functions to display the direction from the user's location point to the vaccination location point selected by the user. There is a search feature to search for vaccination locations and there is also a pop up feature to display the name of the location and a "go here" button.
3. The Guide menu functions to display a guide for using this web-based application, there are pictures and text that explain how to use it.
4. The Vaccination List menu displays a form for registering vaccinations at the selected location. There is a map that has a search feature to find the desired vaccination location and a pop up feature that displays information on the name of the location and the capacity of the vaccination patient at that location as well as a "go here" button. This registration data will later be sent to the database of vaccination outlets.
5. The login menu is an access menu to go to the admin layout, where on that page the admin can add, change, and delete data. On the admin page there is a data menu which has the added csv feature which functions to add csv files to this website. Then there is a print report feature which functions to print vaccination reports in pdf file form. In addition, there is also a search feature to find data on vaccination reports.

WEBGIS Design Implementation Results

WebGIS is designed to have 3 users, namely the community, vaccination outlets and admin (Health Office).

Community Layouts

The community layout has 5 menus namely Home, Route, Guide, Vaccination List and Login.

1. Home Menu
   When a user opens the COVID-19 vaccination WEBGIS for Banda Aceh City, a "Home" page will appear as an opening displaying information on vaccination achievements in the form of graphs, charts and maps.
2. Route Menu
   The Route menu contains points for vaccination locations in Banda Aceh City. On this page the user can search for a route to the desired vaccination location from the user's current position by entering the location name keyword then a pop up will appear containing information on the location name and a "go here" button, then route instructions will appear from the user's location to the vaccination location which has been selected.
3. Guide Menu
   The guide menu contains text and images that explain the guide for using this website.
4. Vaccination List Menu
   The Vaccination List menu contains a vaccination registration form which later the registration data will be entered into the vaccination outlet database. This page also provides a map of the distribution of vaccination locations which is included with a pop up feature. Where the pop up feature displays capacity information on the number of vaccinated patients at that location and the types of vaccines available.
5. Login Menu
   The Login menu is access to go to the admin layout (Health Service and vaccination booths). In this menu the Health Service and vaccination outlets will enter the email and password that has been registered by the admin.

Vaccination booth layout

The layout of the vaccination booth has 3 menus namely Registration Data, Verification, and guides.

1. Registration Data Menu
   The Registration Data menu contains data from people who have registered at that location. On this page, vaccination outlets must verify for people who have already been vaccinated.
2. Verification Menu
   The Verification menu contains data on people who have been verified as vaccinating. On this page, vaccination outlets can view data on people who have already been vaccinated. This page also provides a search feature to make it easier to find data.

Layout of the Health Office

Layout Health Office has 4 menus, namely Dashboard, Maps, Data and Guidelines.

1. Dashboard Menus
   The Dashboard menu is the start page when you first enter the admin layout. This page displays information on vaccination achievements in the form of graphs, charts and maps.
2. Maps Menu
   The Maps menu consists of 3 sub-menus, namely Village Maps, District Maps and Route Maps.
   a. Village Maps
      Village Maps displays information on vaccination achievements for each village in Banda Aceh City in the form of a thematic map which is divided into 3 color categories, namely red for 0% - 34% achievement, yellow for 35% - 69% achievement and green for 70% achievement. - 100%. On this page there is a search feature to find villages where you want to know the number of vaccination achievements, if you click on it, a pop up will appear containing information on vaccination achievements per dose. In addition, on this page there are also 3 buttons, namely dose 1, dose 2 and dose 3 which will display a thematic map based on the number of achievements per dose.
   b. District Maps
      District Maps display information on vaccination achievements for each sub-district in Banda Aceh City in the form of a thematic map which is divided into 3 color categories,

namely red for 0% - 39% achievement, yellow for 40% - 69% achievement and green for 70% achievement. - 100%. On this page there is a search feature to find villages where you want to know the number of vaccination achievements, if you click on it, a pop up will appear containing information on vaccination achievements per dose. In addition, on this page there are also 3 buttons, namely dose 1, dose 2 and dose 3 which will display a thematic map based on the number of achievements per dose.

c. Route Maps
Route Maps displays the distribution of vaccination location points. on this page the user can search for the desired vaccine location then a pop up will appear containing the name of the location and the “go here” button. If the button is pressed, a route will appear from the user's location point to the selected vaccination location.

3. Data Menu
   a. Vaccination data
   The vaccination data sub-menu contains data on vaccination achievements per village and per sub-district. On this page the admin can add data manually or by adding csv data. In addition, the admin can also change and delete data. On this page there is a print report feature that can print vaccination reports in pdf file format. Data from registrations that have been verified by vaccination outlets will be entered automatically on this page to add statistics on vaccination achievements in Banda Aceh City. This page also provides a search feature to make it easier to find data.
   b. Vaccination Site Data
   The vaccination location data sub menu contains data on the location of vaccinations carried out in Banda Aceh. On this page the admin can add, change and delete vaccination location data.
   c. Village Data
   The village data sub-menu contains data on village names and the GeoJSON file of the village. On this page the admin can also add, modify and delete data.
   d. District data
   The sub-district data sub menu contains data on the names of the sub-districts and the GeoJSON file from the village. On this page the admin can also add, modify and delete data.
   e. User Data
   The User Data sub menu contains user data registered as vaccination locations in Banda Aceh City.

Testing and Analysis

System testing aims to find out about the feasibility of WEBGIS. Usability testing is carried out using the USE (Usefulness, Satisfaction and ease of use) Questionnaire method. The USE Questionnaire method consists of 30 questions divided into 4 assessment sections consisting of 8 questions for usefulness of the system, 11 questions for ease of use, 4 questions for ease of learning and 7 questions for satisfaction (Satisfaction). Each question in this questionnaire uses a Likert scale with answer choices and scores, namely Strongly Disagree (STS) has a score of 1, Disagree (TS) has a score of 2, Neutral (N) has a score of 3, Agree (S) has a score of 4 and Strong Agree (SS) has a score of 5. Data collection from usability testing was carried out by filling out a questionnaire involving 30 respondents consisting of 24 respondents from the people of Banda Aceh City, 3 respondents from Banda Aceh City health workers and 3 respondents from the Health Office of Banda Aceh City.

Validity test

The answers from respondents who filled out the questionnaire were then tested for validity using the Analyze Correlate Bivariate tool on IBM SPSS Statistics. Each question item whose correlation value has been calculated will be compared with the coefficient value from the r-table. Based on the r-table calculation for a total of 30 respondents, with a significance value of 5%, the r-table coefficient value is 0.361. If each questionnaire item has a correlation value of more than 0.361 then the questionnaire item is declared valid but if the correlation value is less than the r¬¬-table then the questionnaire item is declared invalid. The results of

calculating Pearson's Product Moment correlation values that have been carried out for questionnaires filled out by respondents, there are 30 valid questions and 0 invalid questions. This means that all questions can be included in the reliability test.

Reliability Test

After testing the validity of the next step is testing reliability, namely by only using valid questionnaire items to do reliability analysis. Testing was carried out using a scale reliability analysis tool on IBM SPSS Statistics to obtain a Cronbach's Alpha value. The summary results of case processing for 30 respondents have 100% valid as shown in the following figure.

Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded[a]	0	.0
	Total	30	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.825	30

Figure 1.
Valid Data and Cronbach's Alpha User Values in SPSS

The results of the reliability test values in Figure 1 show the Cronbach's Alpha value for the user of 0.825; based on the table of reference values for the level of reliability in table 3.2 the range of values is in the very high category, it can be concluded that the questionnaire used is reliable as a usability measurement.

Usability Measurement

After the reliability test was carried out and the questionnaire items were declared valid, the usability test was then carried out. This test is carried out by calculating the maximum scale score and the observation score for each dimension of the question.
The number of respondents is 30 people with valid question items as many as 30 so that the maximum score for community users is 4500. The scoring score for each question item uses a 5-point Likert scale. Observation values are seen in the following table.

Table 3
User Observation Value

No	Dimensions	Valid Item	Max Score	Observation Score	%	Average
1	Usefulness	8	1200	1091	91,90	4,54
2	Ease Of Use	11	1650	1497	90,72	4,53
3	Ease Of Learning	4	600	526	87,66	4,38
4	Satisfaction	7	1050	897	85,42	4,27
	Amount	30	4500	4011		
	Average				88,67	4,43

Once it is known that the questionnaire items have proven to be valid and reliable, the usability value is calculated with the average result of filling out the questionnaire points by the user on the usefulness dimension, namely 4.54; the dimension of ease of use is 4.53; the ease of learning dimension is 4.38 and the satisfaction dimension is 4.27. The overall average total of respondents answered on a scale of 4.43

Usability measurement results for users are shown in table 3. It can be seen that the feasibility value of usefulness is 91.90%, ease of use is 90.72%, ease of learning is 87.66%, and satisfaction is 85.42%; The overall average dimension is 88.67%. So it can be concluded that usability for users is in the very feasible category.

CONCLUSION

WEBGIS development regarding COVID-19 vaccination in Banda Aceh City using the Laravel framework and the Leaflet library has been successfully created. This WEBGIS provides information on vaccination achievements for the sub-district/village level in Banda Aceh City in the form of printable graphs and maps for the three doses, as well as providing information on the distribution of vaccination locations and routes to these locations. In addition, this WEBGIS also provides a form for registration of vaccinations at selected locations, where information on patient capacity and types of vaccines available at the vaccination booth is also available on the form. The WEBGIS also provides a print report feature which can print vaccination reports in pdf file format. The WEBGIS test uses the USE Questionnaire method with an average score of 88.67%. Based on the score obtained by WEBGIS, it belongs to the very decent category.

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