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Visualizing Data Palm Oil Plantation in Indonesia: Interactive Map Prototype

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ABSTRACT

This journal Interactive Maps for Visualizing Palm Oil Plantation Data in Indonesia is related to software development process. The idea started from recognizing the opportunity to visualize information about palm oil plantation using interactive map with the aim of making information easier to find and increasing the attentiveness related information about pam oil plantation. The information is statistical data shown in tabular form in "National Leading Plantation Statistics" book which is published periodically every year and publicly accessed via official website of Directorate General of Plantations. The prototype approach chosen as Software Development Life Cycle (SDLC) methodology. This journal as an output after the initial prototype was built and usability testing was carried out. The initial prototype was implemented using several tools, one of the tools that significant in data visualization is the Plotly library in python programming language. The initial prototype implemented as a website and the interactive map displays several information such as production distribution, land area and other information as data per province in Indonesia. Usability testing is accomplished by inviting potential users to become respondents. Respondent tried the product and carried through specified tasks and then answered a questionnaire which is the questions were designed to observed whether the research objectives were successfully achieved. The results of the questionnaire showed that the product helps users find information better than statistical data in tabular form and increases user interest in palm oil plantations. Some inputs from user also used as a reference for future development of the product.

Keywords: Prototype methodology SDLC, Interactive Maps, Plotly, Usability Testing

Introduction

The rapid transition development of Information and Communication Technology is affecting many aspects of human life. One of significant changes is the use of paper as a media communication swift into digital form. This transformation also impacts a conventional map. The conventional map usually uses paper with static display changes into an animated and interactive one [1]. This digital form of map that is dynamic displaying information that adapt to user needs and trigger directly by the user called interactive map.

Interactive maps are a form of cartographic interaction. Cartographic means a way to combine science and art in making maps, while interaction in this concept is a dialogue that occurs between humans and maps through computer tools [2]. Refers to that explanation, Interactive maps can define as a geovisualization software that used to provide option for displaying geographic information interactively and eager user to explore more to conduct hypothesis and constructive knowledge[3].

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Interactive map is the other way to visualize statistical data. The aims of data visualization are to help understand the existing data (visual thinking) and to convey properly the information to the user (data visualization). Presenting data with interactive maps makes it easier for users to understand existing data, the relationship between one and another data more readably, especially in relation to spatial aspects [4]. Interactive maps are an effective communication option in attracting society to obtain and understand some information. Interactive maps can be a new leading transformation of social communication [5].

The idea of this research is to utilize the advantages of using interactive maps to support data service programs related to the dissemination of statistical data information, especially statistical data related to oil palm plantations in Indonesia. The need to disseminate statistical data in an effective way is also strengthened by Law of the Republic of Indonesia Number 16 of 1997 related Statistics Data, the contents of which reinforce that the public is given the same opportunity to know and gain benefit from data published by the Badan Pusat Statistik Indonesia[6] . To nourish the idea of building interactive map, data and information service become a substantial point as a technical support and it is mentioned in Strategic Plan of the Directorate General of Plantations, Ministry of Agriculture[7].

Palm oil plantations chosen as a topic considering that agricultural commodities especially palm oil plantations have a significant role in Indonesia's national income and foreign exchange. Based on export data from the Badan Pusat Statistik Indonesia (BPS) for January 2024, palm oil exports have become one of the leading commodities in the agricultural sector, even boosting the country's foreign exchange by contributing around 33.75 percent of total export income from agricultural sector[8]. Badan Pusat Statistic (BPS) regularly disseminates information regarding oil palm plantations. Every year BPS publishes the "Indonesian Plantation Statistics Book", including the book "National Leading Plantation Statistics". The book "National Leading Plantation Statistics" contains information on Palm Oil Plantation data such as: area, production, productivity both nationally and provincially which are categorized according to type of business status, as well as data on the export and import value of these commodities. This book was published as an effort to disseminate information so it can be used by various groups of society and as a reference in policy making [7].

Research questions addressed in this paper are:
1. Does an interactive map help recipients of information (especially information related to oil palm plantations) to understand better than the statistical data in tabular form that is currently used? (RQ1)
2. Test the selected tool to see whether it is suitable and meets the expectation especially in displaying the information (RQ2)

Aside from answering the research question, this paper also narrated the software product as an initial prototype for interactive map as a visualization palm oil plantation statistical data.

Materials and Prior work

A map as an instrument for visualizing data must be able to meet several user experiences so that it can be called an interactive map. There are 4 important things that need to be in place to produce an interactive multimedia experience[5].

a. Interactivity. Interactive is defined as the user can be involved in the selection process, configuration, display selection or various options to display several information reports.
b. Multimediality. Interactive maps make it possible to combine several other information formats, such as information in textual, visual or audiovisual.
c. Reticularity of reading. Maps as a form of spatial information can be added with customization features so the information will be presented as a desired or according to the user's personal needs criteria.
d. Participation. Interactive maps can also offer user participation in constructing information. For example, the information resource is from collaboration and participation between experts and the society. Some research utilizes interactive maps not only to provide information but also as a tool to prepare participation from society as a source of information. Projects like this are called citizen science[9], [10].

[1]openstreetmap : https://download.geofabric.de/asia.html

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Table 1. State of the art of interactive map

No	Publisher	Author	Published Year	Journal Title	Data	Developement Tools	Result
1	ACM	Yuanhui Lin and Daniel Gatica-Perez	2023	Characterizing Swiss Alpine Lakes: from Wikipedia to Citizen Science	Swisstopo, and Google API.	Google API	Interactive Map
2	(Sinta3) GeoID Journal of Geodesy and geomatics	Hanif Ilmawan, Purnama Budi Santosa	2021	Visualisasi Data Statistik Kabupaten Banyumas Menggunakan Peta Interaktif	Statistical Data: Number of Population, Population Density, Number of Population by Genre, Sex Ratio, Number of Births, Number of Deaths, Crude Birth Rate	StatPlanet	Interactive Map, Usability Test, Functionality Test
3	Teknik Geomatika ITS	Fakhrusy Luthfana Mahfudzh, Agung Budi Cahyon	2017	Pembuatan Peta Interaktif Berbasis Augmented Reality (Studi Kasus Kawasan Pariwisata Pulau Bawean)	Creating Bawean map data markers	ArcGIS 10.3, Blender, Sketchup, Unity 3D Engine 5.5	Interactive Maps use augmented reality where 3D images can be activated using an Android application
4	Jurnal Geodesi Undip	Kindly Ibrahim Hari, Aried Laila Nugraha, Moehammad Awaluddin	2015	Aplikasi Peta Interaktif Kabupaten Banyumas Berbasis Flash Sebagai Media Promosi Pariwisata	1. Location coordinate data for tourist objects is obtained from handheld GPS through field surveys 2. Administrative map and road network of Banyumas Regency in 2014, obtained from BAPPEDA Banyumas Regency 3. Data on the list of Banyumas Regency tourist attractions was obtained from the Banyumas Regency Sports, Culture and Tourism Office 4. Attribute data, obtained from the Banyumas Regency Sports, Culture and Tourism Office and field surveys	Adobe Flash CS5, Adobe Photoshop CS6, ArcMap10, Corel Draw X4, AutoCad 2007, Microsoft Office 2010, SWFKit Pro 3.5	Creating a map using Handheld GPS and Google Maps, Taking Google Maps points - assuming the point is with a friend Handheld GPS point taking - Google Maps Testing aspects of functionality Maintainability aspect, Portability aspect.
5	(Sinta3) GeoID Journal of Geodesy and Geomatics	Ardana Jati Adyatmanto, Muhammad Taufik, Abdul Munif	2012	Pembuatan Peta Interaktif Kampus ITS Sukolilo Surabaya Berbasis WEB	1. Satellite image of the ITS Sukolilo Surabaya campus area from Google Map 2011 as spatial data 2. Digital line map of the 2010 ITS Master Plan from PIMPITS as spatial data 3. 2006 Physical Building Master Book from NAPSI as non-spatial data 4. 2010 ITS Master Plan Road Development Plan Model from PIMPIITS as non-spatial data 5. Data on buildings, roads and rooms on the ITS Sukolilo Surabaya campus from field surveys as non-spatial data	Satelit Image Google Map : HTML5 dan Java Script,	Field Accuracy Analysis
6	Seminar Nasional Aplikasi Teknologi Informasi 2010 (SNATI 2010)	Iwan Handoyo Putro, Petrus Santoso, Eddy Nugroho	2010	Interactive Map supports Tourism Information Site	Peta kota malang dalam bentuk image (web)	Macromedia Dreamweaver MX - Design, MySQL5, dan PHP5	Added shortest route algorithm, and alternative routes

Research related to interactive maps is not a recently developed idea, several published papers show that interactive maps has been widely used to support various demands. The recap of research related to interactive maps is summarized in table 1.

Research conducted by Yuanhui Lin and Daniel Gatica-Perez utilized interactive maps to support the Citizen Project to disseminate information as well as collect information from society with the aim of increasing awareness of lakes in Switzerland [9]. This research uses the Google API to construct maps and makes them interactive with zoom features and displays detailed information when users access certain locations on the map.

There is also research related to the development of interactive maps that help with the promotional needs of a region in Indonesia. Among the research on interactive maps for tourism purposes are: Research conducted by Fakhrusy Luthfana Mahfudzh and Agung Budi Cahyon using interactive maps for the Bawean Island tourism area[11], Research conducted by Kindy Ibrahim Hari et al created an interactive map for the Banyumas tourism area[12], and research by Iwan Handoyo Putra et al created an interactive map for the city of Malang [13]. The interactive map in this research uses various tools such as ArcMap and Google Map Satellite Imagery to create the map, while the interactive features use HTML5, Java Script, Macromedia Dreamweaver and even Blender and Unity 3D to add 3D effects.

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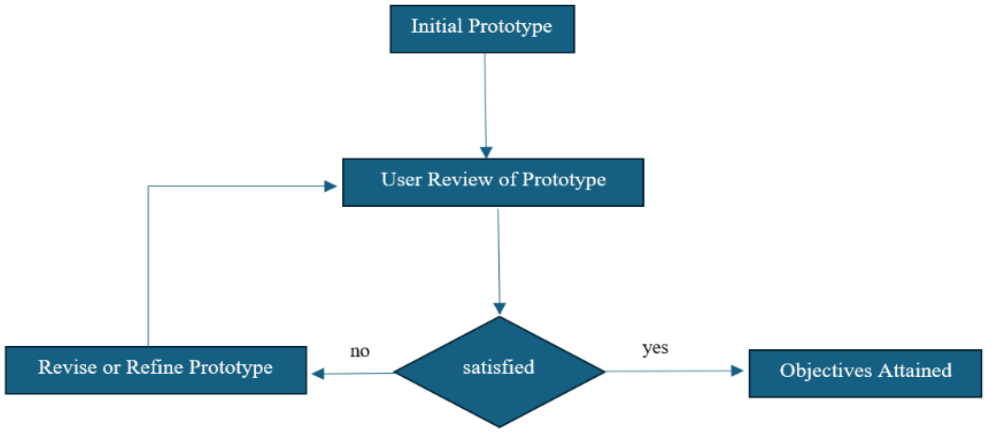

Figure 1. Prototype methodology

The use of interactive maps to support statistical data was also carried out in research conducted by Hanif Ilmawan and Purnama Budi Santosa. Their research uses interactive maps to display statistical data within the Banyumas district, Central Java. The statistical data used are: Number of Population, Population Density, Number of Population by Gender, Sex Ratio, Number of Births, Number of Deaths, Crude Birth Rate. Their research uses functionality testing and Usability Testing as additional results and discussions which are the output of the final stages of the software development life cycle[4].

Methods

SDLC Methodology

The research method used adapts to software development methods. Software development methods are known by terms such as the software process model or also known as the software development life cycle, which will later be shortened to SDLC. SDLC is a process that is generally used by the software development industry to produce a quality software product [14]. This process takes the form of a framework that defines what needs to be done at each stage of the software development process. The stages that generally exist in software development are panning, defining requirements, designing software architecture, development and testing[15]

The SDLC modeling that was first developed was the waterfall model, which is an example of the application of the plan driven principle. The stages in the waterfall model show the fundamental components of the activity phases. The stages are as follows: Requirements analysis and definition, System and software design, Implementation and unit testing, Integrating and System Testing, and Operation and maintenance

The waterfall method was developed into several other methods to suit the needs of software development itself. One form of waterfall development is the prototype approach model. Prototype is a software development method that adopts the manufacturing industry, namely reconstructing a prototype as a model which is a simulation or part of a system implementation to test the feasibility of the product to be developed, by looking at various aspects such as the technical aspects of implementing the system or in some cases can help describes user requirements for the system to be developed[16].

The SDLC Prototyping method allows system developers to demonstrate existing features in the system before implementing it, thus giving users the opportunity to try the system at an early stage of system development, this can help them to understand and clarify what they want from the system to be developed [17]. Looking at the advantages of SDLC using the prototype method, this method is suitable to be applied for

[1]openstreetmap : https://download.geofabric.de/asia.html

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system development in this research, which is an initial project for developing interactive maps of oil palm plantations in Indonesia.

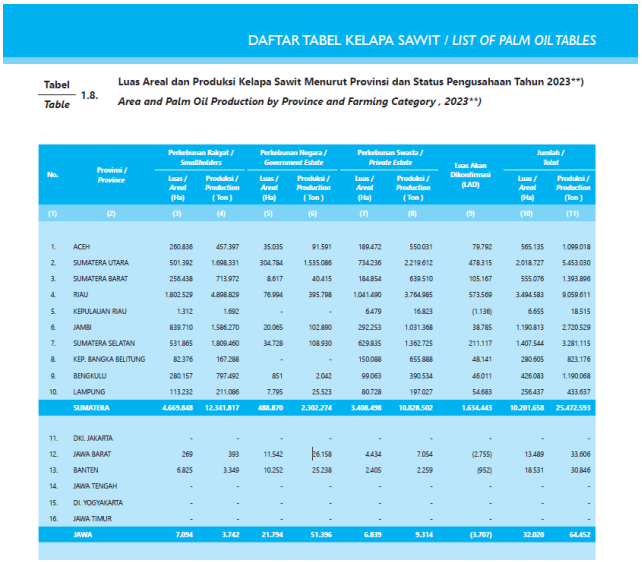
In general, Prototype does not replace traditional SDLC, but rather complements [18]. The flow of the SDLC Prototyping stages can be seen in Figure 1[16]. In this picture the initial prototype was built, a review of the prototype was immediately carried out, and the results of the review will be used for subsequent development. When the prototype has been designed and developed, usability testing is performed to obtain qualitative data [19].

A base map is needed before developing interactive map. Qgis is used to create the base map. Quantum Geographic Information System (Qgis) is a geographic information system (GIS) that is free, open-source, cross-platform and scalable[20]. Qgis is used to extract provincial maps of Indonesia.

The map visualization was built using the Python programming language. Python is a high-level programming language [21]. Python library was used to create visualization data in the shape of interactive map. Plotly is a visualization library that offers rich features for creating web-based dashboards and data visualization [22].

This Python-based web development utilizes the Flask framework to help organize interactions between the frontend and backend. The front-end in web development is in charge formin the behavior, substance and design which is displayed on user side (on screen) when the application runs [23]. The backend is server-side programming that bridges communication between application and the database [24]. The flask framework is a website framework to structures code and library for building a website and to manage communication between front-end and back-end. Flask task is managing the receipt of requests via URL and how to respond to these requests [25]. The front-end is built using .html along css settings, while the backend especially for the database use MySQL. MySQL is a popular open-source database management system.

Data Resource



DAFTAR TABEL KELAPA SAWIT / *LIST OF PALM OIL TABLES*

Tabel / *Table* 1.8. Luas Areal dan Produksi Kelapa Sawit Menurut Provinsi dan Status Pengusahaan Tahun 2023**) / *Area and Palm Oil Production by Province and Farming Category , 2023***)*

No.	Provinsi / Province	Perkebunan Rakyat / Smallholders		Perkebunan Negara / Government Estate		Perkebunan Swasta / Private Estate		Luas Akan Dikonfirmasi (LAD)	Jumlah / Total	
		Luas / Areal (Ha)	Produksi / Production (Ton)	Luas / Areal (Ha)	Produksi / Production (Ton)	Luas / Areal (Ha)	Produksi / Production (Ton)		Luas / Areal (Ha)	Produksi / Production (Ton)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1.	ACEH	260.836	457.397	35.035	91.591	189.472	550.031	79.792	565.135	1.099.018
2.	SUMATERA UTARA	501.392	1.698.331	304.784	1.535.086	734.236	2.219.612	478.315	2.018.727	5.453.030
3.	SUMATERA BARAT	256.438	713.972	8.617	40.415	184.854	639.510	105.167	555.076	1.393.896
4.	RIAU	1.802.529	4.898.829	76.994	395.798	1.041.490	3.764.985	573.569	3.494.583	9.059.611
5.	KEPULAUAN RIAU	1.312	1.692	-	-	6.479	16.823	(1.136)	6.655	18.515
6.	JAMBI	839.710	1.586.270	20.065	102.890	292.253	1.031.368	38.785	1.190.813	2.720.529
7.	SUMATERA SELATAN	531.865	1.809.460	34.728	108.930	629.835	1.362.725	211.117	1.407.544	3.281.115
8.	KEP. BANGKA BELITUNG	82.376	167.288	-	-	150.088	655.888	48.141	280.605	823.176
9.	BENGKULU	280.157	797.492	851	2.042	99.063	390.534	46.011	426.083	1.190.068
10.	LAMPUNG	113.232	211.086	7.795	25.523	80.728	197.027	54.683	256.437	433.637
	SUMATERA	4.669.848	12.341.817	488.870	2.302.274	3.408.498	10.829.502	1.634.443	10.201.658	25.472.593
11.	DKI. JAKARTA	-	-	-	-	-	-	-	-	-
12.	JAWA BARAT	269	393	11.542	26.158	4.434	7.054	(2.755)	13.489	33.606
13.	BANTEN	6.825	3.349	10.252	25.238	2.405	2.259	(952)	18.531	30.846
14.	JAWA TENGAH	-	-	-	-	-	-	-	-	-
15.	DI. YOGYAKARTA	-	-	-	-	-	-	-	-	-
16.	JAWA TIMUR	-	-	-	-	-	-	-	-	-
	JAWA	7.094	3.742	21.794	51.396	6.839	9.314	(3.707)	32.020	64.452

Figure 2.capture book of "National Leading Plantation Statistic 2021 – 2023"

This research uses statistics data published periodically by the Direktorat Jendral Perkebunan Indonesia. This statistics data can be accessed publicly within the book with the title "National Leading Plantation Statistics 2021 – 2023" on the official website of Direktorat Jenderal Perkebunan Indonesia. Figure 2 is a cut image from that book, that information related to oil palm plantation data.


```
{
"type": "Feature",
"properties": {
    "OBJECTID": 1,
    "PROVINSI": "ACEH",
    "Shape_Leng": 27.455786151800002,
    "Shape_Area": 4.6254360171100002 },
    "geometry":
      { "type": "MultiPolygon",
       "coordinates": [ [ [ [ 97.391782109956466, 2.037480907018278, 0.000026499998512 ], ..
        [ 97.388986974769125, 2.03754087830896, 0.000026499998512 ], [ 97.387601960362247, ..
         ...
         ...
         ...
         ...
        [ 95.118828314974792, 6.071350416788334, 0.000026499998512 ], [ 95.118729348180921, ...] ] ] ]
      }
    }
}
```


Figure 3. Example geojson file data of Aceh province.

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Figure 4. Interactive Map of Indonesia Palm Oil Plantation

The data used to develop the interactive map is size of area palm oil plantation and production per ton in 2023 according to the province of Indonesia and Plant Status (Smallholders, Government Estate and Private Estate).

The Province of Indonesian map extracted form map created by the OpenStreetMap community[1]. We extracted the province data and converted into a file of type geojson. Figure 3 is a snippet of the extracted data of Aceh province that store in geojson file.

Data Usability Testing

Usability testing consist of several important attributes: learnability, efficiency, memorability, errors and satisfaction [26]. Learnability is how easy the system to learn, efficiency is how the system can increase productivity, memorability is how the use and information provided in the system is easy to remember, Errors is the absence of errors that appear and satisfaction is seeing how the system can be accepted and liked by users [27].

Usability testing is performed by inviting users to test the initial prototype. Users will be given assignments as instructions, asked questions associated with the assignments given. Users are also given free time to explore the prototype products. After the task is completed, the user will answer the questionnaires. Users who have completed the given task and provided feedback called respondents.

The tasks that need to be done are:

1. Read a statistics book (digital version) related to palm oil for data for 2023. Then look for the following information:
   - Province with the largest production data
   - Province with the smallest production data
   - Province with the largest oil palm plantation area data
   - Province with the smallest data on oil palm plantation area

Figure 5. Information shows when the cursor is directed at the province of North Sumatra

[1]openstreetmap : https://download.geofabric.de/asia.html

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2. Use the interactive map and look for the following information
   - Province with the largest production data
   - Province with the smallest production data
   - Province with the largest oil palm plantation area data
   - Province with the smallest data on oil palm plantation area

The questions asked to users are:

1. Is the interactive map easy to operate? (RQ2)
2. Is the color display comfortable to look at and not boring? (RQ2)
3. Is the written information on the interactive map easy to read? (RQ2)
4. Does the additional information on the right side of the map (legend) help the information search process? (RQ2)
5. Is the requested information easier to find compared to digital statistics books? (RQ1)
6. After using the interactive map, does some information become easier to remember? (example of provinces producing the largest palm oil production in Indonesia)" (RQ1)
7. Do users gain new insights / new knowledge from viewing this interactive map? (RQ1)
8. Do users interested in knowing more about the distribution of palm oil data in Indonesia? (Examples of production data, land area data and human resource data) (RQ1)
9. Do users interested in knowing more about data statistic of palm oil plantation, which is Indonesia's leading agricultural export commodity? (RQ1)

Open questions to get feedback from users:

1. What information do users remember most, after using an interactive map?
2. Write feedback regarding interactive maps.
3. For future development, What information do users want on an interactive map?

Result and Discussion

Initial Prototype

The initial prototype is an interactive map website. The screen shot when user access website is in Figure 4. The interactive map is connected to a database with statistical data of oil palm plantation production in 2023.

The colors on the interactive map show information about the area in hectare of oil palm land in each province. The redder the color, the largest area of oil palm land in that province. From this interactive map the province with the largest area of oil palm land is Riau, then followed by West Kalimantan and Central Kalimantan. The color differences according to the total oil palm area per hectare can be seen in the legend on the right side of the map.

This interactive map can show detailed information on each province by pointing the cursor at the desired province. The action example is in Figure 5. This image illustrates when the cursor is directed at the province of North Sumatra.

Figure 6. Province of Jakarta appears after the map is zoomed in and the position is adjusted

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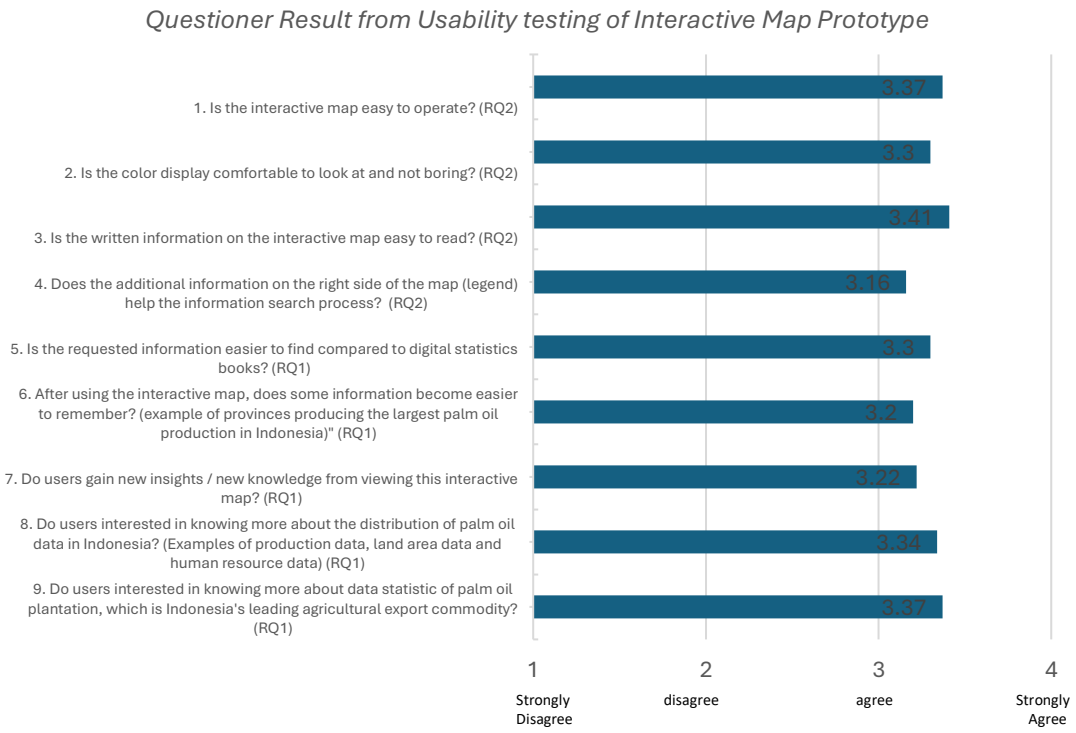

Figure 7. Bar graph show questioner result

Other features from interactive map are users can do zoom in, zoom out and swipe left - swipe right in order to find the information they need. For example, when user looking for the province of Jakarta or DIY which has a smaller area compare the other provinces, the map needs to be zoomed in to find the specific location. Figure 6 shows the province of Jakarta appears after the map is zoomed in and the position is adjusted.

Results of Qualitative Testing Initial Prototype

There were 71 respondents who performed usability testing on initial prototype products that had been developed. Usability testing was performed by palm oil polytechnic students N=53, employees (lecturers and education staff) N=11 and SMK students who were doing internship work at the palm oil polytechnic N=4. The average age of respondents was 22.28 years (minimum = 19 years and maximum = 43 years), with a gender distribution of N = 24 women and N = 17 men.

Result of the questioner result is shows as graph in figure 8. The highest score is in question “the written information on the interactive map is easy to read” with 3.41 point as a mean score (where a score of 4 is completely agree).

The next highest value with 3.37 point as a mean score was obtained from the following questions: "Is the interactive map easy to operate?" and " Do users interested in knowing more about data statistic of palm oil plantation, which is Indonesia's leading agricultural export commodity?".

From these questions, it can be concluded that the aim of the interactive map to make easier user for gaining information about palm oil plantation and to increases user curiosity regarding the agricultural commodity especially palm oil plantation, which is one of the objectives of disseminating agricultural commodity statistics books is accomplished.

The research question was also answered in the question "Is the requested information easier to find compared to digital statistics books?" which is obtained a 3.3 point of mean score. Based on questions which is mapped to the research objectives (RQ1 and RQ2), the initial prototype goal was fulfilled.

Several open questions were also asked to obtain feedback from users for the next prototype development. Table 1 is collected feedback grouped based on similarity topics.

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Table 2. collected feedback grouped based on similarity topics

Details of district data	16
Detailed of CPO production company/factory	14
Appearance (some did not specify what kind of attractive appearance, two respondents related to color, asked to clarify, user friendly, sentences)	6
Updated information for each year	6
Add searching function	3
International Data	2
Data distribution of CWE Polytechnic students	1
Other information outside the scope of research (palm price/profit, export data, history, issue, ranking, percentage, scale, etc.	10
More details (some not specified the request, one respondent asked for details data per block)	7
No meaningful feedback (It's good, enough, nothing, etc.)	6

Some of the suggestions are interactive maps should display more detailed information, such as district data (not just provincial data), CPO production company/factory data, international data and so on. Some feedback also related to additional displays and features for the interactive map.

Conclusions

This research is software development project for a website-based interactive map. This software is developed using a prototype software development life cycle methodology. There are two important objectives of this research : finding out whether interactive maps are more effective in conveying information (especially related to oil palm plantation data) compared to statistical data in tables format, and testing whether the chosen tool can meet system needs.

This research report is a progress report from the development of the initial prototype. The initial prototype is developed using several tools chosen by the research team to support interactive maps features. Tools that used to develop this interactive map are : python as programming language, flask as a website framework, mysql as a database, html and css as a web display, and Plotly as a library that significanly contribute to the features.

Usability testing is carried out to see whether the research question is fulfiled as well as to get feedback from users as an inputs for further development. The Result conducted from usability test shows that the goal of the interactive map to make easier user in gaining information about palm oil plantation and to increases user curiosity regarding the agricultural commodity especially palm oil plantation is achieved. Some feedback also recorded as a reference for next development.

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