Geographic Information System Mapping of Plantation

Pramuditha Shinta Dewi Puspitasari, Arvita Agus Kurniasari, & Trismayanti Dwi Puspitasari[*]

Politeknik Negeri Jember, Mastrip POBOX 164, Jember 68101, Indonesia

Abstract

Perusahaan Daerah Perkebunan (PDP) Kahyangan is a Regional Owned Enterprise in Jember Regency which was formed to realize the prosperity of the community. In Regional Regulation Number 2 of 2012-chapter 3 clauses 2, the government can manage regional finances by exploring sources of Regional Original Income, one of which is from the PDP. In addition, the purpose of the establishment of the PDP is as a means of developing the economy in the context of regional development by increasing productivity from all aspects to increase regional income. The main commodities are coffee and rubber, cloves, Mahoni, and Sengon wood are supporting commodities. Based on interviews PDP's profit contribution to Jember's income has continued to decline in recent years due to the absence of good management of its potential. So, this research will manage a system that can assist in obtaining information about the distribution of plantation land commodities in Jember, as well as mapping existing commodities by Geographic Information System (GIS). The method for developing GIS uses a Design Sprint. The output of this method prototypes and will implement in the GIS application.

Keywords: Design Sprint, Geographic Information System, GIS, Plantation

1. Introduction

Perusahaan Daerah Perkebunan (PDP) Kahyangan is a Badan Usaha Milik Daerah (BUMD) in Jember Regency which was formed to realize the prosperity of the community (Wibowo et al., 2019). In Peraturan Daerah Number 2 of 2012-chapter 3 clause 2, the government can manage regional finances by exploring sources of Regional Original Income, one of which is from the PDP. In addition, the purpose of the establishment of the PDP is as a means of developing the economy in the context of regional development by increasing productivity from all aspects to increase regional income. PDP manages many of the products in its three main estates and two sub-gardens. The main products are coffee and rubber, and clove, mahogany and segon wood as supporting products. Based on interviews conducted, the contribution of Jember's PDP benefits to Pendapatan Asli Daerah (PAD) has continued to decline in recent years due to poor management of its potential. In 2020 the PAD target from plantation products is 20 million rupiah, but the realization is only 20%, which is 4 million rupiah. So, it has been identified as an area of urgent priority research.

The aim of this research is to plan and manage natural resources carefully, this is very necessary in plantation development in order to increase Jember PAD through PDP. It will be much easier to increase plantation commodity output in a sustainable manner if information on the potential of land resources for the expansion of plantation commodities is readily available. One of the main pieces of information needed for plantation expansion is spatial data (map) of land resource potential since it provides essential information on the distribution, area, level of land suitability, limiting restrictions, and alternative technologies that can be applied (Oematan, 2020). The geographic information system (GIS) is a spatial technology that greatly facilitates planning (Boyacı & Şişman, 2022). In addition to being used for managing geographical data, GIS technology can be used to improve decision-making with relation to planning land use and increasing food production (Bhermana et al., 2021)(Yadav et al., 2016).

In light of the issues raised, it is clear that PDP Jember requires an application that will help with data collection about the distribution of plantation and forestry land commodities in Jember as well as GIS mapping of current plantation and forestry land commodities. The PDP Jember government is expected to devote more attention to the possibilities for plantation production on PDP territory as a result of making this application.

---

[*] Corresponding author.
E-mail address: arvita@polije.ac.id

2. Research Methods

A methodology has a short duration of three to five days. It combines activities to respond to a problem with creative ideas and a tested prototype as the final result is called Design Sprint (Sanglier Contreras et al., 2021). The design sprint is appropriate for a project requiring limited time to get a solution because it is a shortcut that can be used before creating and launching an application (Puspitasari & Anita, 2019). So it is suitable for making an application with a limited budget. The Design Sprint method guides designers and developers on their goals (Toda et al., 2019). A geographic Information System (GIS) is a tool for mapping (Alami Merrouni et al., 2018). The territory geography is described in three dimensions structural, spatial, and temporal (Sassi et al., 2020). In this research, spatial dimensions are used for implementation in application. Spatial means longitude and latitude to know the area of the plantation. The research methods for this research look in Fig 1.

Fig. 1. Design System.

The research phases depicted in Figure 1 commence with implementing the Design Sprint Process, a system development method. It is implemented to produce GIS applications based on the system's development. The resulting system is then put to the test. The system development phases will be evaluated if there is a mismatch in the system's output.

3. Results and Discussion

The design sprint consists of five stages: understanding, digressing, deciding, prototyping, and validating (Jones & Schou, 2022). The following is an explanation of each step of the design sprint:

3.1. Understand

Fig. 2. Design Sprint of Understand.

Understand took the initial step to equate a perception of a research discussion (Wales & Wales, 2022). At this stage, digging for information is needed by interviewing several experts or experts in plantations and production. The resource persons (experts) in this study were Mr. Sofyan Sauri, S. M., as the main director, and Mr. Moh. Ismail Haqiqi, S.T.P., as director of the production, marketing, and development at Perusahaan Daerah Perkebunan (PDP) Kahyangan Jember Regency. The following is the identification of the problems obtained, among others, namely:

1. Data on the planted areas for main products such as coffee, rubber, and cloves in the Perusahaan Daerah Perkebunan (PDP) Kahyangan is still not presented spatially.

2. Data on the planting area for supporting products such as mahogany and sengon wood from the Perusahaan Daerah Perkebunan (PDP) Kahyangan has not yet been presented spatially.
3. Based on the description above, the problem is that there is no geographic information system to provide information on the area of planting land in the Perusahaan Daerah Perkebunan (PDP) Kahyangan. The existing data so far is only in the form of a table without knowing the objective area.
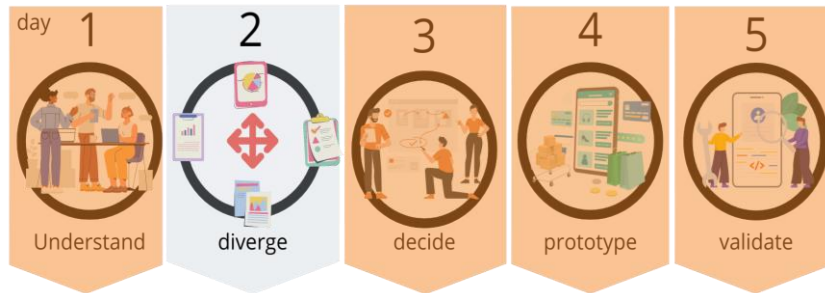
3.2. Diverge

Fig. 3. Design Sprint of Diverge

The next stage is divergence. Individuals from each IT team carry out this stage by providing as many ideas as possible. Thoughts or pictures can be in the form of plantations or from technology that will be used to describe the features that will be applied to the application (Fransiska et al., 2022).

3.2.1. Spatial Data

1) Polygon Layers

The process of the map design stage is done by creating layer polygons, which are used to determine areas or objects based on their location. A polygon layer consists of 5 main layers, where the site is part of the plantation in the land area belonging to the Perusahaan Daerah Perkebunan (PDP) Kahyangan. Here are the five land areas:

    a. Desa Magisan
    b. Gunung Pasang
    c. Sumber Wadung
    d. Desa Pace
    e. Desa Gelang

2) Point Layers

The map design stage is done by creating a point layer, which is used to determine the block area and distribution of planting land. Layer points also provide information in the form of space and the land area's height. The following are some sample point layer data for producing land blocks.

Table 1. An example of a point layer data.

Id	Name	Latitude	Longitude
1	Blok Tempur 1-3-4-5	-8.25905	113.801
28	Blok C 9-12 / D 9-10 / E 9-10	-8.26504	113.8065
29	Blok E 2-6	-8.27	113.8086
40	Blok Swd 17-19	-8.24384	113.8058
59	Gentong I	-8.09214	113.6334
60	Gentong II	-8.09099	113.6357
79	KP I	-8.07504	113.6319
98	GP III	-8.09605	113.6259
104	Boma III	-8.10861	113.6261

3.2.2. Non-Spatial Data

Non-spatial data is data that describes complementary attribute data for data information outside of geospatial information. The data consists of a description of land data, land area, and land height data. Here are some examples of non-spatial data for planting land blocks.

Table 2. An example of non-spatial data.

Id	Section_Id	Name	Description	Area	Elevation
1	3	Blok Tempur 1-3-4-5	Blok Tempur 1-3-4-5 Deskripsis	6.1	365
28	4	Blok C 9-12 / D 9-10 / E 9-10	Blok C 9-12 / D 9-10 / E 9-10 desc	27.3	349
29	4	Blok E 2-6	Blok E 2-6 desc	13.86	361
40	6	Blok Swd 17-19	desc Blok Swd 17-19	7.04	349
59	7	Gentong I	Legger Kopi TM	15.99	550
60	7	Gentong II	Legger Kopi TM	19.77	571
79	8	KP I	Legger Kopi TM	10.38	683
98	9	GP III	Legger Karet TM	20.03	464
104	9	Boma III	Legger Karet TTAD	22.58	380

The following is an overall description of the relational database of spatial data and non-spatial data.
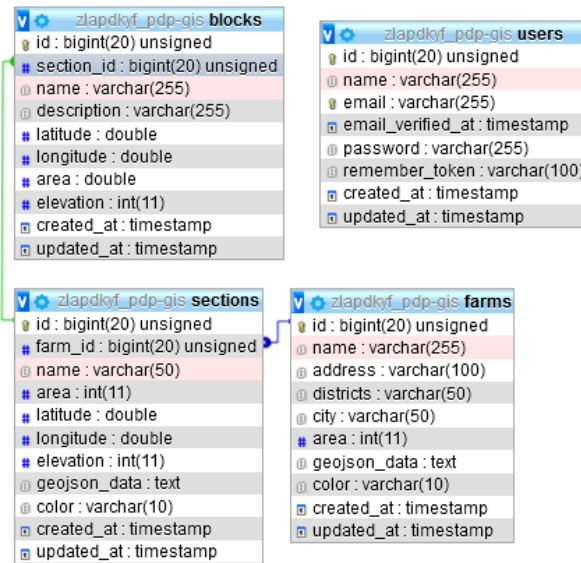

Fig. 4. Relation Database.
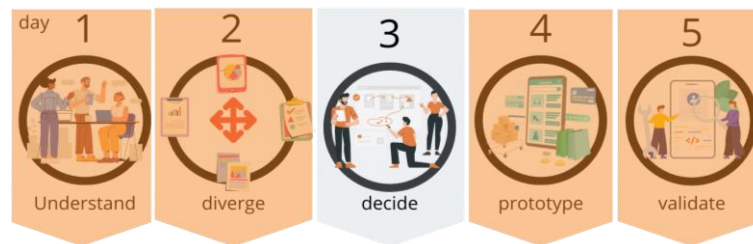
3.3. Decide

Fig. 5. Design Sprint of Decide.

The stage on the third day is decided. In this stage, the Teams gather to determine the best design by voting. The following illustrates the flowchart of the Geographic Information System Mapping of Plantation method (Khoirunisa & Ramadhani, 2022).
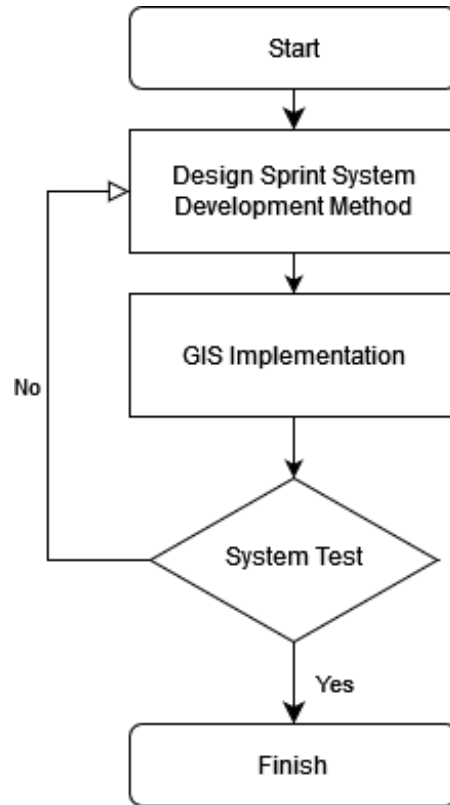

Fig. 6. Flowchart System.

The research stages in Figure 6 begin with the application of the system development method, the method used is the Design Sprint Method. This method is a framework based on Design Thinking. Design thinking in question is a framework that is carried out in a short time, which will then be used to solve existing problems. The research has been carried out by researchers using the Design Sprint method (Puspitasari & Anita, 2019). Then a test is carried out on the resulting system. If there is a discrepancy with the system's output, the stages of system development will be reviewed.
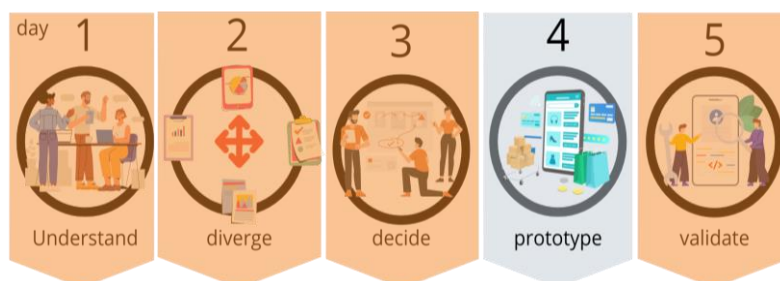
3.4. Prototype

Fig. 7. Design Sprint of Prototype

This stage will design the system's interface that will be made based on the approved system design (Anggraini et al., 2022). The main page is a map display of land design in Perusahaan Daerah Perkebunan (PDP) Kahyangan, which appears when you first open the application.

Fig. 8. Main Page

If one of the markers is pressed, a detail of one of the details will appear from the view of the Land village in the Perusahaan Daerah Perkebunan (PDP) Kahyangan. Detailed village data consists of harvested area, production, and the village land.
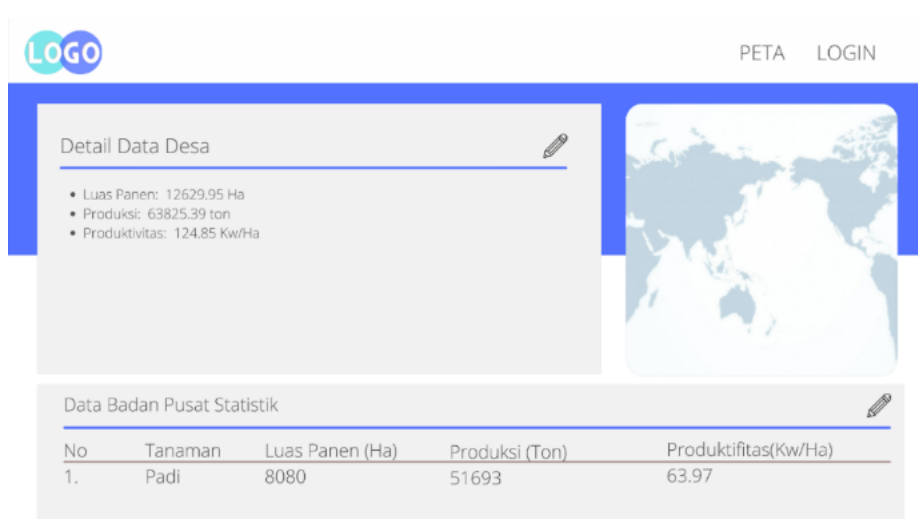

Fig. 9. Map Details

3.5. Validate

Fig. 10. Design Sprint of Validate

In the last stage, the prototype is tested directly to potential users. The goal is to get feedback from the user by knowing whether the built system follows the design and process (Thoring et al., 2022). If the results obtained are not following the initial plan, the Team will adjust according to the wishes of the prospective user. This stage minimizes the occurrence of errors during the program code implementation process. So, this step is crucial to do to get maximum results.

3.5.1. App View

1) Land Map Display

Provide information on planting land at the Perusahaan Daerah Perkebunan (PDP) Kahyangan. The information provided includes the area of the garden village in the land area, the planting area's location, and information on the spot and elevation of the site.
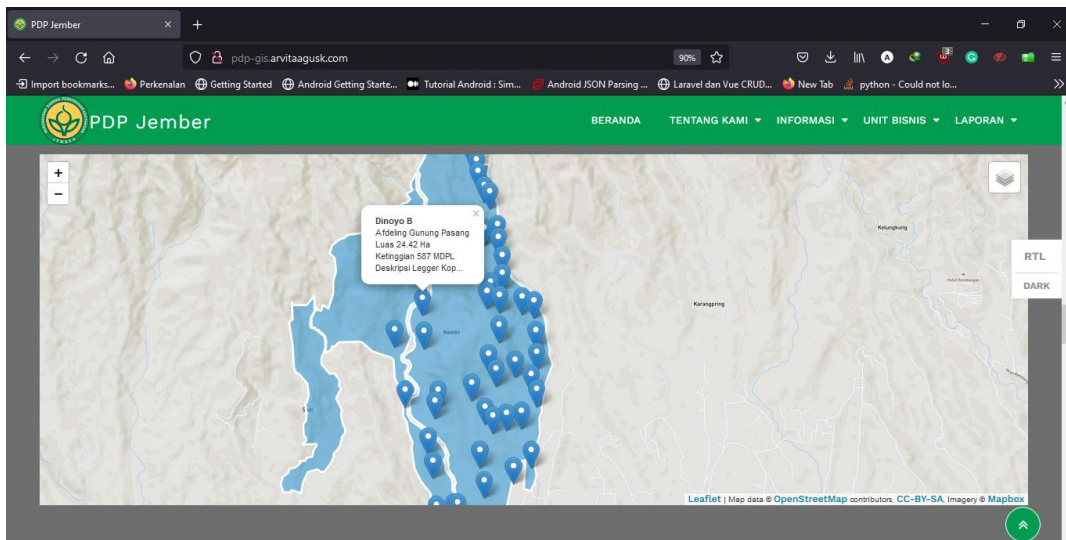

Fig. 11. Land Map

2) Admin View

Map description managed by the Perusahaan Daerah Perkebunan (PDP) Kahyangan, admin can add users, manage planting land, blocks, and afdeling.
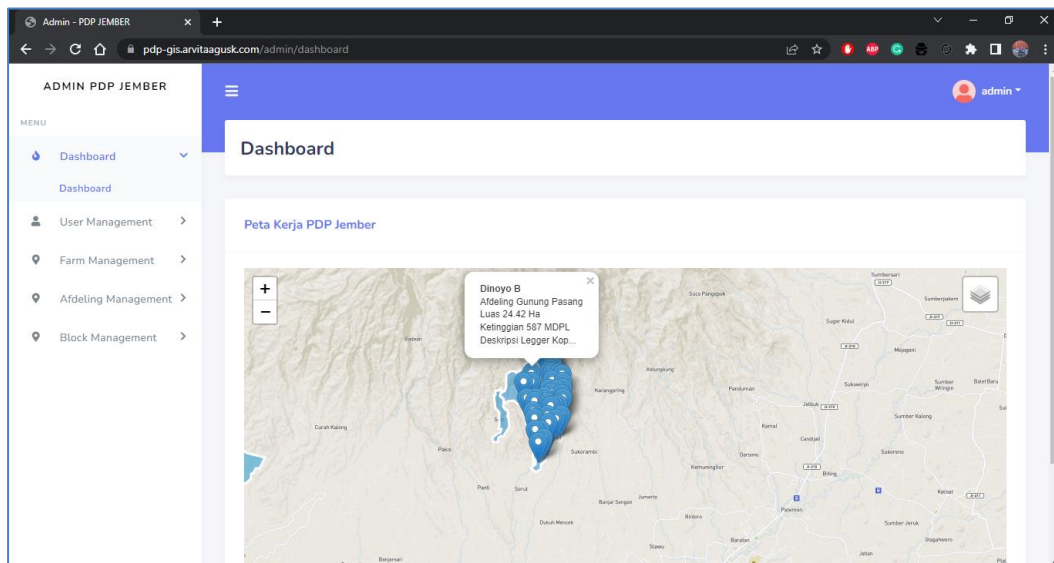

Fig. 12. Admin Dashboard

3) User Management View

In this menu, the admin can add, change, and delete a new user who can manage this application through the admin side.
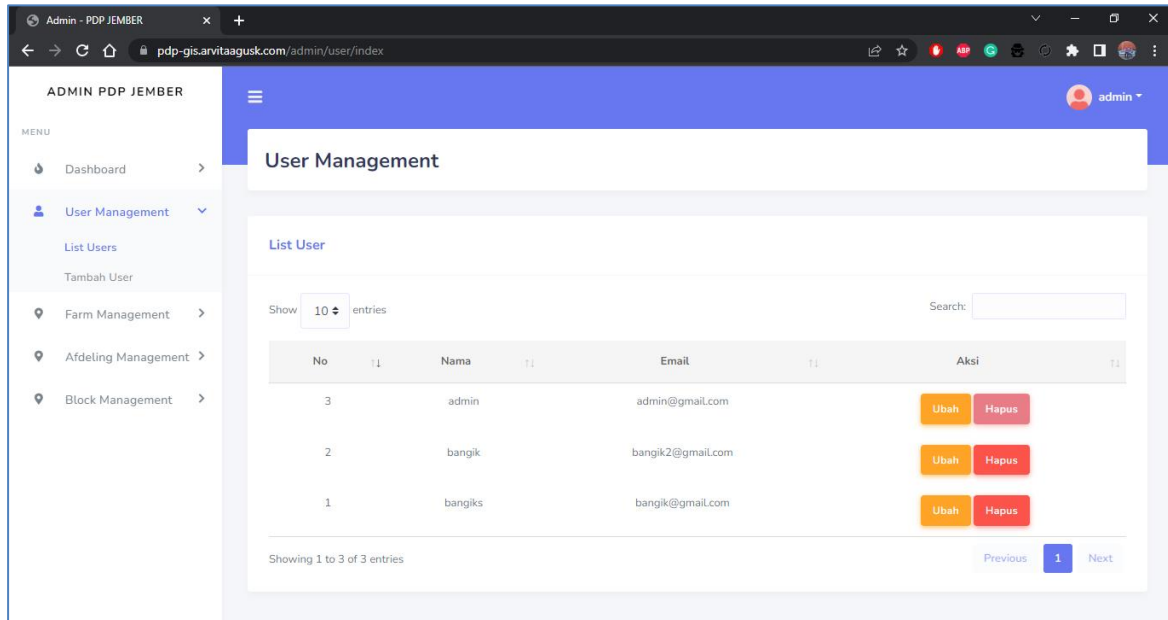

Fig. 13. User Management

4) Farm management view

The admin can manage existing plantations on the menu by directly adding, changing, and deleting plantation data in the Perusahaan Daerah Perkebunan (PDP) Kahyangan.
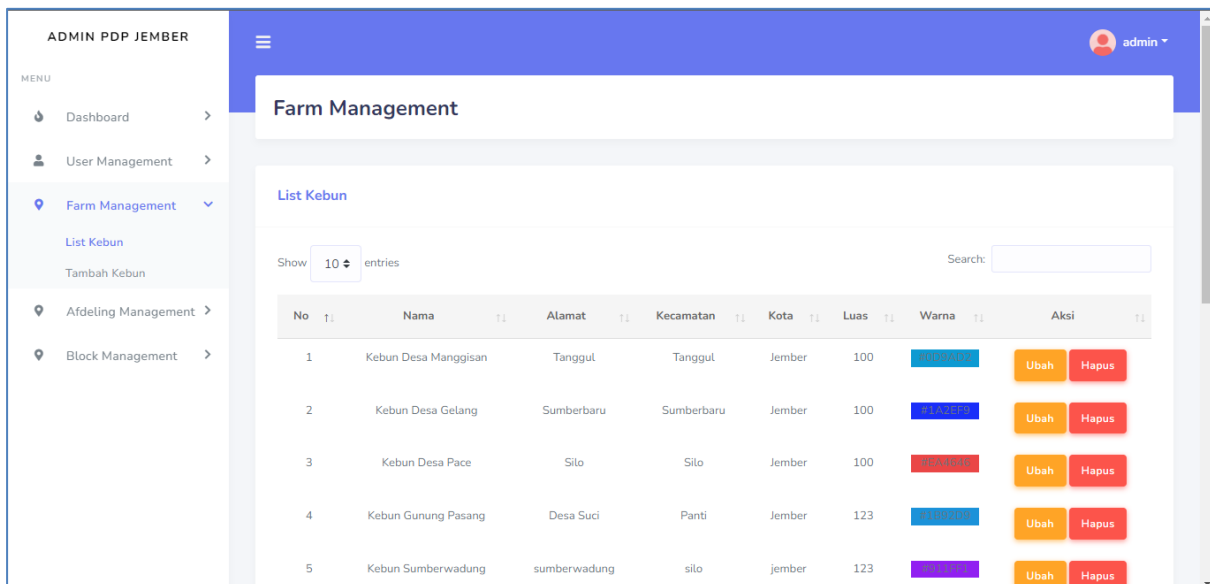

Fig. 14. Farm Management

5) Afdeling Management View

In this menu, the admin can add, change, and delete afdeling data on each plantation land owned by the Perusahaan Daerah Perkebunan (PDP) Kahyangan.

Fig. 15. Afdeling Management

6) Block Management View

In this menu, the admin can add, change, and delete data blocks in each data distribution for each plantation area at the Perusahaan Daerah Perkebunan (PDP) Kahyangan.

Fig. 16. Block Management

3.5.2. Questionnaire Test

Questionnaire testing is a stage of testing that combines data collected through questionnaires administered by respondents who test GIS apps (Kamińska et al., 2022). Respondents who are workers of the Perusahaan Daerah Perkebunan (PDP) Kahyangan (PDP) responded to questionnaire questions to collect data.

Table 3. XYZ Method Performance Test Results

No	Assessment Criteria	Grade	Range Value
1	Strongly agree	A	80-100
2	Agree	B	60-79
3	Disagree	C	40-59
4	don't agree	D	20-39
5	Strongly Disagree	E	0-19

The results of this assessment were obtained based on the respondents' answers through the distributed questionnaire questions.

1) Is the appearance of this application attractive to employees or visitors of the Kahyangan PDP GIS application?

Table 4. Respondents' Assessment Results

No	Assessment Criteria	Grade	Range Value
1	Strongly agree	7	70%
2	Agree	3	30%
3	Disagree	0	0%
4	don't agree	0	0%
5	Strongly Disagree	0	0%

In Table 4, the observations made based on the application's appearance attract employees or visitors to the Kahyangan PDP GIS application. Respondents stated strongly agree as much as 7 or 70%, stated agree as much as 3 or 30%, said less agree 0 respondents or 0%, stated disagree 0 respondents or 0%, and stated strongly disagree 0 respondents or 0%.

2) Is this application easy to reach for employees or visitors of the Kahyangan PDP GIS application?

Table 5. Respondents' Assessment Results

No	Assessment Criteria	Grade	Range Value
1	Strongly agree	8	80%
2	Agree	2	20%
3	Disagree	0	0%
4	don't agree	0	0%
5	Strongly Disagree	0	0%

Table 5 shows the observations made based on the appearance of the application, easy to reach for employees or visitors of the Kahyangan PDP GIS application. Respondents stated strongly agree as much as 8 or 80%, stated agree as much as 2 or 20%, stated less agree 0 respondents or 0%, stated disagree 0 respondents or 0%, and said strongly disagree 0 respondents or 0%.

3) Does the application positively impact employees or visitors of the Kahyangan PDP GIS application?

Table 6. Respondents' Assessment Results

No	Assessment Criteria	Grade	Range Value
1	Strongly agree	7	70%
2	Agree	3	30%
3	Disagree	0	0%
4	don't agree	0	0%
5	Strongly Disagree	0	0%

In Table 6, the observations made based on the application positively impact employees or visitors of the Kahyangan PDP GIS application. Respondents stated strongly agree as much as 7 or 70%, stated agreed as much as 3 or 30%,

stated less agree 0 respondents or 0%, stated disagreed 0 respondents or 0%, and said strongly disagree 0 respondents or 0%.

4) Does the application provide sufficiently complete information for employees or visitors of the Kahyangan PDP GIS application?

Table 7. Respondents' Assessment Results

No	Assessment Criteria	Grade	Range Value
1	Strongly agree	7	70%
2	Agree	3	30%
3	Disagree	0	0%
4	don't agree	0	0%
5	Strongly Disagree	0	0%

In Table 7, the observations based on the application provide sufficiently complete information for employees or visitors of the Kahyangan PDP GIS application. Respondents stated strongly agree as much as 7 or 70%, stated agree as much as 3 or 30%, stated less agree 0 respondents or 0%, stated disagree 0 respondents or 0%, and said strongly disagree 0 respondents or 0%.

5) Does the map display well?

Table 8. Respondents' Assessment Results

No	Assessment Criteria	Grade	Range Value
1	Strongly agree	8	80%
2	Agree	2	20%
3	Disagree	0	0%
4	don't agree	0	0%
5	Strongly Disagree	0	0%

Table 9. Analysis of Questionnaire Results

No	Assessment Criteria	Strongly agree	Agree	Disagree	Disagree	Strongly Disagree
1	Is the appearance of this application attractive to employees or visitors of the Kahyangan PDP GIS application?	7/10x100% =70%	3/10x100% = 30%	0/10x100% =0%	0/10x100% =0%	0/10x100% =0%
2	Is this application easy to reach for employees or visitors of the Kahyangan PDP GIS application?	8/10x100% =80%	2/10x100% = 20%	0/10x100% =0%	0/10x100% =0%	0/10x100% =0%
3	Does the application have a positive impact on employees or visitors of the Kahyangan PDP GIS application?	7/10x100%= 70%	3/10x100% =30%	0/10x100% =0%	0/10x100% =0%	0/10x100% =0%
4	Does the application provide sufficiently complete information for employees or visitors of the Kahyangan PDP GIS application?	7/10x100% =70%	3/10x100% = 30%	0/10x100% =0%	0/10x100% =0%	0/10x100% =0%
5	Does the map display well?	8/10x100% =80%	2/10x100% = 20%	0/10x100% =0%	0/10x100% =0%	0/10x100% =0%
	Average	**74%**	**26%**	**0%**	**0%**	**0%**

In Table 8, the results of observations made based on the map are displayed well. Respondents stated strongly agree as much as 8 or 80%, stated agree as much as 2 or 20%, said less agree 0 respondents or 0%, stated disagree 0 respondents or 0% and stated strongly disagree 0 respondents or 0%.

Based on the results of the questionnaire in Table 9 for each criterion, there are several conclusions from each assessment criteria:

a. The first assessment criteria, namely whether the appearance of this application is attractive to employees or visitors of the Kahyangan PDP GIS application, get a Strongly Agree score in the percentage of 70%.
b. The second assessment criterion, whether this application is easy to understand for employees or visitors to the GIS PDP Kahyangan application, gets a Strongly Agree score of 80%.
c. The third assessment criterion, namely whether the application has a positive impact on employees or visitors of the Kahyangan PDP GIS application, gets a Strongly Agree score in the percentage of 70%.
d. The fourth assessment criterion is that the application provides sufficient complete information for employees or visitors to the Kahyangan PDP GIS application, getting a Strongly Agree score of 70%.
e. The fifth assessment criterion is whether the application displays the map well, getting a Strongly Agree score of 80%.

4. Conclusion

Perusahaan Daerah Perkebunan (PDP) Kahyangan is a Regional Owned Enterprise in Jember Regency, which was formed to realize the community's prosperity. In addition, the purpose of establishing the PDP is to develop the economy in the context of regional development by increasing productivity in all aspects to increase regional income. The primary commodities are coffee, rubber, cloves, Mahoni, and Sengon wood are supporting items. This research manages a system that assists in obtaining information using the design sprint method about the distribution of plantation land commodities in Jember, mapping existing commodities by Geographic Information System (GIS), and the staff will quickly understand the commodity in the PDP land area. The application gives information on planting land at the Perusahaan Daerah Perkebunan (PDP) Kahyangan, map description managed by PDP staff admin that can add users, manage to plant land, blocks, and afdeling also provided includes the area of the garden village in the land area, the planting area's location, and information on the spot and elevation of the site. The output of this method is prototypes and will implement in the GIS application. The end before launching the application is already checked by the user using questioner, and shown 74% strongly agreed that the application could be used for the PDP.

Conflicts of Interest: The authors declare that have no conflicts of interest to report regarding the present study.

Contribution: Pramuditha Shinta Dewi Puspitasari: analyze the data plantations. **Arvita Agus Kurniasari**: create the application GIS. **Trismayanti Dwi Puspitasari:** create the design sprint.

References

Alami Merrouni, A., Elwali Elalaoui, F., Ghennioui, A., Mezrhab, A., & Mezrhab, A. (2018). A GIS-AHP combination for the sites assessment of large-scale CSP plants with dry and wet cooling systems. Case study: Eastern Morocco. *Solar Energy*, *166*, 2–12. https://doi.org/https://doi.org/10.1016/j.solener.2018.03.038

Anggraini, W. F., Susanto, T., & Ahmad, I. (2022). Sistem Informasi Pemasaran Hasil Kelompok Wanita Tani Desa Sungai Langka Menggunakan Metode Design Sprint. *Jurnal Teknologi Dan Sistem Informasi*, *3*(1), 34–40.

Bhermana, A., Syamsuddin, Suparman, Agustini, S., Susilawati, Irwandi, D., & Firmansyah, M. A. (2021). Spatial landuse planning for developing sustainable food crop areas using land evaluation approach and GIS application (a case study of Pulang Pisau Regency, Central Kalimantan). *IOP Conference Series: Earth and Environmental*

Science, *648*(1), 64–72. https://doi.org/10.1088/1755-1315/648/1/012011

Boyacı, A. Ç., & Şişman, A. (2022). Pandemic hospital site selection: a GIS-based MCDM approach employing Pythagorean fuzzy sets. *Environmental Science and Pollution Research*, *29*(2), 1985–1997. https://doi.org/10.1007/s11356-021-15703-7

Fransiska, V., Sari, A., Kanthi, Y. A., Yahya, S., Visual, D. K., Informatika, M., & Kanthi, Y. A. (2022). *Perancangan User Interface Aplikasi E-Nelayan Berbasis Mobile Menggunakan Metode Design Sprint User Interface Design Of E-Nelayan Mobile Application Using The Design Sprint Method*. *4*(1), 14–26.

Jones, M., & Schou, P. K. (2022). Structuring the Start-up: How Coordination Emerges in Start-ups through Learning Sequencing. *Academy of Management Journal*. https://doi.org/10.5465/amj.2021.0149

Kamińska, D., Zwoliński, G., & Laska-Leśniewicz, A. (2022). Usability Testing of Virtual Reality Applications—The Pilot Study. *Sensors*, *22*(4). https://doi.org/10.3390/s22041342

Khoirunisa, N. I., & Ramadhani, E. (2022). *Implementasi Metode Design Sprint dalam Perancangan UI / UX Aplikasi Golek Kost Berbasis Mobile*. *3*, 464–472. https://doi.org/10.30865/json.v3i4.4262

Oematan, O. K. (2020). *STRATEGI PENGEMBANGAN KOMODITAS PINANG BERKELANJUTAN BERDASARKAN EVALUASI KESESUAIAN LAHAN DI KECAMATAN MOLLO UTARA, KABUPATEN TIMOR TENGAH SELATAN*. *April*, 11–22.

Puspitasari, T. D., & Anita, N. (2019). Sistem Pendukung Keputusan Untuk Tanaman Hortikultura Dengan Metode Desain Sprint. *Jurnal Teknologi Informasi Dan Terapan*, *5*(2), 81–84. https://doi.org/10.25047/jtit.v5i2.83

Sanglier Contreras, G., Zuíl Escobar, J. C., Martinez Cepa, C. B., Serrano Fernandez, I., & Hernandez Gonzalez, A. (2021). Project accelerator methodology: DESIGN SPRINT. *Contemporary Engineering Sciences*, *14*(1), 35–41. https://doi.org/10.12988/ces.2021.91651

Sassi, E., Benabdelhafid, A., & Hammami, S. (2020). Territory Planning Model Integrating GIS and Supply Chain. *International Journal of Transportation Engineering and Technology*, *6*(1), 1. https://doi.org/10.11648/j.ijtet.20200601.11

Thoring, K., Klöckner, H. W., & Mueller, R. M. (2022). Designing the Future With the "Delphi Design Sprint": Introducing a Novel Method for Design Science Research. *Proceedings of the 55th Hawaii International Conference on System Sciences*, 5798–5807. https://doi.org/10.24251/hicss.2022.706

Toda, A. M., Palomino, P. T., Oliveira, W., Rodrigues, L., Klock, A. C. T., Gasparini, I., Cristea, A. I., & Isotani, S. (2019). How to Gamify Learning Systems? An Experience Report using the Design Sprint Method and a Taxonomy for Gamification Elements in Education. *Journal of Educational Technology & Society*, *22*(3), 47–60. https://www.jstor.org/stable/26896709

Wales, N. S., & Wales, N. S. (2022). *A comparative study between design thinking , agile , and design sprint methodologies Ketmanto Wangsa * Ritesh Chugh Shakir Karim and Raj Sandu*. *15*(2), 225–242.

Wibowo, Y., Maulida, Y. R., & Purnomo, B. H. (2019). Rencana Produksi Olahan Kopi Di Perusahaan Daerah Perkebunan (Pdp) Kahyangan Jember Menggunakan Metode Fuzzy Tsukamoto. *Agrointek: Jurnal Teknologi Industri Pertanian*, *13*(1), 61–71.

Yadav, K. K., Gupta, N., & Kumar, V. (2016). 2016 National Conference. *American String Teacher*, *66*(1), 53–60. https://doi.org/10.1177/000313131606600112