A Geovisualization Dashboard of Granular Food Security Index Map using GIS for Monitoring the Provincial Level Food Security Status

D K Syaputri[1,2], B P Josaphat[1,2], A W Wijayanto[1,2,*]

[1] Department of Statistical Computing, Politeknik Statistika STIS, Jakarta, Indonesia
[2] BPS-Statistics Indonesia, Jakarta, Indonesia

*Corresponding author's e-mail: ariewahyu@stis.ac.id

Abstract. This study aims to build a web-based interactive geovisualization dashboard from a granular food security index map using satellite imagery and other geospatial big data. The map dashboard is built using a two-dimensional (2D) data visualization approach. Making a two-dimensional map using QuantumGIS (QGIS) tools, displayed in the form of WebGIS with the plugin used "Qgis2web" based on javascript leaflets. Once included in WebGIS, interactive visualizations are displayed on websites with interfaces based on hypertext markup language (HTML), cascading style sheets (CSS), and JavaScript (JS). The dashboard map is equipped with interactive features such as legend, click grid, zoom, show me where I am, measure distance, and search. Therefore, the dashboard map can be used to monitor the food security index, search for food security index areas, as well as geographical identification of food security index areas which are useful for supporting the analysis of decision-making or policies by the government regarding food security strategies.

1. Introduction

In the second point of *the Sustainable Development Goals* (SDGs), namely eliminating hunger (*zero hunger*), it is hoped that all forms of hunger in the world can end, so that every individual has the right to access proper food [1]. Strong food security is urgently needed as an effort to form healthy, active, and productive human resources, in line with the ultimate goal of developing national food security by the *Food Agriculture Organization* (FAO), namely to build people who can live with a better quality. Food security is also an important factor in sustainable economic development [2]. If the state of food in a country is poor, it will cause various health problems which will also have an impact on the emergence of economic problems.

To determine the level of food security in a region and its supporting factors, several indicators have been developed in the form of a food security index [3]. Globally, based on *the United Nations Convention to Combat Desertification* (UNCCD), *the Global Food Security Index* (GFSI) is compiled from 113 countries and has been managed and updated by *The Economist's Intelligence Unit* since 2012. The overall average GFSI score for all 113 countries in 2021 was 60.9, while the score for Indonesia in that year was 59.2. This means that in 2021 Indonesia's food security index score will still be below the world average. This should be a concern for Indonesia in increasing food security.

In Indonesia, the official food security index data is managed and published by the Food Security Agency, Ministry of Agriculture. The data used to compile the food security index comes from various ministries/agencies, namely the Ministry of Agriculture, the Central Bureau of Statistics (BPS), and the Ministry of Health. The data collection used is a sample survey which has various limitations, such as expensive costs, limited coverage, and taking a long time to present the data. As a result, official data on the food security index in Indonesia can only be released every year with the smallest level being the district/city.

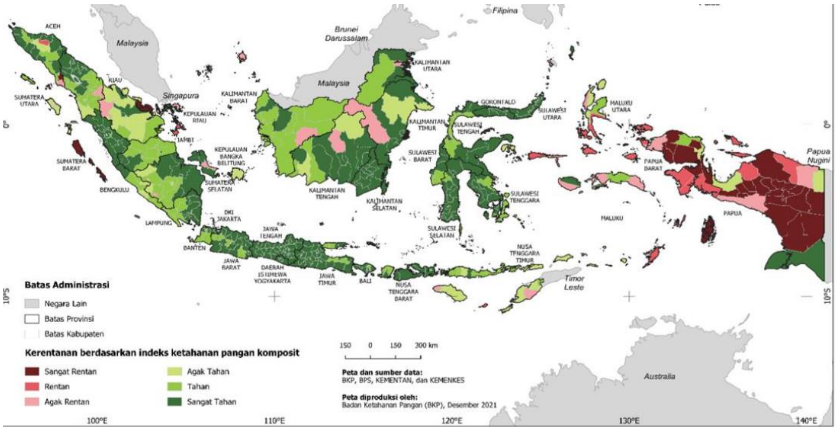

Figure 1. Map of Indonesia's Food Security Index 2021
Source: Ministry of Agriculture, 2021

The visualization provided to monitor the food security index by the Food Security Agency, Ministry of Agriculture is only available in a static map view. On the other hand, the National Food Agency built a *web-based Food and Nutrition Insecurity Early Warning System (SKPG)*. SKPG is one of the early warning system tools in preparing food and nutrition policy analysis and recommendations. The concept of food security and nutrition in the SPKG by the National Food Agency is also built based on three aspects, namely the aspect of food availability, the aspect of food affordability, and the aspect of food utilization. The data used consists of primary data and secondary data. Primary data is obtained from the National Food Agency or Regional Apparatuses that carry out tasks and carry out functions in the Food sector. Secondary data was obtained from the relevant ministries/agencies and Regional Apparatuses by submitting a written request to the relevant ministries/agencies and Regional Apparatuses. However, the data used in the development of each aspect of the food security index is different from the indicators for the food security index developed by the Food Security Agency, Ministry of Agriculture. SKPG is prepared periodically by the central and regional governments on a regular basis (monthly). However, the presentation of the Food and Nutrition Insecurity Early Warning System map is only available at the provincial level with information on vulnerable, alert, and safe, without displaying a value.

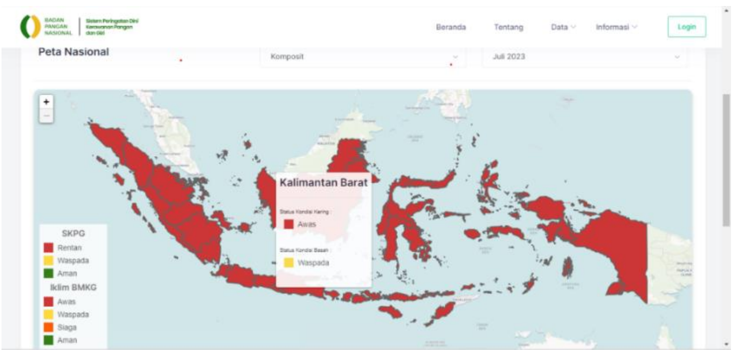

Figure 2. *Web*- Based Food Security and Nutrition Early Warning System
Source: https://skpg.badanpangan.go.id/

On the other hand, policies on food and nutrition are designed to achieve the target of meeting the food and nutritional needs of the community nationally, regionally, and up to individuals. Law 18 of 2012 concerning food also explains, that food security is a condition of fulfilling food for the state down to individuals, which is reflected in the availability of sufficient food, both in quantity and quality, safe, diverse, nutritious, equitable, and affordable, and does not conflict with religion, belief, and culture of the community, to be able to live a healthy, active and productive life sustainably [17]. This is in line with the ultimate goal of developing national food security by *the Food Agriculture Organization* (FAO) which focuses on building human beings who can live with a better quality of life. In other words, it is necessary to monitor food security which does not only have a fast *update period* but is also presented at a more granular level.

Recent developments in Earth observation technology and satellite image analytics have created numerous opportunities for precise and effective monitoring of Earth's surface geographic features [18-20]. Remote sensing satellite imagery data and other geospatial *big data* have the potential to complement the current limitations of food security data. This data has a fast *update period*, the availability of data at a granular level, and is inexpensive and even free [21-23]. The availability of information from satellite imagery data and other geospatial *big* data can provide food security information that is accurate, comprehensive, and well organized to provide information to decision-makers in making programs and policies to prioritize food security interventions and programs [5].

To support this policy analysis, stakeholders need an interactive data presentation that has a fast *update period* and the availability of data at a granular level and updates more quickly. The official Food Security index data by the Food Security Agency and Ministry of Agriculture only displays static map visualizations, with limitations on updating data for a long time (1 year), the smallest level is in districts/cities. Meanwhile, the Food and Nutrition Insecurity Early Warning System (SKPG) has displayed an interactive web-based map, but only at the provincial level.

Previously, we conducted research on developing a food security index using multisource satellite imagery and other geospatial big data in West Kalimantan Province [16]. West Kalimantan Province is a province that has 16 sub-districts that directly border Malaysia. Border areas are synonymous with remote, isolated conditions, low levels of community welfare, and lack of accessibility of basic facilities or infrastructure. The agricultural sector in Indonesia's border areas, especially in West Kalimantan, has the potential to be developed in the agricultural sector, but often faces challenges, especially in terms of accessibility and high agricultural costs. Border areas must be of concern to the government because border areas have an important role in the economy, politics and national defense. The government must be able to issue appropriate policies in dealing with food security problems in a region, especially in border areas.

Research on developing a food security index using multi-source satellite imagery and geospatial big data has been able to provide solutions to the limitations of food security index data. On the other hand, granular GFSI also has limitations, such as multi-source satellite imagery which is still affected by clouds. However, the research results are still displayed in the form of a static map. Good data visualization, not only can communicate information better but will also help to understand the data more clearly and deeply [4]. Therefore, to facilitate monitoring of the food security index for policy making, interactive visualization is needed so that stakeholders can easily analyze the areas they wish to further review. Interactive visualization allows users to interact with the visualization displayed, in this research it’s a map. To solve this problem, we propose an interactive visualization of a granular food security index map in the form of an interactive two-dimensional (2D) website-based interactive dashboard with interactive features that can help monitor and identify the food security index of a region. With website-based, users can view the dashboard for free and can access it freely without limited permission to view the dashboard. The research framework can be seen in Figure 3.

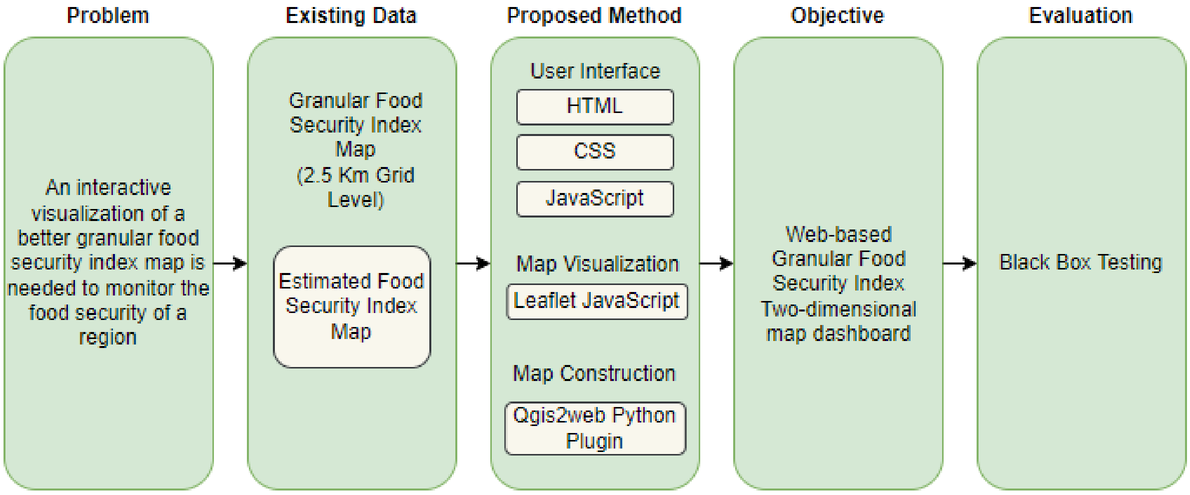

Figure 3. Research Flow

2. Methods

2.1. Granular Food Security Index Estimation Data

The data visualized in this study is a granular map of the estimated food security index of West Kalimantan, Indonesia (grid level 2.5 km). Details of the data used are described in Table 1.

Table 1. Details of the data used to make a granular food security index map

Aspect	FSI Official Data		FSI Data Proposal				
	Indicator	Data source	Data source	Spatial Resolution	Variable	Bands Used	Reference
Food availability	The ratio of normative consumption per capita to net production of rice, corn, sweet potatoes, cassava, and regional government rice stocks	BPS and Ministry of Agriculture	Sentinel-2	10m	Normalized Difference Vegetation Index (NDVI)	B4 (Red) and B8 (NIR)	[5]
					Normalized Difference Drought Index (NDDI)	B4 (Red), B8 (NIR), and B11 (SWIR 1)	[1]
					Soil Moisture	B4 (Red), B8 (NIR), and B11 (SWIR 1)	[1]
			NASA SRTM	30m	elevation slopes	elevation	[6]
Food Affordability	Percentage of households without access to electricity	SUSENAS - BPS	NOAA-VIIRS	750m	Nighttime Light Intensity (NTL)	Average DNB Radiance Values (avg_rad)	[7]
			Sentinel-2	10m	Built-Up Index (BUI)	B4 (Red), B8 (NIR), and B11 (SWIR 1)	[8]
			WorldPop	1km	Population Density	-	[9]
	Percentage of population living below the poverty line Percentage of households with a proportion of expenditure on food that is more than	SUSENAS - BPS	*Facebook* /Meta	2.4km	Relative Wealth Index (RWI)	The distance from the center of the grid is 2.5 km x 2.5 km to the nearest point	[10]

Aspect	FSI Official Data		FSI Data Proposal				
	Indicator	Data source	Data source	Spatial Resolution	Variable	Bands Used	Reference
	65% of total expenditure						
Food Utilization	The average length of schooling for girls is over 15 years	SUSENAS - BPS	Wilkerstat - BPS	*points*	POI Distance Education Facilities	The distance from the center of the grid is 2.5 km x 2.5 km to the nearest point	[11], [12]
					POI Density of Educational Facilities	The number of points on the grid is 2.5 km x 2.5 km	
	The ratio of population per health worker to population density	Ministry of Health	Wilkerstat - BPS	*points*	POI Distance Health Facility	The distance from the center of the grid is 2.5 km x 2.5 km to the nearest point	
	Percentage of toddlers with below standard height (stunting)				Health Facility Density POI	The number of points on the grid is 2.5 km x 2.5 km	
	Life expectancy at birth	SUSENAS - BPS					
	Percentage of households without access to clean water	SUSENAS - BPS	-				

The Food Security Index Estimation Map was built using the best *machine learning model* based on related geospatial variables, as shown in the table of alternative data proposals in Table 1. Figure 4 shows a static visualization of the estimated granular food security index map of West Kalimantan.

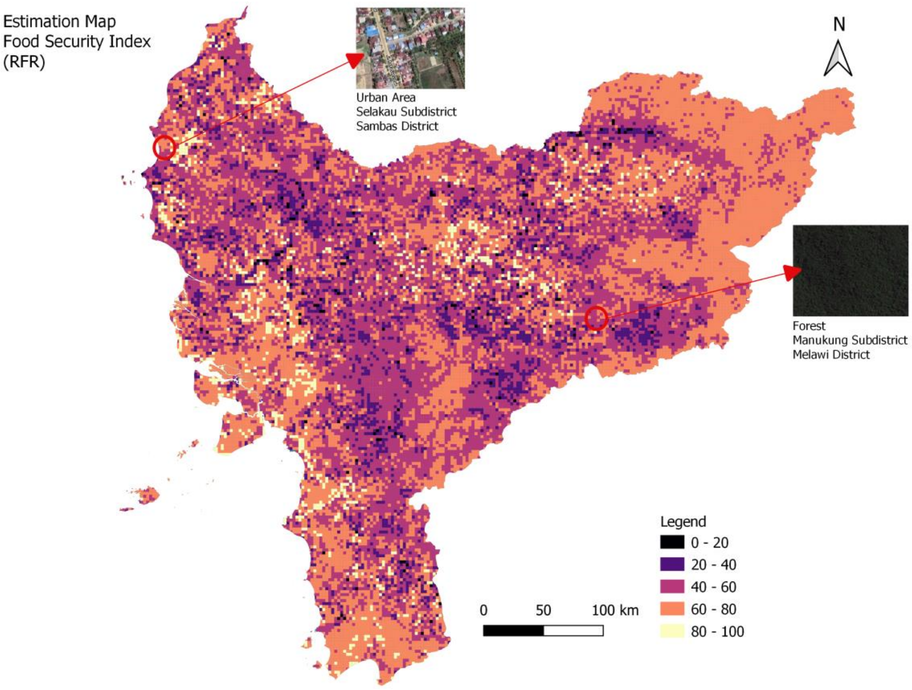

Figure 4. Estimated Map of Food Security Index using Random Forest Regression for West Kalimantan

2.2. Dashboard Development

The dashboard was built using a two-dimensional (2D) data visualization approach. To build a two-dimensional data visualization map, based on the referred research, raw data was collected from multi-source satellite imagery and other geospatial big data as shown in Table 1. The data was integrated in a 2.5 km grid level, followed by pre-processing data so that it becomes data ready to be used in machine learning modeling.

The estimated food security index data is stored in *geojson format* to be visualized as a two-dimensional map. Making a two-dimensional map using QuantumGIS (QGIS) *tools*, displayed in the form of *WebGIS* with *the pluggin* used is "Qgis2web" based on javascript leaflets. The “Qgis2web” *plugin is an open source* feature in QGIS. After being displayed in *WebGIS*, interactive visualizations are embedded in websites with interfaces based on hypertext markup language (HTML), cascading style sheets (CSS), and JavaScript (js). Figure 5 displays the dashboard framework with data preparation which refers to research on developing a food security index using multisource satellite imagery and other geospatial big data.

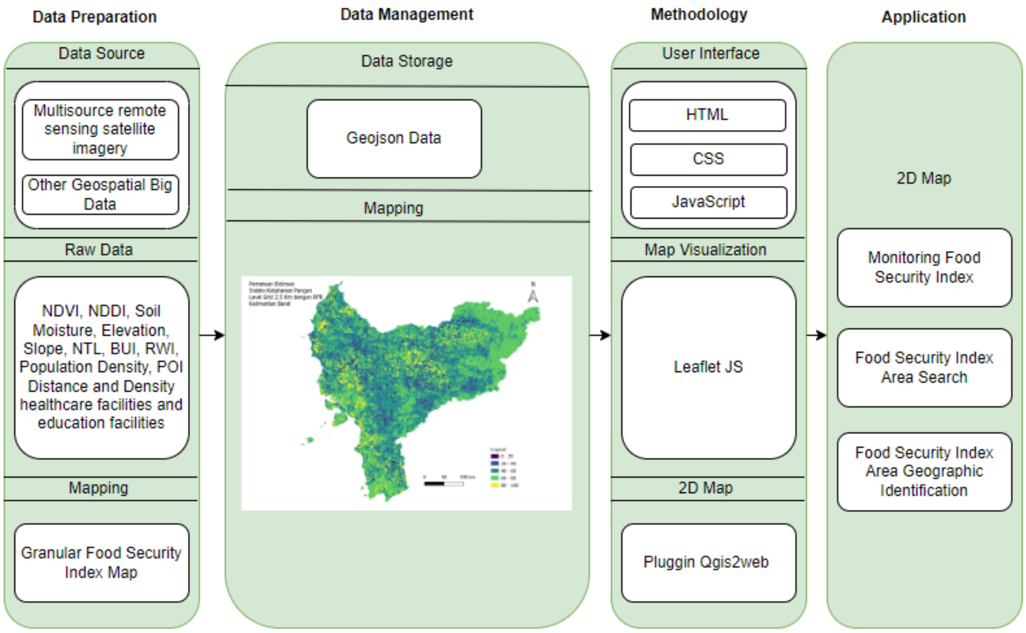

Figure 5. Website-based granular food security index map dashboard framework

2.3. Evaluation

Evaluation in this study used the System Usability Scale (SUS). System Usability Scale (SUS) is a questionnaire that can be used to measure the usability of systems on computers from the subjective point of view of users. SUS is widely used to measure usability and has several advantages [13]. Technically, the SUS has 10 questions which are packaged in the form of a questionnaire, but in its development it is possible to make it in the form of an image called PictorialSUS [14], but in this study only used a questionnaire. Questions on the system usability scale questionnaire can be seen in Table 2.

Table 2. SUS Questionnaire [13]

No	A list of questions	Likert Scale				
		Strongly disagree				Strongly agree
1	I think I will use this *dashboard* again	1	2	3	4	5
2	I find this *dashboard* complicated to use	1	2	3	4	5
3	I find this *dashboard* easy to use	1	2	2	3	4	5
4	I need help from other people or technicians in using this *dashboard*	1	2	3	4	5
5	*dashboard* features work as they should	1	2	3	4	5
6	I feel there are many things that are inconsistent (not harmonious on this *dashboard*)	1	2	3	4	5
7	I feel like others will understand how to use this *dashboard* quickly	1	2	3	4	5
8	I find this *dashboard* confusing	1	2	3	4	5
9	I feel there are no obstacles in using this *dashboard*	1	2	3	4	5
10	I need to get used to it first before using this *dashboard*	1	2	3	4	5

The SUS questionnaire has 10 questions with assessments using a *lighter scale* in the range of 1-5, where point 1 means strongly disagree, 2 means disagree, three means neutral, 4 means agree, and 5 means strongly agree. In determining the results of the SUS score calculation, there are three research points of view, namely acceptability, grade scale, and adjective rating. As in Figure 6 below.

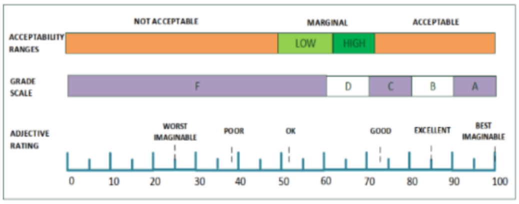

Figure 6. SUS Score Determination Standards [15]

The score weighting to indicate *dashboard status* is in the range 0-100 and is divided into 5 letter grades from A, B, C, D, and F.

Table 3. SUS Questionnaire Weighting [9]

SUS Score	Letter Value	Information
Above 80.3	A	Very good
Between 68 and 80.3	B	Good
68	C	Enough
Between 51 and 67	D	Bad
Under 51	F	Very bad

3. Results

The web dashboard for mapping the estimated food security index can be accessed at https://bigdata.stis.ac.id/pemetaan-indeks-ketahanan-pangan-granular/ .

3.1. UserInterface

When the user presses the web dashboard *link* above, the user will immediately see the initial display as shown in Figure 7. The dashboard link has open access. This means that all users can access the dashboard for free without needing certain permissions.

Figure 7. Web Dashboard Initial Appearance

Next, an explanation will be shown regarding the importance of food security, the food security index, alternative data proposals used to map the estimated food security index, methodology, and a two-dimensional (2D) dashboard map.

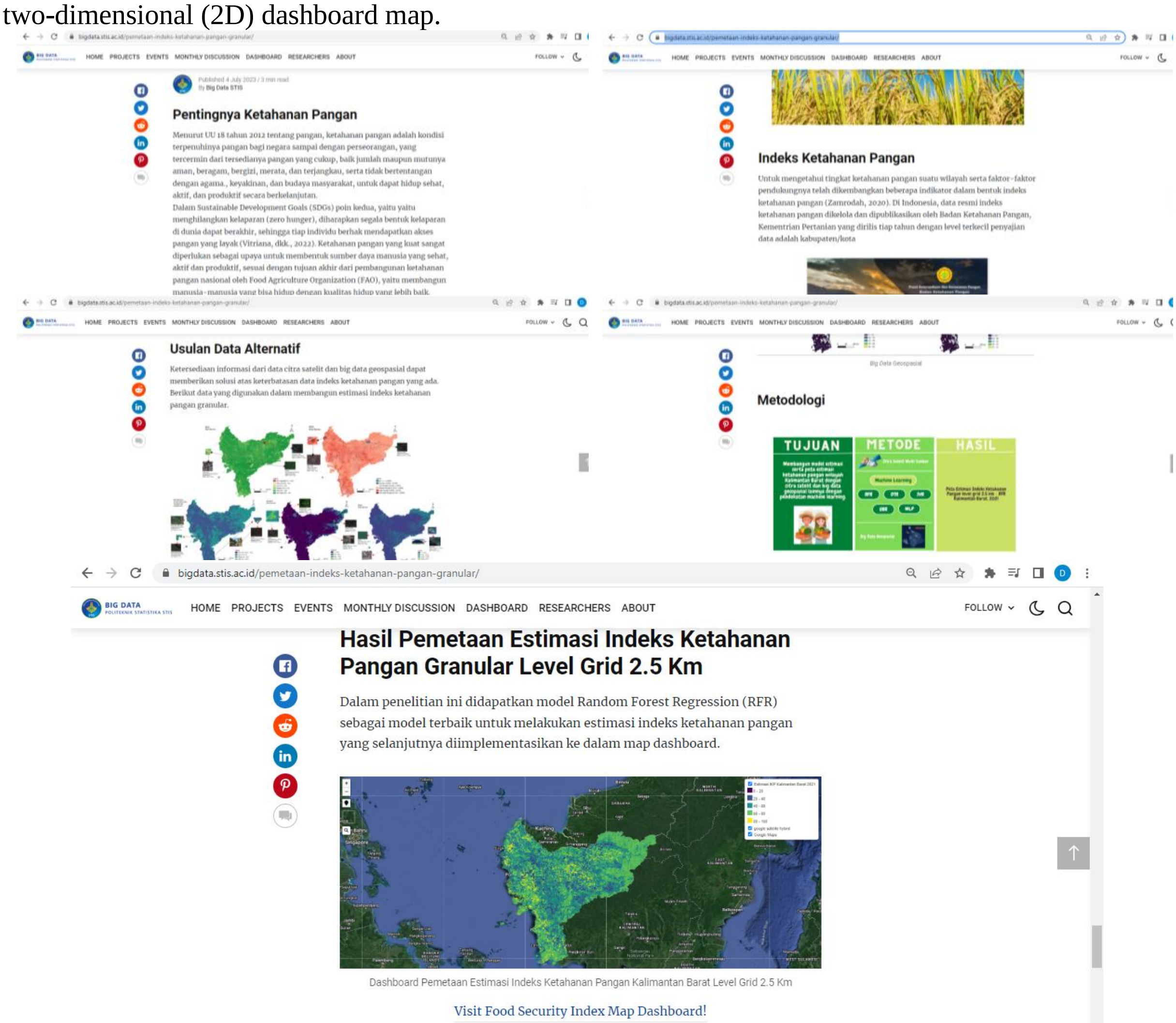

Figure 8. Display of the web dashboard user interface start page

Two-Dimensional (2D) Dashboard User Interface and Functional Features

Mapping of food security index estimates is displayed in the form of a web-based two-dimensional map dashboard. Figure 9 displays the dashboard map visualization and its features.

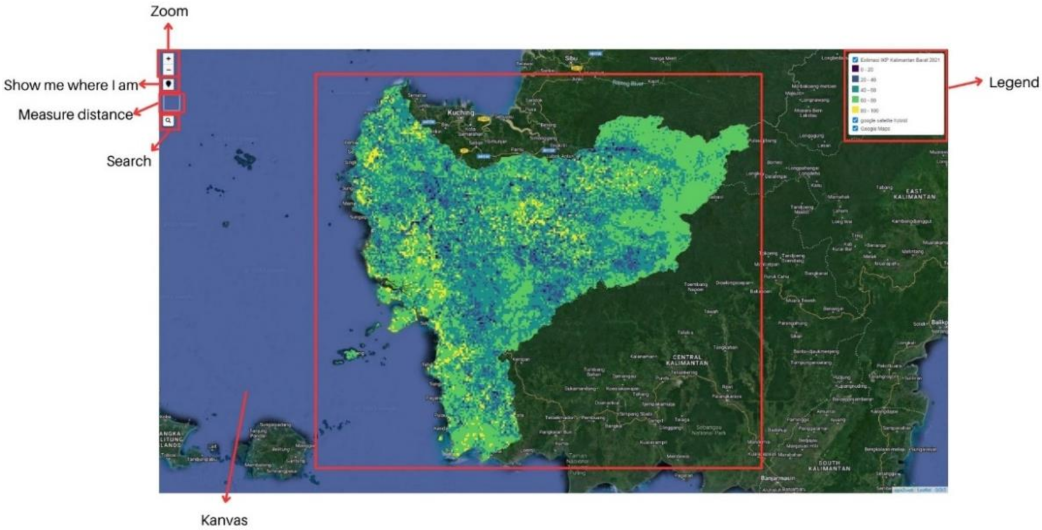

Figure 9. Two Dimensional (2D) Granular Food Security Index Dashboard

On the dashboard, there are several features as shown in Figure 9, with the following details.

a. Canvas
   The canvas is used as a place to display the map.

b. Legend
   A legend feature that shows the currently displayed map layer. The legend function is useful for illustrating the level of the food security index based on the color of the map.
   In the legend section, you can uncheck map layers that you don't want displayed and vice versa. This feature can be used for geographic visual identification with Google Satellite as well as area identification with Google Maps.

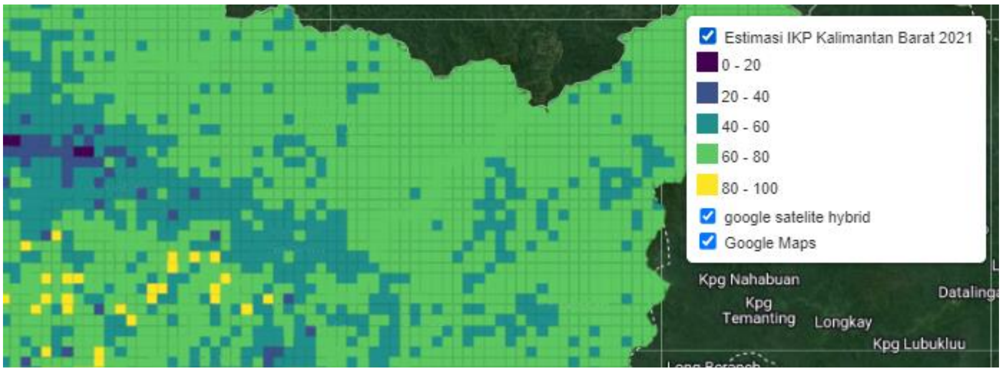

Figure 10. Legend

c. Zoom
   Zoom feature is used to zoom in and zoom out the map view. With this zoom feature, users can observe an area that they want to observe further.

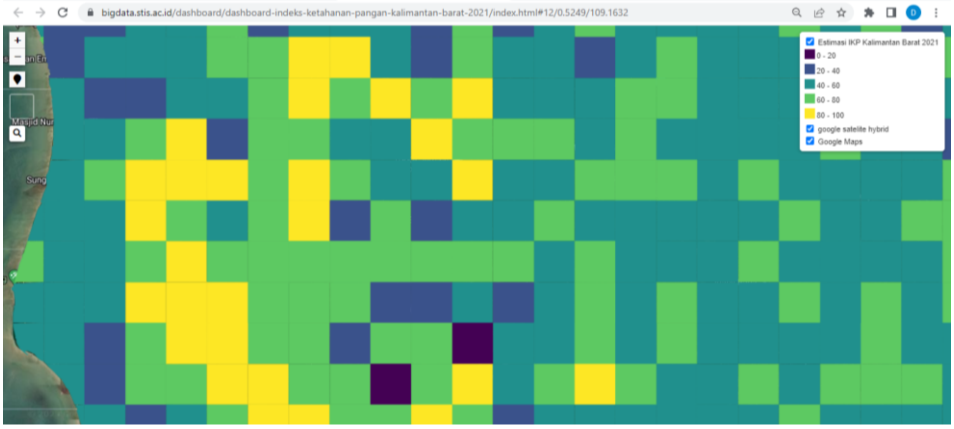

Figure 11. Zoom in map

d. Show me where I am

Show me where I am feature to display the user's location position. Figure 12 shows an example of visualization when the user presses the show me where I am feature, the dashboard will immediately direct the user to the user's current location.

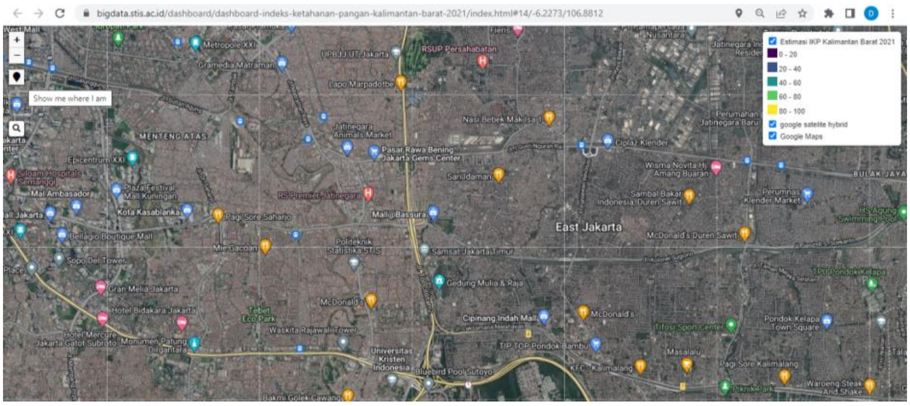

Figure 12. Show me where I am feature

e. measure distance

The measure distance feature is used to measure the distance between two specified positions. Users can click on the start point and end point to measure the distance, then it will display the distance between the two points in meters or kilometers. Figure 13 shows an example of using the measure distance feature. The user presses the two points of the location where you want to measure the distance, then the distance between the two points selected by the user will be displayed, as shown in Figure 13.

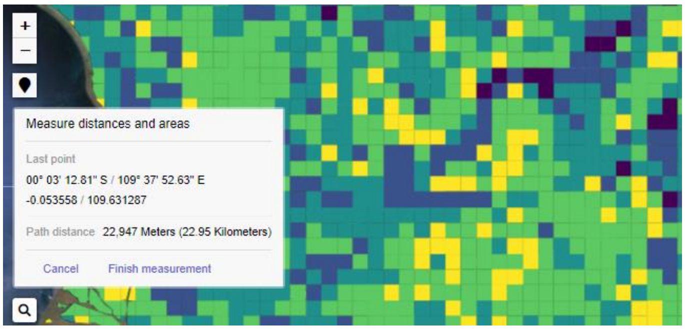

Figure 13. Visualization of the Measure Distance Feature

f. Search
The search feature is used to find the desired location on the map, as shown in Figure 14. The search feature will only take users to the desired area. If the user wants to know detailed GFSI information, the user can use the grid click feature.

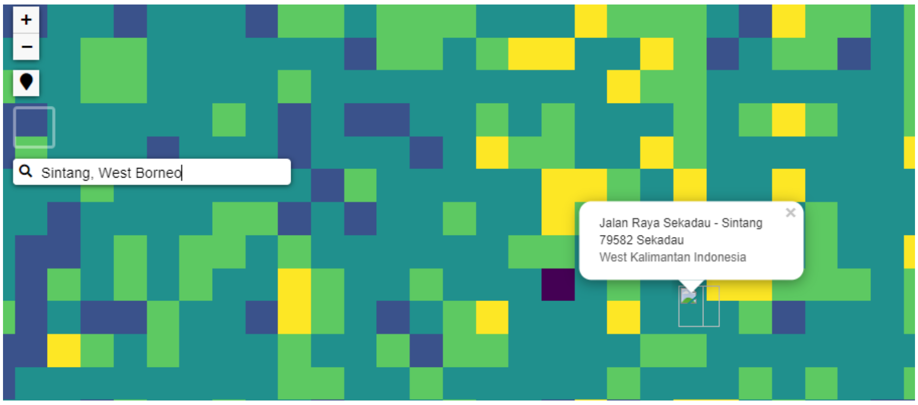

Figure 14. Search Feature Visualization

g. Grid Click
The grid click feature is used to make it easier for users to view estimated food security index data, starting from the aspect value of food utilization, the aspect of food availability, the aspect of food affordability, to the composite food security index value of an area. A description of the grid id, name of the district, and the name of the selected grid district are also displayed.

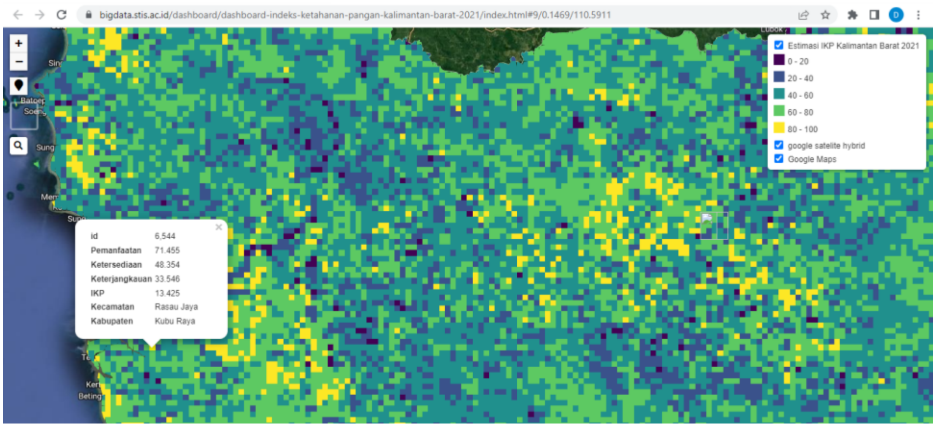

Figure 15. Grid Click Visualization

3.2. Evaluation Results

Evaluation uses the system usability scale (SUS) score. The SUS questionnaire was created using Google Form with the results of filling it out can be seen in Table 4

Table 4. Recapitulation of Results of SUS Questionnaire Distribution

Respondent	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
1	5	2	5	2	4	2	4	1	2	3
2	5	1	5	1	5	1	5	1	5	1
3	4	1	4	2	5	1	5	1	4	2
4	5	1	5	1	5	1	4	1	5	2
5	4	2	4	1	4	1	4	1	4	1
6	5	1	5	1	5	2	5	1	5	2

Respondent	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
7	5	2	5	1	5	2	5	1	5	2
8	5	2	4	1	5	1	5	1	5	5
9	4	1	4	2	5	1	4	1	4	2
10	5	1	5	1	5	1	5	1	5	1

Preprocessing is carried out , such as data transformation and selecting variables that will be used for further analysis so that the data is ready to be processed. A recapitulation of the results of distributing the SUS questionnaire which had carried out data preprocessing is shown in Table 2. The number of respondents who filled out the questionnaire was 10. Data processing used Microsoft Excel. The data that has been collected is calculated to give SUS weighting. However, there is a rule for calculating questionnaire scores, namely that every odd numbered question is reduced by one and even numbered questions are reduced by 5. The SUS score weighting is obtained from the sum of the user's overall scores multiplied by 2.5.

Table 5. Recapitulation of SUS Questionnaire calculation results

Respondent	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Amount	Total ×2.5
1	4	3	4	3	3	3	3	4	1	2	30	75
2	4	4	4	4	4	4	4	4	4	4	40	100
3	3	4	3	3	4	4	4	4	3	3	35	87.5
4	4	4	4	4	4	4	3	4	4	3	38	95
5	3	3	3	4	3	4	3	4	3	4	34	85
6	4	4	4	4	4	3	4	4	4	3	38	95
7	4	3	4	4	4	3	4	4	4	3	37	92.5
8	4	3	3	4	4	4	4	4	4	0	34	85
9	3	4	3	3	4	4	3	4	3	3	34	85
10	4	4	4	4	4	4	4	4	4	4	40	100
Amount	37	36	36	37	38	37	36	40	34	29	360	900

After calculating the score, proceed with calculating the average score by adding up the total scores and then dividing by the number of respondents, as in equation 1. The average score is symbolized by $\bar{x}$, the total SUS score is symbolized by $\sum_{i=1}^{n} x$, and the number of respondents is symbolized by n.

$$\bar{x} = \frac{\sum_{i=1}^{n} x}{n} \quad (1)$$

Based on calculations using equation 1, the average score obtained for the interactive *dashboard* visualization of Indonesian educational statistics data was 90, thus getting a letter grade of A, which means very good.

4. Discussion

In accordance with the explanation in the background, the food security index dashboard map can assist the government in monitoring the food security index for each region up to the 2.5 Km grid level. Users can view information starting from the name of the district, the name of the sub-district, and the grid identity of the area with a description of the availability aspect score food, aspects of food affordability, and aspects of food utilization, as well as composite food security index scores as shown in Figure 15, in the explanation of the click grid section.

In monitoring the food security index, users can directly search for a particular area using the 'search' feature on the dashboard. For example, if the user wants to monitor the 'Entikong' area which is the border area with Malaysia, the user can input 'Entikong' in the search field, then the map will direct the user to that area.

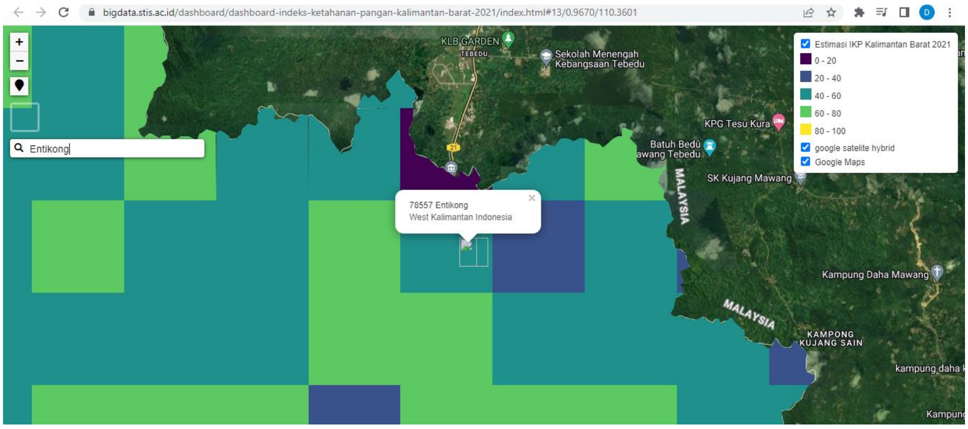

Figure 16. Food security index area search simulation of Entikong

This dashboard map can be used to identify the geographical conditions of the target location, namely field checks using Google Satellite and high-resolution Google Maps. Figure 17 shows an example if the user selects a grid to identify, the user can zoom in on that area. Figure 18 shows that if the user deactivates the 'Estimated IKP West Kalimantan 2021' layer, the system will display a photo of the earth's surface using Google Satellite. Furthermore, Figure 19 shows if the user deactivates the 'Estimated IKP West Kalimantan 2021' layer and the 'Google Satellite' layer, then the system will display the condition of the area based on Google Maps. So, users can identify geographic areas of concern in the food security index. This website has limitations, such as only being able to display GFSI in West Kalimantan according to the study location in the research referred to.

Figure 17. Area Identification

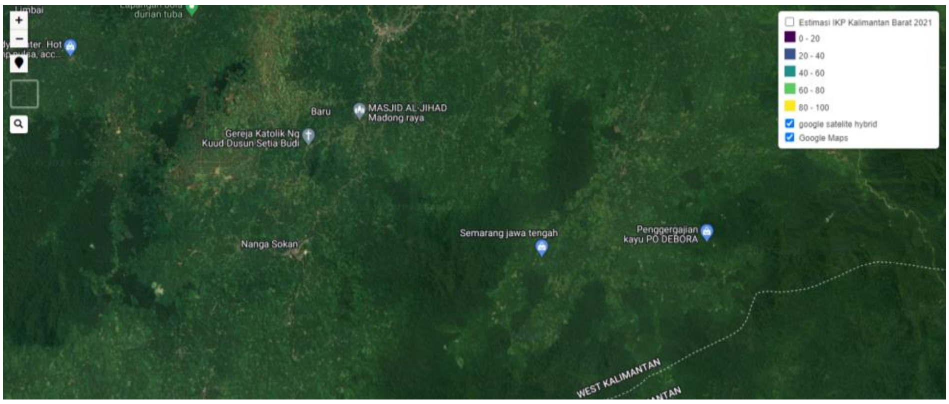

Figure 18. Area geographic identification using Google Satellite

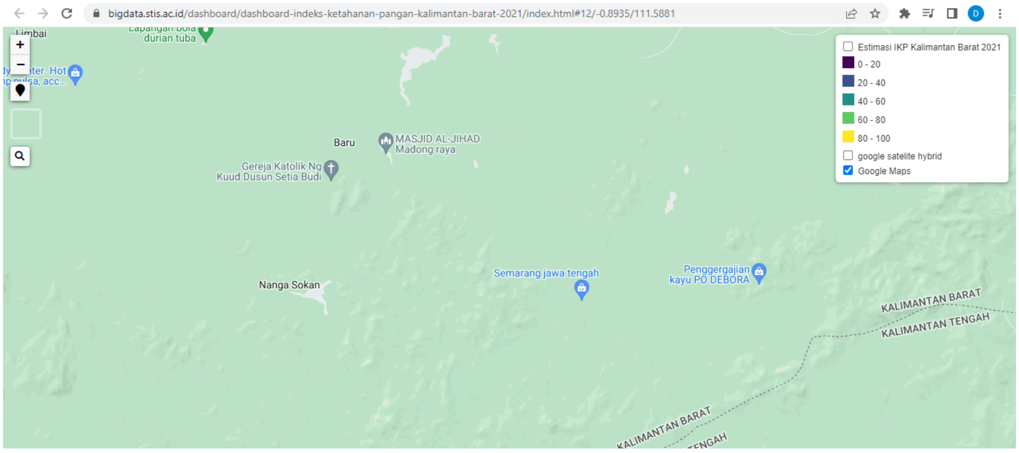

Figure 19. Area Map using Google Maps

5. Conclusion

This research succeeded in building a web-based granular food security index map dashboard which can be accessed at the link https://s.stis.ac.id/Indeks_Ketahanan_Pangan_Kalbar . The dashboard is built using a two-dimensional (2D) visualization approach. At the base of the map there is a canvas as a place to display the map. There is a *zoom* feature to *zoom in* and *out of* the map view, the show me where I am feature to display the position of the user's location, the measure distance feature to measure the distance between two specified positions, the search feature to find the desired location on the map, and there is a feature legend showing the currently displayed map layer. In the legend section, you can uncheck map layers that you don't want displayed and vice versa. In addition, there is a click grid feature to display location names (grid id, sub-district name, district name), food utilization aspect scores, food availability aspects, food affordability aspects, and a composite food security index score. The features and functions of the dashboard map have been running according to expectations as evidenced by the evaluation of black box testing.

References

[1] Virtriana, R., Riqqi, A., Anggraini, TS, Fauzan, KN, Ihsan, KTN, Mustika, FC, ... & Wikantika, K. (2022). Development of a Spatial Model for Food Security Prediction Using Remote Sensing Data in West Java, Indonesia. ISPRS International Journal of Geo-Information, 11(5), 284.

[2] Shi, S., Ye, Y., & Xiao, R. (2022). Evaluation of Food Security Based on Remote Sensing Data—Taking Egypt as an Example. Remote Sensing, 14(12), 2876.

[3] Zamrodah, Y. (2020). Compilation of the Probolinggo Regency Food Security Index . Scientific Journal of Soci Agribis , 20(2).

[4] Handayani, R., & Rasyidi, MA (2019). SHOPVIS: INTERACTIVE VISUALIZATION OF ONLINE SHOP SPREAD IN INDONESIA USING CROWDSOURCED DATA. *SISFO VOL 8 NO 2 , 2 . *

[5] Berd, I., Ekaputra, EG, Yanti, D., & Stiyanto, E. (2022, July). The use of the NDVI algorithm in predicting the productivity of rice fields of Talang District of Solok Regency. In IOP Conference Series: Earth and Environmental Science (Vol. 1059, No. 1, p. 012004). IOP Publishing.

[6] Pailler, S., Naidoo, R., Burgess, ND, Freeman, OE, & Fisher, B. (2015). Impacts of community-based natural resource management on wealth, food security and child health in Tanzania. PloS one , 10 (7), e0133252.

[7] Afrianto, F. (2022). East Java Province GRDP Projection Model Using Night-Time Light Imagery. East Java Economic Journal, 6(2), 208-223.

[8] Saipova, B. (2021). Using Geospatial Technologies to Detect and Monitor Changes in Land Cover and Land Management. CENTRAL ASIAN JOURNAL OF MATHEMATIC THEORY AND COMPUTER SCIENCES, 2 (11), 103-111.

[9] Kumar, A., & Sharma, P. (2022). Impact of climate variation on agricultural productivity and food security in rural India. Available at SSRN 4144089.

[10] Bahamonde, H. (2018). Aiming right at you: Group versus individual clientelistic targeting in Brazil. Journal of Politics in Latin America, 10(2), 41-76.

[11] Putri, SR, Wijayanto, AW, & Permana, S. (2023). Multi-source satellite imagery and point of interest data for poverty mapping in East Java, Indonesia: Machine learning and deep learning approaches. Remote Sensing Applications: Society and Environment, 29, 100889.

[12] Putri, SR, Wijayanto, AW, & Sakti, AD (2022). Developing relative spatial poverty index using integrated remote sensing and geospatial big data approach: a case study of East Java, Indonesia. ISPRS International Journal of Geo-Information, 11(5), 275.

[13] Setiawan, D., & Rafianto, N. (2020). Pengukuran usability pada learning management system perguruan tinggi menggunakan pedoman system usability scale. Teknologi: Jurnal Ilmiah Sistem Informasi, 10(1), 23-31.

[14] Baumgartner, J., Frei, N., Kleinke, M., Sauer, J., & Sonderegger, A. (2019). Pictorial System Usability Scale (P-SUS): Developing an Instrument for Measuring Perceived Usability. CHI '19: Proceedings of CHI Conference on Human Factors in Computing Systems. Glasgow, Scotland UK: ACM.

[15] Fatah, D. A. (2020). Evaluasi Usability dan Perbaikan Desain Aplikasi Mobile Menggunakan Usability Testing dengan Pendekatan HumanCentered Design (HCD). Rekayasa, 13(2), 130-143.

[16] Syaputri, Dwi Karunia. (2023). Development of a Food Security Index Using Multisource Satellite Imagery and Geospatial Big Data. Working Paper. Unpublished. Politeknik Statistika STIS: Jakarta.

[17] Republik Indonesia. 2012. *Undang-Undang Republik Indonesia Nomor 18 Tahun 2012 Tentang Pangan*. Lembaran Negara RI Tahun 2012 Nomor 227. Sekretariat Negara. Jakarta.

[18] Afira N, Wijayanto AW 2022 Mono-temporal and multi-temporal approaches for burnt area detection using Sentinel-2 satellite imagery (a case study of Rokan Hilir Regency, Indonesia), Ecological Informatics, 69, 101677, Elsevier

[19] Wijayanto AW, Afira N, Nurkarim W 2022 Machine Learning Approaches using Satellite Data for Oil Palm Area Detection in Pekanbaru City, Riau, Proceedings of the 2022 IEEE International Conference on Cybernetics and Computational Intelligence (CyberneticsCom).

[20] Putri SR, Wijayanto AW 2022 Learning Bayesian Network for Rainfall Prediction Modeling in Urban Area using Remote Sensing Satellite Data (Case Study: Jakarta, Indonesia), Proceedings of The International Conference on Data Science and Official Statistics, 2021, 1, 77-90

[21] Saadi T D T and Wijayanto A W 2021 Machine learning applied to Sentinel-2 and Landsat-8 multispectral and medium-resolution satellite imagery for the detection of rice production area in Nganjuk, East Java, Indonesia International Journal of Remote Sensing and Earth Sciences 18 19-32

[22] Wijayanto AW, Triscowati DW, Marsuhandi AH 2020 Maize Field Area Detection in East Java, Indonesia: An Integrated Multispectral Remote Sensing and Machine Learning Approach. 2020 12th International Conference on Information Technology and Electrical Engineering (ICITEE).

[23] Nurmasari Y, Wijayanto AW 2021 Oil Palm Plantation Detection in Indonesia using Sentinel-2 and Landsat-8 Optical Satellite Imagery (Case Study: Rokan Hulu Regency, Riau Province), International Journal of Remote Sensing and Earth Sciences (IJReSES), 18, 1, 1-18, LAPAN