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Harvest Data Processing Information System for Rice Productivity Prediction in Indramayu Regency

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Abstract

Rice plants that are processed into rice are the staple food of the Indonesian people, and the lack of rice production will have an impact on weakening national food security. Efforts that can be made are to process harvest data in national rice barn areas such as the Indramayu Regency properly. So far, there are still many errors and differences in harvest data both by agencies and original data in the field. Differences in data cause inaccurate harvest data to be used as a reference for policies or to see the potential of rice in Indramayu. This study aims to build a website-based data processing information system so that it can be accessed and managed by agricultural officers in all sub-districts in Indramayu, and the agricultural service as admin, so that the data produced is accurate data and provides predictions of harvest results, and makes predictions of future harvests based on harvest data, land area and rainfall that affect the rice harvest in Indramayu using fuzzy tsukamoto. From the predictions made, there are 16 sub-districts that have the potential to experience a decrease in harvest from 31 sub-districts in Indramayu. This information system also displays harvest data and graphs based on year and sub-district in Indramayu so that the increase or decrease in harvest in previous years can be seen compared to predictions for the coming year.

Keywords: Information System; Prediction; Fuzzy Tsukamoto; Rice Harvest; Indramayu.

1. Introduction

Food is a basic human need that must be met at all times. Obtaining food is also one of the rights of every citizen. The importance of food security is reflected as one of the development priorities in the government work plan (Wibowo, 2020). So that the shortage of food compared to its needs will cause various social and political upheavals that can affect economic stability both regionally and nationally. In Indonesia itself, food security is always associated with rice. This is related to this type of food being the main staple food for most people. To meet the food needs of its population, the government always tries to increase domestic rice production (Azzahra et al., 2021). Another consideration is that with the large population and geographical coverage, one of the efforts that can be made is to maintain the stock of rice originating from areas that have long been known as national rice barns.

Indramayu is an area known as a national rice barn. This is proven by data from the Central Bureau of Statistics (BPS) West Java Province, which states that in 2021, rice production by district/city states that Indramayu Regency, is the district/city with the highest rice production, reaching 1,768,3256 tons (Bahtiar, 2023) . If we look back at the data, it only displays overall production data in the Indramayu Regency, which does not explain which areas or sub-districts have the highest and lowest production, so that the local government can make policies to increase production in sub-districts that have low production. With the number of rice harvest figures, it should be a concern for all parties, especially the local and central governments, to maintain and even increase rice harvest production in the Indramayu Regency so that national food security can be maintained.

There are many components that can affect rice harvest. In general, one important component in maintaining rice production is the availability of agricultural land. Land area has a fixed nature, but is increasingly reduced because it is used as non-agricultural (Henny et al., 2021). The size of the land area significantly affects rice production. In addition, a study related to rice production stated that land area and harvest area have a positive effect on rice production, and the diversity of production variables can be explained by the land area variable (Matulessy & Tambunan, 2023). Other components that affect the harvest are climate change and rainfall patterns for water supply. Rice plants on rain-fed land have a high risk of failure (Ofdiansyah et al., 2023). In addition, the type of rice field used that is predominantly rain-fed in Indramayu (Mujiono & Sodikin, 2022), causes rainfall to have an effect on the harvest.

With the strategic role of Indramayu Regency as a national rice barn, as well as the importance of updating and processing agricultural data in Indramayu Regency, an information system is needed that can process agricultural data, which can improve harvest data, especially rice commodities based on

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existing sub-districts by looking at various indicators such as land area per sub-district, previous harvest results, and rainfall that can affect harvest production in each sub-district in Indramayu Regency.

2. Theoretical Framework

The agricultural sector is very dynamic and is influenced by external factors such as climate, weather, and land topography. This uncertainty requires flexible prediction methods. Adaptation to climate change is a strategic step in maintaining food production, especially in the face of fluctuations in rainfall and uncertain planting seasons (Priyatno et al., 2021).

2.1. Fuzzy Logic in Decision Making

Fuzzy logic is a system designed to handle uncertain or incomplete information, unlike classical binary logic. The Tsukamoto Fuzzy Method is a variant of the fuzzy inference system that uses IF-THEN rules, where each rule produces a sharp output value through a monotonic membership function. (Dellas et al., 2020).

2.2. Fuzzy Tsukamoto in Rice Harvest Prediction

Utilization of Fuzzy Tsukamoto to estimate rice production based on inputs in the form of fertilizers, seeds, and land area, with research results showing that this method provides accurate estimates (Sapura et al., 2020). Application of the Fuzzy Tsukamoto method to predict rainfall which is one of the important variables in the agricultural sector.(Sholihah, 2022).

2.3. Web-Based Harvest Data Processing Information System

The development of a web-based harvest information system provides an opportunity for farmer groups to monitor production results directly through an interface that displays harvest graphs and agricultural history. This system is equipped with security features and multi-user capabilities so that it can be accessed by farmers, agricultural extension workers, and related institutions through one integrated platform (Purba & Katuju 2023).

Utilizing frameworks such as Laravel in developing agricultural information systems is also a better choice because it has characteristics that can be customized, separated, and secure. Laravel allows integration with REST APIs and relational databases such as MySQL which are very important for managing large amounts of crop data.

3. Research Methodology

In this research, a research framework is prepared which aims to be a guideline in completing each process of developing the information system to be developed, as shown in Figure 1.

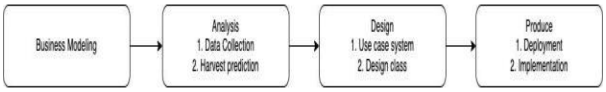

Figure. 1. Research Framework

The research framework developed in this study refers to the general system development model, by adding two approaches in determining predictions at the analysis stage, namely data collection and harvest prediction using Tsukamoto fuzzy logic.

3.1. Business Modelling

The main purpose of business process modeling is to explain how the current process works. The tool used in business process modeling here uses UML (Unified Processing Language), which supports business modeling notation through business use cases. (Yanti, 2021).

3.2. Analysis

The analysis stage is used to obtain valid research results. This stage focuses on collecting agricultural data in Indramayu.

1. Data Collection
   Data collection focused on land area data and rice harvest results in Indramayu with a time span between 2020-2023. In addition, rainfall intensity data was also collected at this stage.
2. Harvest Prediction
   The aim is to determine the estimated rice harvest in Indramayu in the future. Predictions are made using the fuzzy tsukamoto method as shown in Figure 2.

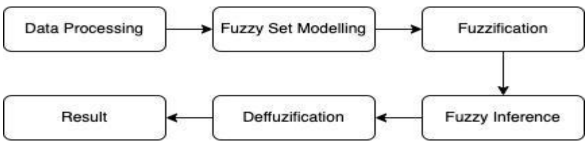

Figure. 2. Fuzzy Tsukamoto Method (Murtopo et al., 2024).

3.3. Design

This stage translates system requirements from the analysis stage into a design representation so that it can be implemented into the program at the next stage.

1. Use Case System
   The use case system describes an interaction between one or more actors with the system (Anindya et al., 2023). It will be clearly visible how actors and use cases interact in the system.
2. Design Class
   A class diagram is a description of the system structure in terms of defining the classes that will

be created to build an information system (Annisa, 2022).

3.4. Produce

At this stage, the design results that have been carried out are made in a web-based programming language, and the results are viewed for use by the actors involved.

4. Results and Discussion

The results and discussion explain the research that has been carried out referring to the methods that have been created.

4.1. Business Modelling

Business process modeling to understand what is inside and outside the agricultural data collection process, especially recording land area and harvest yields in each sub-district in Indramayu which has been carried out so far, as depicted in Figure 3.

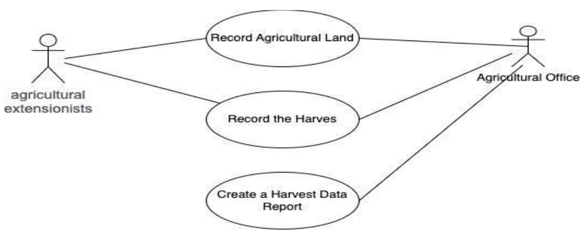

Figure. 3. Business Use Case for Rice Harvest Data Recording

4.2. Analysis

The analysis process in this study aims to find and explore agricultural data, especially data on land area, harvest yields and rainfall as variables that determine rice harvest yields.

4.2.1. Data Collection

The data collection process is carried out by tracing various data sources. Secondary data is obtained from the Food and Agriculture Security Service, and also the central statistics agency. The data used in this study is data obtained from 2020 to 2023 in 31 sub-districts in Indramayu such as the 2022 dataset listed in Table 1.

Table 1. Indarmayu rice harvest results dataset in 2022

Subdistrict	Year	Land Area	Rain fall	Rice Harvest (Tons/GKP)
Hargeulis	2022	8812	370	60138.3
Gantar	2022	20696	603	143691
Kroya	2022	13832	496	102356.8
Gabuswetan	2022	11900	407	93844.7
Cikedung	2022	12562	333	94104.06
Terisi	2022	16108	342	111162.53
Lelea	2022	9996	333	73711.28
Bangodua	2022	5446	308	44719.22
Tukdana	2022	7462	349	55174.31
Widasari	2022	5712	308	44251.95
Kertasemaya	2022	5760	285	46875.08
Sukagumiwang	2022	5140	338	38805.26
Krangkeng	2022	9242	135	65618.12
Karangampel	2022	4487	337	29994.24
Kedokan Bunder	2022	4218	337	31997.2
Juntinyuat	2022	7712	210	64468.13
Sliyeg	2022	8518	338	62716.09
Jatibarang	2022	5952	349	43474.6
Balongan	2022	3882	269	27012.06
Indramayu	2022	3608	333	28275.9
Sindang	2022	3432	267	23538.95
Cantigi	2022	3806	267	29178.5
Pasekan	2022	1775	267	12700.09
Lohbener	2022	5099	239	37688.09
Arahan	2022	4918	267	36160.74
Losarang	2022	10376	413	72475.03
Kandanghaur	2022	11053	290	83413.91
Bongas	2022	7860	412	54627
Anjatan	2022	12200	367	85400
Sukra	2022	6890	278	50782.75
Patrol	2022	6350	214	48097.57

In the dataset there are rainfall variables, which are grouped into three categories, namely low, medium, and high. The determination of rainfall scoring is obtained from the Meteorology, Climatology, and Geophysics Agency (BMKG) format is shown in Table 2.

Table 2. Rainfall Category (mm)

Low	Moderate	High
0 – 20	100 – 150	300 – 400
20 – 50	150 – 200	400 – 500
50 - 100	200 – 300	

4.2.2. Harvest Prediction

This prediction is included in one of the functions in the information system that is built by utilizing data that has been processed by the system, such as land area data, harvest results, and rainfall, as shown in Table 3. These variables are then analyzed to be calculated using the fuzzy tsukamoto method.

1. Fuzzy Set Modelling
   Fuzzy set theory allows the assessment of membership of elements in a set in stages. This is explained with the help of membership functions assessed in real number intervals (Davvaz et al., 2021). The formation of fuzzy sets in this study is based on data that has been collected in the previous stage on the variables of land area, rainfall, and harvest.

Table 3. Prediction Data Set

Variable	Set	Value
Land area (ha)	Small	1000
	Large	125000
Rainfall (mm)	Low	100
	Medium	300
	High	500
Rice Harvest (Tons/GKP)	Decreased	7000
	Increased	170000

2. Fuzzification
   In the calculation example explained, the sub-district used is Hargeulis sub-district with variables to be entered using a linear

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representation membership function, namely the area of planted rice fields is 8812 ha, and the rainfall is 370 mm. From these input variables, a solution process is carried out to find the value of the membership function.

A.Land Area

The land area variable consists of two sets, namely small with a value of 1000 and large with a value of 125000, as shown in Figure 4.

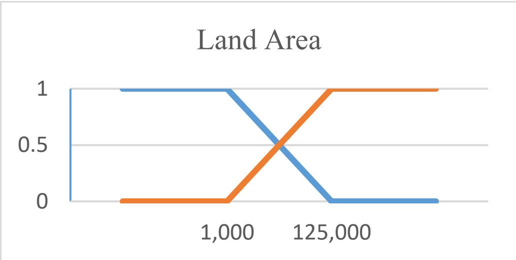

Figure. 4. Land Area Membership Degree Graph.

Small land area membership degree.

μ small [8812] = $\frac{125000-8812}{125000-1000}$ = 0,937

Large land area membership degree.

μ large [8812] = $\frac{8812-1000}{125000-1000}$ = 0,063

B. Rainfall

Rainfall variables consisting of three sets, namely low, medium, and high. Membership or membership function, as shown in Figure 5.

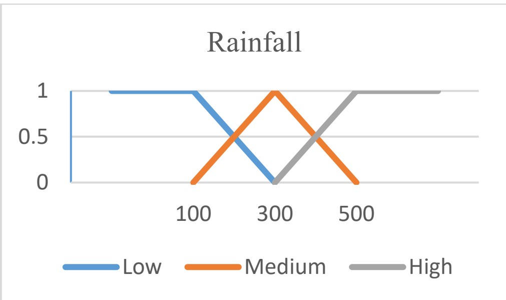

Figure. 5. Rainfall Membership Degree Graph.

Low rainfall membership degree.

μ low [370] = 0

Medium rainfall membership degree.

μ medium [370] = $\frac{500-370}{500-300}$ = 0,65

High rainfall membership degree.

μ high [370] = $\frac{370-300}{500-300}$ = 0,35

C. Rice Harvest Variable

The yield variable consists of two sets, namely decreasing and increasing. Membership or its membership function, as shown in Figure 6.

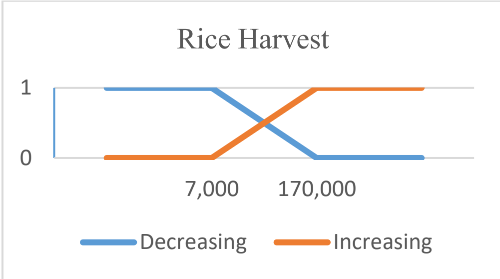

Figure. 6. Rice Harvest Membership Degree Graph.

Determination of prediction using fuzzy tsukamoto in this study aims to find the value of z (crop yield). To find the value of (z), the next step is to perform fuzzy inference.

3. Fuzzy Inference

The inference stage aims to issue rules from fuzzy logic (Wijaya et al., 2021). From the defined input variables, after analyzing the limit data of each fuzzy set on each variable, six fuzzy rules are formed. From these rules, the calculation of the value (z) for each rule is carried out using the MIN function with the application of the implication function which represents the inference stage as Equation (1) adn listed in Table 4.

$$\alpha\text{-predicate} = \mu\text{Land Area}(x) \cap \mu\text{Rainfall}(x) \quad (1)$$

Table 4. Fuzzy inference Hargeulis district

Rule	α-predicate	Z-value
[R1] IF the harvest area is SMALL **AND** the rainfall is LOW **THEN** the harvest yield is DECREASE.	0	170000
[R2] IF the harvest area is SMALL **AND** Rainfall is MEDIUM **THEN** harvest yield is DECREASE.	0,65	64050
[R3] IF the harvest area is SMALL **AND** rainfall is HIGH **THEN** harvest yields **INCREASE**	0,35	64050
[R4] IF the harvest area is LARGE **AND** rainfall is LOW **THEN** harvest yield DECREASE	0	170000
[R5] IF the harvest area is LARGE **AND** rainfall is MEDIUM **THEN** harvest yield INCREASES	0,063	17269
[R6] IF the harvest area is LARGE **AND** rainfall is HIGH **THEN** harvest yields INCREASE	0,063	17269

4. Deffuzification

The defuzzification process is used to find the output value based on the membership function formed. Defuzzification is an important method. The method used is the average using Equation 2. (Soebroto et al., 2022).

$$Z^* = \frac{\sum_i^n =\alpha\ predicate_i{}^* z_i}{\sum_i^n =\alpha\ predicate_i} \quad (2)$$

where the predicted rice harvest in Haurgeulis sub-district is 58815, 181172291. The same Tsukamoto

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calculation method is also applied to other sub-districts in Indramayu.

4.3. Design

4.3.1. Use case System

Use case system created is shown in Figure 7. There are three actors consisting of admin as the system manager who can process user data, sub-districts, datasets, process predictions, process history data, and view the results of rice harvest predictions, as well as agricultural extension actors who can process data like admins except for user data. Visitors can only see the harvest data and predictions produced.

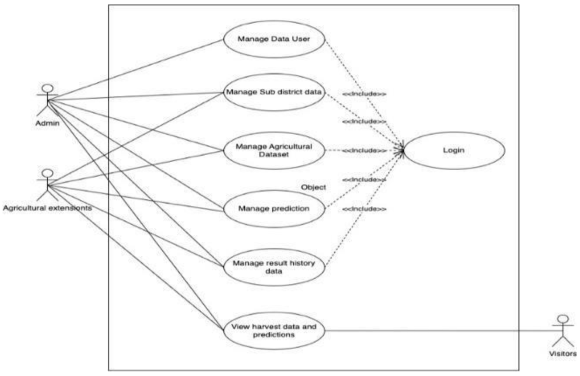

Figure. 7. Use case system.

4.3.2. Design Class

The creation of class diagrams is used to show the system structure clearly, and to get an overview of a program's scheme, as shown in Figure 8.

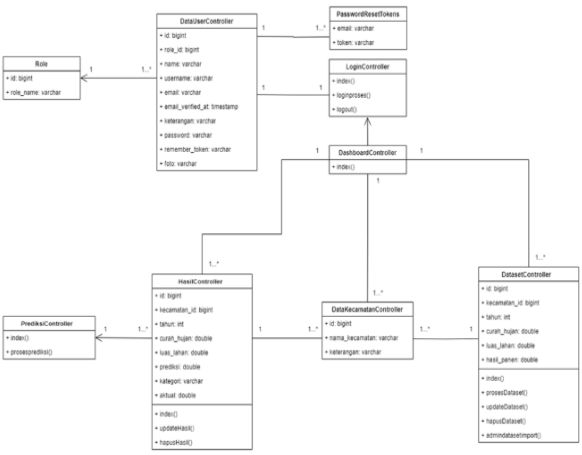

Figure. 8. Class diagram.

4.4. Produce Information System

This stage is the final stage in this research, where, in general, the system that has been designed begins to be architected and implemented.

4.4.1. Deployment

Deployment diagrams as in Figure 9 show how components are inserted into the system infrastructure, where they are placed on machines, servers, or hardware, the network functionality that exists at those locations, detailed information about server specifications and other physical characteristics (Dien at al., 2021).

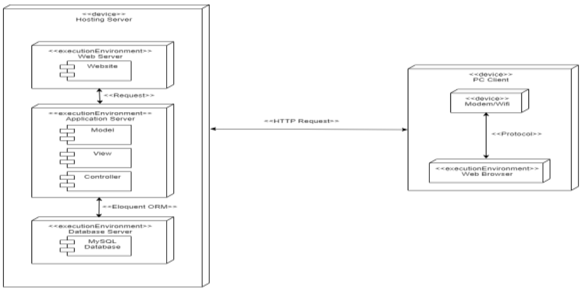

Figure. 9. Deployment diagram.

4.4.2. Implementation

This section is a discussion that explains the results of the implementation of the information system that has been created. So that it allows users to run this system. After logging in, users will be directed to the dashboard page, as shown in Figure 10.

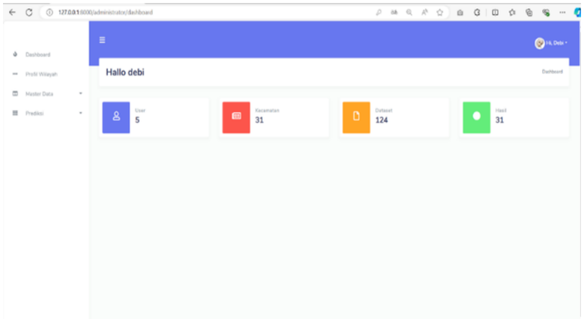

Figure. 10. Dashboard user.

The dataset menu in this system is for entering data on land area, harvest yields and rainfall data, as shown in Figure 11.

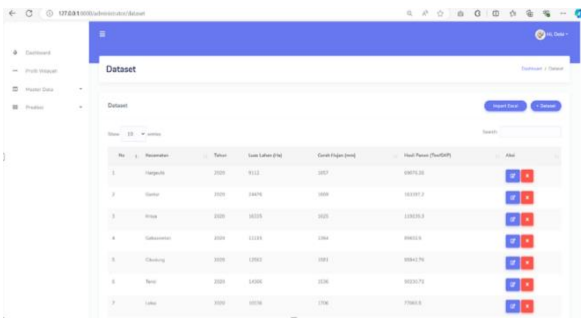

Figure. 11. Manage dataset.

Data on land area, harvest yields and rainfall that have been entered into the dataset will be used to predict rice harvest yields in the coming year, which can be found in the prediction menu, as shown in Figure 12.

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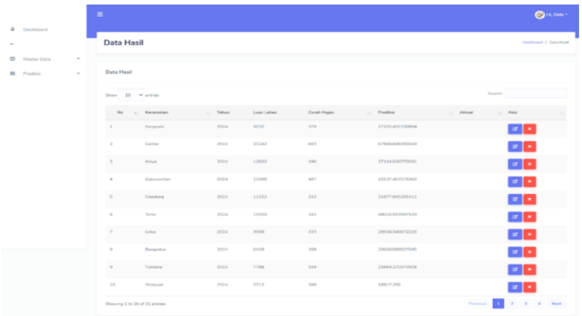
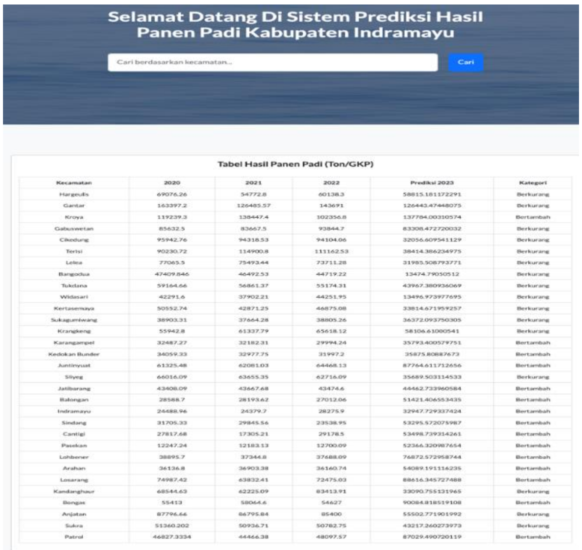


Figure. 12. Prediction result

The prediction results that have been processed in this information system can be seen by system visitors without having to log in, which displays data from the previous year, predictions, and information on increases or decreases, as shown in Figure 13.



Kecamatan	2020	2021	2022	Prediksi 2023	Kategori
Hargeulis	69076.26	54772.8	60138.3	58815.181172291	Berkurang
Gantar	163397.2	126485.57	143691	126443.47448075	Berkurang
Kroya	119239.3	138447.4	102356.8	137784.00310574	Bertambah
Gabuswetan	85632.5	83667.5	93844.7	83308.472720032	Berkurang
Cikedung	95942.76	94318.53	94104.06	32056.609541129	Berkurang
Terisi	90230.72	114900.8	111162.53	38414.386234975	Berkurang
Lelea	77065.5	75493.44	73711.28	31985.508793771	Berkurang
Bangodua	47409.846	46492.53	44719.22	13474.79050512	Berkurang
Tukdana	59164.66	56861.37	55174.31	43967.380936069	Berkurang
Widasari	42291.6	37902.21	44251.95	13496.973977695	Berkurang
Kertasemaya	50552.74	42871.25	46875.08	33814.671959257	Berkurang
Sukagumiwang	38903.31	37664.28	38805.26	36372.093750305	Berkurang
Krangkeng	55942.8	61337.79	65618.12	58106.61000541	Berkurang
Karangampel	32487.27	32182.31	29994.24	35793.400579751	Bertambah
Kedokan Bunder	34059.33	32977.75	31997.2	35875.80887673	Bertambah
Juntinyuat	61325.48	62081.03	64468.13	87764.611712656	Bertambah
Sliyeg	66016.09	63655.35	62716.09	35689.503114533	Berkurang
Jatibarang	43408.09	43667.68	43474.6	44462.733960584	Bertambah
Balongan	28588.7	28193.62	27012.06	51421.406553435	Bertambah
Indramayu	24488.96	24379.7	28275.9	32947.729337424	Bertambah
Sindang	31705.33	29845.56	23538.95	53295.572075987	Bertambah
Cantigi	27817.68	17305.21	29178.5	53498.739314261	Bertambah
Pasekan	12247.24	12183.13	12700.09	52366.320987654	Bertambah
Lohbener	38895.7	37344.8	37688.09	76872.572958744	Bertambah
Arahan	36136.8	36903.38	36160.74	54089.191116235	Bertambah
Losarang	74987.42	63832.41	72475.03	88616.345727488	Bertambah
Kandanghaur	68544.63	62225.09	83413.91	33090.755131965	Berkurang
Bongas	55413	58064.6	54627	90084.818519108	Bertambah
Anjatan	87796.66	86795.84	85400	55502.771901992	Berkurang
Sukra	51360.202	50936.71	50782.75	43217.260273973	Berkurang
Patrol	46827.3334	44466.38	48097.57	87029.490720119	Bertambah

Figure. 13. Landing page.

Systematically, the landing page also displays a graph of the development of the rice harvest for the previous year, as well as a comparison with the prediction graph that has been made, as shown in Figure 14.

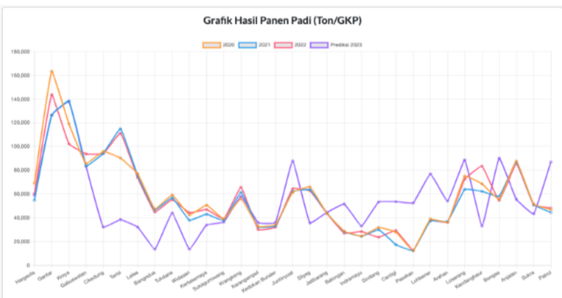


Figure. 14. Rice harvest graph.

From the prediction data and rice harvest graphs in Indramayu, it can be seen that the sub-districts experienced a decrease and increase in the amount of rice harvest based on the year in the inputted data. From the results of the research conducted, there are 16 sub-districts out of a total of 31 sub-districts in Indramayu that have the potential to experience a decrease in rice harvest production, based on the variables that have been inputted in the prediction calculation using fuzzy tsukamoto. Therefore, further handling is needed in the sub-districts that have experienced a decrease so that rice production and food security are maintained.

5. Conclusion

Based on the research that has been conducted on the rice harvest data processing information system, the data managed are land area data, harvest yields, and rainfall, where the data is used in making harvest predictions using the fuzzy tsukamoto method, which is chosen because of its ability to predict uncertainties such as rainfall. Therefore, data synchronization between institutions is also needed to support this system. The data used for predictions is obtained from data sourced from 2020 to 2023. The information system built is web-based, with three main users, namely agricultural extension workers, the agricultural service as admin, and visitors. System processing can be done by admins and extension workers, while visitors only see harvest data in Indramayu. From the results of harvest data processing and productivity predictions, there are 16 sub-districts that have experienced a decrease in harvest potential from a total of 31 sub-districts in the Indramayu Regency. In addition, this system also displays a harvest graph based on the year and its predictions. With this information system, it can be a source of agricultural data, especially for processing rice harvest data in Indramayu, as well as knowing the prediction of the upcoming harvest so that it can be a reference in determining policies for the agricultural service or related parties.

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