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Implementation of the Least Square Method for The Application of Population Growth Rate Prediction in Air Sugihan District

Rizqi Prasetyo[1], Andri[2], Susan Dian Purnamasari[3], Febriyanti Panjaitan[4]

[1]Fakultas Ilmu Komputer , Universitas Bina Darma, Palembang, Indonesia
[2,3]Program Studi Sistem Informasi, Universitas Bina Darma, Palembang, Indonesia
Email: [1]rizqyreus11@gmail.com, [2]andri@binadarma.ac.id, [3]susandian@binadarma.ac.id, [4]febriyanti_panjaitan@binadarma.ac.id

Abstract

Air Sugihan is one of the 18 sub-districts in Ogan Komering Ilir Regency, South Sumatra Province which has 19 villages. After observation, in the annual program policy planning carried out by the Air Sugihan District, almost all development plans need to have an information base for future time estimates, namely predictions of population growth rates. Therefore, this study aims to contribute to the Air Sugihan sub-district by conducting a predictive analysis of the population growth rate with the least square method and implementing it into an application. The use of the least square method is a suitable method for predicting the rate of population growth. From the results of the analysis of prediction calculations for 2021, the same results were obtained with the details of the birth value of 762 with MAD errors (77.04) and MAPE (11.78 %), the death value of 460 with MAD errors (65.41) and MAPE (20.41 %), the Migration-coming value of 637 with MAD errors (190.67) and MAPE (81.55 %) and the Migration-away value of 877 with errors MAD (169.99) and MAPE (45.35 %). With the implementation into the application, it facilitates the process of managing population growth rate data in determining the results of predictions or forecasting and conclusions can be drawn from the prediction results for which factors or variables are more specific to affect the rate of population growth in the future.

Keywords : Prediction, Population Growth Rate, Least Square, Application

1. INTRODUCTION

Air Sugihan is one of the 18 sub-districts in Ogan Komering Ilir Regency, South Sumatra Province. Air Sugihan Subdistrict itself consists of 19 villages. Based on data from the topography, Air Sugihan District has an area of around 1,923.3 km^2 with a population of around 32,699 people consisting of 17,189 men and 15,510 women [1]. Based on observations made in Air Sugihan Subdistrict in recent years, the population growth of Air Sugihan Subdistrict continues to change. With the growth of the population in Air Sugihan sub-district, the district management in planning must prepare carefully to be more targeted by understanding the situation

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of the population. To understand the situation of the population, it is necessary to have a demographic study which is an overview of the number of inhabitants in an area [2].

In the annual program policy planning carried out by the Air Sugihan Subdistrict, almost all development plans need to have a basis for information about population data, population distribution, and the frequency of population growth patterns that are relevant or in accordance with the plan. The source of such required information concerns not only the circumstances at the time the plan was drawn up, but also information on the past and especially forecast information for the future. Sources of information about population data in the past and current times can be obtained by the Air Sugihan District from the results of surveys and censuses that have been carried out by the Central Statistics Agency (BPS) of Ogan Komering Ilir Regency, while to meet the needs of population data in the future, it is necessary to predict the rate of population growth in the future.

Population growth rate prediction is an estimate of the number of people using scientific calculations based on assumptions from population growth rate factors, namely births, deaths and migration [3]. Of these three factors that can give a big picture of the population in the future. In determining the assumptions of the future rate of development of births, deaths and migrations requires historical data that presents trends in the past to the present and the factors that influence the rate of growth of the population. From the prediction of the population growth rate, it can produce information about what are the factors or variables that affect the population growth rate in Air Sugihan District.

In helping the Air Sugihan Subdistrict government to find out the factors that affect the population growth rate there, this study provides an application solution as information on predicting the population growth rate using the Least Square method. The calculation of the Least Square method provides quite good accuracy in the prediction results and with more components [4]. Thus, the use of the Least Square algorithm method is considered good and suitable for predicting population growth rates, this algorithm is also one part of time series forecasting which is used to see trends from a time series data using previous period data. In this case, it will be more focused on discussing time series analysis with the least square's method, which is divided into two cases, namely odd data and even data.

2. METHODS

In this study, researchers used several methods for achieving research purpose. The following is a description of the methods used:

1. Literature Studies. Search and study data from books or other references, which are related to writing a thesis research report.
2. Experimental Method using several stages including:
   a. Data collection
   b. Application of the algorithm
   c. Evaluation of results
   d. Application Design
   e. Due Diligence
   f. Application Evaluation
   g. Experiment documentation

2.1. Data Collection Methods

1) Observation
   The author made a visit to the Air Sugihan Subdistrict office addressed in Kertamukti, Air Sugihan District, Ogan Komering Ilir Regency, South Sumatra 30656.
2) Interview
   The researcher conducted a direct interview by giving several questions to the staff / employees of The Air Sugihan Subdistrict.
3) Literature Studies
   The author studies and collects data from various sources to get theories that the author will use to support the research carried out. The data is taken from journals, books, and literature – literature related to research.

2.2. **Least Square** Methods

The Least Square method is the most widely used method for determining data trend equations because it generates mathematically [5][6]. The formula used is:

$$\mathbf{Y' = a + bX} \quad (1)$$

To find a value and it can be searched using the formula :

$$\mathbf{a} = \frac{\sum \mathbf{Y}}{\mathbf{n}} \quad (2)$$

and

$$\mathbf{b} = \frac{\sum \mathbf{XY'}}{\sum \mathbf{X^2}} \quad (3)$$

Information:
Y= prediction result data

Y'= periodic data (time series)
X= time variable
a = trend value in the base year
b = average growth of trend value every year
n= amount of data

The determination of the value of X is used in alternative techniques by providing a score or code. In this case, the division of data into two parts is carried out, namely:

1. Even Data, with a score of X value (...,-5,-3,-1,1,3,5,...)
2. Odd Data, with a score of X value (...,-3,-2,-1,0,1,2,3,...)

To make the value $X^2 = 0$ the sum of the year data that is the benchmark is even and odd [7]. Guided by the following:

1. If the number of year data is not divided into two, namely odd, then the scale X = 1 year is used. As well as the year on which the basis is laid in the middle year.
2. If the number of years of data is divided into two, namely even, the scale X = 1/2 year is used. And the year that is the basis is the year in the middle.

2.3. Forecasting Methods

In forecasting, provisions are seen as a criterion for rejection in choosing a method of forecasting. With this, the accuracy of the method serves to measure the suitability of a forecasting method that obtains a data that has been processed [8]. The following are some measures of the provisions of the methods that are often used:

1) Standard Statistical Measures
If Xi is the actual data for period i and Fi is a forecast for the same period, then e or error is defined using the following equation [9]:

$$\mathbf{e = Xi - Fi} \tag{4}$$

Then look for the middle value of the absolute error of the MAD (Mean Absolute deviation) method using the following equation:

$$\mathbf{MAD} = \frac{\sum_{i=1}^{n}[Xi-Fi]}{n} \tag{5}$$

2) Relative Measures
The middle value of the absolute percentage error of the MAPE (Mean Absolute Percentage Error) method uses the following equation:

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$$\mathbf{MAPE} = \frac{\sum_{i=1}^{n}[PEi]}{n} \quad (6)$$

Information:
Xi – Fi= Error in the i-th period
Xi= Actual data on the i-th period
Fi = Forecast value in the i-th period
n = Number of time periods

2.4. System Development Methods

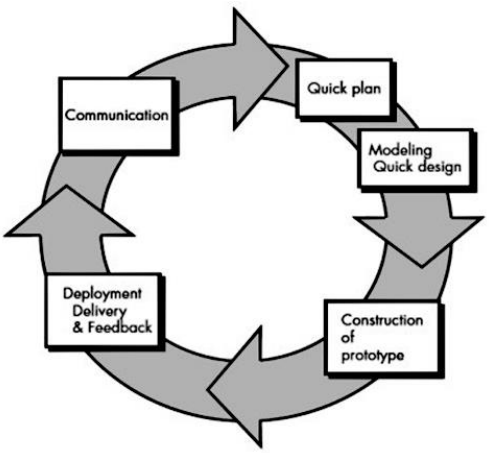

Figure 1. Prototype System Development Methods

The system development method used in this study is Prototype. A prototype is defined as a tool that provides an idea for both the maker and potential user of how the system functions in its full form, and the process of producing a prototype is called prototyping [10].

Prototyping is a simple software development process that allows the user to have a basic idea of the program to be created as well as perform the initial testing stage [11]. The use of this method of prototyping is aimed at allowing developers to form the expected software model (prototype). The prototype is then evaluated and repaired together if it is considered feasible, then the software is immediately produced while if there are still shortcomings, then improvements are made. The advantage of prototypes is that there is a compatibility between user requests and designs made by developers more quickly [12].
The stages in the development of the prototype model [10] are:
1. Communication, at this stage, identification of problems and needs of the system is carried out through intensive communication with the user.

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2. Quick Plan, Planning quickly focuses on representing all aspects of the software that are visible to the end user such as the design of the user interface in the form of Mockups or display design.
3. Modeling Quick Design, Modeling uses UML Diagrams such as Use Case Diagrams, Activity Diagrams and Class Diagrams.
4. Construction of Prototype, at this stage, a prototype is made that represents the system to be built.
5. Deployment Delivery and Feedback, at this stage, an evaluation of the prototype that has been built with the user is carried out, then the feedback is used to filter the user's needs. The application must be tested first before use or shown to the customer.

2.5. UML (Unified Modeling Language)

UML (Unified Modeling Languange) is a general purpose visual modeling language used to specify, visualize, build and document the artifacts of a software system [13].

3. RESULTS AND DISCUSSION

3.1 Communication

The purpose of this stage of communication is to issue problems and new ideas to find solutions or improvements to existing applications or problems that are being faced, these ideas can come from users or from developers who will create the software.

3.2 Quick Plan

3.2.1 Functional Needs Analysis

The analysis of these functional needs the researcher describes about some of the needs of the services, features or functions provided by this system, namely:

1. The system can store data into databases such as village data and population data, namely data on deaths, births, migrations (coming) and migration (leaving).
2. The system must be able to display village data and population data, namely data on deaths, births, migrations (coming) and migration (leaving) according to the period.
3. The system can predict the rate of population growth by using population growth data in the previous period through a calculation system from Least Square.
4. The system can print reports.

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3.2.2 Analysis of least Square Method

The following is data on the population growth of Air Sugihan District for the 2015-2020 period. In this study, we will predict the population growth rate in the next period, namely in the 2021-2025 period using calculations from the Least Square method.

1) Predicted birth rate

Table 1. Predicted birth rate data for 2021

Periode	Y'	X	X^2	XY'
2015	701	-5	25	-3505
2016	722	-3	9	-2166
2017	543	-1	1	-543
2018	783	1	1	783
2019	630	3	9	1890
2020	830	5	25	4150
∑	4209	0	70	609

$$\mathbf{a} = \frac{\sum Y'}{n} = \frac{4209}{6} = \mathbf{701{,}5} \qquad \mathbf{b} = \frac{\sum XY'}{\sum X^2} = \frac{609}{70} = \mathbf{8{,}7}$$

$Y = \mathbf{a} + \mathbf{bX}$

$Y = 701{,}5 + (8{,}7 \times 7)$

$Y = 762$

Table 2. Error calculation data predicting birth rate prediction

Periode	Actual (Y')	Predict (Y)	e =Y-Y'	| e |	| e/Y' |
2015	701	658	43	43	0,06
2016	722	675	47	47	0,06
2017	543	693	-150	150	0,28
2018	783	710	73	73	0,09
2019	630	728	-98	98	0,15
2020	830	745	85	85	0,10
∑	4164	4209		495	0,75

$$\text{MAD} = \frac{\sum|Y'-Y|}{n} = \frac{494{,}8}{6} = 82$$

$$\text{MAPE} = \frac{\sum\frac{|Y'-Y|}{Y}}{n} \times 100\,\% = \frac{0{,}75}{6} \times 100\,\% = 13\,\%$$

So the predicted results of the birth rate in 2021 are 762 people with an error in mad birth predictions of 82 and MAPE of 13%.

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Table 3. Prediction Results for 2021-2025

Jenis Variabel	Hasil Perhitungan														
	2021			2022			2023			2024			2025		
	Prediksi	MAD	MAPE	Prediksi	MAD	MAPE	Prediksi	MAD	MAPE	Prediksi	MAD	MAPE	Prediksi	MAD	MAPE
Kelahiran	762	82	13%	803	80	12%	334	211	29%	344	158	24%	157	134	23%
Kematian	460	65	20%	496	64	20%	176	136	33%	254	113	36%	83	104	30%
Datang	637	192	82%	-	-	-	-	-	-	-	-	-	-	-	-
Pergi	877	170	44%	983	168	43%	360	278	39%	549	252	46%	203	216	33%
Keterangan	Dengan menggunakan data aktual dari tahun 2015-2020. Jika dari hasil perhitungan prediksi nilai MAPE melebihi dari 50% maka tidak akan dilanjutkan untuk proses prediksi untuk tahun berikutnya.			Dengan menggunakan 5 data aktual tahun 2016-2020 dan 1 data prediksi tahun 2021 dengan menghapus data sebelumnya tahun 2015.			Dengan menggunakan 4 data aktual tahun 2017-2020 dan 2 data prediksi tahun 2021-2022 dengan menghapus data sebelumnya tahun 2015-2016.			Dengan menggunakan 3 data aktual tahun 2018-2020 dan 3 data prediksi tahun 2021-2023 dengan menghapus data sebelumnya tahun 2015-2017.			Dengan menggunakan 2 data aktual tahun 2019-2020 dan 4 data prediksi tahun 2021-2024 dengan menghapus data sebelumnya tahun 2015-2018		

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3.3 Modeling Quick Design

Modeling stages for a system built using UML (Unified Modeling Language), here is a use case diagram of the system to be built:

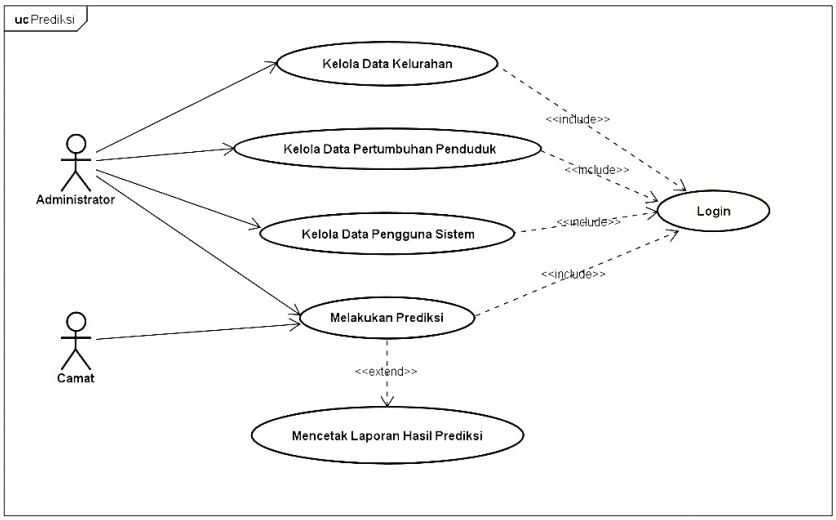

Figure 2. Usecase Diagram System to be built

1) Dashboard page design
Is the initial page interface design that appears when accessing the system.

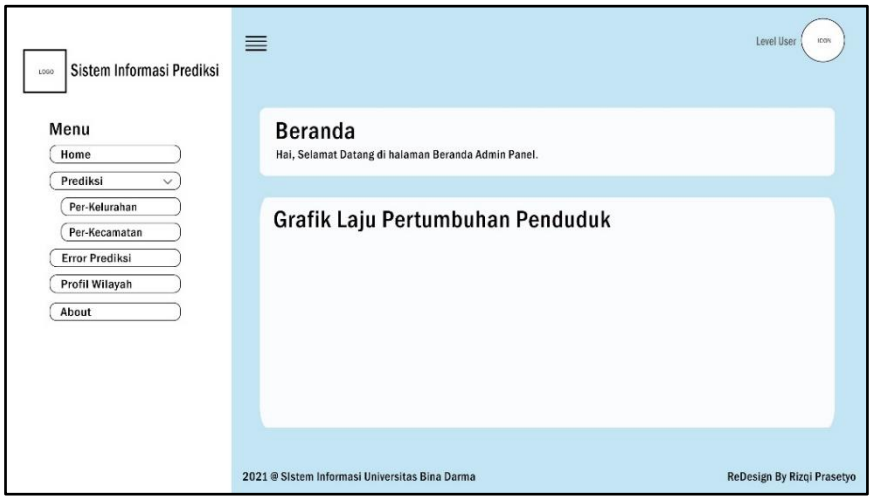

Figure 3. Dashboard page design

2) Prediction page design
It is a page interface design to carry out the prediction process by passing through the input form for the selection of the year to be predicted.

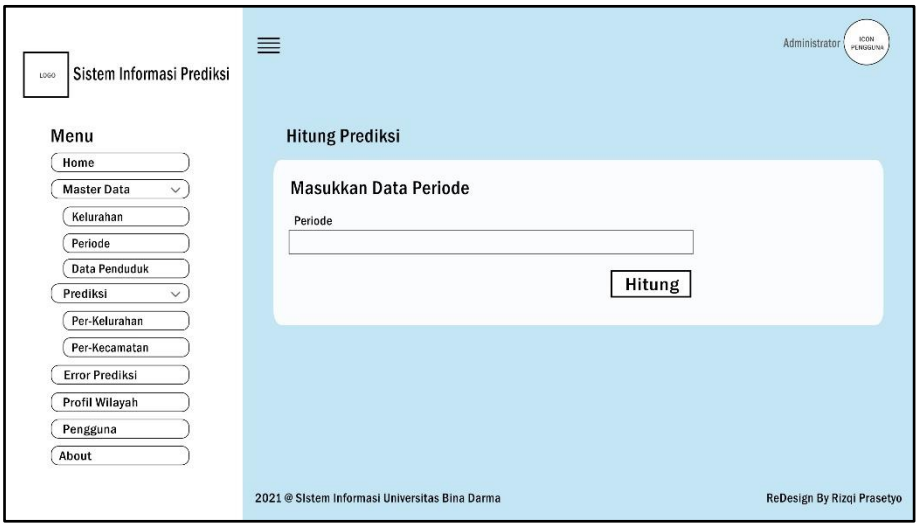

Figure 4. Prediction page design

3) Prediction results page design
It is a page design for the results of calculating the prediction of population growth rate by displaying the results of calculating all types of variables on the population growth rate.

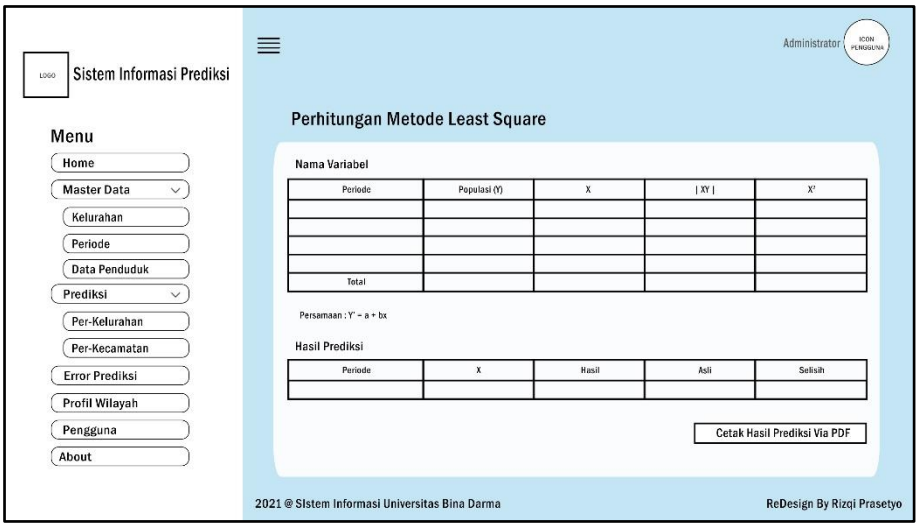

Figure 5. Prediction results page design

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3.4 Construction

3.4.1 System Implementation

At this stage, the construction of the application (Construction) of the prototype development method is the implementation of the previously defined system design. The program display will be used by the user to interact with the built software.

1) Login page view

This login page is the start page before entering the dashboard page that users use to access applications or systems to carry out processes on the system.

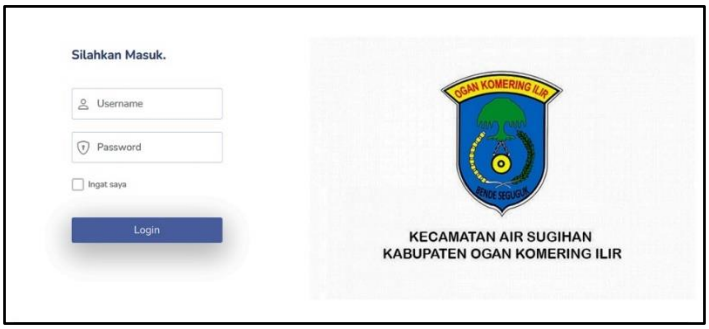

Figure 6. Login page view

2) Dashboard page view

Represents the start page after the user has successfully logged in. On this page users can use the functionality of the application's population growth rate.

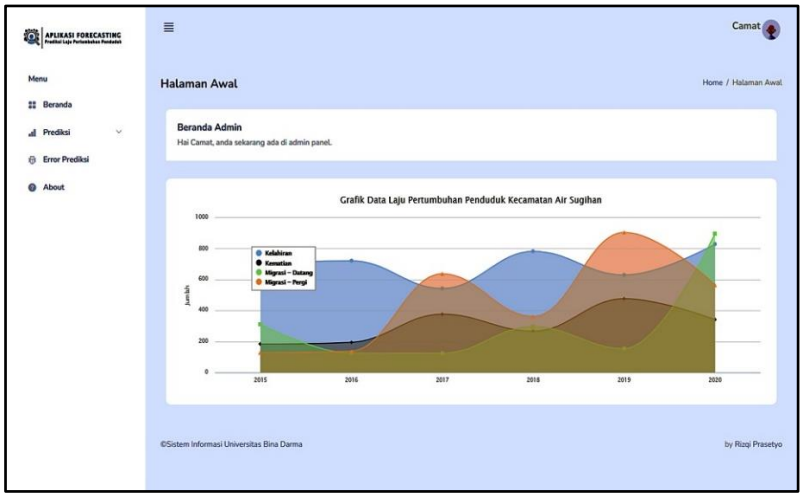

Figure 7. Dashboard page view

3) Prediction Page Views

The prediction page is a page that serves to calculate the prediction of the population growth rate. On this page users can carry out the process of predicting the rate of population growth.

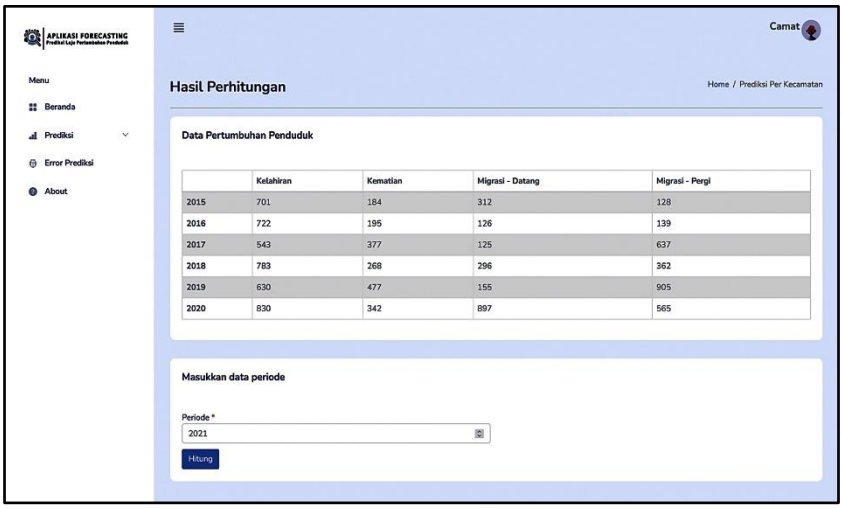

Figure 8. Predictions page

In the per-district prediction form, after filling in the data of the period to be predicted, by pressing the calculate button, the system will carry out the least square calculation process using historical data that has been inputted in the system and display the details of the calculation results as follows:

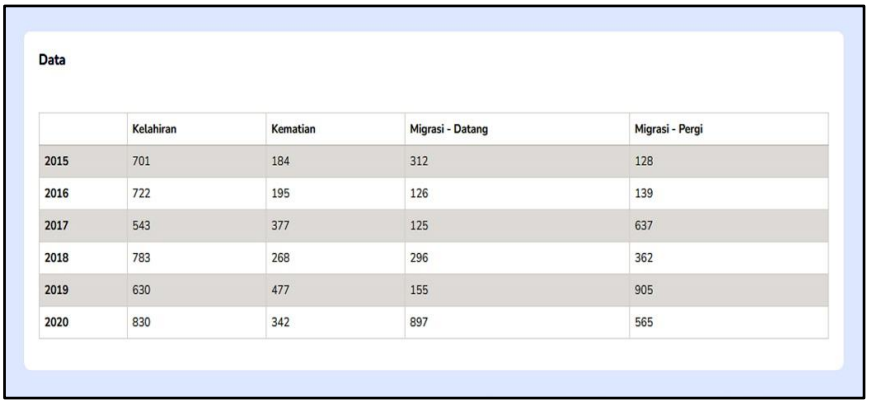

Figure 9. Details of the prediction calculation results

In figure 9, the first is shown, namely historical data on the population growth rate of each variable and grouped each period. Furthermore, the system will find which

period will be predicted according to the input period on the per-district prediction page as follows:


Dicari

	Kelahiran	Kematian	Migrasi - Datang	Migrasi - Pergi
2021	?	?	?	?

Figure 10. Details of prediction calculation results per-district

With the population growth rate data in figure 10, the system calculates the sum of the period data whether the data is an odd or even amount used in the determination of the value of x. After that the system will re-display the data of each type of population growth rate data variable and determine the values of the total Population (X), total XY, total X2, value a and niali b. With this value, the system immediately performs calculations using the formula **Y = a + bx** and displays predictions for the next period year that has been determined as can be seen in the following figure:


Kelahiran

No	Periode	Populasi (Y)	X	XY	X ^ Y
1	2015	701	-5	-3,505	25
2	2016	722	-3	-2,166	9
3	2017	543	-1	-543	1
4	2018	783	1	783	1
5	2019	630	3	1,890	9
6	2020	830	5	4,150	25
Total		4,209		609	70

Nilai a = 702
Nilai b = 9

Persamaan : Y = a + bx

No	Periode	X	Hasil Prediksi
1	2021	7	762

Grafik Data Real & Data Prediksi

Figure 11. Predicted birth results

Figure 12. Predicted outcomes of mortality

Figure 13. Predicted results of migration-coming

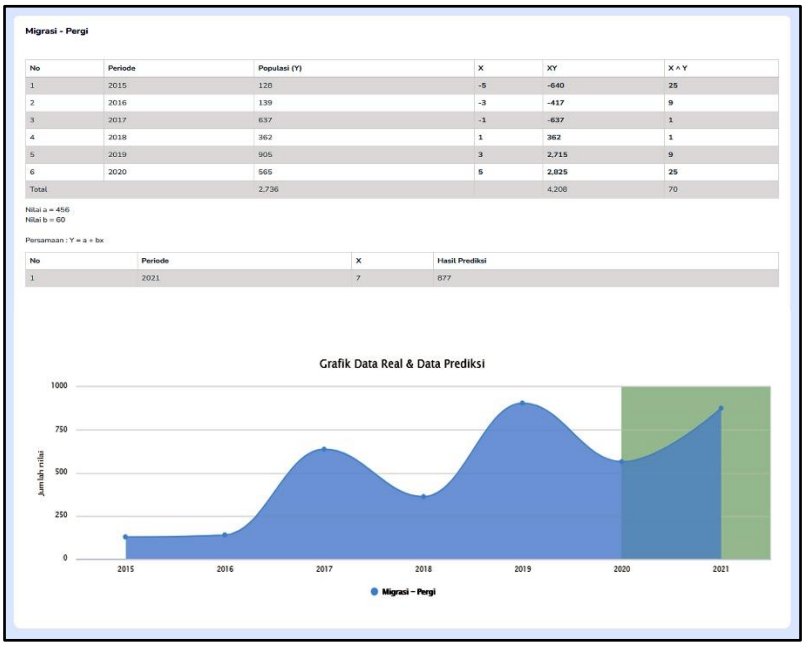

Figure 14. Migration-away prediction results

3.4.2 Testing

Researchers conducted tests on the Population Growth Rate Prediction Application using Black Box Testing which aims to test the functionality of the population growth rate prediction application that has been built with the following results:

Table 4. Blac box testing results

No	Running the App	Application Process	Status	Information
1	Run the application by entering the application url.	When running the application for the first time, a login page will appear with the input of the username and password and the login button.	Succeed	Successfully displayed logins.
2	Display dashboard home menu when The user has already logged in.	When successfully logged in, a home menu will appear according to the access level of the logged-in user.	Succeed	Successfully displayed the Home Dashboard page.
3	Run the Per-District Prediction	When pressing the per-district prediction menu, a	Succeed	Successfully displayed the per-district

No	Running the App	Application Process	Status	Information
	Menu and perform prediction calculations	prediction calculation page for all villages will appear by specifying the period to be predicted and then pressing the calculate button.		prediction calculation page and successfully performed the prediction.
4	Run the Per-Kelurahan Prediction Menu and perform prediction calculations	When pressing the per-kelurahan prediction menu, a prediction calculation page for each village will appear by specifying the period and village to be predicted and then pressing the calculate button.	Succeed	Successfully displayed the per-kelurahan prediction calculation page and successfully made a prediction.
5	Run the Per-Kelurahan Prediction Error Menu and perform prediction error calculations	When pressing the prediction error menu, a prediction error calculation page will appear by specifying the type of variable and then pressing the calculate button.	Succeed	Successfully displayed the prediction error calculation page and successfully performed the prediction error calculation.
13	Print a report of prediction results	When successfully making a prediction, a button will appear to print the report. Then press the print button.	Succeed	Successfully printed the prediction report via PDF.

3.5 Deployment

This stage is carried out to get feedback from users which is used because of an evaluation of the stages that have been carried out previously and the implementation of the system that has been developed. The system that has gone through the stages of testing, will then be submitted so that it can be implemented and can be utilized by users. The submission stage is carried out directly to the relevant unit as a research location. At the submission stage, the researcher handed over the software to the object of the study, namely the Air Sugihan District Office which is located in Kertamukti Village, Air Sugihan District, Ogan Komering Ilir Regency, South Sumatra, Zip Code 30656.

4. CONCLUSION

Based on the results of the study, a prediction calculation analysis has been carried out with the least square method for 4 types of variables, namely birth, death,

migration-coming and migration-away and calculating the accuracy of the forecasting method. With the results of these calculations, it can be concluded that if the Mean Absolute Percentage Error (MAPE) value is below 50%, this means that the calculation is suitable for forecasting use and can be done for calculating predictions in the following year using data on prediction results in the previous year. If it exceeds a figure greater than 51% then the result of the prediction is not suitable for prediction use and cannot be done for predictions in the following year. And for its implementation, the application that has been built simplifies the process of managing population growth rate data in determining the results of predictions or forecasting and conclusions can be drawn from the results of predictions for which factors or variables are more specific to affect the rate of population growth in the future.

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