

FORECASTING POPULATION GROWTH IN TANJUNG TIRAM USING LEAST SQUARE METHOD

Rainah¹, Nofriadi^{2*}, Ahmad Muhazir¹

¹Information System, Universitas Royal

²Computer System, Universitas Royal

*email: *rainahalfa09@gmail.com*

Abstract: The rapid population growth in Tanjung Tiram District, primarily driven by increased in-migration, demands an accurate forecasting system to support effective and sustainable development planning. This study aims to predict population growth in Tanjung Tiram District in 2024 using the Least Square method. The analysis covers birth, arrival, and migration data from 2019 to 2023. The results show that the Least Square method successfully predicts 936 births, 104 arrivals, and 142 migrations in 2024, with a very low error rate: MAPE for births is 0.01%, arrivals 0.12%, and migrations 0.04%. These findings demonstrate that the Least Square method can effectively support data-driven development policies and improve the accuracy of public service distribution planning.

Keywords: forecasting; least square method; population growth; tanjung tiram.

Abstrak: Pertumbuhan penduduk yang pesat di Kecamatan Tanjung Tiram, terutama akibat peningkatan migrasi masuk, menuntut adanya sistem prediksi yang akurat untuk mendukung perencanaan pembangunan yang efektif dan berkelanjutan. Penelitian ini bertujuan untuk memprediksi pertumbuhan penduduk di Kecamatan Tanjung Tiram pada tahun 2024 menggunakan pendekatan metode Least Square. Data yang dianalisis mencakup jumlah kelahiran, kedatangan, dan perpindahan penduduk dari tahun 2019 hingga 2023. Hasil penelitian menunjukkan bahwa metode Least Square mampu memprediksi jumlah kelahiran sebesar 936 jiwa, kedatangan 104 jiwa, dan perpindahan 142 jiwa pada tahun 2024, dengan tingkat kesalahan yang sangat rendah: MAPE untuk kelahiran sebesar 0,01%, kedatangan 0,12%, dan perpindahan 0,04%. Temuan ini membuktikan bahwa metode Least Square dapat digunakan secara efektif untuk mendukung penyusunan kebijakan pembangunan yang berbasis data dan memperkuat akurasi distribusi layanan publik.

Kata kunci: metode least square; peramalan; pertumbuhan penduduk; tanjung tiram.

INTRODUCTION

Information technology plays a very important role in today's world development, because it is widely used in government agencies and individuals who involve a lot of information in decision making. Computer technology

allows a government agency to process data quickly and accurately so that it can produce reliable information and can increase work efficiency and the capabilities of government agencies [1].

Tanjung Tiram District is the 3rd largest district in Batu Bara Regency. The administrative area in the Tanjung



Tiram District government consists of 9 villages with an area of 157.19 Km² [2], [3]. Based on data from Tanjung Tiram District, in-migration that occurred in Tanjung Tiram District experienced an increase in 2020, namely 11,391,000 people and a growth rate of 2.16%, so it can be concluded that population growth in Tanjung District Oysters often increase [4].

The negative effects of this high population growth will occur if the population growth is not balanced with sufficient infrastructure and facilities to support the population's survival in order to obtain a prosperous and prosperous life and livelihood. Three factors contribute to population growth: migration, birth (fertility), and death (mortality) [5]. These three factors have a significant impact on the process of population growth, and the development of population growth in a sub-district has a crucial role to detail [6].

In terms of providing facilities and infrastructure to offset the negative impacts of population growth, the government is required to make various breakthroughs in activities and the ability to predict the rate of population growth. Because with the ability to predict population growth, it will make it easier for the government to divide the budget portion to support the policies taken to minimize problems caused by the rate of population growth. Algorithm is one of the methods in statistics used to predict something with a forecasting algorithm [7].

Forecasting is an important tool in effective and efficient planning. An important step after the forecast is carried out is to verify the forecast in such a way that it reflects past data and the causal system underlying the growth [8]. In previous research entitled "Comparison

of Least Square Method with Moment Method in Preparing Sales Budget and Its Implications for Profit Planning at Ud Timbul Variasi" [9]. Stated that the 2023 sales forecast based on the moment method is more in line with actual sales of 2,873 with a Standard Forecasting error of 27.45. The SKP difference of 0.1 is considered immaterial. So the moment method is feasible to be applied in the company. In previous research entitled "Application of the Least Square Method in Predicting Instant Noodle Sales" [10]. Stated that the Least Square method on sales data from January 2022 to August 2022, the prediction results obtained the highest accuracy of 99% and the lowest accuracy of 85%.

In a previous study entitled "Using the Least Square Method for Forecasting Milkfish Production Volume in East Java Province" [11]. Stated that the forecast results showed an increasing trend in production volume from 2024 to 2028 with details of 2024 amounting to 195,411.5 tons; 2025 amounting to 202,190.2 tons; 2026 amounting to Forecast Accuracy Level (MAPE) of 11.05%.

In a previous study entitled "Drug Sales Forecasting Analysis Using the Least Square Method (Case Study at the King Medika Pelibaler Clinic)" [12]. Stated that the final result of this research produces an equation model $Y = 72.069,11 + (-993,82435)(X)$. From the equation model, it shows that the predicted results of rice using the least square method in Padang Lawas Regency in 2023 are estimated at 63,115.69 tons, and from the results of data processing, the calculation of the error value using MAPE is 4.23%. To make drug sales predictions using drug sales data from the previous period.

In a previous study entitled

"Implementation of the Least Square Method in the Website-Based Stock Forecasting System for Kampoeng Mas Qirun Meatballs"[13]. Stated that the implementing a stock forecasting system for meatballs at the Kampoeng Mas Qirun meatball stall. In a previous study entitled "Sales Forecasting Analysis of Battery Electric Vehicle Model Electric Cars in Indonesia (Least Square Method)" [14]. Stated that the Hyundai, DFSK, Lexus, Toyota, Mini, and Wuling are considered quite feasible and reliable to be used. Meanwhile, the sales forecasting model for the Nissan, KIA, Mercedes-Benz, Morris Garage, and BMW brands is considered not quite feasible and reliable.

In a previous study entitled "Application of the least square support vector machine (LSSVM) model for forecasting COVID-19 cases in Indonesia "[15]. Stated that the Least Square method has been widely used in a number of case studies, including the results of the optimal LSSVM model for forecasting Covid-19 cases in Indonesia from 1 February 2021-28 February 2022, namely the M14 and V24 models. In a previous study entitled "Projection of Increase in Sales of Honda Brand Motorcycles Using the Least Square Method" [16]. Stated that the it is a fixed calculation to determine the sales target for Honda brand motorcycles, with an average MAPE value of 5.3% or an accuracy value of 94.7%.

From the background description that has been mentioned previously, this study aims to predict population growth in Tanjung Tiram District in 2024 using the Least Square method, based on three main components: births, deaths, and migration. The prediction results in 2024 show a birth rate of 936 people, arrivals of 104 people, and migration of 142 people, with an error rate of less than 5%.

This study also evaluates the accuracy offorecasting both manually and using software. It is hoped that the results can provide insight into population growth trends and assist the government in strategic planning, including the distribution of social assistance and village development more effectively.

METHOD

The calculation algorithm uses the Least Square method to predict Least Square. The Least Square method is a method in the form of periodic series data where in making predictions past data is needed to be calculated and produce predictive information in the future using the latest observation data, each data used in this method with the least squares that produces the smallest error level value will be selected for use in the forecasting model [17]. Population growth data from 2019 to 2023 as in table 1.

Table 1. Population Data

No	Year	Birth	Arrival	Displacement
1	2019	829	196	113
2	2020	833	128	124
3	2021	857	133	142
4	2022	889	147	131
5	2023	907	132	129

The Last Square approach assumes that the data is unstable or oscillatory and requires relatively little historical data. A complex weighted moving average forecasting technique that is still easy to use is the last square. For inventory quantity data, the calculation uses the least squares algorithm [18]. The calculation algorithm uses the Least Square method to predict population growth in Tanjung

Tiram District with the formula below:

$$Y=a+bx.....(1)$$

Information:

Y = periodic data (*time series* data).

X = time variables (day, week, month, year).

a and b = constant number.

To get the Y value, you must first find the values of the constants a and b using the following formula:

$$a=\frac{\sum y}{n}.....(2)$$

(n is a lot of data)

$$b=\frac{\sum xy}{\sum x}.....(3)$$

To carry out calculations on the data, a certain value is needed for the time variable (X) as the weight. In general, what is given a value of 0 is the time variable which is located in the middle of 1. To carry out calculations on the data, a certain value is needed for the time variable (X) as the weight. In general, what is given the value 0 is the time variable which is located in the middle of 1. For odd data, the distance between two times is given a value of one unit.

Above 0 is marked + and below it is marked – (For example: 0, 1, 2, 3... and ... , -3, -2, -1, 0). 2. For even data, the distance between two times is given a value of two units. Above 0 there is a + sign, below it is a – sign (0, 1, 3, 5, ... and ... -5, -3, -1, 0). The accuracy of a forecast can be measured by several measures, among others [19]:

Mean Square Error (MSE) The average of the squared differences between the estimated value and the actual value:

$$MSE=\frac{\sum |x_t-F|^2}{n}.....(4)$$

Mean Absolute Deviation (MAD)

$$MAD=\sum \left(\frac{\text{Actual}-\text{Forecast}}{n}\right).....(5)$$

Mean Absolute Percentage Error (MAPE)

$$MAPE=\left(\frac{100\%}{n}\right)\sum_{t=1}^n \left|\frac{x_t-f_t}{x_t}\right|.....(6)$$

RESULTS AND DISCUSSION

The results of the study on the Tanjung Tiram District series using Last Square, namely Birth, Arrival Migration. An example of the calculation for one of the population growths, namely birth, can be seen in table 2.

Table 2. Calculation of Population Growth by Births

Year	Actual Data (Yt)	Ft	Abs Error Yt-Ft	Error ² Yt-Ft ²	Abs Error/Yt
2019	829	819,50	9,50	90,25	1,14
2020	833	848,50	15,50	240,25	1,861
2021	857	863,00	6,00	36,00	0,700
2022	889	877,50	11,50	132,25	1,294
2023	907	906,50	0,50	0,25	0,055
2024	-	935,5	-	-	-
		Total	43,00	499,00	5,06

Estimated population growth calculation for births in the period 2024.

$$a = \frac{\sum y}{n} = \frac{4315}{5} = 863$$

$$b = \frac{\sum xy}{\sum x^2} = \frac{290}{20} = 14.50$$

Once the forecasting model is determined, the next step is to predict the growth of the birth population with a value of $X = 5$ using the following equation:

$$Y_{2024} = 863 + 14.50 (5) = 935.5 \Rightarrow 936$$

Mean Square Error (MSE) The average of the squared differences between the estimated value and the actual value:

$$MSE = \frac{\sum |x_t - F|^2}{n} = \frac{499,00}{5} = 99,80$$

Mean Absolute Deviation (MAD) is the first measure of overall

forecasting error for a model:

$$MAD = \frac{|At-Ft|}{n} = \frac{43,00}{5} = 8,60$$

Mean Absolute Percentage Error (MAPE):

$$MAPE = \frac{|At-Ft|(100)}{Y_t} = \frac{5,06}{5} = 0,01\%$$

The following are the forecasting results using the Last Square method, namely the birth rate of 936 with an error value of 0.01%, arrivals of 104 with an error value of 0.12%, and migration of 142 with an error value of 0.04% in 2024. The results of the error values of population growth can be seen in table 3.

The following is an example of population growth forecasting, namely growth is a graph of the Last Squares Method in predicting population growth at birth which can be seen in Figure 1.

Table 3. Forecasting Error Value

No	Forecasting Error Value		
	Population Growth	Forecasting Results	Error Result
1	Birth	936	0,01%
2	Arrival	104	0,12%
3	Move	142	0,04%

**Kelahiran**

Periode (t)	Y_t	X_t	$X_t \cdot Y_t$	X_t^2	F_t	e_t	e_t^2	$ e_t $	$ e_t / y_t $
2019	829	-3	-2487	9	819.5	-9.5	90.25	9.5	1.146%
2020	833	-1	-833	1	848.5	15.5	240.25	15.5	1.861%
2021	857	0	0	0	863	6	36	6	0.7%
2022	889	1	889	1	877.5	-11.5	132.25	11.5	1.294%
2023	907	3	2721	9	906.5	-0.5	0.25	0.5	0.055%
Total	4315		290	20					
MSE (Mean Squared Error)							99.800		
RMSE (Root Mean Squared Error)							9.990		
MAE (Mean Absolute Error)								8.600	
MAPE (Mean Absolute Percentage Error)									0.010 %

$$a = 863$$

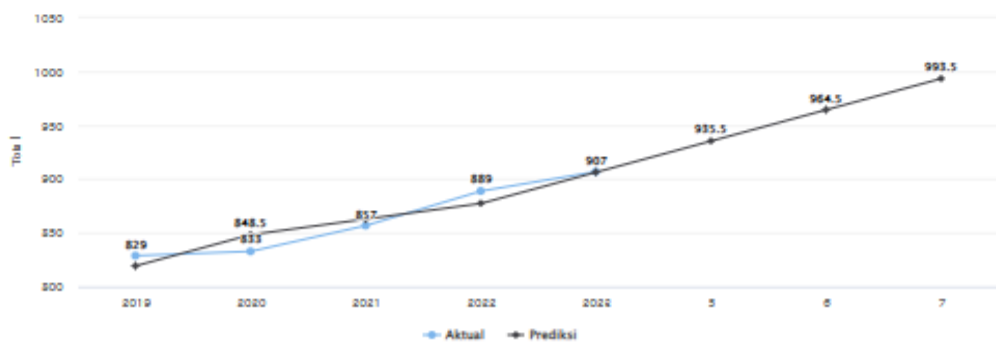
$$b = 14.5$$

$$F_t = 863 + 14.5X_t$$

Hasil Prediksl:

Periode (t)	X	F_t
2024	5	935.500
2025	7	964.500
2026	9	993.500

Grafik Data dan Hasil Prediksi Kelahiran



Diketahui
Tanjung Tiram, 04-02-2025

Image 1. Forecasting Results Report

CONCLUSION

System built using the PHP programming language and MySQL database can predict population growth in the Tanjung Tiram area using the Least Square method in the following year. The implementation of population growth forecasting at the Tanjung

Tiram Subdistrict Office using the Least Square method provides results of forecasting population growth for birth rate of 936 with an error value of 0.01%, arrivals of 104 with an error value of 0.12%, and migration of 142 with an error value of 0.04% in 2024.

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