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PREDICT FACTORS OF POPULATION GROWTH AND THE NUMBER OF POPULATION OF KARO DISTRICT USING STOCHASTIC MODEL

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Abstract

Population growth is population transition, both growing and declining. Population growth in a region is based on birth (birth), death (death), death (in-migration) and movement out out-migration). Three factors affect population growth. One is birth, death, and displacement. Population growth in Karo District has increased annually, BPS (2002). From these details, the rising population can be classified. From the truth, examining factors driving population growth in Karo District is interesting. From these results, a stochastic model can be modelled.

Population growth and population growth can be measured using birth, death and movement trends. Birth, death is a mechanism of Poisson. Population growth indicates residential land and jobs decline. A stochastic model is required to predict population growth in Karo district.

This study aims to establish a stochastic growth model for the phase of birth, death and displacement trends, forecasting future demographic growth and population growth in Karo district using the assumption of making stochastic population growth models and trend data. Data is analyzed using pattern analysis and mixing processes.

Karo Regency's population growth projection results per day in 2030 are 26,2095 and population growth per day is 30,5232 in 2031. So the expected value of the Karo Regency population whose population is unknown in 2030 is 530,529 and 541,670 in 2031.

Keywords: population growth, stochastic model, Karo population forecast.

1. Introduction

Population growth is population transition, both increase and decline, caused by many factors. The following factors affect population growth, namely death (Mortality). Many death-causing factors are typically affected by age, local climate, or place of residence where life-support facilities such as food, hygiene, and health exist or not. Extraordinary incidents, including natural disasters, can also affect these variables. Typically this element is a low percentage. If Mortality rises, the population rate will decline, but if the death rate falls, the population will still rise as the birth rate rises rapidly. Next is birth (fertility). This birth factor can be said to be the main cause of population growth in the world since the average population rise is the high birth rate relative to death rate due to a philosophy that recommends many children. This incident normally happens in areas far from the capital. If births can be accelerated by health technologies, the population will increase dramatically due to increasing birth rates. Births contribute to individuals. The next factor is migration, which is human movement from place to place. In certain cases, people move in search of disbursement outlets because they don't work in good jobs and don't meet the family's daily food needs. Besides migration, there's another term for population dynamics, namely mobility. This concept of mobility is wider than migration since it encompasses regional permanent and temporary movement. A regional migration review is very significant, particularly regarding population density and uneven distribution.

In Karo district, population increases from the previous year relative to last year, there is a growing population. In 2010 (350,960 people), 2011 (354,242), 2012 (358,823)[1]. From these results, it can be concluded that Karo Regency's population is growing every year.

Karo Regency is one of the regenerations in North Sumatra Province with an area of 2,127.25 km2 or 2.97 per cent of North Sumatra Province and a population of around 500,000. This regency is located in the Karo highlands, North Sumatra's Bukit Barisan range, most of its territory is high. Two active volcanoes (Sinabung and Sibayak) are in Karo. They located 77 km from Medan, North Sumatra Province capital. Karo Regency area between 200 and 1,500 meters above sea level. Since at this altitude, Tanah Karo Simalem, another name for this district, has a cool climate with temperatures varying from 16°C to 17°C.

Population growth can be measured using death, birth, and displacement variables. Birth, death and migration is a Poisson process. Population growth has resulted in less housing space and more challenging work prospects. A stochastic model is required to predict population growth in Karo district.

This research aims to create a stochastic model of population growth by involving death, birth, and displacement factors in order to forecast the future population in 2030 and use the assumption of making a stochastic model of population growth by analyzing trend data. The combination method processes data.

The idea of this research came from [2] The approach used is to model population growth, forecast population growth, and predict Karo Regency population in 2030 and 2031.

Study concerns

The amount of year-to-year population growth in Karo district is growing. Population growth has an effect on living and farming density, and the number of unemployed rises. This needs a population growth model to assess population growth in Karo district. The model is generated using a mathematical assumptions stochastic model. The data obtained then refers to the model generated.

2. Reviewing the literature

2.1 The Stochastic Population Growth Model of Assumptions

Assumptions for making a stochastic model of population growth in Karo District use the assumptions from[2], where Karo Regency population data is used to measure population growth. Where this analysis replaces it with mathematical assumptions. Let (X(t,t+h) be a random variable representing the number of people over time t,t+h):

a. $N(t, t+h)$represents the number of groups at the time $(t, t+h)$, and $N(t, t+h)$ is a poison process with an expectation value $(\alpha+\mu+\theta)h$, where α is the mean birth rate, μ is the average mortality rate, and $\theta = \theta_1 - \theta_2$ is the average population displacement (where in-migration $(\theta_1)$and out-migration (θ_2)).

b. Random variable X_i, which is the number of events that occur in group i. The number of events that occur in different groups is mutually independent and has the same distribution of opportunities.

c. Parameters $\{\alpha_n = n\alpha + \theta\}$ and$\mu_n = n\mu\}$are positive number sequences which state the rate of births and deaths resulting in population movements, with the initial state $M(0) = i$and$M(t) = E[X(t)]$. To determine the value of $M(t +$

$h)$, the expected value is used with the terms $X(t)$, so that the equation is:

$$M(t+h) = E[X(X(t+h)]$$
$$= E[E\big[X(t+h)\big|X(t)\big)]]. \qquad (2.1)$$

Thus in the time period (t,t+h), the likelihood of events occurring in the course of group birth and death resulting in population relocation is one or more population movements or does not result in one or more births and deaths or individual population movement. Every incident involving a citizen has the following opportunities:

a. The probability of having one or more individuals, , $\frac{1}{\sum_{i=1}^{N(t)} Xi} E[X_i]X(t)\alpha h + o(h)$ with$h \to 0$.
b. The probability of the death of one or more individuals, , $\frac{1}{\sum_{i=1}^{N(t)} Xi} E[X_i]X(t)\mu h + o(h)$ with$h \to 0$.
c. The probability of a population displacement of one or more individuals, $\frac{1}{\sum_{i=1}^{N(t)} Xi} E[X_i]X(t)\theta h + o(h)$with $h \to 0$.
d. Chances of no birth, death, and population displacement$1 - \frac{1}{\sum_{i=1}^{N(t)} Xi} E[X_i]X(t)(\alpha+\mu)+\theta]h + o(h)$.with $h \to 0$.

Soif X (t) is known, then the number of individuals at t + h is:

$(t+h)$

$$= \begin{bmatrix} (X(t) + \sum_{i=1}^{N(t)} X_i, & \text{with probability} \frac{1}{\sum_{i=1}^{N(t)} Xi} E[X_i]X(t)\alpha + \theta]h + o(h) \\ (X(t) - \sum_{i=1}^{N(t)} X_i, & \text{with probability} \frac{1}{\sum_{i=1}^{N(t)} Xi} E[X_i]X(t)\mu + \theta]h + o(h) \\ (X(t), & \text{with probability } 1 - \frac{1}{\sum_{i=1}^{N(t)} Xi} E[X_i]X(t)(\alpha+\mu)+\theta]h + o(h) \end{bmatrix}$$

2.2 Cluster Analysis

Cluster analysis is a multiple variable statistical analysis that is used if there are n individuals or objects with p variables and the n objects want to be clustered into k groups based on the observed properties such that individuals in one category have the greater similarity of properties than those in another unit. Cluster analysis is a multivariate method of interdependence (interdependence). Therefore there is no difference between the independent variable and dependent variable in cluster analysis. Cluster analysis is used to classify observational data based solely on data that can explain observations and their relationships. The object of this study is to differentiate observations in one group from observations in other groups. The greater the group similarity (homogeneity), and the greater the distinction (heterogeneity) between classes, the stronger and more different the bulking[3].

2.3 Grouping

It is divided into a hierarchical clustering method and non-hierarchical clustering method in cluster analysis. The hierarchical approach is used because several groups are not identified beforehand. The hierarchical method is used if there is no selected group number of knowledge. At the same time, the non-hierarchical approach tends to group n objects into k (k<n), where k is predetermined. The cluster analysis approach requires a dissimilarity (distance) measure for each pair of objects to be clustered. Distance widely used in cluster analysis is Euclid distance.

2.4 Euclid distance

Cluster analysis uses nuclide spacing most frequently. Euclid's gap between two points can be well interpreted. Distance is a continuous variable. Distance between the p variable's ith and j-th bands is defined as:

$$d(i,j) = \left[\sum_{t-1}^{p} (\,\overline{x}_{tj} - \overline{x}_{\iota})^2\right]^{\frac{1}{2}}$$

Where :

$d(i,j)$ =distance between object i to object j

$\overline{x}_{tj}$= middle value on variable t to j button

$\overline{x}_{i}$= middle value on variable t to i button

p = number of variables observed

2.5 Hinarki Mode

Hinarki method is divided into two grouping methods, namely combining method and solving method[4]. This research uses a combination approach to analyze the cluster.

2.6 Form of combination

The grouping method using the Down to Top approach starts with n groups, so each group is exactly one object, then the two nearest groups are identified and merged into a new group. Combining two groups is replicated until one group is obtained that includes all data sets. Note that in this process, any combination is always followed by an increase in the distance matrix. This method's cluster analysis findings are viewed as a dendrogram.

2.7 Pattern analyzes

Trend analysis is a method of mathematical analysis for future prediction or forecasting. It takes a lot of different kinds of data to make a good prediction that is observed in a very long time so that the effects of the study can figure out how much fluctuation has occurred and what factors cause these shifts. There are three trend analysis models—linear trend, quadratic trend, and exponential trend[5].

Linear pattern with persistent data patterns over time. The model is linear trend equation[6]:

$$Y_t = a + bt$$

Information :

Y_t = time series data at period t

t = time (day / month / year)

a, b = constant

The values a, b are obtained from:

$$b = \frac{\sum_{t=1}^{n} Y_t t - \sum_{t=1}^{n} Y_t \sum_{t=1}^{n} t}{\sum_{t=1}^{n} t^2 - (\sum_{t=1}^{n} t)^2}$$

And

$$a = \frac{\sum_{t=1}^{n} Y_t}{n} - b\frac{\sum_{t=1}^{n} t}{n}$$

2.8.1. Quadratic trend

A quadratic trend is a trend in data whose curves are curved. Mathematically, the quadratic trend is between the dependent variables and t and t2. The quadratic equation model is [6]:

$$Y_t = \beta_0 + \beta_1 t + \beta_2 t^2$$

Information :

Y_t =time-series data at period t

t = time (day / month / year)

$\beta_0 + \beta_1 t + \beta_2 t^2$= constant

is the tendency for data change to increase exponentially. There are two models for exponential trends, namely: For discrete variables$Y_t = \beta_0 + (1 + \beta_1)$ and for continuous variables: $Y_t = \beta_0{}^{e\beta_1 t}$ Information:

Y_t = time-series data at period t

t = time (day / month / year)

β_0, β_1 = Constant

The selection of the trend analysis model to get the best forecasting value is based on the smallest standard error of the Estimate (SSE).

2.8.3 Size Error

In this study, the measure of the accuracy of the forecasting results is a measure of the degree of difference between the forecasting results and the actual value. There are four commonly used measures, namely the average absolute deviation (Mean Absolute Deviation = MAD), the average square error (Mean Square Error = MSE), the average forecast error (Mean Forecast Error = MFE), and the average absolute error percentage (Mape Absolute

Percentage Error = MAPE). In this study, the error measure used is MAPE (Mape Absolute Percentage Error), as for the equation:

$$MAPE = \sum_{i}^{n} \frac{|PE_i|}{n}, with : PE = \left(\frac{x_i - F_i}{x_i}\right)$$

Information :

x_i = actual data in period i

x_i = predicted value in period i

n = number of time periods.

3. Research Methods

3.1 Research and Calculation Data

The data used in this study is population data in 2016, namely the population in Karo district (in the base year) used in a year.

3.2 Variable analysis

This analysis used secondary data from the Central Statistics Bureau (BPS) in Karo district. Population statistics taken are 2002-2016 data. The stochastic increment model uses Karo district birth, death, and displacement variables using stochastic increment model assumptions. Then the next move is to perform cluster analysis to determine Karo district characteristics. They are checking with linear, quadratic, and exponential trend analysis, estimating Karo Regency's population growth prediction with MAPE. Data analysis was conducted using a model to gain predictive value for population growth and forecast the future population.

4. Results and discussion

4.1 The Stochastic Model of Population Growth

By using the assumptions that have been built from equation (2.1), we can obtain a stochastic model of population growth in factors of births, deaths and population movements in Karo district: $M_t = \frac{\theta}{\alpha - \mu}\left[e^{E[X_i](\alpha-\mu)t} - 1\right] + ei^{E[X_i](\alpha-\mu)t}$.

Proof :: $E[X(t+h)|X(t) = \left[(X(t)+\sum_{i=1}^{N(t)} X_i\right]\left[\frac{1}{\sum_{i=1}^{N(t)} Xi} E[X_i]X(t)\alpha+\theta]h\right] + \left[(X(t)-\sum_{i=1}^{N(t)} X_i\right]\left[\frac{1}{\sum_{i=1}^{N(t)} Xi} E[X_i]X(t)\mu]h\right] X(t)\left[1-\frac{1}{\sum_{i=1}^{N(t)} Xi} E[X_i]X(t)(\alpha+\mu)+\theta]h+o(h)\right] = \frac{X(t)}{\sum_{i=1}^{N(t)} Xi} E[X_i]X(t)\alpha+\theta]h + \frac{X(t)}{\sum_{i=1}^{N(t)} Xi} E[X_i]X(t)\mu]h - E[X_i]X(t)\mu]h + X(t) - \frac{X(t)}{\sum_{i=1}^{N(t)} Xi} E[X_i][X(t)(\alpha+\mu)+\theta+o(h) = E[X_i]X(t)\alpha - X(t)\mu+\theta]h + X(t) + o(h)$. Sehingga, $M(t+h) = E\big[E[X(t+h)|X(t)]\big] = E[E[x_i]X(t)\alpha - X(t)\mu+\theta]h + X(t)o(h)] = E[E[x_i]X(t)\alpha - \mu(t)\mu+\theta]h + X(t) + o(h)$

$M(t+h) = E[X_i][M(t)(\alpha-\mu)+\theta]h + M(t) + o(h)$

$M(t+h) - M(t) = E[X_i][M(t)(\alpha-\mu)+\theta]h + o(h)$

$$\frac{M(t+h)-M(t)}{h} = E[X_i][M(t)(\alpha-\mu)+\theta] + \frac{o(h)}{h}$$

By adding $h \to 0$ then $\lim_{h\to 0} \frac{0(h)}{h} = 0$

so, $\lim_{h\to 0} \frac{M(t+h)-M(t)}{h} = E[X_i][M(t)(\alpha-\mu)+\theta$

$= E[X_i][M(t)(\alpha-\mu) + E\big[X_j\big]\theta$

So that the following equation is obtained: $M'(t) = E[X_i][M(t)(\alpha-\mu) + E[X_i]\theta$ (2.2)

Solve equation (2.2) using ordinary differential equations [Forlow],

if $h(t) = E[X_i][M(t)(\alpha-\mu) + E\big[X_j\big]\theta$ (2.3)

than $h'(t) = E[X_i][M'(t)(\alpha-\mu)$.

So it's the equation (2.2) can be written as follows:

$h'(t) = E[X_i][M'(t)(\alpha-\mu)$

$$\leftrightarrow \frac{h'(t)}{E[X_i](\alpha-\mu)} = M'(t)$$

$$\leftrightarrow \frac{h'(t)}{E[X_i](\alpha-\mu)} = h(t)$$

$$\leftrightarrow \int \frac{h'(t)}{h(t)}dt = \int E\,[X_i](\alpha-\mu)dt$$

$$\leftrightarrow log\ h(t)] = \int E\,[X_i](\alpha-\mu)t + C$$

$h(t) = e^{E[X_i](\alpha-\mu)t+C} = Ke^{E[X_j](\alpha-\mu)t}$

From the equation (2.3),

$h(t) = E[X_i][M(t)(\alpha-\mu) + E[X_i]\theta$

$Ke^{E[X_j](\alpha-\mu)t} = E[X_i][M(t)(\alpha-\mu) + E[X_i]\theta$ (2.4)

With initial values *M(0) = i*, where *t = 0* so that it is obtained:

$K = E[X_i][i(t)(\alpha-\mu) + E[X_i]\theta$

$= E[X_i][i(t)(\alpha-\mu) + \theta$

Then substitute the X value in the equation (2.4):

$$E[X_i][M(t)(\alpha-\mu)+E[X_i]\theta = Ke^{E[X_j](\alpha-\mu)t}$$
$$\leftrightarrow E[X_i][M(t)(\alpha-\mu)+E[X_i]\theta = E[X_i][i(t)(\alpha-\mu)+e^{E[X_j](\alpha-\mu)t}$$
$$\leftrightarrow E[X_i][M(t)(\alpha-\mu) = E[X_i][i(t)(\alpha-\mu)+\theta]e^{E[X_j](\alpha-\mu)t} - E[X_i]\theta$$
$$M(t) = \frac{E[X_i][i(\alpha-\mu)+\theta e^{E[X_i](\alpha-\mu)t} - E[X_i]\theta}{E[X_i](\alpha-\mu)}$$
$$= \left[i+\frac{\theta}{(\alpha-\mu)}\right]e^{E[X_j](\alpha-\mu)t} - \frac{\theta}{(\alpha-\mu)}$$
$$= ie^{E[X_j](\alpha-\mu)t} + \frac{\theta}{(\alpha-\mu)}e^{E[X_i](\alpha-\mu)t} - \frac{\theta}{(\alpha-\mu)}$$
$$= ie^{E[X_i](\alpha-\mu)t} + \frac{\theta}{(\alpha-\mu)}e^{E[X_j](\alpha-\mu)t} - \frac{\theta}{(\alpha-\mu)}$$
$$M(t) = \frac{\theta}{(\alpha-\mu)}e^{E[X_i](\alpha-\mu)t} - 1] + ie^{E[X_i](\alpha-\mu)t} \quad (2.5)$$

$$M(t) = \frac{\theta}{(\alpha-\mu)}e^{E[X_i](\alpha-\mu)t} - 1] + ie^{E[X_i](\alpha-\mu)t} \quad (2.5)$$

So that the stochastic model of population growth in Karo district is obtained for factors of birth, death and population movement:

$$M_t = \frac{\theta}{\alpha-\mu}\left[e^{E[X_i](\alpha-\mu)t} - 1\right] + ei^{E[X_i](\alpha-\mu)t}. \quad (2.6)$$

4.2 Data Analysis Method with Clusters

In this study, the clustering method was carried out. The data used are the ratio of childbirths, and the ratio of child mortality in each sub-district 2016 [7] can be seen in Table 1. The results of clustering can be seen in Table 2 and Figure 1.

No	districts	Child birth ratio	Child mortality ratio
1	Mardingding	881	7
2	Laubaleng	928	3
3	Tigabinanga	596	14
4	Juhar	424	8
5	Munte	631	11
6	Kutabuluh	364	12
7	Payung	310	6

8	Tiganderket	365	12
9	Simpang Empat	533	7
10	Naman Teran	453	8
11	Merdeka	445	9
12	Kabanjahe	2076	16
13	Berastagi	1192	3
14	Tigapanah	747	2
15	Dolat Rayat	213	1
16	Merek	526	2
17	Barusjahe	559	4

Table 1.Data on Child Birth Ratio (CBR) and Child Dead Ratio (CDR) every sub-district in Karo Regency per 2016

Cluster Membership

Case	3 Clusters	2 Clusters
1:Mardingding	1	1
2:Laubaleng	2	1
3:Tigabinanga	1	1
4:Juhar	1	1
5:Munte	1	1
6:Kutabuluh	1	1
7:Payung	1	1
8:Tiganderket	1	1
9:Simpang Empat	1	1
10:Naman Teran	1	1
11:Merdeka	1	1
12:Kabanjahe	3	2
13:Berastagi	2	1
14:Tigapanah	2	1
15:Dolat Rayat	2	1
16:Merek	2	1
17:Barusjahe	2	1

Tabel 2. Cluster Membership

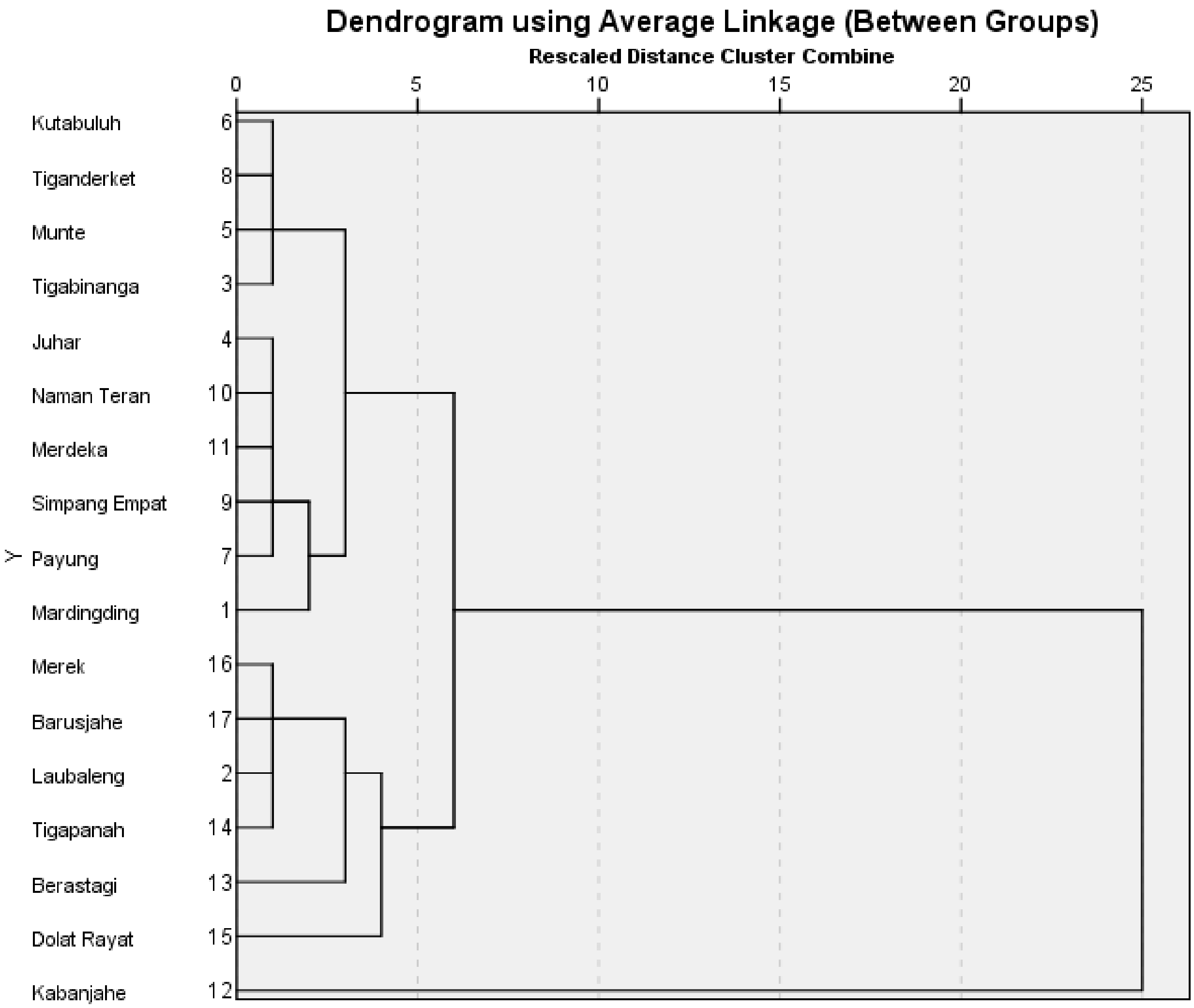

Figure 1. The results of the dendrogram with the combination method

Based on the results in Table 2 and Figure 1, the results of the dendrogram with the merging method indicate that if the distance is 25, then in 2016 each sub-district can be grouped into one category. So it can be assumed that each Karo district sub-district is homogeneous (similarity), which is high in one cluster (within-cluster) among members.

4.3 Population projection results Increase in Karo's 2030 and 2031

Calculating the approximate value of population growth per year in Karo district uses a model made, namely equation (2.6). The parameter values are shown in Table 4. They are using MAPE (Mean Absolute Percentage Error) after obtaining the approximate value of population growth.

The estimation of population growth forecast in Karo district using the parameter value table 4. The results of the study of average daily birth trend in each district of Karo are as follows:

Year	Average births for each kecamatan per day (α)	Average deaths for each kecamatan per day (μ)	Average population movements per sub-district per day (θ)
2002	0.8517	0.00032	- 0.0184
2003	0.9099	0.00032	- 0.7427
2004	1.0388	0.00064	- 0.8966
2005	1.6634	0.00016	- 0.7906
2006	2.0151	0.00016	- 0.2540
2007	1.8815	0.00080	- 0.2960
2008	2.7729	0.00016	- 0.5210
2009	4.3472	0	- 0.2617
2010	4.6816	0.0033	- 0.9460
2011	8.8064	0.0053	- 0.7368
2012	1.9709	0.0056	- 0.9308
2013	3.1587	0.0109	- 0.6158
2014	1.2328	0.0149	- 1.0741
2015	1.5954	0.0164	- 1.1884
2016	1.8119	0.0194	- 0.7892

Table 4. Parameter Values

The estimated value of population growth in Karo district

Table 5. The estimated value of population growth

Years	Population growth per year	The estimated value of population growth per year	Error
2002	2,68	-	
2003	3,11	-	
2004	2,43	-	
2005	2,19	6,60	49,6598
2006	3,19	6,27	96,5517
2007	3,10	5,68	83,2258
2008	3,05	6,41	90,7738
2009	3,01	7,30	70,1631
2010	2,15	7,15	43,0000
2011	0,86	6,77	14,5516
2012	1,07	5,44	24,4851

2013	1,17	3,36	53,4246
2014	2,18	2,32	6,4220
2015	2,11	2.96	40,2843
2016	2,48	4.05	63,3064
	MAPE		**52,98735 %**

Based on the results in the table, it can be seen that the estimated value of population growth per year in 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016 with a value of α> 1, (α - 1) <1, θ <0 can be said to be quite close to the real population growth value with a MAPE value of 52.98735%.

Average births, deaths and population movements from 2002 to 2016 [7], [8], [9] [10], [11], [12], [13], [14], [15] , [16], [17] in table 6. The number of births, deaths and movements recorded is based on those registered with the civil registry office by district.

Tahun	Average Births for each kecamatan	Average Mortality for each kecamatan	Average population movements (in) for each kecamatan	Average population movements (Out) for each kecamatan
2002	5285/17 = 310.88	2/17 = 0.1176	21/299149 x 1000 = 0.0701	265/299149 x 1000 = 0.0885
2003	5646/17 = 332.117	2/17 = 0.1176	14/311012 x 1000 = 0.0450	245/311012 x 1000 = 0.7877
2004	6446/17 = 379.17	4/17 = 0.2352	32/312300 x 1000 = 0.1024	312/312300 x 1000 = 0.9990
2005	10446/17 = 614.47	1/17 = 0.0588	17/316207 x 1000 = 0.0537	267/316207 x 1000 = 0.8443
2006	12504/17 = 735.52	1/17 = 0.0588	34/342555 x 1000 = 0.0992	121/342555 x 1000 = 0.3532
2007	11675/17 = 686.76	5/17 = 0.2941	45/351368 x 1000 = 0.1280	149/351368 x 1000 = 0.4240
2008	17206/17 = 1,012.11	1/17 = 0.0588	18/360880 x 1000 = 0.0498	206/360880 x 1000 = 0.5708
2009	26975/17 = 1,586.76	0/17 = 0	23/370.619 x 1000 = 0.0620	120/370.619 x 1000 = 0.3237
2010	29050/17 = 1,708.82	21/17 = 1.23	13/350.960 x 1000 = 0.0370	345/350.960 x 1000 = 0.9830
2011	54644/17 = 3,214.35	33/17 = 1.94	6/354.242 x 1000 = 0.0169	267/354.242 x 1000 = 0.7537
2012	12230/17 = 719.411	35/17 = 2.05	11/358.823 x 1000 = 0.0306	345/358.823 x 1000 = 0.9614
2013	19600/17 = 1,152.94	68/17 = 4	15/363.755 x 1000 = 0.0412	239/363.755 x 1000 = 0.6570
2014	7650/17 = 450	93/17 =5.47	45/382.622 x 1000 =	456/382.622 x 1000

			0.1176	= 1.1917
2015	9900/17 = 582.35	102/17 = 6	24/389.591 x 1000 = 0.0616	487/389.591 x 1000 = 1.2500
2016	11243/17 = 661.35	121/17 = 7.11	32/396.598 x 1000 = 0.0806	345/ 396.598 x 1000 = 0.8698

Table 6. Average Births, Deaths and Population Movements in 2002 to 2016

4.4 Results of Forecasting Population of Karo Regency in 2030 and 2031

In the future population forecasting in Karo district, the past data are taken. Past data that is measured periodically will form a time series of data (time series). A time series is a series of data in the form of observed values for a single variable measured over a certain period of time. The calculation of the predicted value of population growth in the Karo district uses trend analysis. In this trend analysis, there are three models, namely the linear trend, quadratic trend, and exponential trend [5]. Calculation of population growth forecasting in Karo district using the parameter forecast values which can be seen in Table 4. The Standard Error of the Estimate (SEE) value of each model can be seen in Table 7.

Results of the Standard Error of the Estimate (SEE) value trend of the average birth pattern

Tren	*Standard Error of the Estimate* (SEE)
Linear	2.080
Quadratic	2.080
Exponential	0.624

Table 7. Standard Error of the Estimate Mean Value of Births

Based on Table 7, the exponential trend model has the smallest SEE value, namely 0.624 compared to the linear and quadratic trend models. So the exponential model is the best model to find the predicted value of the average births per day in each district. So that the coefficient value $\beta_0 = 4.437$ dan $\beta_1 = 0.056$. Are obtained. Thus the formula can be taken $\alpha_t = 4.437e^{0.056t}$ u = 4.437 or + (0.056).

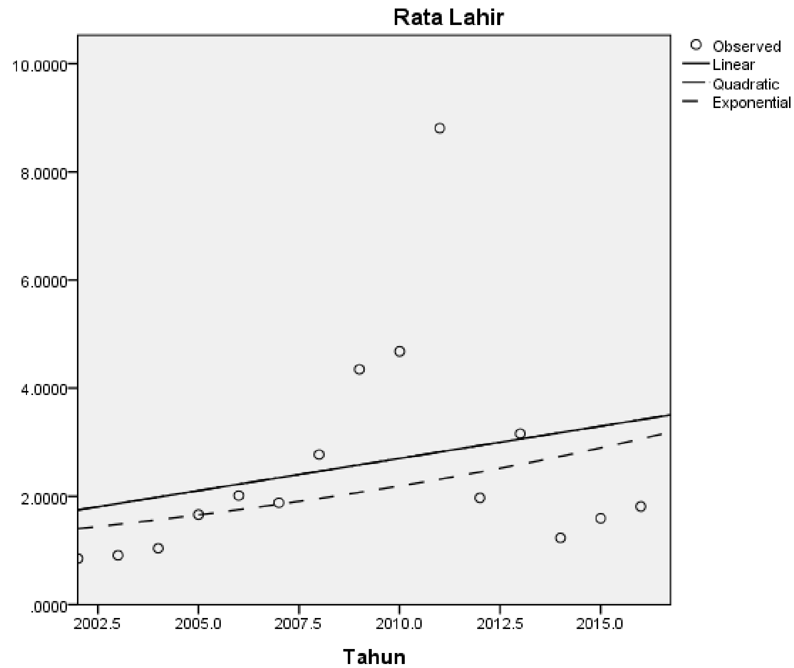

Figure 2. Trends in Linear, Quadratic and Exponential Rates of Births

Results in The output of the average Mortality per day for each kecamatan

The Standard Error (SEE) value is the trend pattern of mean Mortality.

Tren	*Standard Error of the Estimate* (SEE)
Linear	0.003
Quadratic	0.003

Table 8. Value of Standard Error of the Estimate mean of Mortality

Based on Table 8, the linear trend model has the smallest SEE value, namely 0.003, because the coefficient value is smaller than the Quadratic model. So the linear model is the best model to find the forecast value of the average Mortality per day for each district. So that the coefficient value$\beta_0 = -2.669$ and $\beta_1 = 0.001$can be obtained so that the formula for the linear trend can be taken is: $\mu_t = -2.669 + (0.001)\mathrm{t}$

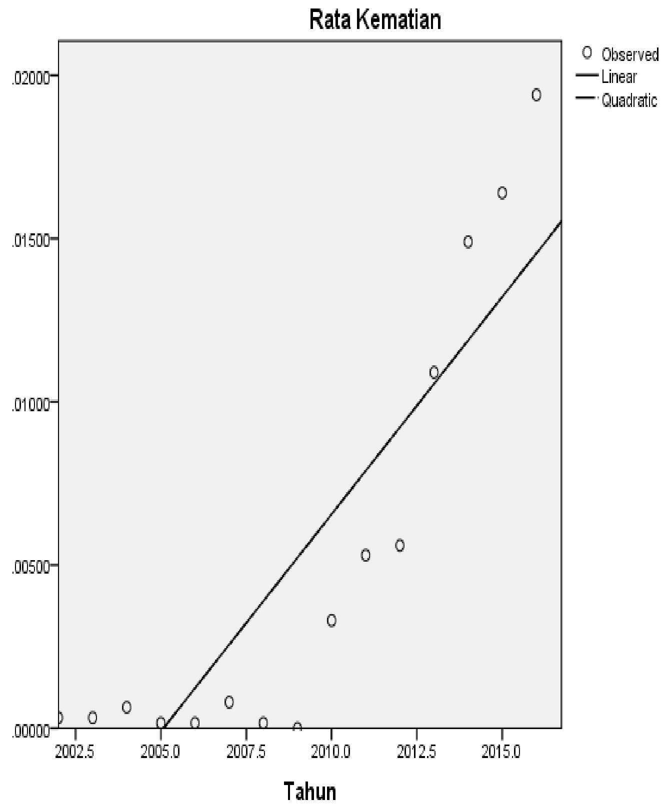

Figure 3. Trends in Linear, Quadratic and Exponential Mean Mortality

The results of the Standard Error of the Estimate (SEE) value are the trend pattern of the average population movement.

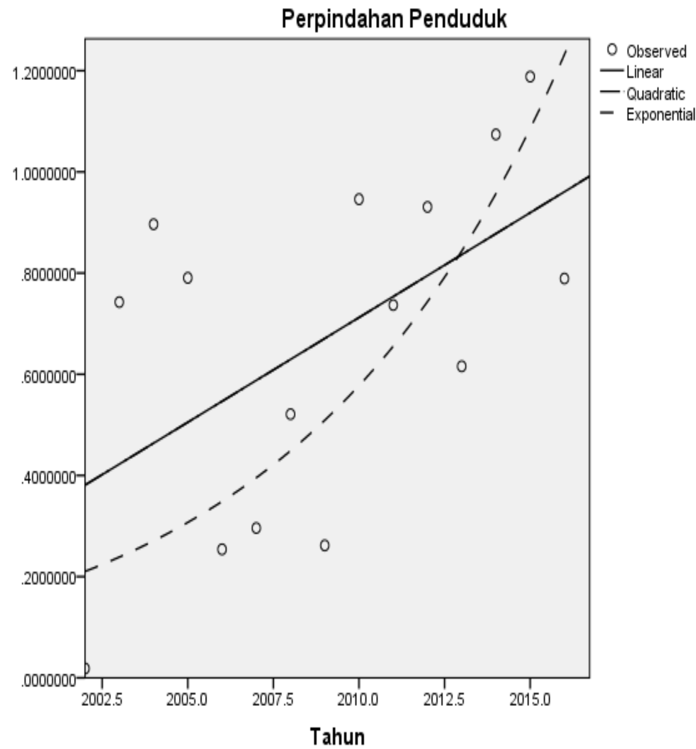

Figure 4. Linear, Quadratic and Exponential Trend of Average Population Movements

The results of the Standard Error (SEE) value of the trend pattern of the average population movement

Tren	*Standard Error of the Estimate* (SEE)
Linear	0.293
Quadratic	0.293
Exponential	0.913

Table 9. Value of Standard Error of the Estimate average population movement

Based on Table 9, the linear trend model has the smallest SEE value, namely 0.0293. So the linear model is the best model to find the forecast value of the average displacement per day for each district. because the coefficient value is smaller than the Quadratic model so that the coefficient value β_0 = -82.524 and β_1 = 0.041 can be taken so that the formula for the linear trend can be taken is: μ_t = -82.524 + (0.041) t

The results of forecasting population growth estimates per day

Tahun	Nilai prediksi pertumbuhan penduduk per hari
2030	26.2095

2031	30.5232

Table 10. Prediction Results of Population Growth per Day

So that the unknown population of Karo Regency in 2030 and 2031 is 530,529 people and 541,670 people.

Data on the population of Karo District from 2001 to 2016 [16].

Years	Total population
2002	299.149
2003	311.012
2004	312.300
2005	316.207
2006	342.555
2007	351.368
2008	360.880
2009	370.619
2010	350.960
2011	354.242
2012	358.823
2013	363.755
2014	382.622
2015	389.591
2016	396.598

Table 11. The population of Karo Regency from 2001 to 2016

Thus it can be calculated that the population growth forecast in 2030 and 2031 are:

Tahun	Jumlah Penduduk
2009	370.619
2010	350.960
2011	354.242
2012	358.823
2013	363.755
2014	382.622
2015	389.591
2016	396.598
2030	530.529
2031	541.670

Table 12. Forecasting Results of Population in Karo Regency in 2030 and 2031

CONCLUSION

The predictive value of population growth from models collected in 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016 is close to the value of population growth. Actually with MAPE 52.98735 per cent. Karo Regency's population projection results in the future can be determined by future forecast value. Karo Regency's population growth projection results per day in 2030 are 26,2095, and by 2031 population growth per day is expected to be 30,5232. So the estimated population value of Karo district whose population cannot be known in the next 2030 is 530,529 inhabitants and 541,670 inhabitants in the next 2031.

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BIBLIOGRAPHY

1. Central Bureau of Statistics (BPS) Karo Regency. 2013. Karo Regency in 2013 figures. BPS Catalog 1102001.1211
2. Rachmawati RN, Bekti RD. 2013. Stochastic Growth Model for Spatial Cluster Birth and Death Process with Migration. Journal of Mathematics and Statistics. 9 (2): 112-118.doi: 10.3844 / jmssp.2013.112.118.
3. Tan P, Steinbach M, Kumar V. 2006. Introduction to Data Mining. Boston: Pearson Addison Wesley.
4. Everitt BS, Landau S, Leese M, Stahl D. 2011. Cluster Analysis. 5th Edition. London: King's College.
5. Juanda B, Junaidi. 2012. Time Series Econometrics. Bogor: IPB Press.
6. Draper N, Smith H. 1992. Applied Regression Analysis. 2nd Edition. Jakarta (ID): PT Gramedia.
7. Central Bureau of Statistics (BPS) Karo.2002. Karo District in 2002 figures. BPS Catalog 1403.12.11. Publication Number 1211.03.01.
8. Central Bureau of Statistics (BPS) Karo.2003. Karo District in 2003 figures. BPS Catalog 1403.12.11. Publication Number 1211.04.01.
9. Central Statistics Agency (BPS) Karo.2004. Karo District in 2004 figures. BPS Catalog 1403.12.11. Publication Number 1211.05.01.
10. Central Bureau of Statistics (BPS) Karo District. 2005. Karo District in 2005 figures. BPS Catalog 1403.12.11. Publication Number 1211.06.01.
11. Central Statistics Agency (BPS) Karo.2006. Karo District in 2006 figures. BPS Catalog 1403.12.11. Publication Number 1211.07.01.
12. Central Bureau of Statistics (BPS) Karo.2007. Karo District in 2007 figures. BPS Catalog 1403.12.11. Publication Number 1211.07.01.

13. Central Bureau of Statistics (BPS) Karo.2008. Karo District in 2008 figures. BPS Catalog 1403.12.11. Publication Number 1211.08.01.
14. Central Bureau of Statistics (BPS) Karo.2009. Karo District in 2009 figures. BPS Catalog 1403.12.11. Publication number 1211.09.01.
15. Central Bureau of Statistics (BPS) Karo.2010. Karo District in 2010 figures. BPS Catalog 1102001.1211
16. Central Bureau of Statistics (BPS) Karo.2011. Karo District in 2011 figures. BPS Catalog 1102001.1211
17. Central Statistics Agency (BPS) Karo.2012. Karo District in 2012 figures. BPS Catalog 1102001.1211
18. Central Statistics Agency (BPS) Karo.2014. Karo District in 2014 figures. BPS Catalog 1102001.1211
19. Central Statistics Agency (BPS) Karo.2015. Karo District in 2015 figures. BPS Catalog 1102001.1211
20. Central Statistics Agency (BPS) Karo.2016. Karo District in figures 2016. BPS Catalog 1102001.1211