



Prediction of the Number of Language Users *Ngapak (Penginyongan)* Using Linier and Logistic Model

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Abstract

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1. Introduction

The local language is one of the riches of the Indonesian nation as well as a characteristic of a person or a community in interacting. This means that regional languages play a role in differentiating one ethnic group from another, and one culture from another, as well as one geographical area from another. Thus, the concept of language contains ideas about ethnicity, culture, and geographic area. The destruction of a regional language means the destruction of ethnicity, culture, and the loss of that ethnic group from its original geographical area (Alamsyah, 2018; Gusnawaty and Nurwati, 2019).

Even though the concepts contained in language are very superior, nowadays many people don't care about the existence of regional languages, so that the sense of belonging to their regional languages also begins to decrease. This is indicated by the increasing number of people interacting using their local languages, so there is a concern that regional languages will become extinct.

One of the regional languages in Central Java Province is *Ngapak* or *Ngapak Banyumasan*. The term *ngapak*, although already very popular, contains a pejorative meaning so that experts and scholars are trying to find another, the more positive name for the name of the language that has been known as the *Ngapak* language (Huda, 2017; Pawestri, 2019).

The *Ngapak Banyumasan* language is not only used by people who inhabit the geographical area of Banyumas Regency but is also used by people in areas called *barlingmascakebayu* (Banjarnegara, Purbalingga, Banyumas, Cilacap, Kebumen, and Bumiayu). Geographically, the area includes six districts in the southern part of Central Java, which are directly adjacent to the speakers of Sundanese and Cirebon languages. Therefore, the idea emerged to name the language with the name *Penginyongan* language. Communities throughout the region use the term *inyong* to refer to me so that the term *penginyongan* contains messages and a spirit of selfishness, ego, self-existence, and pride in the identity of their language. The First Congress of *Penginyongan* Languages was held in 2017.

The trend is observed, the number of users of the Language of *Penginyongan* decreases in the sense that these users are no longer consistent in using the language of *Penginyongan* but mixed with Indonesian. In addition to combining the two languages in daily conversation, the ability to speak *Penginyongan* is also decreasing. Ownership of *Penginyongan* language vocabulary individually is also declining so that communication with that language requires substitution from other languages such as Indonesian. Therefore, we need an estimate of the development of the language of *Penginyongan* to find out whether in the long term the language of *Penginyongan* will experience extinction due to the decrease or exhaustion of individuals who can use the language. To estimate the number of users (speakers) of the *Penginyongan* language, the calculations are carried out using linear and logistical models.

2. Discussion

Penginyongan language is one of the regional languages which has quite a large number of speakers among the regional languages found in Indonesia. However, recently some of its functions have been taken over by the Indonesian language which has been designated as the state language. On the other hand, the life of the Javanese people who live in geographically barlingmascakebayu has also experienced quite basic social changes in their lives. As a consequence, the use of the *Penginyongan* language is decreasing (Ramadhan and Masykur., 2018). To predict this, it is necessary to calculate the prediction (projection) of the population of Banyumas who are still able to use the *Penginyongan* language in 2017-2021 using linear and logistical models.

In this modeling, it is assumed that the extinction of a language is due to the extinction (reduction) of users or speakers of the language. A dictionary of the local language may be available, but there are no more speakers. Another assumption is that in this modeling every baby born to a mother with a *Penginyongan* language will automatically be in the *Penginyongan* language. This birth will increase the number of speakers. Furthermore, the number of people who die and leave the geographic area barlingmascakebayu (withdrawal) will cause a decrease in the number of speakers. Meanwhile, it is assumed that immigrants from outside the region after domiciling in the Barlingmascakeb area will not use the *Penginyongan* language, including their descendants. However, for simplicity of the model, it is assumed that the number of people who withdraw (emigration) and the number of people who enter the barlingmascakeb area (immigration) are the same so that in this model the growth or decay of the number of speakers of the *Penginyongan* language is only influenced by two factors, namely birth (characterized by birth rate). and death (characterized by the rate of death).

2.1. Linear Model

Suppose $P(0)$ states the number of populations at the beginning of time ($t = 0$), $P(n)$ states the number of populations at time n , and $P(t)$ states the number of populations at time t ($0 \leq t \leq n$), then

$$P(t) = \left(1 - \frac{t}{n}\right)P(0) + \frac{t}{n}P(n), \quad (1)$$

or

$$P(t) = P(0) + \frac{t}{n}[P(n) - P(0)]. \quad (2)$$

This method is used if it is assumed that the increase in population occurs linearly. Besides, equations (1) and (2) can also be used for the linear extrapolation method, i.e. prediction/projection for $t > n$. But for t values that are large enough (eg $t > 2n$), this method should not be used to perform linear extrapolation (Brown, 1997), unless the researcher assumes that the increase in population numbers will continue to occur linearly (Solomons, 2019; Zieseemer, 2020).

2.2. Logistic Model

This model was first introduced by a mathematician and also a Dutch biologist, namely Pierre Verhulst in 1838. The discovery of this model was because the natural growth model was not sufficiently precise for a large enough population and limited space so that obstacles arose due to the density of the population that would reduce the population itself. As a result, population growth will take place stationary/constant after a certain time (Mujib et al., 2019; Budiono et al., 2020; Panigoro and Rahmi, 2020).

This logistic population growth model is a refinement of the exponential growth model. In this model, the population size is influenced by the size of the carrying capacity of the environment such as language skills and the consistency of using a language. The logistic model assumes that at a certain time the population will approach the equilibrium point. At this point, the numbers of births and deaths are assumed to be equal so that the graph is approximately constant. The simplest form of relative growth rate that accommodates this assumption is

$$\frac{1}{P} \frac{dP}{dt} = k \left(1 - \frac{P}{K}\right), \quad (3)$$

where K is maximum carrying capacity and k is growth rate. Multiply equation (3) by P , then we get a model for population growth known as the logistic differential equation

$$\frac{dP}{dt} = kP \left(1 - \frac{P}{K}\right), \quad (4)$$

If P is small compared to K , then P/K approaches 0 and $dP/dt \approx kP$. However, if $P \rightarrow K$ (population is close to its carrying capacity), then $P/K \rightarrow 1$, so $dP/dt \rightarrow 0$. If the population P is between 0 and K , then the right-hand side of the equation above is positive, so $dP/dt > 0$ and the population goes up. But if the population exceeds its carrying capacity ($P > K$), then $1 - (P/K)$ is negative, so $dP/dt < 0$ and the population decreases. Logistic equation solutions can be obtained through the following steps

$$\begin{aligned} \frac{dP}{P\left(1 - \frac{P}{K}\right)} &= kdt \\ \int \frac{dP}{P\left(1 - \frac{P}{K}\right)} &= \int kdt \\ \int \frac{dP}{P - \frac{P^2}{K}} &= \int kdt \\ \int \frac{KdP}{KP - P^2} &= \int kdt \\ \ln P - \ln(K - P) &= kt + c \\ \ln\left(\frac{P}{K - P}\right) &= kt + c \\ \frac{P}{K - P} &= e^{kt+c} \\ P &= Ke^{kt+c} - Pe^{kt+c} \\ P - Pe^{kt+c} &= Ke^{kt+c}, \end{aligned}$$

it is obtained

$$P = \frac{Ke^{kt+c}}{1+e^{kt+c}} \tag{5}$$

From equation (5), if we give the initial value $t = 0$ and $P(0) = P_0$, then the value $c = \ln(P_0/(K - P_0))$ will be obtained, then the c value is substituted back into equation (5), so that obtained a specific solution from the logistics model as follows

$$\begin{aligned} P &= \frac{Ke^{kt+\ln\left(\frac{P_0}{K-P_0}\right)}}{1 + e^{kt+\ln\left(\frac{P_0}{K-P_0}\right)}} \\ P &= \frac{Ke^{kt} \frac{P_0}{K - P_0}}{1 + e^{kt} \frac{P_0}{K - P_0}} \\ P &= \frac{\frac{Ke^{kt} P_0}{K - P_0}}{\frac{K - P_0 + e^{kt} P_0}{K - P_0}} \\ P &= \frac{Ke^{kt} P_0}{K - P_0 + e^{kt} P_0} \\ P &= \frac{KP_0}{(K - P_0 + e^{kt} P_0)e^{-kt}} \\ P &= \frac{KP_0}{Ke^{-kt} - P_0e^{-kt} + P_0} \\ P &= \frac{K}{\frac{K}{P_0}e^{-kt} - e^{-kt} + 1}, \end{aligned}$$

it is obtained

$$P = \frac{K}{e^{-kt}\left(\frac{K}{P_0}-1\right)+1} \tag{6}$$

where P is the total population at time t , P_0 is the initial population size at $t = 0$, K is the capacity of an area for the population, k is the per capita population growth rate, and t is time.

Equation (6) is a simple form of a specific solution for the logistics model that will be used in carrying out population projections. The function graph for the logistics method can be seen in Figure 1.

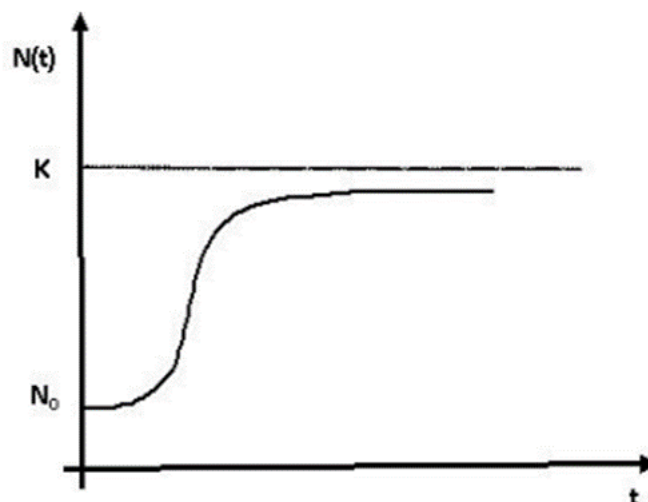


Figure 1: Graph of functions for logistic methods

To find out the level of accuracy of the model, the following error measures can be used. By using MAPE whose value is at intervals of 0% - 100% percent, the smaller the MAPE value, the better the model obtained. The formula for Mean Absolute Percentage Error (MAPE) is

$$MAPE = \sum_{i=1}^n \left| \frac{X_i - F_i}{X_i} \right| \times \frac{100}{n},$$

where X_i is the actual i -th data value, F_i is the i -th predicted value, and n is the amount of data used.

In determining the projection of the number of *Penginyongan* speakers in 2017-2021, data on the population in Banyumas Regency from 2010-2015 were used and data on the number of Banyumas residents who used the *Penginyongan* language in 2010-2015 (assuming the number of Banyumas residents who used the *Penginyongan* language was 90% of the total population of Banyumas).

Modeling with data from the Banyumas Regency area is due to the unavailability of population data in the entire Barlingmascakeb geographic area. Likewise, there is no data on the number of residents in the Banyumas district who speak *Penginyongan*, so it is assumed that 90% of the total population in Banyumas Regency speaks *Penginyongan*.

Population data according to BPS Banyumas Regency in 2010-2015 along with the number of Banyumas residents who use the *Penginyongan* language in 2010-2015 are given in Table 1.

From the data available in Table 1, it can be made a model for *Penginyongan* language speakers which is then used to predict the number of speakers in the following years.

Table 1: Total population of Banyumas Regency in 2010-2015

Year	Total Population	Assumption of Total Population Speaking <i>Ngapak Banyumasan</i> (90% of Total Population)
2010	1,557,667	1,401,900
2011	1,574,001	1,416,601
2012	1,590,011	1,431,010
2013	1,605,579	1,445,021
2014	1,620,918	1,458,826
2015	1,635,909	1,472,318

Data source: <https://banyumaskab.bps.go.id/>

2.3. Linear Growth Model

For the linear model, the derivation of the formula is carried out as follows: $P(0) = P(2010) = 1,401,900$ and $P(n) = P(2015) = 1,472,318$. By substituting $P(0)$ and $P(2015)$ into equation (1) or (2), the linear model is obtained as follows

$$\begin{aligned}
 P(t) &= \left(1 - \frac{t}{6}\right) 1,401,900 + \frac{t}{6} 1,472,318 \\
 &= 1,401,900 + \frac{t}{6} (1,472,318 - 1,401,900) \\
 &= 1,401,900 + \frac{t}{6} (70,418) \\
 &= 1,401,900 + 11,736.3t.
 \end{aligned}$$

By using a linear growth model, the estimated population of Banyumas using the *Penginyongan* language and the error value in 2010-2015 is obtained as shown in Table 2.

Table 2: Prediction of the Number of Speakers of *Ngapak Banyumasan* Language (*Penginyongan*) with Linear Model

Year	Total Population in <i>Penginyongan</i> Language		MAPE
	Actual Data	Projection	
2010	1,401,900	1,401,900	0.00000021
2011	1,416,601	1,413,636	0.00209276
2012	1,431,010	1,425,373	0.00393939
2013	1,445,021	1,437,109	0.00547549
2014	1,458,826	1,448,845	0.00684180
2015	1,472,318	1,460,582	0.00797151
	Total		0.00438686

The error rate in using the linear model is

$$MAPE = \sum_{i=1}^n \left| \frac{X_i - F_i}{X_i} \right| \times \frac{100}{n} = 0.004438686.$$

Based on the table, the graph of the estimation of the development of the *Ngapak Banyumasan* language (*Penginyongan*) is obtained as follows.

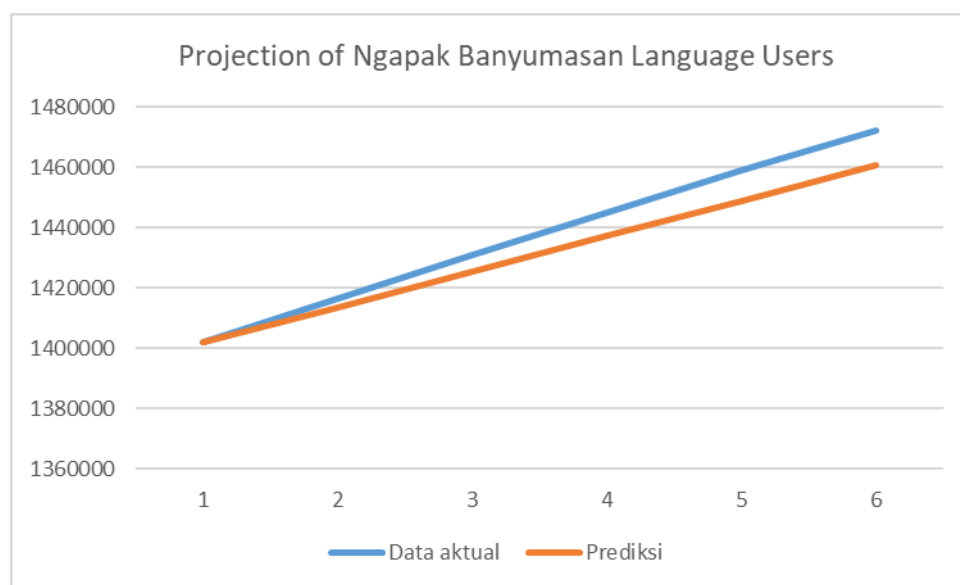


Figure 2: Graph Prediction of the Number of Speakers of *Ngapak Banyumasan* Language (*Penginyongan*) with a Linear Model

2.4. Logistics Growth Model

To determine the logistic model from the data on the population of Banyumas, it was previously assumed that time (t) was measured in years, and if $t = 0$ in 2010, then the initial requirement was $P(0) = 1,401,900$. Since the total population of Banyumas since 2010-2015 is still below 1,500,000, it is assumed that the capacity for the capacity is $K = 1,500,000$, so that if the $P(0)$ value and the K value are substituted into the equation, the logistic model solution will be obtained as follows

$$P = \frac{K}{e^{-kt} \left(\frac{K}{P_0} - 1 \right) + 1}$$

$$P = \frac{1,500,000}{e^{-kt} \left(\frac{1,500,000}{1,401,900} - 1 \right) + 1}$$

$$P = \frac{1,500,000}{0.06998e^{-kt} + 1} \tag{7}$$

Furthermore, equation (7) will look for a logistic model that can represent the growth rate of the *Ngapak Banyumasan* language users. For $t = 5$ in 2015, $P(5) = 1,472,318$, if substituted for equation (3) it is obtained

$$1,472,318 = \frac{1,500,000}{0.06998e^{-5k} + 1}$$

$$0.06998e^{-5k} + 1 = \frac{1,500,000}{1,472,318}$$

$$0.06998e^{-5k} = 0.01880$$

$$e^{-5k} = 0.26865$$

$$-5k = \ln(0.26865)$$

$$k = 0.2629.$$

The k value obtained is substituted back in equation (3), yielding

$$P = \frac{1,500,000}{0.06998e^{-(0.2629)t} + 1}.$$

By using the logistical growth model, the estimated number of Banyumas residents who use the *Ngapak Banyumasan* language and the error values in 2010-2015 are obtained as shown in Table 3.

Table 3: Prediction of the Number of Speakers of *Ngapak Banyumasan* Language (*Penginyongan*) with a Logistic Model

Year	Total Population in <i>Penginyongan</i> Language		MAPE
	Actual Data	Projection	
2010	1,401,900	1,401,895	0.00000352
2011	1,416,601	1,423,708	0.00481186
2012	1,431,010	1,440,875	0.00657487
2013	1,445,021	1,453,303	0.00605325
2014	1,458,826	1,464,756	0.00368435
2015	1,472,318	1,472,862	0.00000042
Total			0.00352202

The error rate in using the logistic model is

$$MAPE = \sum_{i=1}^n \left| \frac{X_i - F_i}{X_i} \right| \times \frac{100}{n} = 0.00352202.$$

Based on the table, the graph of the estimated development of the *Penginyongan* language is given in Figure 3.

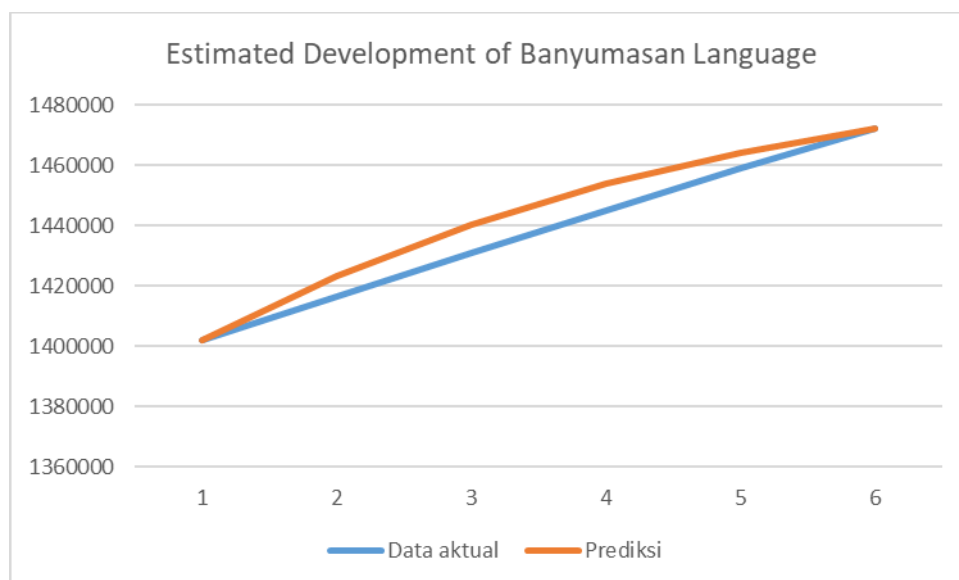


Figure 3: Graph Prediction of the Number of Speakers of *Ngapak Banyumasan* Language (*Penginyongan*) with a Logistic Model

2.5. Determining the Best Model

To determine the best model, the error rate of each model can be seen. The best models are those with the smallest MAPE. Based on the calculation results, the logistic growth model is preferred.

2.6. Estimated Population of Banyumas who uses *Penginyongan* Language

The projection of the number of Banyumas residents who use the *Ngapak Banyumasan* language in 2016-2021 based on the logistical growth model is given in Table 4.

Table 4: Projection of the Number of Speakers of *Ngapak Banyumasan* Language (*Penginyongan*) in 2016-2021 with a Logistic Model

Year	Projection of the Number of Speakers of <i>Ngapak Banyumasan</i> Language
2016	1,479,131
2017	1,483,967
2018	1,487,692
2019	1,490,557
2020	1,492,758
2021	1,494,449

The results obtained show that the number of *Penginyongan* language users tends to increase towards the carrying capacity of $K = 1,500,000$. This study determined the carrying capacity to be $K = 1,500,000$ and the results showed that in an 11-year time interval (2010-2021) the carrying capacity figure could be said to be achieved. This means that for each year there is an increase in the population who use the *Penginyongan* language, on average, around 10,000 people per year.

To conclude whether the *Ngapak Banyumasan* language (*Penginyongan*) is headed for extinction is to make comparisons with the average population growth of Banyumas every year from 2010 to 2021. If the number is less than 10,000, then the *Ngapak Banyumasan* language will still exist.

3. Conclusion

Of the two models produced, the logistical growth model is a better model for estimating the number of Banyumas residents who use the *Penginyongan* language in 2016-2021. The logistic model that estimates the number of Banyumas residents who use the *Penginyongan* language is based on an equation

$$P = \frac{1,500,000}{0.06998e^{-(0.2629)t} + 1}, P(2010) = P(0) = 1,263,273.$$

Based on this model, it can be interpreted that after 2010 the number of Banyumas residents who use the *Penginyongan* language tends to increase every year.

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