Multi-variable forecasting model using ARIMA (P,Q,N) method to project number of population in Bandung, Indonesia

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Abstract. The focus of this research is to doing analysis and study of public cemeteries as supporters of green space in Bandung regency for 2018 until 2028 period with the aim to determine number of populations in Bandung Regency with considering total population, population growth rate, and mortality rate. The method used in this study is ARIMA (P,Q,N). Based on the results of the analysis and study of public cemeteries (TPU) as supporters of Green Open Space in the Bandung Regency area for the period 2018 to 2028, state that cemetery conditions in Bandung Regency require new grave yard sites. This is evidenced by the results of forecasting (forecasting) of the population per district in Bandung Regency from 2019 to 2028. In making forecasting there are special cases in certain districts.

1. Introduction
Population growth: refers to change in the size of a population which can be either positive or negative, over time depending on the balance of births and deaths. Population measured in both in absolute and relative terms. Population growth also a critical challenge that put pressure on growth and development, thereby retards the maintaining of a sustainable society. Research that discusses forecasting methods in the population has also been done before. Such as Haque et al. presented a logistics population model which is parameterized by growth rate along with capacity human population of Bangladesh [1]. The research used fourth order Runge-Kutta scheme for the numerical solution of the non-autonomous and non-linear model where they incorporate the growth rate as a function of time [2]. Research Azuh and Matthew studied the forecasting method in Nigeria with a co-integration approach [3]. Based on this research found out that infant mortality and maternal mortality rates have long run relationship the factors which influence Nigeria’s population growth.

Due to time series data has its own structure, then ARIMA model can works well. Because ARIMA Model has a fixed structure and is specifically built for time series (sequential) data. Several studies about predict number of population has been done using ARIMA model. Research Nyoni presented annual time series data on inflation rates in Burundi from 1966 to 2017 using ARIMA Models [4]. The diagnostics test further imply that the presented optimal ARIMA (0.1.1) model was stable and acceptable for prediction inflation in Burundi. Research Nyoni and Mutongi developed model to forecast total population over the next 3 decades using the Box Jenkins ARIMA Technique [5]. Based on the AIC, the research presents the ARIMA (3.2.0) model as the best model and proposed 3 policy recommendations have been suggested for consider by the government of Togo. Research Nyoni also developed forecasting model to predict inflation of population using ARIMA models with a data set...
ranging over the period 1974 to 2017 [6]. The results imply that the presented optimal ARIMA (0.1.2) model was stable and acceptable for prediction inflation in Lesotho. Research Zakaria dan Muhammad modelled population of Pakistan using Box Jenkins ARIMA Methodology and relied on annual time series data over the period from 1951 to 2007 [7]. The population of Pakistan is also forecasted for the next 20 years using the parsimonious ARIMA (1.2.0) focused on time series analysis of Ethiopian population based on annual data from 1961 to 2009 using Trend Analysis and Box Jenkins time series models on the population [8]. The appropriate time series model chooses ARIMA (2.1.2) since it shows the minimum MSE.

From all the studies that have only done population forecasting, whereas research on forecasting is needed to determine number to public cemeteries as support the green space in certain area. Because of that the focus of this research is to doing analysis and study of public cemeteries as support of green space in Bandung regency for 2018 until 2028 period with the aim to determine number of populations in Bandung Regency with considering total population, population growth rate, and mortality rate.

2. Method and materials

2.1. Data collection
Data collection in this analysis is a combination of primary survey and secondary survey. The method used was interviews with local authorities and the community. The results of the primary survey are outlined in the form of an overview of existing condition data in the field, supported by digital maps and images. The results of the survey which are generally in the form of existing grave yard data both managed by the community and those managed by the relevant government, management systems and systems in the field.

2.2. Analysis method
The analysis was carried out to determine the region's population for the next 20 years by distinguishing between the four religions using the formula:

\[
P_n = P_0 \left(1 + r\right)^n
\]

To calculate population growth using the back five-year time series data, it is calculated annually for five years and to calculate population projections for the next 20 years.

3. Results and discussion

3.1. Problem discussion
Bandung Regency which is part of the Province of West Java, Indonesia is geographically located at coordinates 107° 22′ - 108° 50 East Longitude and 6° 41′ - 7° 19 South Latitude is located in the highlands. With the total area of Bandung Regency 176,238.67 hectares, which consists of 31 districts, 270 villages and 10 villages. Bandung Regency is administratively on the north bordering West Bandung Regency, Bandung City, and Sumedang Regency; The east is bordered by the Sumedang Regency and Garut Regency; in the south bordering Garut Regency and Cianjur Regency; West side is bordered by West Bandung Regency, Bandung City and Cimahi City.

Based on data from the Bandung Regency Statistics Agency states that the population of Bandung Regency in 2017 reached 3,657,701 people with Baleendah District having the largest population reaching 266,198 people with a male population composition of 135,332 people and 130,860 women, while Rancabali District has the lowest population of 52,072 with a male population of 26,044 and female population of 26,028, with an area of 1,762.40 km², the average population density of Bandung Regency is 2,075 people per km², where Margahayu District has the highest density of 12,634 inhabitants/km², while Rancabali District is the lowest density of 351 inhabitants/km².

The level of population density in each district in the Bandung Regency region varies due to the population growth each year in the Bandung Regency area. This is evidenced by data from the
Bandung Regency Statistics Agency regarding the population in the Bandung Regency over the past four years which shows an increase in the population in the Bandung Regency.

![Figure 1. Total population of Bandung District.](image)

The amount of population growth in Bandung Regency which is increasing can be caused by several components namely; birth (fertility), death (mortality), in-migration and out-migration, which can be seen in Figure 1. The difference between birth and death is called natural growth. Whereas the difference between in and out migration is called net migration. Fertility (birth) includes the role of birth in population growth, while natality includes the role of birth in population growth and reproduction. High or low fertility illustrates the speed of population growth. While mortality is the number of deaths that occur in every 100 population in a period of one year. Mortality has the property in reducing the population.

However, the increase in the number of residents in Bandung Regency is not accompanied by an increase in the amount of land for grave yard in Bandung Regency. Based on actual condition of the TPU in Bandung regency at this time is still scattered in several different points. This causes difficulties in coordination between the government and related parties. On the other hand, if you look at the condition of other cities, for example, the city of Surabaya has implemented an integrated system at the cemetery. This is indicated by the location of a grave yard centre that is centralized and integrated so as to increase the potential of the region's special income to the local government.

Seeing the condition of green open space in Indonesia which is increasingly critical, the right alternative for overcoming these conditions is to use a funeral green open space. The cemetery has not yet utilized its beauty or function as an effective green open space to create a cool and comfortable city air climate. Open grave yard space is currently only in the form of vacant land or open space with some kind of green plant arrangement. Public Cemetery Park has a dual function. First, in addition to having a social function, namely a place to bury a body, the second also functions as a Green Open Space for water absorption, reducing air pollution, noise, heat sinks and noise absorber and supporting ecosystems.

3.2. Forecasting population growth

The initial stage to identify the temporary model is to determine whether the time series data that will be used for forecasting is stationary or not. Forecasting in time series data requires that the data must be stationary, so stationarity tests need to be carried out before modelling. Stationarity is very important in making models, because non-stationary data is difficult to predict so that the resulting model is not optimal. To check the stationarity of a data can be seen through a time series plot, Autocorrelation Function (ACF), and Partial Autocorrelation Function (PACF) of the data to be examined for stationarity. Before calculating the Autocorrelation Function (ACF), and the Partial Autocorrelation Function (PACF), the first step that must be done is to plot the data into a graph.

The final step is to use the best model for forecasting. If the best model has been set, the model is ready to be used for forecasting. Pay attention to non-stationary homogeneous series, because what is needed is the original series forecast, then the difference shape must be returned to the original
variable form, by carrying out an integral process. This forecasting technique can also provide confidence intervals. If further forward, the confidence interval is generally wider, but not so for the pure average moving average confidence interval. After the AR and MA orders are determined which may be suitable for obtaining the forecasting model, the next step is to determine the estimated parameter values in the ARMA model. The selection of a suitable model for forecasting is based on the results of the t test, R2, F test, AIC (Akaike Information Criteria), SIC (Schwarz Information Criteria). A good forecast model based on the t-test is if the estimation parameters are significant, the R2 value is high, the F test is significant, and the AIC and SIC are low. The ARIMA order model (1.1.0) was chosen to forecast the population because it has the lowest AIC value than other ARIMA orders. To make predictions, we use the e-Views application by entering the values of the ARIMA parameters (1.1.0).

![Figure 2](image)

**Figure 2.** (a) Comparison of sample data and forecasting data; (b) model selection comparison; (c) AIC comparison of the 20 best models.

Population growth is a phenomenon of change in human population from time to time [9]. Changes in this phenomenon can be calculated using the number of individuals in a population based on units per unit time [10]. Population growth is a dynamic balance between forces that increase and forces that reduce population. The factors influencing population growth are births (fertility), mortality (mortality), and population movement (migration), both residents who come (out-migration) or residents who leave (out-migration). Population growth is divided into 3 types namely, natural population growth, migration population growth, and total population growth. Based on the growth in the total population of Bandung regency in 1997-2018 experienced an increase and decrease, the graph of population growth can be seen in Figure 3.

Significant decrease in the population of Bandung Regency in 1997-2017 occurred in 2007, amounting to 30.94%. This significant decrease was due to the breakdown of parts of sub-districts in Bandung Regency into West Bandung Regency sub-districts. Based on the division of part of the sub-district in Bandung Regency, in 2017 shows that Bandung District has 31 sub-districts.  

![Figure 3](image)

**Figure 3.** Growth chart of Bandung regency population years in 1997 – 2018.
Population growth that continued to increase after 2007 led to an increase in the need for Green Open Space, especially Cemeteries. Currently, the cemetery has not been used effectively and functions as green space to create a cool and comfortable city air climate. Open grave yard space is currently only in the form of vacant land or open space with several types of green plants. Public Cemetery Park has a dual function. First, besides having a social function, namely a place to bury a body, the second also functions as a Green Open Space for water absorption, reducing air pollution, noise, heat sinks and noise absorber and supporting ecosystems. Funeral needs are also taken into account in the drafting of the Bandung Regency laws and regulations. The analysis used to study the analysis of grave needs is by analysing the projected population of Bandung and grave yard needs analysis.

3.3. Projection analysis of Bandung regency population
Analysis of the projected population of Bandung regency is used to predict the population for the next 10 years. Forecasting the population of Bandung regency is done using historical data 20 years back, from 1997 to 2017. Analysis of the projected population number aims to find out the increase in population in the next 10 years. Data from the projection of population is used to project the needs of grave yards for the next 10 years for each sub-district in Bandung regency. The grave yard needs include the need for the number of grave yards, land requirements of each grave yard, and the location of the grave yard. In addition, with the projected population, it can design the integration of graves between districts. Figure 4 shows the results of the population projection from 1997-2028. However, there are some insufficient historical data to produce projections for the next 10 years, so that projections can only be made until 2023.

![Figure 4. Bandung regency population growth projection by district (1997-2028).](image)

4. Conclusion
Based on the results of the analysis and study of public cemeteries (TPU) as supporters of Green Open Space in the Bandung Regency area for the period 2018 to 2028, state that cemetery conditions in Bandung Regency require new burial sites. This is evidenced by the results of forecasting (forecasting) of the population per district in Bandung Regency from 2019 to 2028. In making forecasting there are special cases in certain districts. ARIMA was chosen as a method for forecasting the need for the number of graves in Bandung because it can be used to select the type of forecasting for some special cases.
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