Acceleration analysis of population growth using winter’s method: case study of lombok island

H R P Negara¹, Syaharuddin², M Ibrahim³, K R A Kurniawati⁴, V Mandailina², D Pramita², Abdillah³, Mahsup², Ahmad², Saddam².

¹Ilmu Komputer, Universitas Bumigora Mataram, Jl. Ismail Marzuki No 22, Cilinaya, Kec. Cakranegara, Kota Mataram, Nusa Tenggara Barat 83127, Indonesia.
²Pendidikan Matematika, Universitas Muhammadiya Mataram, Jl. KH. Ahmad Dahlan No.1, Pagesangan, Kec. Mataram, Kota Mataram, Nusa Tenggara Bar. 83115, Indonesia.
³Teknik Informatika, Universitas Nahdlatul Ulama NTB, Jl. Pendidikan No.6, Dasan Agung Baru, Kec. Selarapang, Kota Mataram, Nusa Tenggara Bar. 83125 universitas Muhammadiya Mataram, Indonesia.
⁴Pendidikan Matematika, Universitas Islam Negeri Mataram, Jl. Gajah Mada No. 100, Pagesangan, Mataram, Jempong Baru, Kec. Sekarbela, Kota Mataram, Nusa Tenggara Bar. 83116, Indonesia.

Email: habib.ratu@universitasbumigora.ac.id

Abstract. The research aims to analyze the acceleration of the population growth in Lombok which consists of 5 districts/cities using forecasting system by constructing the winter's method in the form of a GUI Multiple Forecasting System (G-MFS) based on Matlab by calculating the indicator level of accuracy to find predictive data for the next 10 years. At the data simulation stage, researchers used population data over the last 11 years. The evaluation of forecasting results is calculated by calculating the value of Mean Absolute Percentage Error (MAPE) with 27 attempts through modified Winter parameter values. From the simulation data obtained the most optimal parameter value is α, β, and γ sequential values of 0.9, 0.5, and 0.9. Then with the value of the parameter obtained MAPE value of 1.25%. Furthermore, it can be noted that for the next 10 years the increase in the population of Lombok Island on average of 1.49%, the average East Lombok district details of 1.15%, the average West Lombok district by 1.17%, the average central Lombok district of 0.98%, the North Lombok district averaged 0.98%, and the average Mataram city of 3.05%. These results suggest that the simulated and numeric techniques using the GUI of MATLAB provide quite accurate results. In subsequent research, it is necessary to do predictions based on the number of births, the number of deaths, the number of transmigration, the amount of productive and non-productive, and other data series that is more complex so that it will be seen how the development of the population productivity on the island of Lombok

1. Introduction

Lombok Island is a small Sundanese archipelago located in the southeastern part of Indonesia [1]. Geography, the eastern island of Lombok is a Bali island separated by the Strait of Lombok and the west of the island of Lombok is Sumbawa island separated by the Alas Strait. The characteristic of this island is round and has a kind of tail on the southwest side with a length of approximately 70 km, and the area
is reached 5,435 km$^2$ which makes the island is ranked 108 from the list of islands based on its breadth in the world.

The population of Lombok has based on the population census of 2019 to 2,450 million inhabitants [2]. This population is in the region of 4 districts and one Madia city namely West Lombok Regency, Central Lombok Regency, East Lombok Regency, and new district which is the result of the regional expansion of North Lombok Regency. Kota Associate is the city of Mataram which is the capital of the province of West Nusa Tenggara (NTB) which includes the island of Lombok and Sumbawa Island.

The pace Indicator of a region's development is population [3]. This Indicator includes knowledge about the quality and quantity of the population. The quality of the population concerns the level of education and expertise, while the knowledge of population quantity can give an overview of the number, growth, and distribution of a region's population.

Data on the growth of population on the island of Lombok in 4 districts and 1 city increased annually. Population increase in 2019, for West Lombok Regency at 1.43%, Center Lombok 0.86%, East Lombok 0.71%, and North Lombok are 0.86% while Mataram City increases 1.93%. This increase in population should be a concern and be known to provide an overview of the population composition, and population distribution for government planning in the development of the island of Lombok in the future [4].

Population growth is a dynamic balance between strength in increasing and reducing the amount of population growth. Uncontrolled population growth can cause economic problems that are increasing year by year [5]. Data stored in large quantities will be useless if unexcavated information available in it. Based on the potential impact resulting from population growth, it can be anticipated to overcome problems that will arise in the future [6-8].

Forecasting is an activity that estimates what will happen in the future or the future making. The determination of the policy to be taken by the Government in the future is reached 5,435 km$^2$ which makes the island is ranked 108 from the list of islands based on its breadth in the world. The population of Lombok has based on the population census of 2019 to 2,450 million inhabitants [2]. This population is in the region of 4 districts and one Madia city namely West Lombok Regency, Central Lombok Regency, East Lombok Regency, and new district which is the result of the regional expansion of North Lombok Regency. Kota Associate is the city of Mataram which is the capital of the province of West Nusa Tenggara (NTB) which includes the island of Lombok and Sumbawa Island.

The pace Indicator of a region's development is population [3]. This Indicator includes knowledge about the quality and quantity of the population. The quality of the population concerns the level of education and expertise, while the knowledge of population quantity can give an overview of the number, growth, and distribution of a region's population.

Data on the growth of population on the island of Lombok in 4 districts and 1 city increased annually. Population increase in 2019, for West Lombok Regency at 1.43%, Center Lombok 0.86%, East Lombok 0.71%, and North Lombok are 0.86% while Mataram City increases 1.93%. This increase in population should be a concern and be known to provide an overview of the population composition, and population distribution for government planning in the development of the island of Lombok in the future [4].

Population growth is a dynamic balance between strength in increasing and reducing the amount of population growth. Uncontrolled population growth can cause economic problems that are increasing year by year [5]. Data stored in large quantities will be useless if unexcavated information available in it. Based on the potential impact resulting from population growth, it can be anticipated to overcome problems that will arise in the future [6-8].

Forecasting is an activity that estimates what will happen in the future or the future making. The determination of the policy to be taken by the Government in the future

Forecasting is an activity that estimates what will happen in the future or the future making. The determination of the policy to be taken by the Government in the future

Forecasting is an activity that estimates what will happen in the future or the future making. The determination of the policy to be taken by the Government in the future
include Moving averages, Naive methods, Exponential Smoothing methods, Interpolation methods and neural Networks (JST), or Artificial Neural Network (ANN) type Back Propagation (Pramita et al, 2019). So to anticipate such incompatibility, each process is indicated by the accuracy of each method such as Mean Absolute Deviation (MAD), Mean Square Error (MSE), and Mean Absolute Percentage Error (MAPE). The method with the least level of error or the highest level of accuracy is called the best method in the case [16].

The Exponential Smoothing method is a continual improvement procedure for forecasting on all the latest observation objects. This forecasting method is based on decreasing the priority scale exponentially on previously observed objects [17]. In exponential or exponential smoothing, there are one or more of the explicitly-defined maturation parameters, and these results will determine the weight imposed on the observation value. In other words, the latest observation will be given a higher priority for forecasting than a longer observation.

This research aims to determine the outcome of data from the forecasting process of population growth on the island of Lombok in 2020 until the year 2029 using the winter's method so that the government will be anticipating when there is a boom in the population that occurs in the future.

2. Method

This type of research is quantitative research, by using the winter's method. The linear exponential smoothing method of the winters is used for forecasting if the data has seasonal components. The winter's method is based on three smoothing equations namely the overall smoothing equation, smoothing trend, and seasonal smoothing.

The exponential smoothing method is a procedure that repeats the calculation continuously using the latest data based on the average calculation of data smoothing in the past exponentially [18]. The superiority of the smoothing method is that it can provide accuracy on short-term forecasts and adjustments can be made quickly and at a low cost.

The Winter formula, s Exponential smoothing can be seen as follows:

\[ S_t = (X_t - I_{m-L}) + (1-a)(S_{t-1} + b_{t-1}) \]  
\[ b_t = \gamma(S_t - S_{t-1}) + (1+\gamma)b_{t-1} \]  
\[ I_{mt} = \beta(X_{t} - S_{t-1} + (1-\beta)I_{m-L} \]  
\[ F_{t+m} = S_t + b_t m + I_{m-L} + m \]

As for the explanation of the above equation is \( S_t \) is the overall smoothing variable on the period to \( t \), while \( S_{t-1} \) is the overall smoothing variable in the period to \( t-1 \), \( B_t \) is a trend-speech variable in the \( t \)-period, while \( B_{t-1} \) is a variable smoothing trend in the \( t-1 \) period. The BMI variables of seasonal smoothing in the \( t \)-period, while the \( F_{t+m} \) variable forecasting in the \( T+M \). \( X_t \) in the actual data in the period \( t \). \( \alpha \), \( \beta \), and \( \gamma \) are constants for smoothing, trend, and seasonality. \( L \) is a seasonal length (the number of months/quarters in 1 year) and \( M \) is the number of fore-foreseen periods.

Data used by researchers in this study is data time series annual period for 10 years, starting from the year 2009 to 2019, which is data on the number of population on the island of Lombok acquired or taken from the website https://ntb.bps.go.id. Figure 1 are the steps used in this study.
Figure 1 describe the process of simulating data from data retrieval, reading data, and choosing the right statistical method. The statistical method used is the method of exponential winter, the selection is used for the type of research data owned, and some research results that demonstrate the accuracy of this method in forecasting practices. The forecasting process by loading the last 10 years of data is then presented in graphical form for easy reading and then making decisions according to the purpose of this research.

3. Result and Discussion
The experiment was conducted 27 times on each data, so there were 135 experiments. As a reference to the accuracy parameter, Mean Absolute Percentage Error (MAPE) is performed by pairing the value of forecasting results with actual value. In the data simulation, testing is done by changing the values of the $\alpha$, $\beta$, and $\gamma$ parameters to determine the effect of these parameters in forecasting results. As a result, the smallest MAPE value is obtained when the value $\alpha = 0.9$, $\beta = 0.5$, and $\gamma = 0.9$, which is with the MAPE value of 1.77%. The results of this experiment were carried out with the Moving Average type 2. At this stage, the results of the prediction in 2020 for East Lombok district of 1,207,135 inhabitants, West Lombok district of 706,711 people, Central Lombok district of 956,337 inhabitants, North Lombok district of 222,291 people, and Mataram City of 491,697 people.

Furthermore, the research team simulates the value of selected parameters based on the smallest MAPE to determine the number of people in the next 10 years as well as see the percentage of improvement. The prediction results can be seen in Table 1.

| Years | East Lombok | West Lombok | Central Lombok | North Lombok | Mataram City |
|-------|-------------|-------------|----------------|--------------|--------------|
| 2020  | 1,207,135   | 706,711     | 956,337        | 222,291      | 491,697      |
| 2021  | 1,247,747   | 705,020     | 969,673        | 227,064      | 541,535      |
| 2022  | 1,231,912   | 725,316     | 975,041        | 226,984      | 517,875      |
| 2023  | 1,267,369   | 725,683     | 987,487        | 231,305      | 562,640      |
| 2024  | 1,258,201   | 743,439     | 993,861        | 231,801      | 546,593      |
| 2025  | 1,291,112   | 747,080     | 1,007,312      | 236,128      | 588,030      |
Based on Table 1, it is seen that the percentage increase for the population of East Lombok District average of 1.15%, the average West Lombok district of 1.17%, average central Lombok district of 0.98%, North Lombok district averaged 0.98%, and the city of Mataram average of 3.05%. These results indicate that for the next 10 years the population in Mataram city has the highest percentage increase. This may be due to the high flows from the population to the city of Mataram, either government officials, employees of the company, merchants, or students. As for the actual data approach and prediction data according to Figure 2.

| Years | East Lombok | West Lombok | Central Lombok | North Lombok | Mataram City |
|-------|-------------|-------------|----------------|--------------|--------------|
| 2026  | 1,284,646   | 761,004     | 1,012,567      | 236,596      | 575,335      |
| 2027  | 1,313,599   | 765,859     | 1,025,314      | 240,565      | 611,957      |
| 2028  | 1,311,133   | 778,922     | 1,031,467      | 241,444      | 636,673      |
| 2029  | 1,336,783   | 784,685     | 1,043,589      | 245,090      | 636,673      |
| MAPE  | 1.9448      | 1.6077      | 0.52436        | 0.9301       | 5.9939       |

(a) West Lombok prediction
(b) Center Lombok prediction
(c) East Lombok prediction
(d) North Lombok prediction
Figure 2. Approach of Factual Data and Forecast

Figure 2 shows actual data approach and prediction data is quite good and increases regularly with the same trend in any city or district. It is also evidenced by the accuracy value of each prediction result, such as MAPE in West Lombok amounted to 1.608%; Center Lombok amounted to 0.524%; East Lombok amounted to 1.945%; North Lombok amounted to 0.930%; and Mataram City amounted to 5.994%. However, from the five images above, the data patterns in the West District and Mataram City look a little different from the higher error rates of other districts/cities, it is seen at the interval of 2010-2015. These results are based on the ups and downs of the amount of data at the intended interval, so that the interpolated from exponential given is slightly different between actual data and predictive data. The introduction of data patterns by the Winter method relies heavily on large data [19]. The smaller the data is simulated then the smoother the rendered graphics, and then if the data is large, the introduction of patterns and graphs displayed will provide a relatively high output of error. This is due to the nature of the exponential functions used in this method [20].

Furthermore, after learning the predicted results of population growth on the island of Lombok from 2020 to 2029 by using Winter's method so that later the government can anticipate when there is a boom in the population that occurs in the future through the implementation of policies that continue to support the welfare of the population. For example, in this case, the central government continues to do several ways to reduce the population density in certain regions, namely by (1) Promoting the Transmigration program, (2) The equitable of employment, (3) suppressing population growth with the Family Planning (KB) program, (4) making laws that set the minimum age of marriage, (5) Limiting child support for civil servants and the TNI to the second child, (6) imposing high fares for immigrants, (7) disseminate the education of the population to various levels of education, (8) Facilitate and improve the service in the field of education and improve the compulsory primary education for the community. That is the way the central government is generally effective enough to address the problem of population density in Indonesia [21]. This is certainly a consideration for the district government or city on the island of Lombok to overcome the problems of the population. With this prediction results at least 10 years in the future, the government already has an overview of how efforts should be made for the welfare of the population, especially in the supply of food clothing and other community needs.

4. Conclusion
The first stage of this forecasting activity began to design, implementation until the test was obtained that the value of the most accurate smoothing parameters obtained in the data simulation is \( \alpha = 0.9 \), \( \beta = 0.5 \), and \( \gamma = 0.9 \). The forecasting parameters of this Winter method provide MAPE accuracy value of 1.25%. Next in the second stage is found results for the next 10 years the number of inhabitants on the island of Lombok increased to 4,046,819 inhabitants or an average increase of 1.49%. The other side also shows that the percentage of population increase in the island of Lombok is still dominated by
Mataram city by 3.05%, while the lowest increase occurred in central Lombok district amounted to 0.97%.

In subsequent research, it is necessary to do predictions based on the number of births, the number of deaths, the number of transmigration, the amount of productive and non-productive, and other data series that is more complex so that it will be seen how the development of the population productivity on the island of Lombok.

5. References

[1] Sumartoyo and Widjojo S 2013 Potential development and disaster risk of natural tourism Lombok Island ACRS 2013: 34th Asian Conference on Remote Sensing 5 3818–3825

[2] Kumila A, Sholihah B, Evizia E, Safitri N and Fitri S 2019 Perbandingan metode moving average dan aetode naïve dalam peramalan data kemiskinan JITAM | J. Teor. Apl. Mat 3 65-75

[3] Soh S 2010 Development of rural villages and resident participation J. Reg. Stud 18 2113–131

[4] Negara H R P, Syaharuddin, Kurniawati K R A and Habibi R P N. 2019 Analysis of nonlinear models for the acceleration of increasing HDI in Asia Int. J. Sci. Technol. Res 8 1 60–62

[5] Population I 2010 Population and Water Environ. Sci 7 1-2

[6] Jiao S 2013 The method of forecasting the population of chinese population attractive cities Applied Mechanics and Materials 29 2654–2659

[7] Sanderson W C, Scherbov S, Lutz W and O’Neill B C 2013 Applications of probabilistic population forecasting The end of world population growth in the 21st century: New challenges for human capital formation and sustainable development (London: Earthscan) pp 85–120

[8] Benzer R 2015 Population dynamics forecasting using artificial neural networks Fresenius Environ. Bull 24 460–466

[9] Irawan M I, Syaharuddin S, Utomo D B and Rukmi A M 2013 Intelligent irrigation water requirement system based on artificial neural networks and profit optimization for planting time decision making of crops in lombok Island J. Theor. Appl. Inf. Technol 58 657–671

[10] Sucipto L and Syaharuddin 2018 Konstruksi forecasting system multi-model untuk pemodelan matematika pada peramalan indeks pembangunan manusia provinsi nusa tenggara barat Regist. J. Ilm. Teknol. Sist. Inf 4 114-124

[11] Adnan F, Damayanti P, Fajariatno G and Prihandoko A. C 2018 Winter exponential smoothing: sales forecasting on purnama jati souvenirs center Proceeding electr. eng. comput. sci. informatics 5 1-10

[12] Xia M and Wong W K 2014 A seasonal discrete grey forecasting model for fashion retailing Knowledge-Based Syst 1 1-10

[13] Primandari A H, Purwaningsih T and Oetama R P 2017 Grey exponential smoothing for forecasting Indonesian income tax Int. J. Adv. Soft Comput. its Appl 9 88–98

[14] Muhajirah A, Safitri E, Mardiana T, Hartina H and Setiawan A 2019 Analisis tingkat akurasi metode neuro fuzzy dalam prediksi data IPM di NTB JTAM | J. Teor. dan Apl. Mat 3 58-68

[15] Syaharuddin S, Pramita D, Nusantara T and Subanji 2019 Accuracy analysis of ANN back propagation, neuro-fuzzy, and radial basis function: A case of HDI forecasting Int. J. Eng. Adv. Technol 9 1299–1304

[16] Syaharuddin S, Pramita D, Nusantara T and Subanji 2020 Maximum turning point and final spread of COVID-19 in Indonesia: A forecasting ARIMA method based G-MFS Int. J. Sci. Technol. Res 9 174–179

[17] Syaharuddin S, Pramita D, Nusantara T and Subanji 2020 Computational of distribution of wind speed as preliminary information for fishers: Case study in lombok sea Int. J. Adv. Trends Comput. Sci. Eng 9 33584-3587

[18] Ostertagová E and Ostertag O 2013 Forecasting using simple exponential smoothing method Acta Electrotech. Inform 12 1-10

[19] Syafei A D, Ramadhan N, Hermana J, Slamet A, Boedisantoso R and Assomadi A. F 2018 Application of exponential smoothing holt winter and ARIMA models for predicting air pollutant concentrations EnvironmentAsia 11 251–262
[20] Tularam G and Almalki T. S 2016 The use of exponential smoothing (ES), holts and winter (HW) and ARIMA models in oil price analysis *Int. J. Math. Game Theory Algebr* **25** 13–22

[21] Demers D M and Pinckney R 2014 Population risk management and workplace health centers (Paris: Great Lakes Cancer Institute)