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Analyzing Future Trends of Under Five Mortality Rate for Sao Tome and Principe Using Artificial Neural Networks

[1]Dr. Smartson. P. NYONI, [2]Thabani NYONI

[1]ZICHIRe Project, University of Zimbabwe, Harare, Zimbabwe
[2]Independent Researcher & Health Economist, Harare, Zimbabwe

***Abstract* - This study uses annual time series data on under five mortality rate for Sao Tome and Principe from 1965 to 2020 to predict future trends of U5MR over the period 2021 to 2030. Residuals and forecast evaluation criteria indicate that the applied ANN (12, 12, 1) model is stable in forecasting under five mortality rate. ANN model projections suggested that annual U5MR will hover around 17 deaths per 1000 live births throughout the out of sample period. Therefore, the government of Sao Tome and Principe should continue providing financial support to the maternal and child health program in order to keep under five mortality under control.**

Keywords: ANN, Forecasting, U5MR.

I. INTRODUCTION

The third sustainable development goal (SDG3)is closely associated with other SDGs. SDG3 focuses on ensuring good health and promotion of well-being for all at all ages (UN, 2015). Good health will enable a population to contribute meaningfully to economic development and on the other hand, the reduction of poverty and hunger will in turn have a positive impact on health. Therefore it is important to channel resources towards maternal and child programs as this has a positive impact on economic development (Bloom *et al.* 2020). SDG3 Target 3.2 aims to reduce under five mortality to as low as 25 deaths per 1000 live births respectively (UNICEF, 2019; WHO, 2019; UNICEF, 2018; Kayode *et al.* 2017; UN, 2016; UN, 2016). In line with the Agenda 2030 for sustainable development, this research applied the multilayer perceptron neural network to predict future trends of under-five mortality rate in Sao Tome and Principe and the findings are going to inform maternal and child health policy formation and allocation of resources so that there is effective control of mortality among under five children.

II. LITERATURE REVIEW

A retrospective and descriptive study was conducted by Lahmini and Bourrous (2020) to investigate epidemiology of the pediatric mortality in the pediatric emergency department (PED), to determine its rate and identify its most frequent causes. The study was conducted over five years (1st January 2012 and 31st December 2016) including all children aged from 0 to 15 years old who died at the PED in the Mohamed VI Hospital in Marrakech. It was revealed that the most frequent causes of neonatal mortality were neonatal infections and prematurity. Sougou & Diouf (2020) conducted a secondary analysis of the 2017 DHS for Senegal to analyze the factors associated with neonatal deaths in Senegal in 2017. The study results revealed that significant predictors of neonatal mortality were newborns with a low birth weight < 2500 g, newborns who are considered "very small" by their mother at birth and birth by caesarean section. Nyoni & Nyoni, 2020 applied the ARIMA methodology to forecast neonatal deaths in Zimbabwe using annual time series data on neonatal deaths in Zimbabwe from 1966 to 2018.The ARIMA (8, 2, 0) was found to be the optimal model. The study findings revealed that the numbers of neonatal deaths per year would decline sharply over the next 25 years. A similar forecasting study by Nyoni & Nyoni, 2020 utilized the ARIMA model to model and forecast infant mortality in Zimbabwe. The ARIMA (1, 2, 5) was the best model and the forecast results indicated that the number of infant deaths per year, over the out-of-sample period, will follow a downward trend. Gayawan *et al.* (2016) examined the residual geographical variations in infant and child mortality and how the different categories of the risk factors account for the spatial inequality in West African countries. Authors pooled data for 10 of the countries extracted from Demographic and Health Surveys and used the spatial extension of discrete-time survival model to examine how the variables exert influence on infant and child mortality across space. Inference was Bayesian based on the computational efficient MCMC technique. They found different geographical patterns for infant and child mortality. In the case of children under five, demographic factors inherent to the mother and child as well as maternal status variables when explained away a good part of the huge variations observed in the crude rates.

III. METHODOLOGY

The Artificial Neural Network (ANN) approach, which is flexible and capable of nonlinear modeling; will be applied in this study. The ANN is a data processing system consisting of a large number of highly interconnected processing elements in architecture inspired by the way biological nervous systems of the brain appear like. Since no explicit guidelines exist for the determination of the ANN structure, the study applies the popular ANN (12, 12, 1) model based on the hyperbolic tangent

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activation function. This paper applies the Artificial Neural Network (ANN) approach in predicting annual under five mortality rate for Sao Tome and Principe.

Data Issues

This study is based on annual under five mortality rate in Sao Tome and Principe for the period 1965– 2020. The out-of-sample forecast covers the period 2021– 2030. All the data employed in this research paper was gathered from the World Bank online database.

IV. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

Variable	X
Observations	44 (After Adjusting Endpoints)
Neural Network Architecture:	
Input Layer Neurons	12
Hidden Layer Neurons	12
Output Layer Neurons	1
Activation Function	Hyperbolic Tangent Function
Back Propagation Learning	
Learning Rate	0.005
Momentum	0.05
Criteria:	
Error	0.035234
MSE	4.366458
MAE	1.051600

Residual Analysis for the Applied Model

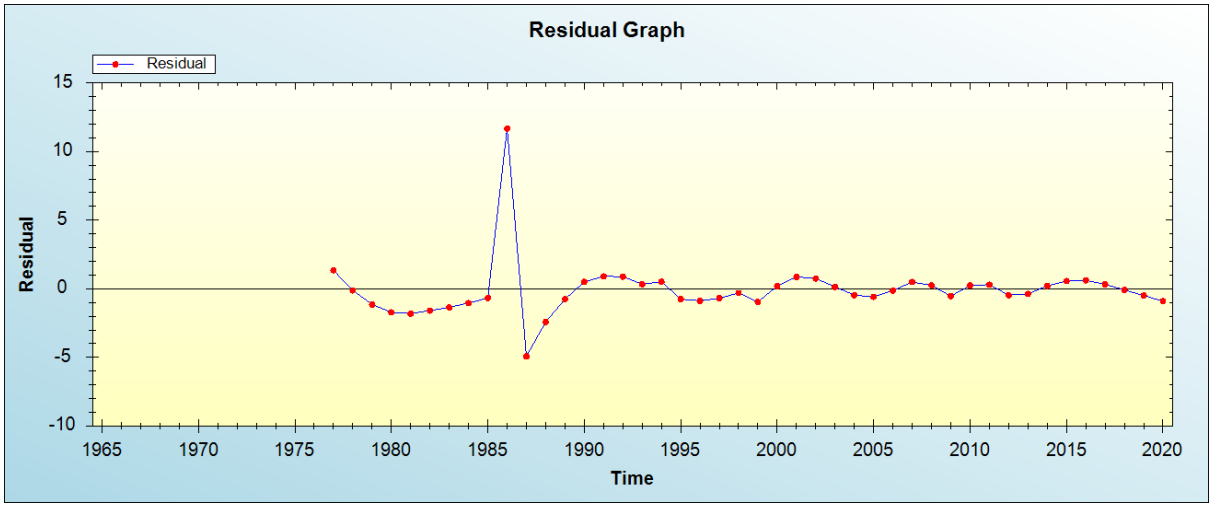

Figure 1: Residual analysis

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In-sample Forecast for X

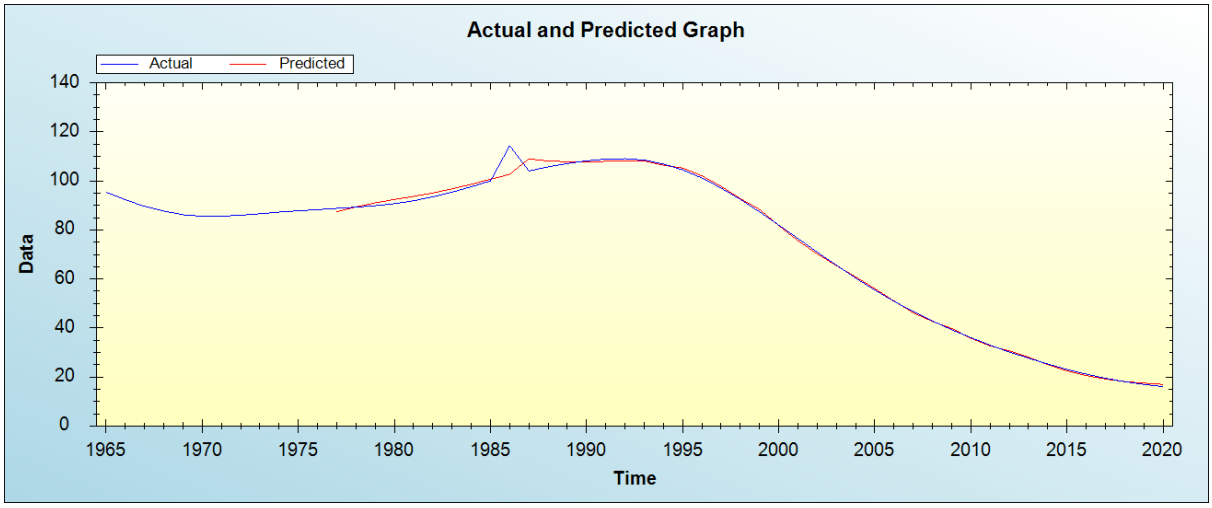

Figure 2: In-sample forecast for the X series

Out-of-Sample Forecast for X: Actual and Forecasted Graph

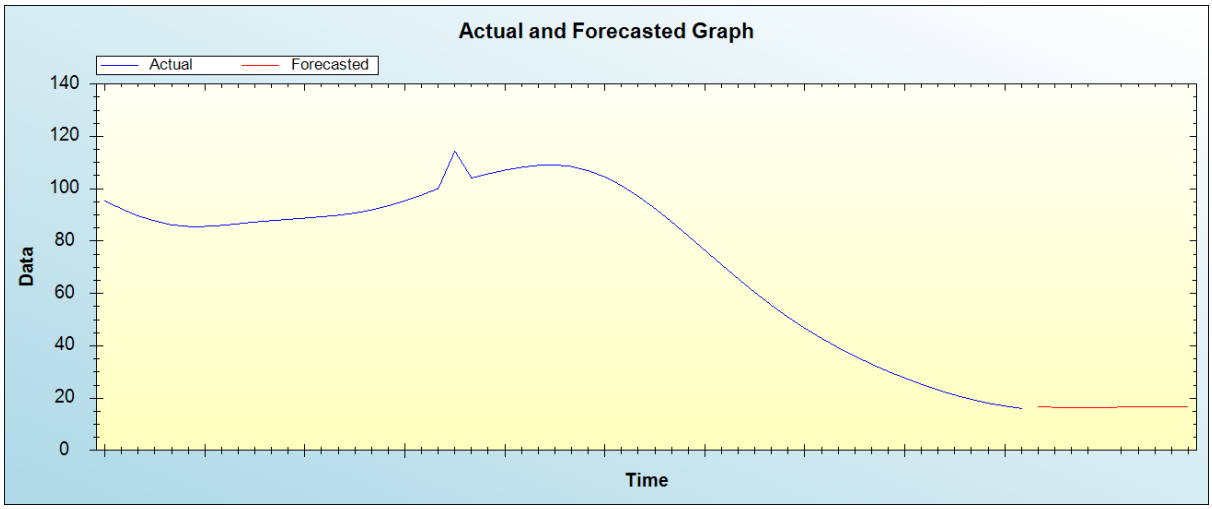

Figure 3: Out-of-sample forecast for X: actual and forecasted graph

Out-of-Sample Forecast for X: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	16.6599
2022	16.5349
2023	16.4851
2024	16.5001
2025	16.5101
2026	16.5643
2027	16.6401
2028	16.7397
2029	16.8045
2030	16.8779

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The main results of the study are shown in table 1. It is clear that the model is stable as confirmed by evaluation criterion as well as the residual plot of the model shown in figure 1. It is projected that annual U5MR will hover around 17 deaths per 1000 live births throughout the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

The 3rd sustainable development goal (SDG3) is linked to other SDGs, hence it is important for leaders in every country to attend to all the 17 thematic areas of the agenda 2030 as the success of each SDG depends on the progress made in other SDGs. Tracking SDG progress will guide policies, planning and allocation of resources. The ANN model was applied in this study to project future trends of under-five mortality rate in Sao Tome and Principe. Forecast results revealed thatannual U5MR will hover around 17 deaths per 1000 live births throughout the out of sample period. Therefore, the government of Sao Tome and Principe must continue providing financial resources to the MNCH program in order to keep under five mortality under control.

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