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Tracking the Future Path of Under Five Mortality in Zambia Using the Multilayer Perceptron Neural Network

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***Abstract* - This study uses annual time series data on under five mortality rate (U5MR) for Zambia from 1960 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 forecast results indicated thatU5MR will remain high over the out of sample period. Therefore, we encourage the Zambian government to allocate more resources to the maternal and child health (MNCH) program and address all the factors that significantly contribute to under five mortality across the country.**

Keywords: ANN, Forecasting, U5MR.

I. INTRODUCTION

The Agenda 2030 for sustainable development is a global document that outlines the 17 thematic areas covering global issues such as poverty reduction, access to quality and affordable healthcare, education for all, promotion of economic growth through appropriate monetary and fiscal policies, sustainable production &consumption, and sustainable governance (UN, 2016; UN, 2015). All member states recognized the importance of political leadership in different countries in order to have a successful implementation of these SDGs. It was agreed that SDGs should be integrated into national plans and budgets.The sustainable development goal on health aims to ensure good health and promotion of well-being for all at all ages. The objective is to ensure universal health coverage and access to high quality healthcare services. SDG3 target 3.1 aims at the significant reduction of maternal mortality to less than 70 deaths per 1000 live births. On the other hand, target 3.2 aims at the substantial reduction of neonatal and under five mortality to as low as 12 deaths per 1000 live births and 25 deaths per 1000 live births respectively by 2030 (UN, 2020, UNICEF, 2019; WHO,2019; UNICEF, 2018;Kayode *et al.* 2017; UN, 2016). The aim of this paper is to project future trends of under-five mortality rate in Zambia using a machine learning technique and the findings are expected to inform policy, planning and allocation of resources to maternal and child programs in the country.

II. LITERATURE REVIEW

Nyoni & Nyoni (2020) predicted neonatal deaths cases at Chitungwiza Central hospital in Zimbabwe using monthly time series data from January 2013 to December 2018 using Box-Jenkins SARIMA models and found out that there will be a slow but steady decrease in neonatal deaths at CCH over the out-of-sample period. Mishra et al. (2019) predicted Infant Mortality Rates (IMR) in India using ARIMA models. The forecast of the sample period (1971-2016) indicated accuracy by the selected ARIMA (2, 1, 1) model. The post sample forecast with the ARIMA (2, 1, 1) model revealed a decreasing trend of IMR (2017-2025). Usman et al. (2019) analyzed the incidence of the rate of neonatal mortality in Nigeria using ARIMA models. Their trend plot of the incidence indicated that there was a steady decrease in the incidence rate over the years. The ARIMA (1, 1, 1) model was found to be the optimal model. The time series analysis also indicated that neonatal mortality rate has reduced by 17.8% from 51.7% in the year 1990 to 33.9% in the year 2017 The forecast IMR for 2025 was found to be 15/1000 live births.Makate & Makate (2016) examined the effect of the quality of prenatal care and its individual components on neonatal, infant and under-five mortality. Their findings indicated that a one-unit increase in the quality of prenatal care lowers the prospect of neonatal, infant and under-five mortality by approximately 42.33, 30.86 and 28.65%, respectively. In a 2015 cross-sectional study by Lukonga & Michello, it was found that low birth weight and overweight were significant predictors of neonatal mortality.

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 Zambia.

Data Issues

This study is based on annual under five mortality rate in Zambia for the period 1960 – 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	
Observations	49 (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	0.004825
MSE	2.454311
MAE	1.239643

Residual Analysis for the Applied Model

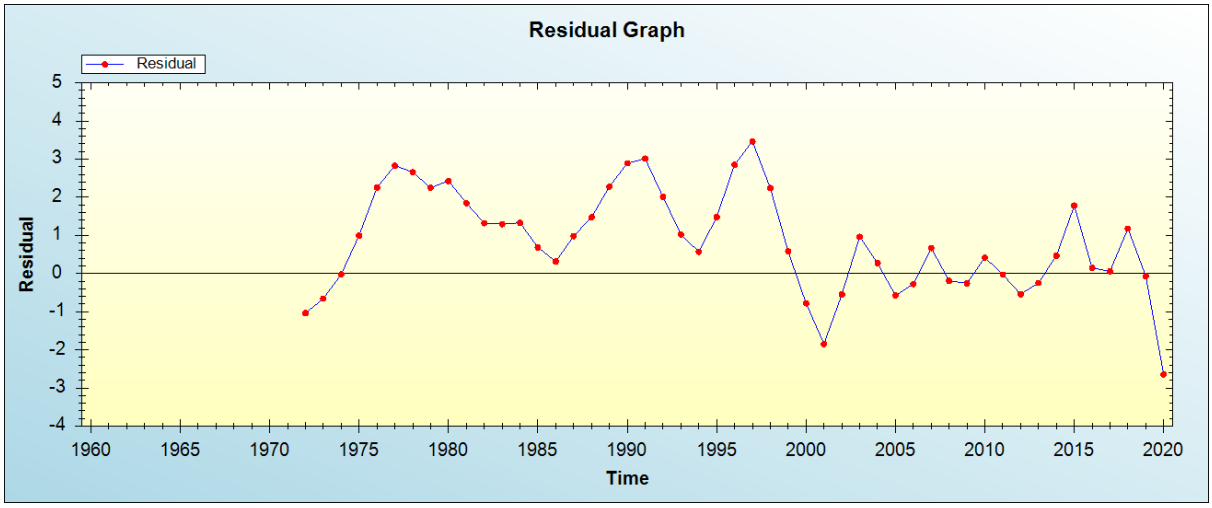

Figure 1: Residual analysis

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In-sample Forecast for C

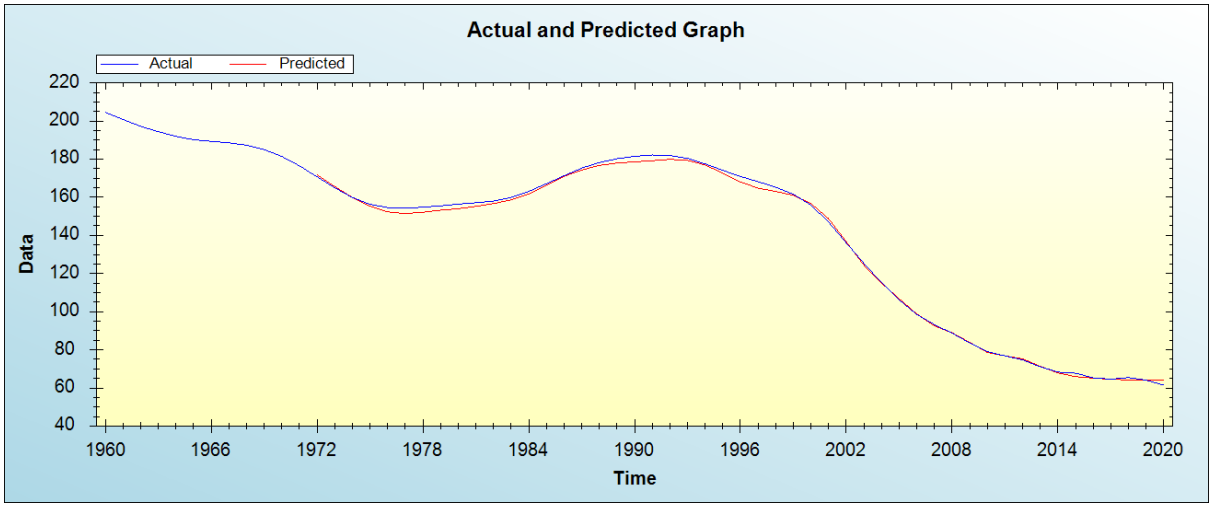

Figure 2: In-sample forecast for the C series

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

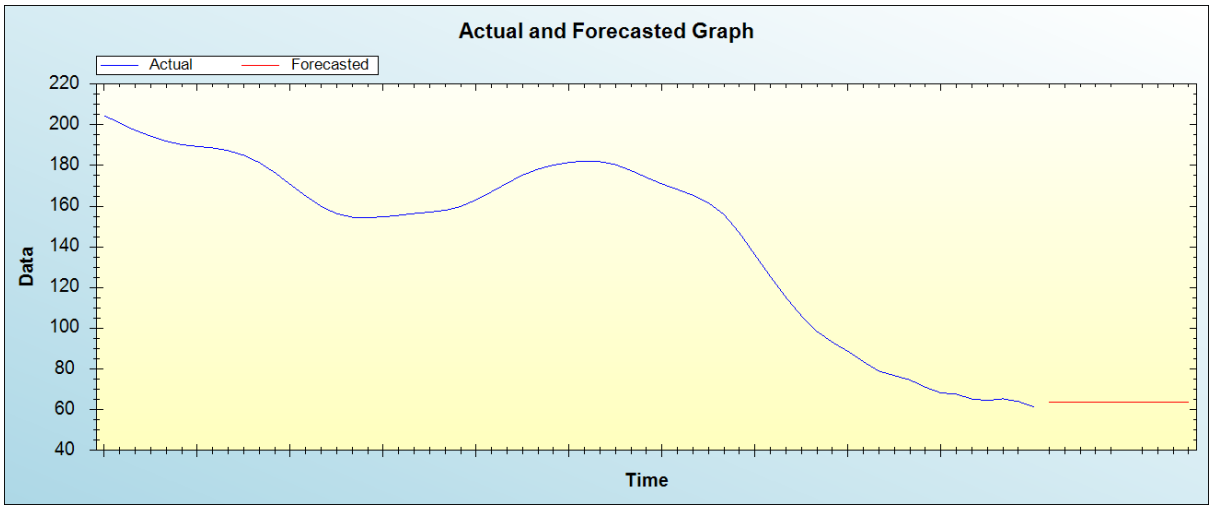

Figure 3: Out-of-sample forecast for C: actual and forecasted graph

Out-of-Sample Forecast for C: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	63.6297
2022	63.6864
2023	63.8602
2024	63.9551
2025	63.7271
2026	63.6768
2027	63.7172
2028	63.6266
2029	63.7034
2030	63.7488

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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 remain high over the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

The Zambian government has made significant progress towards achieving the set targets under the 3rd sustainable development goal (SDG3). Over the years, there was a gradual decline of under-five and neonatal mortality rates indicating government's commitment to the agenda 2030 for sustainable development. However, absolute numbers of under five deaths are still high. Therefore the government must craft new strategies to address this problem. The ANN model was utilized in this study to project future trends of under-five mortality rate and forecast results revealed thatU5MR will remain high over the out of sample period. Hence, the Zambian government must allocate more resources to the maternal and child health (MNCH) program and address all the factors that significantly contribute to under five mortality across the country.

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