

Forecasting Future Trends of Under Five Mortality Rate for Mali Using Artificial Neural Networks

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Abstract - This study uses annual time series data on under five mortality rate for Mali from 1963 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 U5MR in Mali. The ANN model projections revealed that annual U5MR will continue to decline over the out of sample period but will remain high. Therefore, we encourage the government of Mali to urgently address all the major challenges that hinder the success of the maternal and child health program in order to substantially reduce under five mortality to as low as 25 deaths per 1000 live births by 2030.

Keywords: ANN, Forecasting, U5MR

I. INTRODUCTION

Ending preventable maternal, neonatal and under five deaths is the aim of the 3rd sustainable development goal (SDG3)(UN, 2020; WHO, 2019; UNICEF, 2019; UNICEF, 2018; UN, 2015).The global under five deaths continue to decline significantly, however under five mortality in Mali remains unacceptably high (You *et al.* 2015). According to the Mali Demographic health survey, in 2018 maternal mortality ratio was at 325 deaths per 100 000 live births, under 5 mortality was 101 per 1000 live births, and neonatal mortality rate stood at 33 per 1000 live births. In line with the Agenda 2030 for sustainable development, this research applies a machine learning algorithm to forecast future trends of under-five mortality rate for Mali. The findings of the study are expected to guide planning, decision making and allocation of resources to Maternal and Child health programs. It is envisioned that appropriate maternal and child health (MNCH) intervention strategies will be implemented to control under five mortality in the country.

II. LITERATURE REVIEW

A description of household factors associated with under-five mortality in Bankass, a remote region in central Mali was done by Boettiger *et al.* (2021). The authors analyzed baseline household survey data from a trial being conducted in Bankass. The survey was administered to households between December 2016 and January 2017. Under-five deaths in the five years prior to baseline were documented along with detailed information on household factors and women's birth histories. Factors associated with under-five mortality were analyzed using Cox regression. The study concluded that U5 mortality is very high in Bankass and is associated with living a greater distance from healthcare and several other household factors that may be amenable to intervention or facilitate program targeting. Tiruneh *et al.* 2021 assessed the pooled estimate of infant mortality rate (IMR), time to death, and its associated factors in SSA using the recent demographic and health survey dataset between 2010 and 2018. Parametric survival modelling was used for analysis and the findings revealed that significant number of infants died in SSA with the most common cause of infant death being a preventable bio-demographic factor. A cross-sectional study in Benin by Tanou *et al.* 2021 examined the effect of geographical accessibility to health facilities on antenatal care and delivery services utilization in Benin, with an emphasis on geographical zones by employing multivariate logistic regression. The findings of the study suggested that geographical accessibility to health facilities is critically important for the utilization of antenatal care and delivery services, particularly in the northern part of Benin. Another cross-sectional study by Soleman *et al.* (2020) in Indonesia described trends and main causes of children mortality in Indonesia from 2000 to 2017. The data was taken from World Health Organization Maternal Child Epidemiology Estimation from 2000 to 2017. The study found that the trend of three parameters of child mortality declined within 17 years and the main causes of mortality were premature birth in neonates, ARI in post neonates and premature birth in under five children.

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 activation function. This paper applies the Artificial Neural Network (ANN) approach in predicting annual under five mortality rate in Mali.

Data Issues

This study is based on annual under five mortality rate in Mali for the period 1963 – 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	Y
Observations	46 (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	0.000374
MSE	0.510811
MAE	0.531642

Residual Analysis for the Applied Model

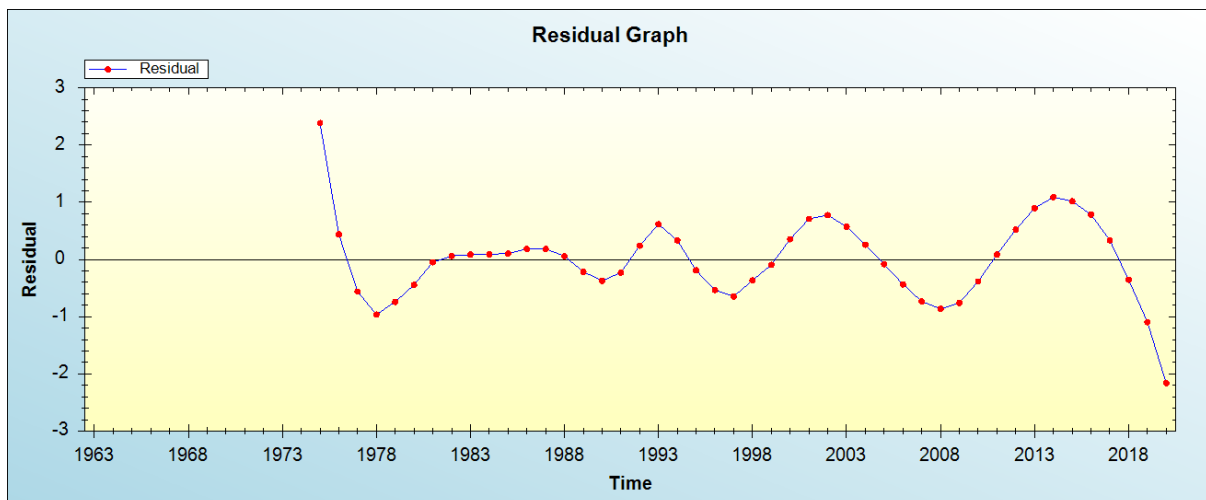


Figure 1: Residual analysis

In-sample Forecast for Y

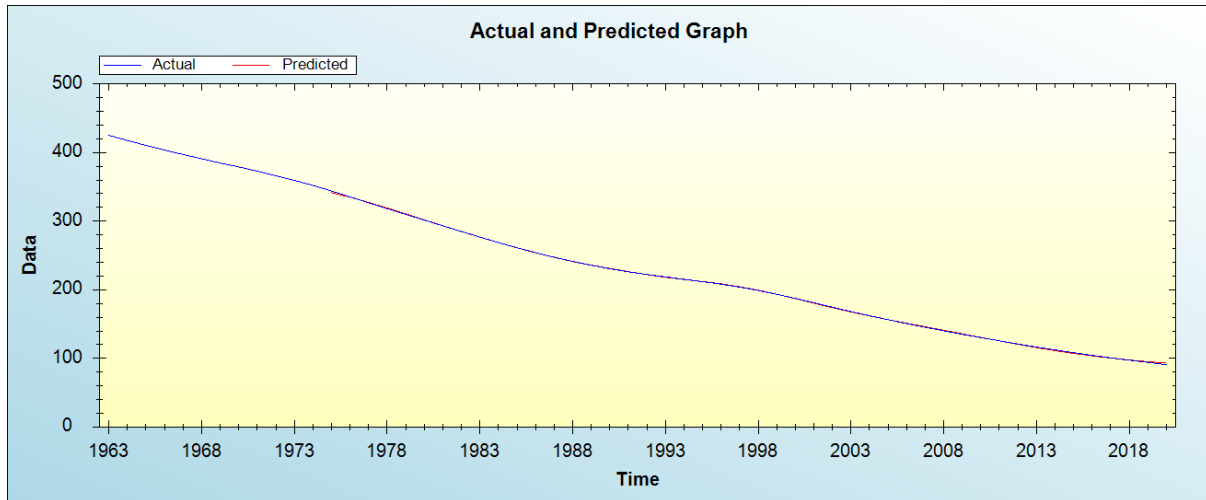


Figure 2: In-sample forecast for the Y series

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

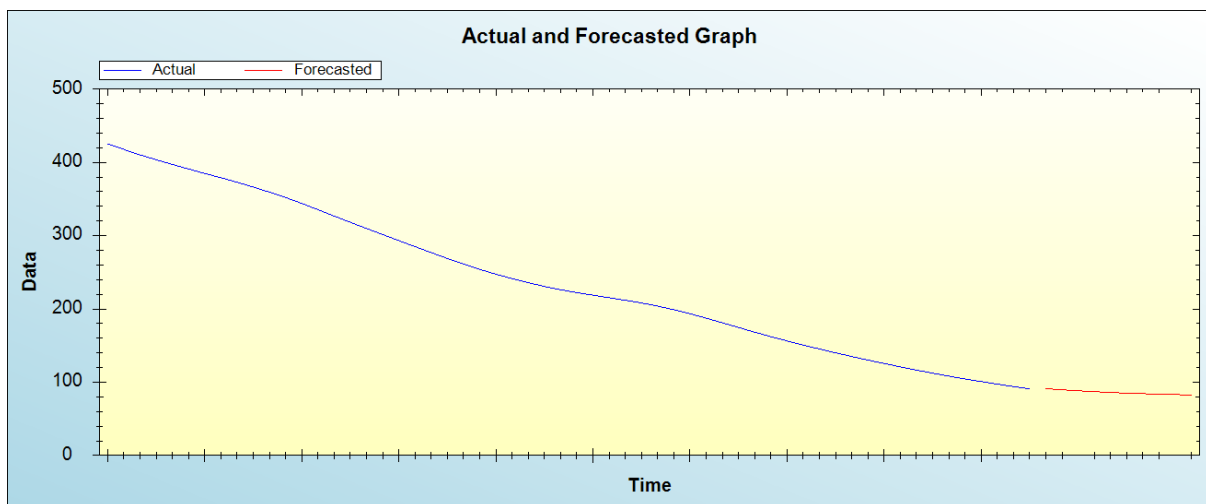


Figure 3: Out-of-sample forecast for Y: actual and forecasted graph

Out-of-Sample Forecast for Y: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	91.2471
2022	89.7721
2023	88.3788
2024	87.1974
2025	86.0829
2026	85.0685
2027	84.4129
2028	83.7520
2029	83.1758
2030	82.8242

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 continue to decline over the out of sample period but will remain high.

V. POLICY IMPLICATION & CONCLUSION

The achievement of set targets of sustainable development goals (SDGs) will remain a pipeline dream if governments are failing to respond to the people's needs as quickly as possible. The 3rd sustainable development goal should be a political priority in order to achieve all the set targets outlined under SDG3. Prediction of under-five mortality rate will inform child health policies, decisions and allocation of resources to the maternal and child health program. This study applied the ANN model to project future trends of under-five mortality rate for Mali and the forecast results revealed that annual U5MR will continue to decline over the out of sample period but will remain high. Therefore, we encourage authorities in Mali to address all the challenges that hinder the success of the maternal and child health program in order to substantially reduce under five mortality to levels as low as 25 deaths per 1000 live births.

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