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Predicting Future Trends of Under Five Mortality Rate for Nepal Using a Machine Learning Technique

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***Abstract* - This study uses annual time series data on under five mortality rate for Nepal from 1960 to 2020 to predict future trends of UMR 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 predictions revealed that U5MR will continue to decline throughout the out of sample period. Therefore, we encourage the government of Nepal to identify and address all the factors that significantly contribute to under five mortality in the country.**

Keywords: ANN, Forecasting, U5MR.

I. INTRODUCTION

The 3rd Sustainable development goal (SDG3)has several targets that seek to solve different health challenges including ending all preventable deaths due to epidemic diseases, non-communicable diseases, road traffic accidents and hazardous chemicals. It also focuses on the prevention and control of maternal, neonatal and under five deaths (UN, 2020; WHO, 2019; UNICEF, 2018; UN, 2015). Under five mortality remains a global health challenge although remarkable progress has been achieved over the past decades (World Bank, 2019). Nepal reported a decline in under 5 mortality rate from 133 deaths per 1000 live births in 1991 to 39 per 1000 live births in 2016 (World Bank, 2019; Nepal MOHP, 2017).The main objective of this study is to model and forecast under five mortality rate for Nepal using the artificial neural network approach. The findings of this study are expected to inform policy, decision making and resource mobilization for maternal and child health programs in the country so that effective MNCH policies are implemented timeously to prevent and control mortality among children below 5years of age.

II. LITERATURE REVIEW

Schellekens (2021) estimated the contribution of maternal education to infant mortality decline in Indonesia. A longitudinal, individual-level analysis of the determinants of trends in infant mortality in Indonesia was done by utilizing pooled data from all available phases of the Demographic and Health Survey (1980-2015).The study findings revealed that maternal education explains 15% of the infant mortality decline in Indonesia from 1980 to 2015. Soleman *et al.* (2020) conducted a cross-sectional study in Indonesia to describe 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.Gage & Bauhoff (2020) assessed the impact of PBF on early neonatal health outcomes and associated health care utilization and quality in Burundi, Lesotho, Senegal, Zambia and Zimbabwe. Authors utilized data from Demographic and Health Surveys and Multiple Indicator Cluster Surveys and applied difference-in-differences analysis to estimate the effect of PBF projects supported by the World Bank on early neonatal mortality and low birth weight and concluded that PBF had no impact on early neonatal health outcomes in the five African countries studied and had limited and variable effects on the utilization and quality of neonatal health care.A secondary analysis of the 2017 DHS for Senegal was conducted by Sougou & Diouf (2020) to analyze the factors associated with neonatal deaths in Senegal in 2017. The study results indicated 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.

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 for Nepal.

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Data Issues

This study is based on annual under five mortality rate in Nepal 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	E
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	0.000366
MSE	0.391617
MAE	0.485439

Residual Analysis for the Applied Model

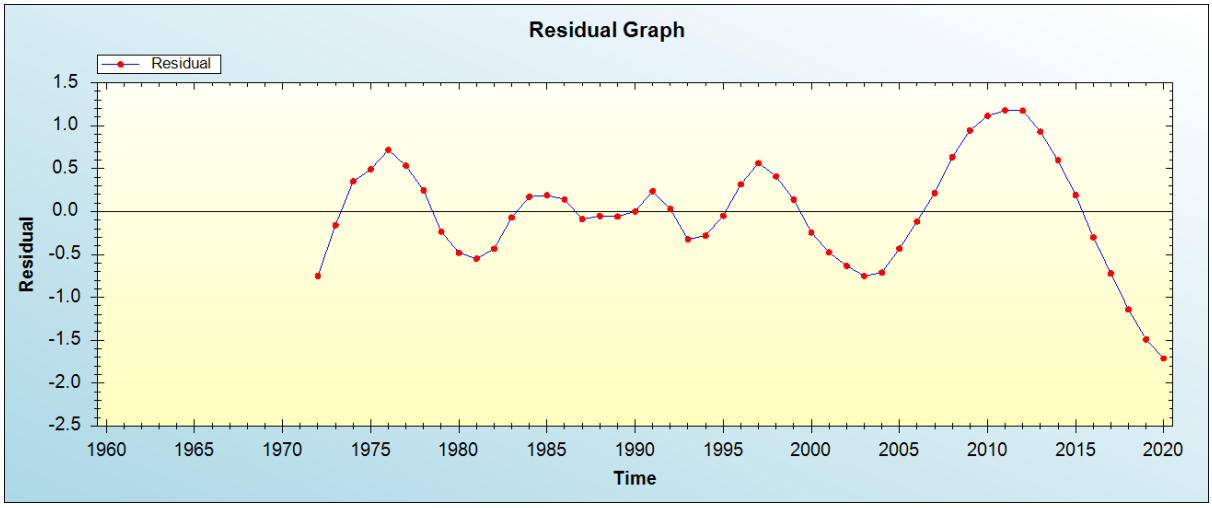

Figure 1: Residual analysis

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In-sample Forecast for E

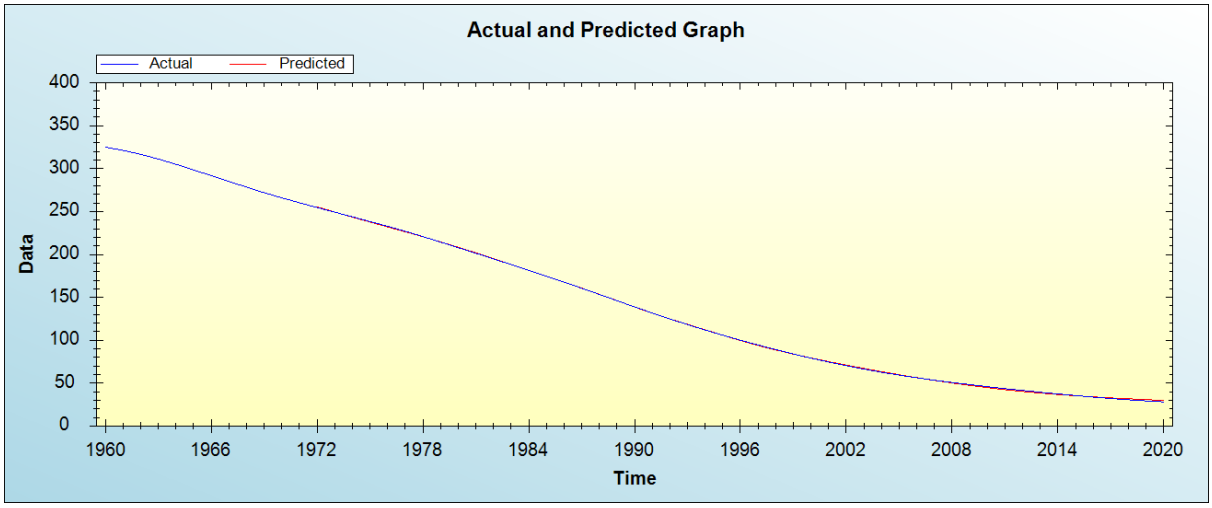

Figure 2: In-sample forecast for the E series

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

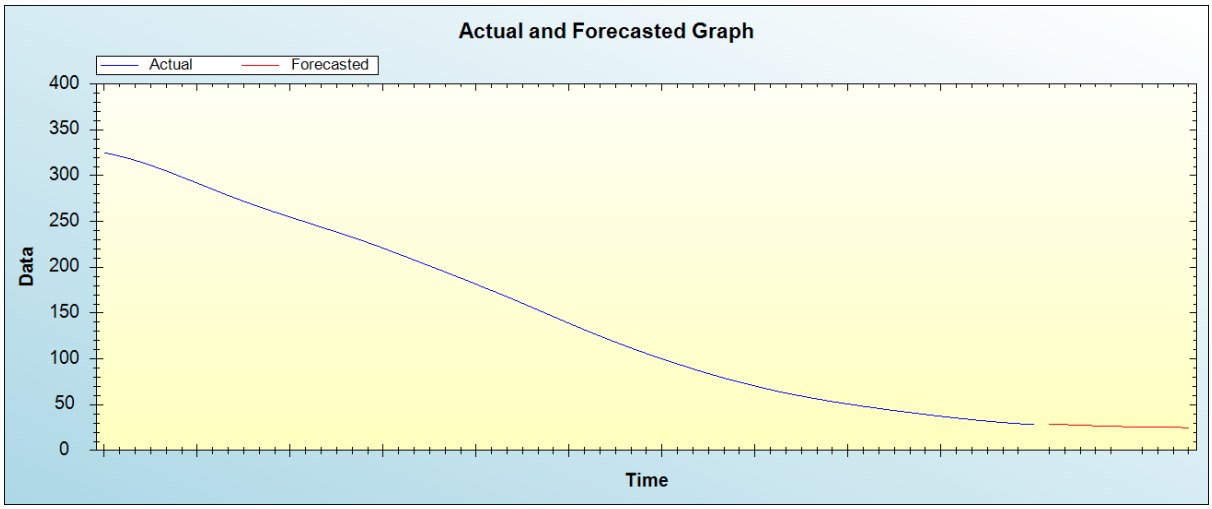

Figure 3: Out-of-sample forecast for E: actual and forecasted graph

Out-of-Sample Forecast for E: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	29.0991
2022	28.3060
2023	27.6946
2024	27.0020
2025	26.4613
2026	26.0587
2027	25.7013
2028	25.5050
2029	25.3086
2030	25.0562

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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 continue to decline throughout the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

Sub-Saharan Africa and South Central Asia continue to report high absolute numbers of under-five mortality as a result of numerous reasons that include socio-cultural, demographic and health system related factors. This study applied the ANN model to project future trends of under-five mortality rate in Nepal. The model projections indicate that U5MR will continue to decline throughout the out of sample period. Therefore, we encourage the government of Nepal to address all the factors that significantly contribute to under five mortality in the country.

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