Time Series Forecasting Of Total Fertility Rate (TFR) In Uganda

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Abstract - The Ugandan population pyramid is broad based reflecting high birth rates, high fertility rates, and lower life expectancies. In this piece of work, the ANN approach was proposed to analyze TFR in Uganda. The employed annual data covers the period 1960-2018 and the out-of-sample period ranges over the period 2019-2030. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model indicate that the model is stable in forecasting TFR in Uganda. The results of the study indicate that annual total fertility rates in Uganda are likely to remain around 5.0 births per woman over the out-of-sample period. Therefore, the Ugandan government is encouraged to focus on creating more demand for family planning, HIV testing and Antiretroviral therapy (ART) services, address challenges being faced by adolescents and young adults in accessing family planning services and continuously fund women empowerment program activities.

Keywords: ANN, Forecasting, Total fertility rate (TFR).

I. INTRODUCTION

Uganda is a low income country in Sub-Saharan Africa with 78% of the general population below 30 years of age and adolescent girls contributing 50% of the female population (UBOS & ICF, 2018). Young people in the Sub-Sahara have many challenges related to their sexual and reproductive health (SRH) such as unplanned pregnancies, STIs and obstetric complications (FCIUAP, 2015). Uganda has a burden of teenage pregnancies with 33% of Ugandan women having given birth by the age of 18 years (Loaiza &Liang, 2013). The high pregnancy rate among adolescents is aggravated by the unmet need of family planning (WHO, 2010). It has been noted in previous studies that in many developing countries adolescents have limited access to contraception and there is shortage of trained staff to address adolescent SRH needs (Renzaho et al, 2017). Bwambale et al (2021) revealed that SRH services utilization among migrant street children and young adults is low compared to their non-migrant counterparts and is independently associated with migration status, age, schooling status, knowledge of place of care and access to SRH information. Nuwamanya et al (2020) in their Ugandan study found out that a mobile phone application increased sexual and reproductive health information (knowledge score), access to goods (contraceptives), and services (HIV voluntary testing and counseling and sexually transmitted infection diagnosis and management) among sexually active university students in Uganda.

Total fertility rates in Uganda have been decreasing over the years from 7.1 births per woman in 1995 to 5.0 births per woman in 2020 (Worldometer, 2020). The country recorded an infant mortality rate of 39.2 infant deaths per 1000 live births and under five mortality rate of 53.3 deaths per 1000 live births in 2020 (Worldometer,2020). There are limited studies in the region which have examined fertility or predicted fertility rates. The purpose of this study is to forecast fertility rates in Uganda using an artificial intelligence technique. The results of the study are expected to reveal likely fertility trends in the out of sample period in Uganda. This will guide policy, planning and resource allocation towards areas like health, education and employment creation.

II. 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 total fertility rates in Uganda.

Data Issues

This study is based on annual total fertility rate (births per woman)in Uganda for the period 1960 – 2018.The out-of-sample forecast covers the period 2019 – 2030.All the data employed in this research paper was gathered from the World Bank online database.

III. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

Variable	N
Observations	47 (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	0.064581
MSE	0.005677
MAE	0.061010

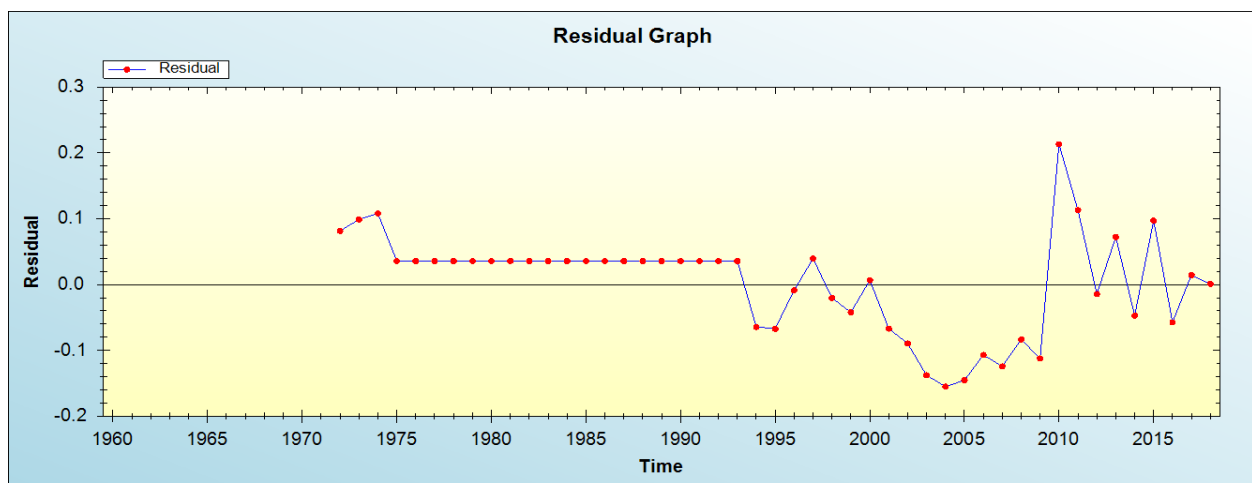*Residual Analysis for the Applied Model*

Figure 1: Residual analysis
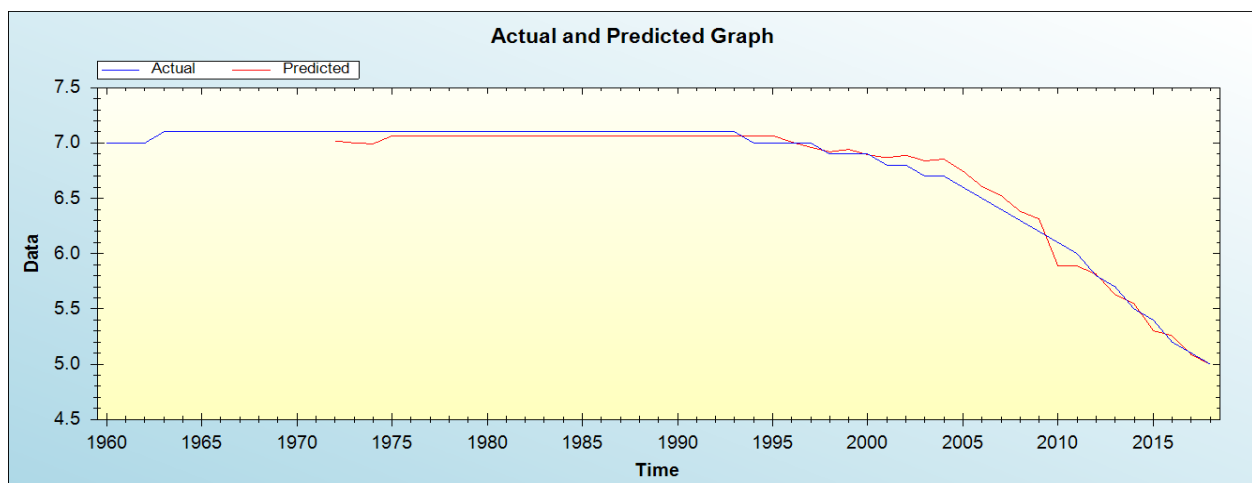
In-sample Forecast for N

Figure 2: In-sample forecast for the N series

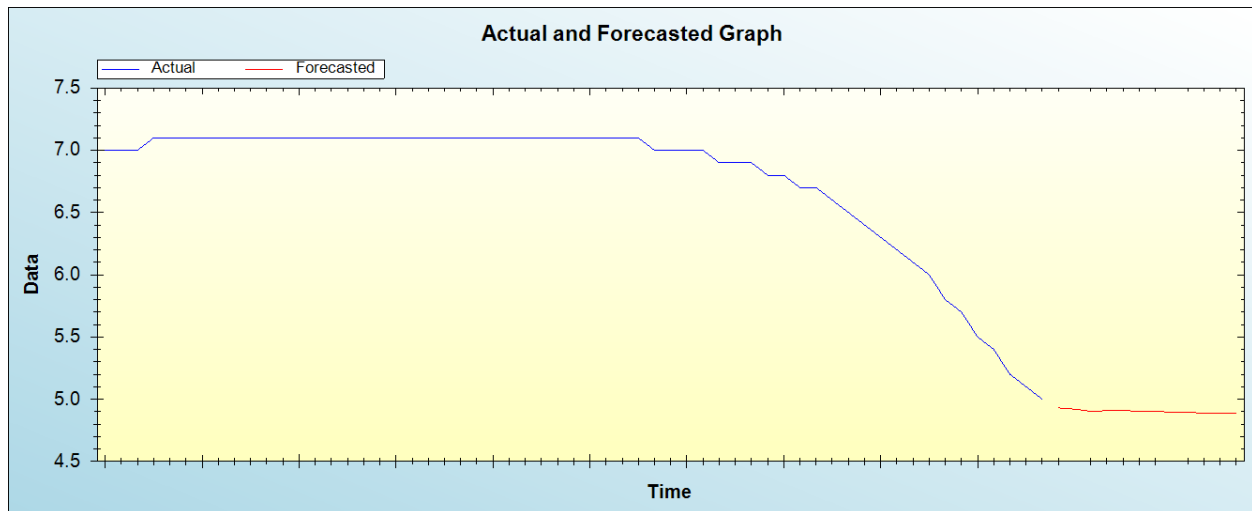*Out-of-Sample Forecast for N: Actual and Forecasted Graph*

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

Out-of-Sample Forecast for N: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecast
2019	4.9303
2020	4.9207
2021	4.9031
2022	4.9084
2023	4.9090
2024	4.9041
2025	4.9028
2026	4.8954
2027	4.8941
2028	4.8893
2029	4.8884
2030	4.8873

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 total fertility rates in Uganda are likely to remain around 5.0 births per woman over the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

The majorities of Ugandans are aged below 30yrs and are at a high risk of experiencing adverse SRH outcomes like STIs, unintended pregnancies, HIV infection, and unsafe abortions. The country is characterized by high adolescent fertility rates. In this paper we propose a machine learning approach to predict total fertility rates in Uganda. The ANN model projections indicated that annual total fertility rates in Uganda are likely to remain around 5.0 births per woman over the out-of-sample period. Therefore, the Ugandan government must focus on creating more demand for family planning and HIV testing services, address challenges being faced by adolescents and young adults in accessing family planning services and continuously fund women empowerment program activities.

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