International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 5, Issue 8, pp 367-370, August-2021

https://doi.org/10.47001/IRJIET/2021.508081

Forecasting Total Fertility Rate (TFR) In Nigeria Using a Machine Learning Approach

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***Abstract* - In this research paper, the ANN approach was applied to analyze TFR in Nigeria. 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 Nigeria. The results of the study indicate that annual total fertility rates in Nigeria are likely to remain around 5.5 births per woman over the out-of-sample period. Therefore, the Nigerian government should to prioritize creating demand for family planning, HIV testing, antiretroviral therapy (ART) services mainly targeting 15-49 age group and women empowerment programs.**

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

I. INTRODUCTION

Great strides have been made by the Nigerian government to address sexual and reproductive health challenges being encountered by adolescent girls and women. The government has put in place policies that uphold the SRH rights of women (Federal Ministry of Health, 2007). However access to SRH information and services for adolescents remains a challenge (Eremutha & Veronica, 2019; Odo et al, 2018; Cortez et al, 2015; Omo-Aghoja, 2013). Approximately 26.1% of Nigeria's population is between 12-24yrs (UN, 2019). The country has reported a high incidence and prevalence of STIs among young people aged 15-24years (Abdul et al, 2018; Francis et al, 2018). Nigeria reported 510 000 new HIV infections among young people aged 10-24 years (UNICEF, 2019). It is also important to mention that teenage pregnancies and unsafe abortions are very high (Dida et al, 2015).

Nigeria has witnessed a downward trend in fertility rates from 6.8 births per woman in 1985 to 5.4 births per woman in 2020. Infant mortality rate has been on a downward trend as well, from 200.29 infant deaths per 1000 live births in in 1950 to 54.74 infant deaths per 1000 live births in 2020 (Worldometer, 2020). Maternal mortality ratio remains very high in the country reflecting the need to channel more resources towards improving health infrastructure, buying medical supplies and equipment and employment of skilled medical staff to conduct safe deliveries and offer essential newborn care. There is a limited number of studies in the region which have focused on examining fertility trends and forecasting fertility rates. Based on qualitative study, Egeh et al (2019) investigated Somali Islamic religious leaders' views on birth spacing. Qualitative individual interviews were conducted with 17 Somali Islamic religious leaders aged 28–59 years and analyzed through content analysis. The study results showed that according to the religious Islamic leaders, selected practice recommendations for contraceptive use is permitted in relation to birth spacing to promote the health of the mother and child. Based on cross-sectional survey, Kågesten et al (2017) described the characteristics of VYA (very young adolescents) aged 10-14 years in two humanitarian settings, focusing on transitions into puberty and access to SRH information. Their findings revealed that Parents/guardians were the most common source of SRH information in both sites, however VYA indicated that they would like more information from friends, siblings, teachers and health workers. Moise et al (2017) examined the density of RHS availability; assessed spatial patterns of RHC facilities; and identified youth-friendly practices associated with adolescents' use of services in post-conflict Burundi. The cross-sectional study findings showed that there is need to improve youth-friendly service practices in the provision of RHS to adolescents in Burundi and suggest that current approaches to provider training may not be adequate for improving these vital practices. Chaumont et al (2015) analyzed public expenditure levels and trends with regards to RH in Burundi between the years 2010 to 2012, looking specifically at financing agents, health providers, and health functions. The analysis was performed using standard RH sub-account methodology. Information regarding public expenditures was gathered from national budgets, the Burundi Ministry of Public Health information system, and from other relevant public institutions. The study revealed that the flow patterns and levels of public funds to RH in Burundi suggest that RH funding correctly reflects governmental priorities for the period between 2010 and 2012.

The aim of the study is to forecast fertility rates in Nigeria using a machine learning technique. The findings of this study are expected to reveal likely future trends of fertility to facilitate planning and resource mobilization for health, education and employment creation.

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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 Nigeria.

Data Issues

This study is based on annual total fertility rate (births per woman)in Nigeria 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	0.107311
MSE	0.006966
MAE	0.066982

Residual Analysis for the Applied Model

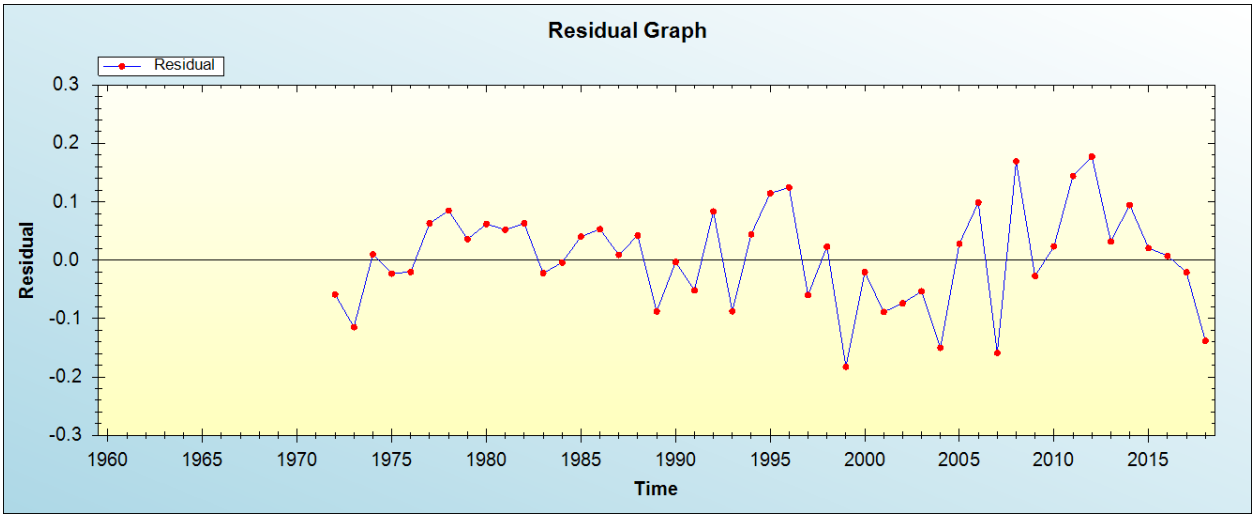

Figure 1: Residual analysis

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In-sample Forecast for N

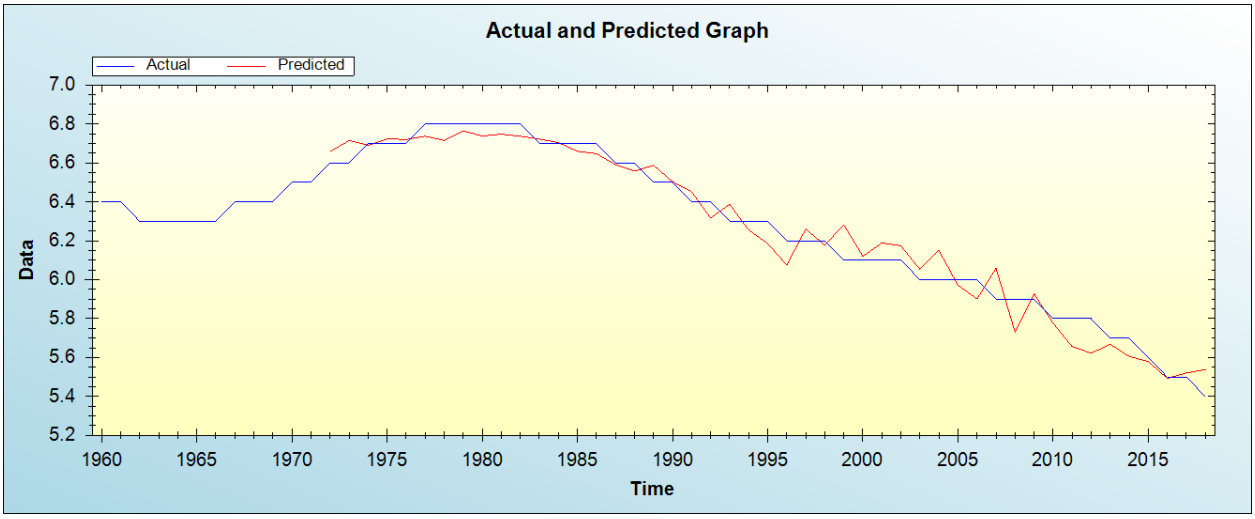

Figure 2: In-sample forecast for the N series

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

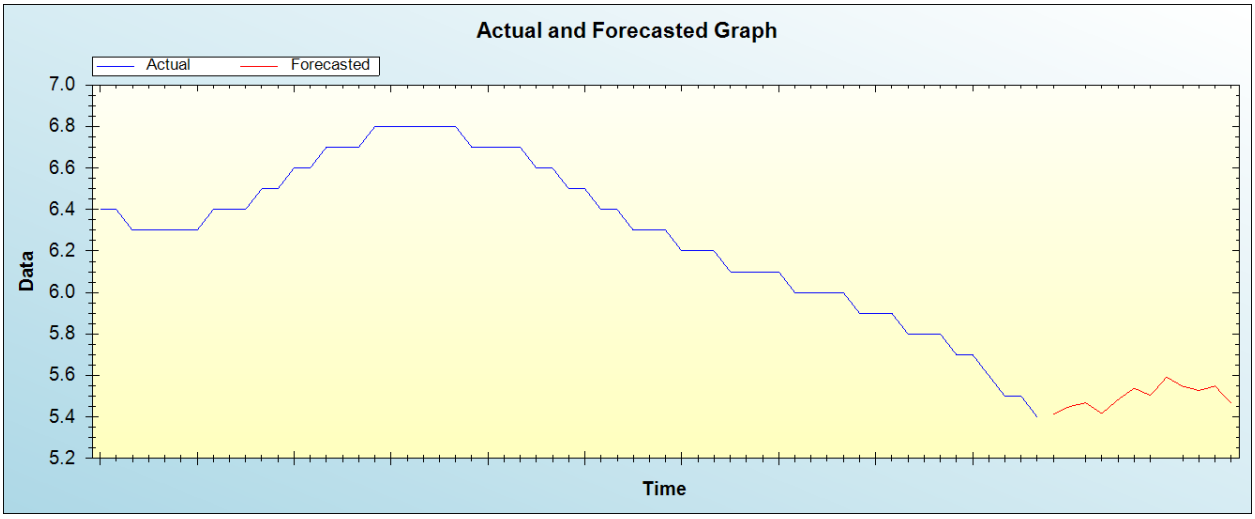

Figure 3: Out-of-sample forecast for N: actual and forecasted graph

Out-of-Sample Forecast for N: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecast
2019	5.4139
2020	5.4506
2021	5.4688
2022	5.4168
2023	5.4833
2024	5.5387
2025	5.5036
2026	5.5918
2027	5.5479
2028	5.5276
2029	5.5491
2030	5.4669

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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 total fertility rates in Nigeria are likely to remain around 5.5 births per woman over the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

Nigeria has reported a decline in total fertility rates over the years, however adolescents and young adults continue to experience adverse SRH outcomes such as HIV infections, STIs, unwanted pregnancies, and unsafe abortions. In this study we proposed a machine learning technique to project total fertility rates in Nigeria. The ANN model projections suggest that annual total fertility rates in Nigeria are likely to remain around 5.5 births per woman over the out-of-sample period. Therefore, the Nigerian government is advised to prioritize creating demand for family planning, HIV testing, antiretroviral therapy (ART) services mainly targeting 15-49 age group and women empowerment programs.

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Citation of this Article:

Dr. Smartson. P. NYONI, Tatenda. A. CHIHOHO, Thabani NYONI, "Forecasting Total Fertility Rate (TFR) In Nigeria Using a Machine Learning Approach" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 5, Issue 8, pp 367-370, August 2021. Article DOI https://doi.org/10.47001/IRJIET/2021.508081

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