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Forecasting Total Fertility Rate (TFR) in Benin Using a Machine Learning Algorithm

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Abstract - In this research paper, the ANN approach was applied to analyze TFR in Benin. The employed annual data covers the period 1960-2019 and the out-of-sample period ranges over the period 2020-2030. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model indicate that the model is stable in forecasting TFR in Benin. The results of the study indicate that annual total fertility rates in Benin are likely to be around 4.8 births per woman throughout the out-of-sample period. Therefore, the government of Benin should improve awareness of family planning services to adolescents and young adults through mass media and other locally available platforms and channel more resources towards girl child and women empowerment program activities.

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

I. INTRODUCTION

The 1994 international conference on Population and development was a landmark event especially for adolescent girls and women's sexual and reproductive health and rights as the signatories agreed to tackle sexual and reproductive health issues for both sexes particularly upholding the rights of women and adolescent girls (UN, 1995). Since then SRH and rights became global health priority (WHO, 1998). WHO developed guidelines to reduce adverse reproductive health outcomes and these included legal reform, strategies to reduce child marriages, increased contraceptive use, reduce coerced sex, unsafe abortions and increase the use of maternity services (WHO, 2011). Family planning is an essential intervention for reducing maternal and infant mortality there by stimulating economic development through increased participation of women in labor force and equitable use of resources sue to reduced population growth (Gribbi et al, 2012; Canning & Schultz, 2012; Cleland et al, 2006).

Benin witnessed a decline in fertility rates over the past decades from 6.8 births per woman in 1980 to 5.4 births per woman in 2020 (Worldometer, 2020). This indicates that TFR is still high and continued effort is required to address unwanted pregnancies which are being reported. The country reported a high infant and under five mortality rates of 54.7 infant deaths per 1000 live births and 90.2 deaths per 1000 live births respectively (Worldometer, 2020). There are few studies in the region which have examined fertility trends to inform policy. However we shall highlight relevant available ones. Dessalegn et al (2020) conducted an explorative qualitative study in five districts. Sixteen key informants and eight focus group discussions were conducted among adult women and men of young adolescents and youth. The study revealed that younger and older women are the most disadvantaged groups of the society. Based on a systematic review, Ganle et al (2020) examined the barriers persons with disabilities face in accessing sexual and reproductive health services in sub-Saharan Africa. An electronic search was conducted in Medline, EMBASE, CINAHL, PsycINFO, and Web of Science from 2001 to 2020. Studies were included if they reported on barriers persons with disability face in accessing sexual and reproductive health services. The Critical Appraisal Skills Programme and Centre for Evidence Based Management (CEBMa) appraisal tools were used to assess methodological quality of eligible studies. The study revealed that Persons with disabilities face a myriad of demand and supply side barriers to accessing sexual and reproductive healthcare in sub-Saharan Africa. Nkata et al (2019) did a systematic review of the available published information on sexual and reproductive health among Tanzanian adolescents. The results of the study highlighted that Adolescents engage in high-risk sexual behaviors and experience its adverse consequences.

The aim of this piece of work is to project TFR in Benin using a machine learning algorithm. The results of the study are expected to provide an insight of the likely fertility trends in the out of sample period. This will facilitate planning and resource allocation towards 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

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activation function. This paper applies the Artificial Neural Network (ANN) approach in predicting annual total fertility rates in Benin.

Data Issues

This study is based on annual total fertility rate (births per woman) in Benin for the period 1960 – 2019. The out-of-sample forecast covers the period 2020 – 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	B
Observations	48 (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	0.051478
MSE	0.004106
MAE	0.052063

Residual Analysis for the Applied Model

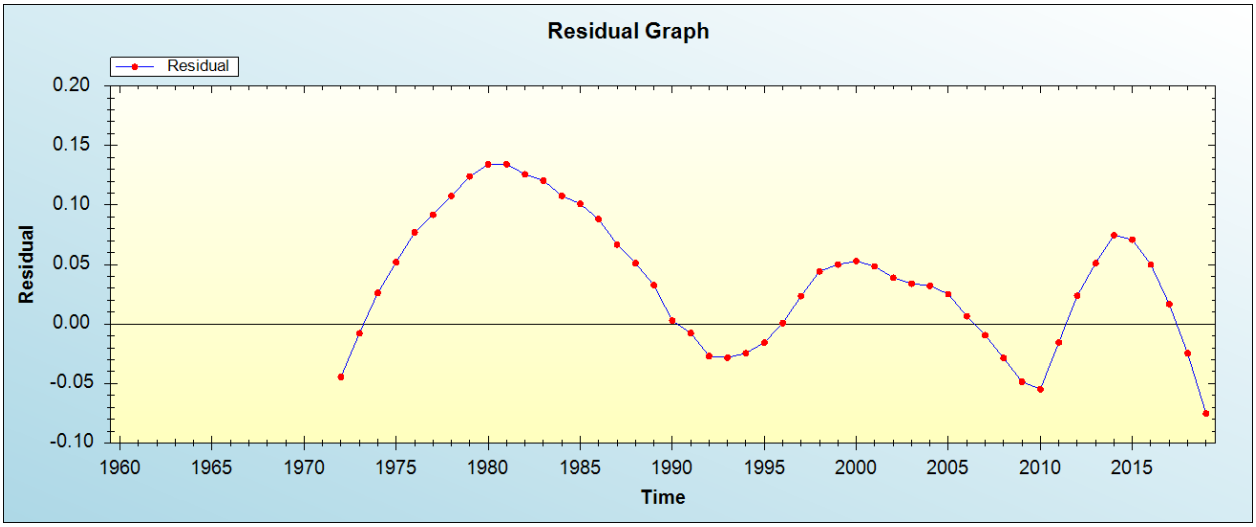

Figure 1: Residual analysis

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In-sample Forecast for B

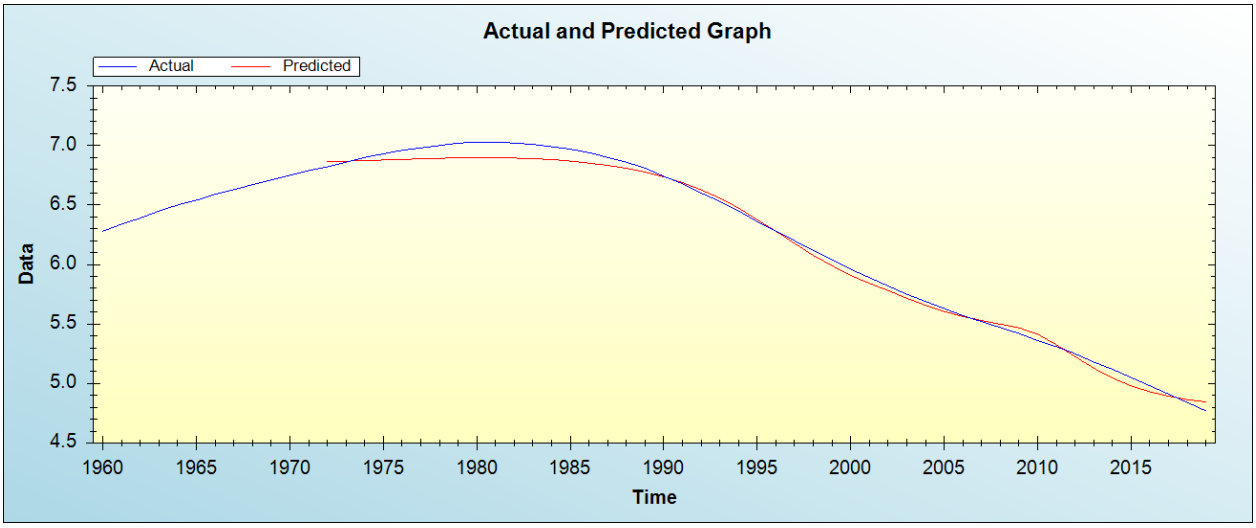

Figure 2: In-sample forecast for the B series

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

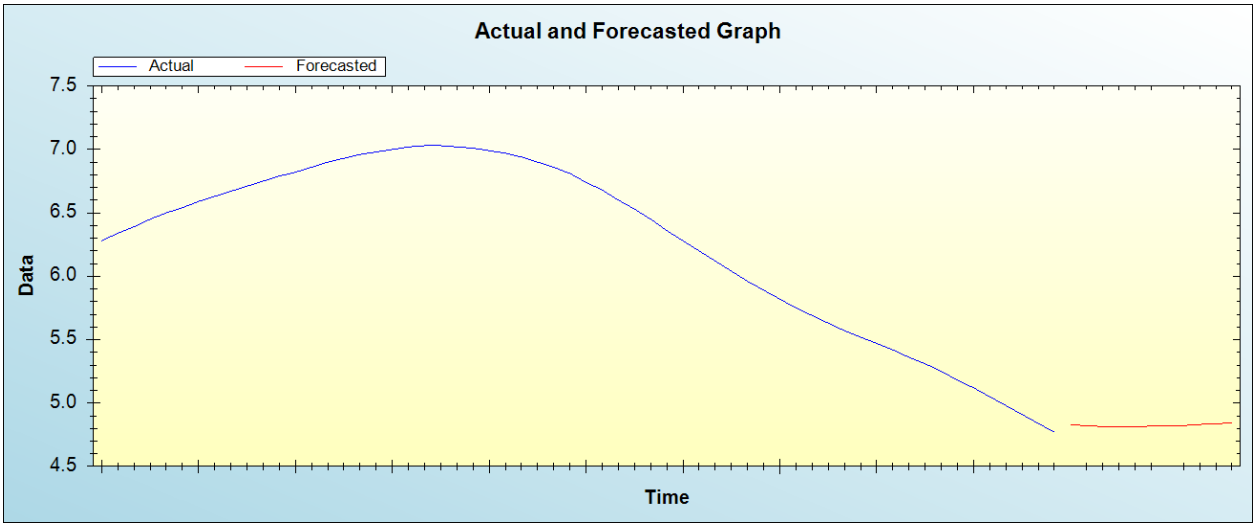

Figure 3: Out-of-sample forecast for B: actual and forecasted graph

Out-of-Sample Forecast for B: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted TFR values
2020	4.8304
2021	4.8201
2022	4.8153
2023	4.8139
2024	4.8142
2025	4.8180
2026	4.8201
2027	4.8223
2028	4.8316
2029	4.8379
2030	4.8418

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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 Benin are likely to be around 4.8 births per woman throughout the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

Many low and middle income countries are characterized by high fertility rates, high infant and maternal mortality rates. Lack of resources, poor infrastructure and shortage of trained medical staff are behind the high mortality rates which then become a driving force for high fertility rates. Lack of comprehensive knowledge of SRH services among adolescent girls and women has been found to result in unwanted pregnancies and other adverse SRH outcomes. In this paper we applied the ANN (12, 12, 1) model to predict total fertility rates in Benin. The results of the study revealed that annual total fertility rates in Benin are likely to be around 4.8 births per woman throughout the out-of-sample period. Therefore, the government of Benin should improve awareness of family planning services to adolescents and young adults through mass media and other locally available platforms and channel more resources towards the girl child and women empowerment program activities.

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