Forecasting Total Fertility Rate (TFR) in Eritrea Using a Machine Learning Technique

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Abstract - **In this research article, the ANN approach was applied to analyze TFR in Eritrea. 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 Eritrea. The results of the study shows that annual total fertility rates in Eritrea are likely to decline slightly over the out-of-sample period. Therefore, the government of Eritrea is encouraged to (1) focus on improving access to family planning services by creating more demand for the service and addressing barriers to access, and (2) engage on a women empowerment drive to improve their labor participation and contribution to economic development.**

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

I. INTRODUCTION

Eritrea is country located in the horn of Africa and has an estimated population of approximately 6.5 million (Eritrea, 2016). Total fertility rate in Eritrea has been declining over the years from 7.0 births per woman in 1955 to 4.1 births per woman in 2020. The country has also seen similar trends for infant and under five mortality rates. In 2020, the nation reported an infant mortality of 27 infant deaths per 1000 live births and under five mortality of 34.6 infant deaths per 1000 live births (World meter, 2020). According to EDHS 2002, Eritrea's fertility rates declined over the past years from 6.1 births per woman in 1995 to 4.8 births per woman in 2002, however rural fertility remains 2.2 births higher than urban fertility. The increase in age at marriage, female education and contraception are among the factors that have contributed to the decline in fertility rates (Eritrea, 2002). The contraceptive prevalence rate in the country remains low at around 8% (EDHS 2012). The unmet need for contraception in 2019 married women in 2019 was 30% (Eritrea FP 2020). In this paper we shall highlight some of the relevant studies which have been published in this region. Mercer et al (2019) estimated the levels and trends of FP indicators at a sub national scale in Nigeria utilizing all available data and accounting for survey design and uncertainty based on a cross-sectional study. The study revealed that the overall rates and trends of mCPR and unmet need have remained low in Nigeria. A systematic review was done by Mac-Seing et al (2019) which examined the relationships between equity-focused legislation and policy and the utilization of SRH services by vulnerable populations in sub-Saharan Africa. We searched nine bibliographic databases for relevant articles published between 1994 and 2019. Thirty-two studies, conducted in 14 sub-Saharan African countries, met the inclusion criteria. They focused on maternal health service utilization, either through specific fee reduction/removal policies, or through healthcare reforms and insurance schemes to increase SRH service utilization. Findings across most of the studies showed that health-related legislation and policy promoted an increase in service utilization, over time, especially for antenatal care, skilled birth attendance and facility-based delivery. Gebrecherkos et al (2018) carried out a cross-sectional study to investigate the unmet need for modern contraception and associated factors among reproductive age group women in Eritrean refugee camps, Tigray, north Ethiopia. The study findings showed that the prevalence of unmet need for modern contraception in this study was found to be 41.8%. Respondents' unfavorable attitude towards modern contraceptive methods and the availability of modern contraceptive methods were factors significantly associated with unmet need for modern contraception.

The aim of this piece of work is to project total fertility rate in Eritrea using a machine learning technique. The finding of this study is expected to provide an insight of the likely trends in fertility in the out of sample period. This will stimulate an appropriate response to the health, education and employment needs of the Eritrean population.

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 Eritrea.

Data Issues

This study is based on annual total fertility rate (births per woman)in Eritrea 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

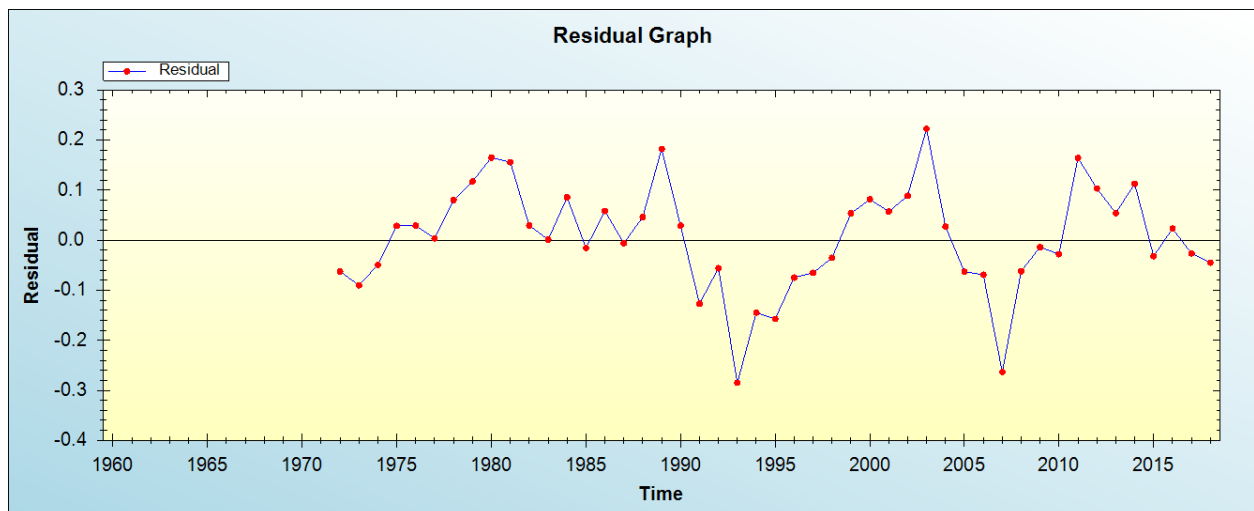| Variable	E
Observations	47 (After Adjusting Endpoints)
Neural Network Architecture:	
Input Layer Neurons	12
Hidden Layer Neurons	12
Output Layer Neurons	1
Activation Function	Hyperbolic Tangent Function
Back Propagation Learning:	
Learning Rate	0.005
Momentum	0.05
Criteria:	
Error	0.066600
MSE	0.010733
MAE	0.080233

Residual Analysis for the Applied Model

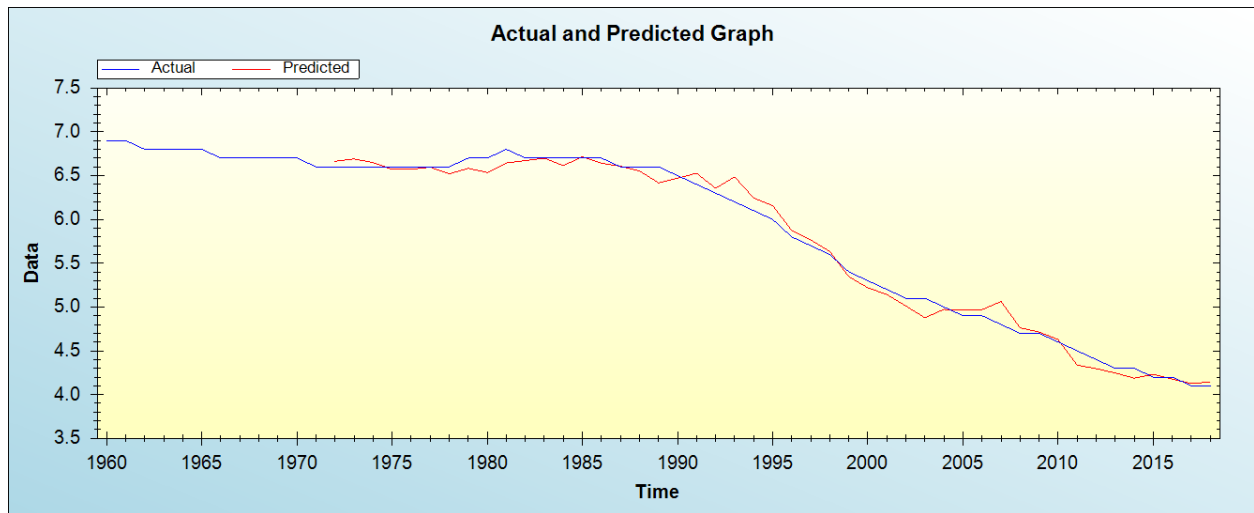Figure 1: Residual analysis

In-sample Forecast for E

Figure 2: In-sample forecast for the E series

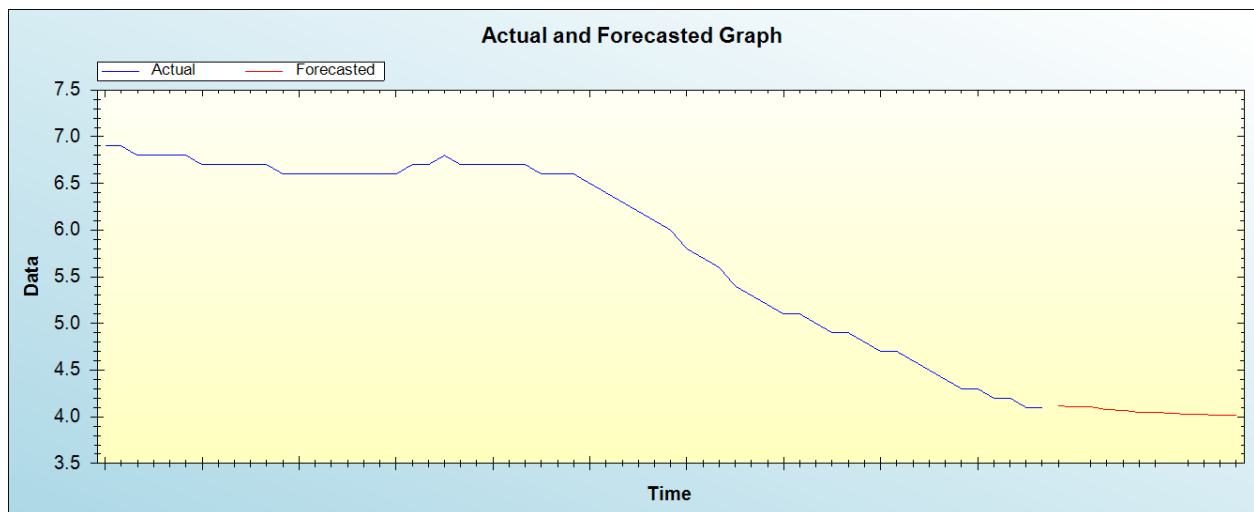*Out-of-Sample Forecast for E: Actual and Forecasted Graph*

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

Years	Forecasts
2019	4.1172
2020	4.1049
2021	4.1071
2022	4.0759
2023	4.0692
2024	4.0470
2025	4.0442
2026	4.0400
2027	4.0252
2028	4.0254
2029	4.0140
2030	4.0173

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 Eritrea are likely to decline slightly over the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

Eritrea has a low contraceptive prevalence and a high unmet need for family planning hence the country continues to report high fertility rates. In this paper we applied an artificial intelligence technique to project total fertility rates in Eritrea. The ANN model projections indicate that annual total fertility rates in Eritrea are likely to decline slightly over the out-of-sample period. Therefore, the Eritrean government should focus on improving access to family planning services by creating more demand for the service and addressing barriers to access as well as promotion of women empowerment.

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