Projection of Total Fertility Rate (TFR) In the Gambia Using an Artificial Neural Network Approach

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Abstract - **In this research paper, the ANN approach was applied to analyze TFR in the Gambia. 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 the Gambia. The results of the study indicate that annual total fertility rates in the Gambia are likely to be between 5.2 and 5.6 births per woman over the out-of-sample period. Therefore, the Gambian government is encouraged to focus on addressing barriers to accessing family planning services, increase public awareness of sexual and reproductive health (SRH) services and scale up women empowerment program activities.**

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

I. INTRODUCTION

Family planning is vital for safe motherhood and a reproductive health right (Barrow, 2020). Globally, 1.1 billion women are in need of family planning of which 842 million are currently on contraception and 270 million have an unmet of family planning (Kantorowa et al, 2020; UN, 2019). In the Gambia contraceptive prevalence rate (CPR) among married women or in union is 16.3%. The urban CPR is 17.7 against 13.5% in rural areas (GBOS, 2012). The number of unwanted pregnancies surged from 18 000 in 2012 to 20 000 in 2016 (FP 2020, 2016). Adolescent girls and young women are at risk of unintended pregnancies, STIs unsafe abortions and drug abuse (UNICEF & Gambia, 2000).

According to the Gambia DHS summary report, total fertility rate is currently 4.4 births per woman. Fertility rate is higher in rural areas (5.9 births per woman) than the urban (3.9 births per woman). Women with higher education level have a lower average fertility of 3.4 children per woman compared to 5.7 births per woman among women with no education. Approximately 14% of adolescent girls aged 15-19 are already mothers or pregnant with their first child (Gambia DHS 2019-2020 report). In the Gambia 24% of married women aged 15-49 have an unmet need for family planning. There are few published research articles on fertility and related issues in the country and region. Barrow (2020) employed a community-based descriptive cross-sectional study to determine the women's proportion of contraceptive uptake and knowledge of FP methods for 643 women of reproductive age (15–49 years) from the selected clusters in rural Gambia through a multistage sampling technique. A pretested structured interview questionnaire was used to collect data. The study revealed a moderately low contraceptive uptake. Mac-Seing et al (2019) 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. A study similar to that of Barrow et al (2020) was carried out in Eritrean refugee camps in Ethiopia by Gebrecherkos et al (2018) who found out that the prevalence of unmet need for modern contraception in their 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 study is to project fertility rates in the Gambia using an artificial neural network approach. The findings of this piece of work are expected to highlight the likely fertility trends in the out of sample period. This will trigger a timeous response to the future health, education and employment needs of the Gambian 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 The Gambia.

Data Issues

This study is based on annual total fertility rate (births per woman)in The Gambia 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	T
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	0.130371
MSE	0.007554
MAE	0.068729

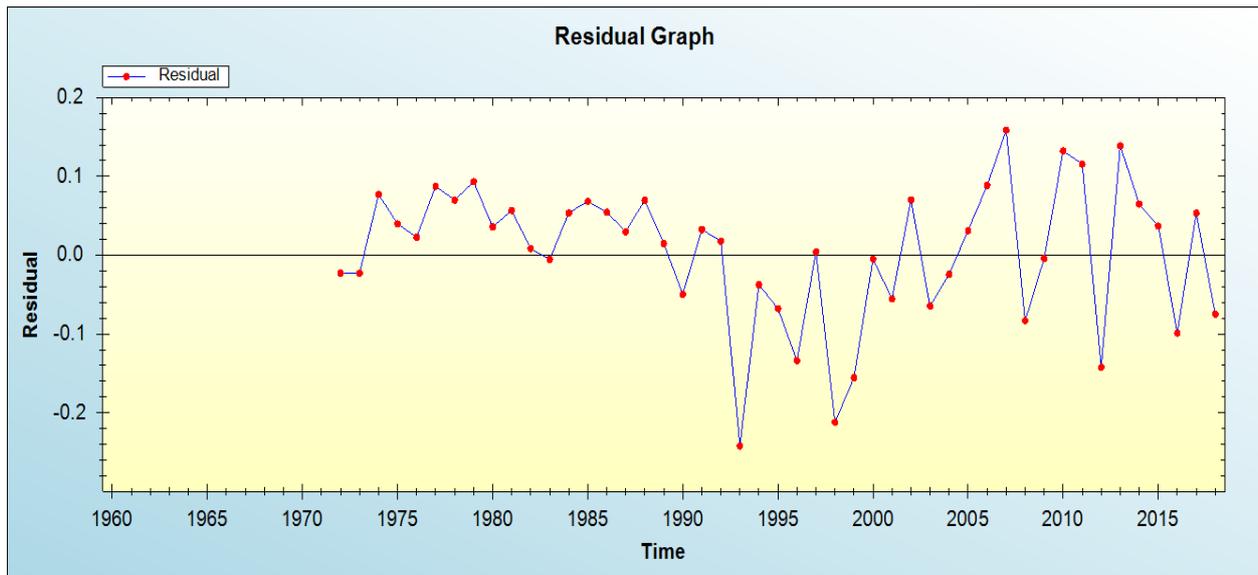*Residual Analysis for the Applied Model*

Figure 1: Residual analysis
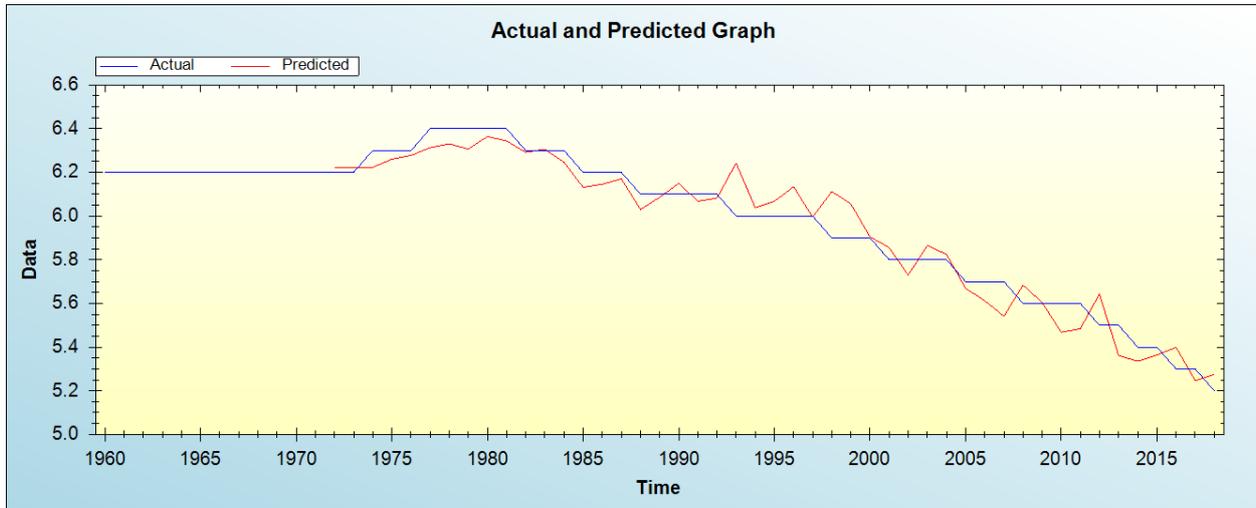
In-sample Forecast for T

Figure 2: In-sample forecast for the T series

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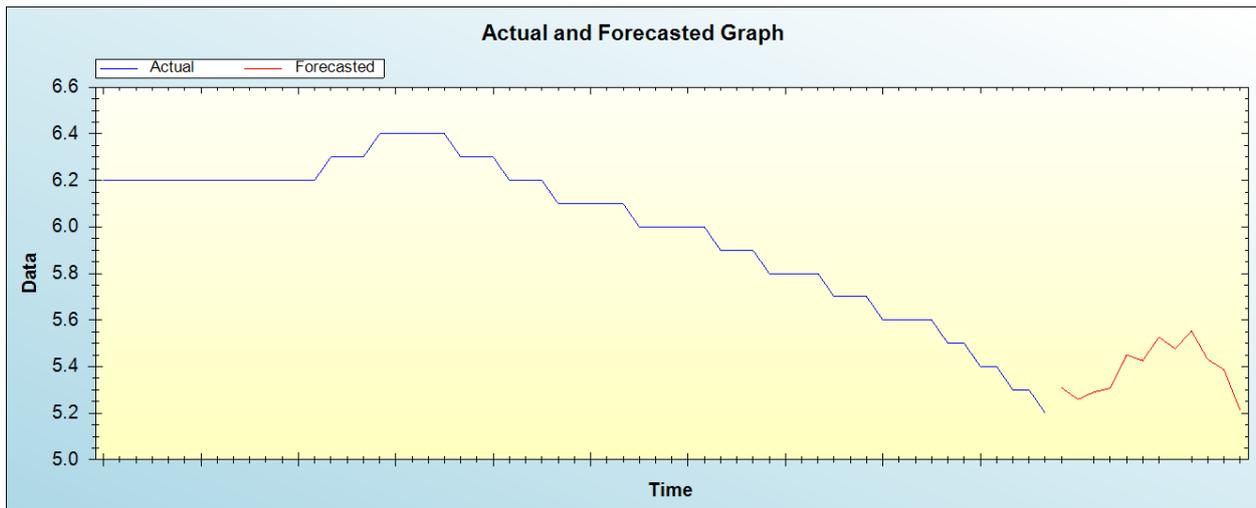

Figure 3: Out-of-sample forecast for T: actual and forecasted graph

Out-of-Sample Forecast for T: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecast
2019	5.3092
2020	5.2596
2021	5.2909
2022	5.3067
2023	5.4495
2024	5.4255
2025	5.5264
2026	5.4765
2027	5.5533
2028	5.4311
2029	5.3869
2030	5.2131

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 The Gambia are likely to be between 5.2 and 5.6 births per woman over the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

Gambia continues to record low contraceptive prevalence rate and high unmet need for family planning. Adolescent girls and young women continue to experience adverse maternal and child health outcomes. In this study we employed an artificial neural network approach to predict total fertility rate in the Gambia. The ANN model projections indicated that annual total fertility rates in The Gambia are likely to be between 5.2 and 5.6 births per woman over the out-of-sample period. Therefore, the government of Gambia is encouraged to focus on addressing barriers to accessing family planning services, increase public awareness of sexual and reproductive health (SRH) services and scale up women empowerment program activities.

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