# Forecasting Total Fertility Rate (TFR) in Liberia

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*Abstract* - **In this research article, the ANN approach was applied to analyze TFR in Liberia. 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 Liberia. The results of the study indicate that annual total fertility rates in Liberia are likely to remain around 4.0 births per woman throughout the out-of-sample period. Therefore, the Liberian government is encouraged to focus on addressing the various challenges being encountered by adolescent girls and women, and promotion of women empowerment.**

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

## I. INTRODUCTION

Adolescent child bearing continues to be a global challenge in many countries and this puts them at risk of poor health and development outcomes (Fonanyeneh, 2020). Adolescent mothers are at risk of having adverse outcomes of pregnancy such as obstructed labor, obstetric fistula and neonatal complications related to difficult delivery particularly birth asphyxia. This is further aggravated by the situation in Liberia which is defined by high prevalence of gender based violence, sexual abuse of adolescent girls and young women, commercial sex work, intravenous drug use, and limited access to SRH information and services (Fonanyeneh, 2020). Liberia is one of the countries in the world with high maternal, neonatal, infant and under five mortality. The country has a MMR which exceeds 725 maternal deaths per 100 000 live births (WHO, 2016). It has witnessed a decline in IMR and under five mortality over the years. IMR declined from 165.36 infant deaths per 1000 live births in 1950 to 46.88 infant deaths per 1000 live births in 2020. Under five mortality declined from 331.57 deaths per 1000 live births in 1950 to 64.32 deaths per 1000 live births in 2020 (Worldometer, 2020). Total fertility dropped from 7.0 births per 1000 live births in 1985 to 4.4 births per woman in 2020 (Worldometer, 2020).

There are limited studies that have focused on examining fertility in the country and region therefore we shall mention relevant papers. Based on a cross-sectional study, Apanga et al (2020) assessed the prevalence and factors associated with modern contraceptive (CP) use among women of the reproductive age. Authors used data from the Multiple Indicator Cluster Surveys (MICSs) from 20 African countries collected between 2013 and 2018. Multivariable logistic regression was used to identify factors associated with modern CP use. The study results showed that the overall prevalence of modern CP use was 26% and ranged from 6% in Guinea to 62% in Zimbabwe. Overall, injectable (32%) was the most preferred method of CP, followed by oral pill (27%) and implants (16%). Women were more likely to use a modern CP if they: had a primary or secondary/higher education compared with women with no formal education; had no delivery in the last 2 years compared with women who delivered in the last 2 years. Iyanda et al (2020) examined the association between incorrect knowledge of ovulation and unintentional pregnancy and child among young women in sub-Saharan Africa countries. Using Pearson's Chi-square, t test, multiple logistic regression, and likelihood ratio test, they analyzed Demographic and Health Survey data (2008–2017) of 169,939 young women (15–24 year). The study concluded that Adolescent women (15–19) generally have poor knowledge of ovulation and are more likely to report an unintentional pregnancy/child than women between ages 20–24. Santhya and Jeejeebhoy (2015) reviewed the evidence on sexual and reproductive health and rights (SRHR) of adolescent girls in low-income and middle-income countries (LMIC) in light of the policy and programme commitments made at the International Conference on Population and Development (ICPD), analyses progress since 1994, and maps challenges in and opportunities for protecting their health and human rights. Findings indicated that many countries have yet to make significant progress in delaying marriage and childbearing, reducing unintended childbearing, narrowing gender disparities that put girls at risk of poor SRH outcomes, expanding health awareness or enabling access to SRH services.

The aim of this study is forecast TFR in Liberia using an artificial neural network approach. The findings of the study are expected to reveal likely future trends of TFR in the out of sample period. This will guide policy and stimulate an appropriate response to the future health, education and employment needs of the Liberian 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 Liberia.

### Data Issues

This study is based on annual total fertility rate (births per woman) in Liberia 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 | L |
|---|---|
| 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 | 0.064375 |
| MSE | 0.009324 |
| MAE | 0.079837 |

*Residual Analysis for the Applied Model*
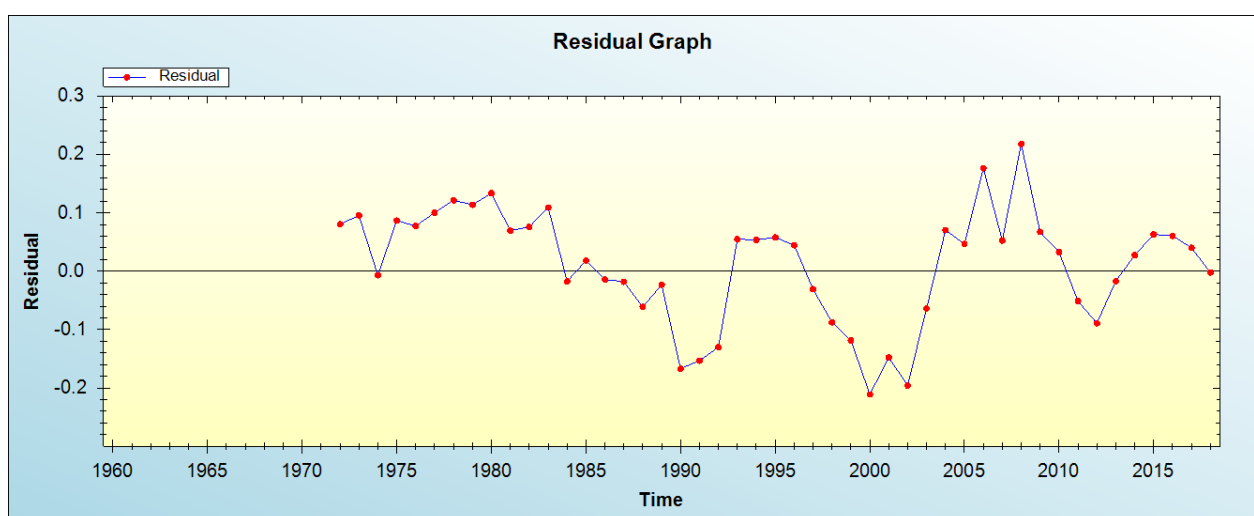


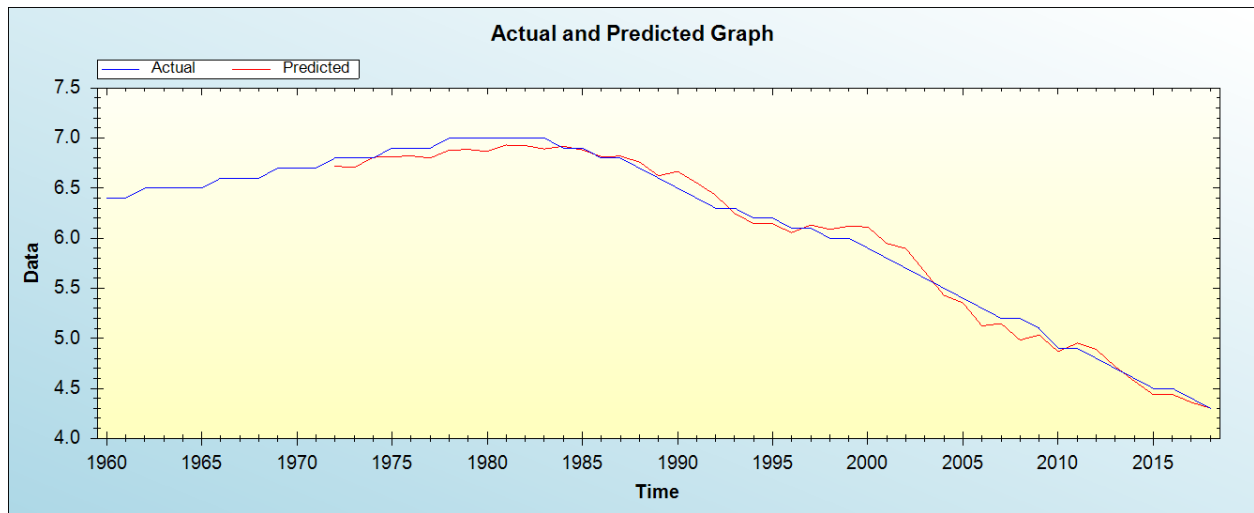Figure 1: Residual analysis

*In-sample Forecast for L*



Figure 2: In-sample forecast for the L series

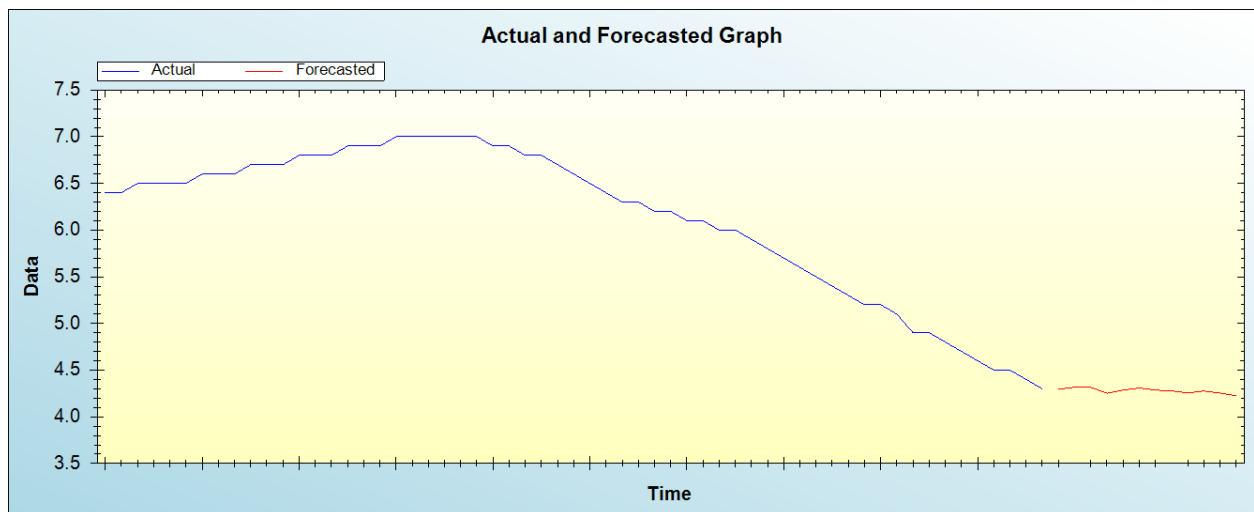*Out-of-Sample Forecast for L: Actual and Forecasted Graph*



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

*Out-of-Sample Forecast for L: Forecasts only*

Table 2: Tabulated out-of-sample forecasts

| Year | Forecasts |
|------|-----------|
| 2019 | 4.2940 |
| 2020 | 4.3180 |
| 2021 | 4.3161 |
| 2022 | 4.2520 |
| 2023 | 4.2870 |
| 2024 | 4.3086 |
| 2025 | 4.2860 |
| 2026 | 4.2770 |
| 2027 | 4.2556 |
| 2028 | 4.2761 |
| 2029 | 4.2541 |
| 2030 | 4.2251 |

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 Liberia are likely to remain around 4.0 births per woman throughout the out-of-sample period.

## IV. CONCLUSION & RECOMMENDATIONS

Liberia is regarded as one of the African countries with high maternal, infant and child mortality rates. The country has reported many cases of gender based violence and sexual abuse of adolescent girls and women. In this paper we proposed an artificial neural network approach to forecast TFR in Liberia. The ANN model projections revealed that annual total fertility rates in Liberia are likely to remain around 4.0 births per woman throughout the out-of-sample period. Therefore the Liberian government is encouraged to focus on addressing the various challenges being encountered by adolescent girls and women, and promotion of women empowerment.

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