

# Forecasting Total Fertility Rate (TFR) In South Sudan

<sup>1</sup>Dr. Smartson. P. NYONI, <sup>2</sup>Tatenda. A. CHIHOHO, <sup>3</sup>Thabani NYONI

<sup>1</sup>ZICHIRE Project, University of Zimbabwe, Harare, Zimbabwe

<sup>2</sup>Independent Health Economist, Zimbabwe

<sup>3</sup>SAGIT Innovation Center, Harare, Zimbabwe

**Abstract - In this research paper, the ANN approach was applied to analyze TFR in South Sudan. 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 South Sudan. The results of the study indicate that annual total fertility rates in South Sudan are likely to hover around 5.0 births per woman over the out-of-sample period. Therefore, the government of South Sudan is encouraged to prioritize family planning services to prevent adverse maternal and child health outcomes and channel more resources towards women empowerment programs.**

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

## I. INTRODUCTION

South Sudan got its independence in July 2011, however the country is still marked by violence and civil conflict in some parts of the country (Kane et al, 2016). The prolonged war resulted in the destruction of existing infrastructure and the health system is weak defined by shortage of medical supplies and trained medical personnel (Mugo et al, 2015; MOHGoSS, 2012). It is not surprising that most of the health indicators in South Sudan are among the worst indicators in the world (Kane, 2016). The country has a very high maternal mortality ratio of 785 deaths per 100 000 live births and has a very low contraceptive prevalence rate of 4.7% (MOH SS, 2011; SSCC, 2010). The country has witnessed a decline in total fertility rate from 6.9 births per woman in 1980 to 4.7 births per woman in 2020. Infant mortality rate and under five mortality rates are still high. In 2020 the country reported an infant mortality rate of 58.6 infant deaths per 1000 live births and under five mortality rates of 89.8 deaths per 1000 live births (Worldometer, 2020). There are limited studies in the region that have focused on examining fertility and predicting fertility rates. Ooms et al (2020) did an assessment of the availability, affordability and stock-outs of essential sexual and reproductive health commodities (SRHC) in East and Southern African countries to inform interventions to improve access. The study utilized the WHO methodology: Measuring Medicine Prices, Availability, Affordability and Price Components. The study indicated that accessibility of SRHC remains a challenge. Low availability of SRHC in the public sector is compounded by regular stock-outs, forcing patients to seek care in other sectors where there are availability and affordability challenges. Coast et al (2019) examined early adolescent understandings and experiences of sexual and reproductive health (SRH) in Ethiopia and Rwanda, drawing on a multisite qualitative research study with 10- to 12-year-old and 14- to 15-year-old male and female adolescents and a range of adult participants. The study concluded that there is need for program designers and implementers to address the role of underlying social norms in a more strategic and context-specific way to help young people navigate their sexual and reproductive lives. 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.

The aim of this study is to forecast TFR in South Sudan using a machine learning approach. The findings of the study are envisioned to reveal the likely future trends of fertility in the country. This will facilitate planning and resource mobilization for 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 activation function. This paper applies the Artificial Neural Network (ANN) approach in predicting annual total fertility rates in South Sudan.

**Data Issues**

This study is based on annual total fertility rate (births per woman) in South Sudan 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	S
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	0.079814
MSE	0.009516
MAE	0.083080

*Residual Analysis for the Applied Model*

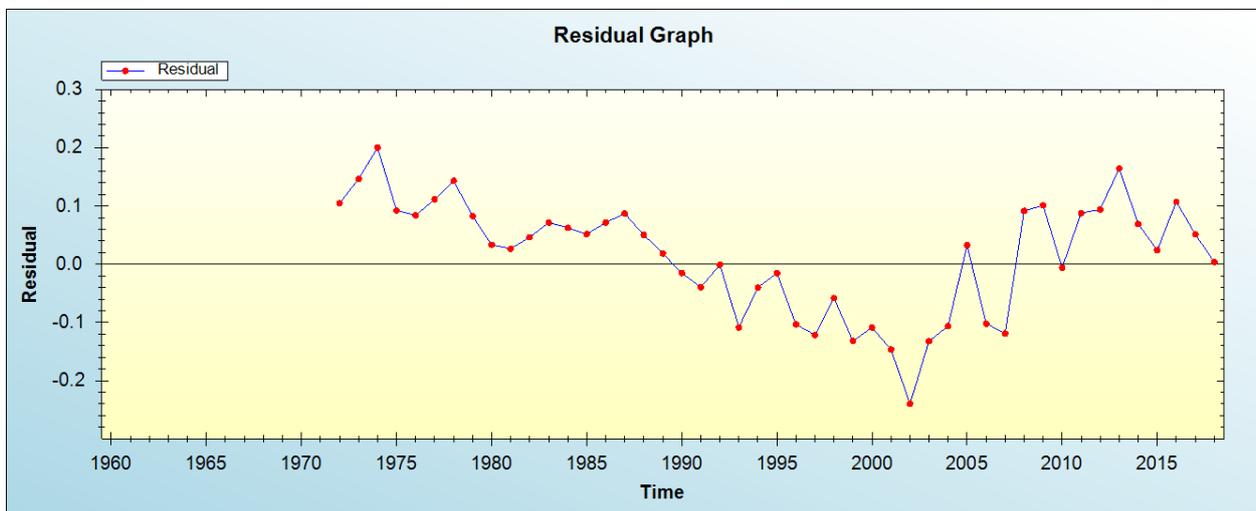


Figure 1: Residual analysis

*In-sample Forecast for S*

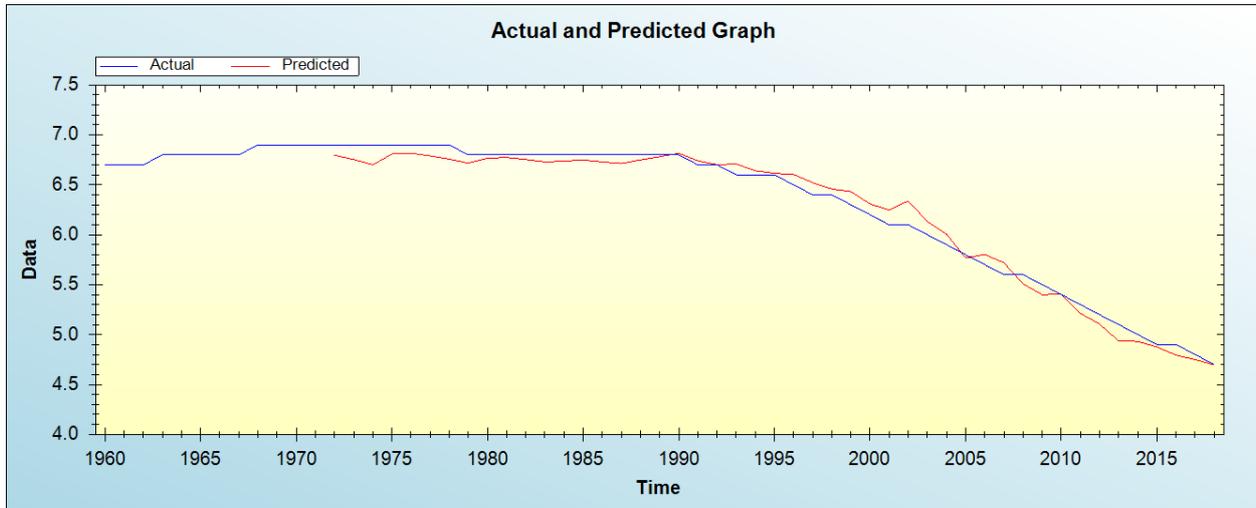


Figure 2: In-sample forecast for the S series

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

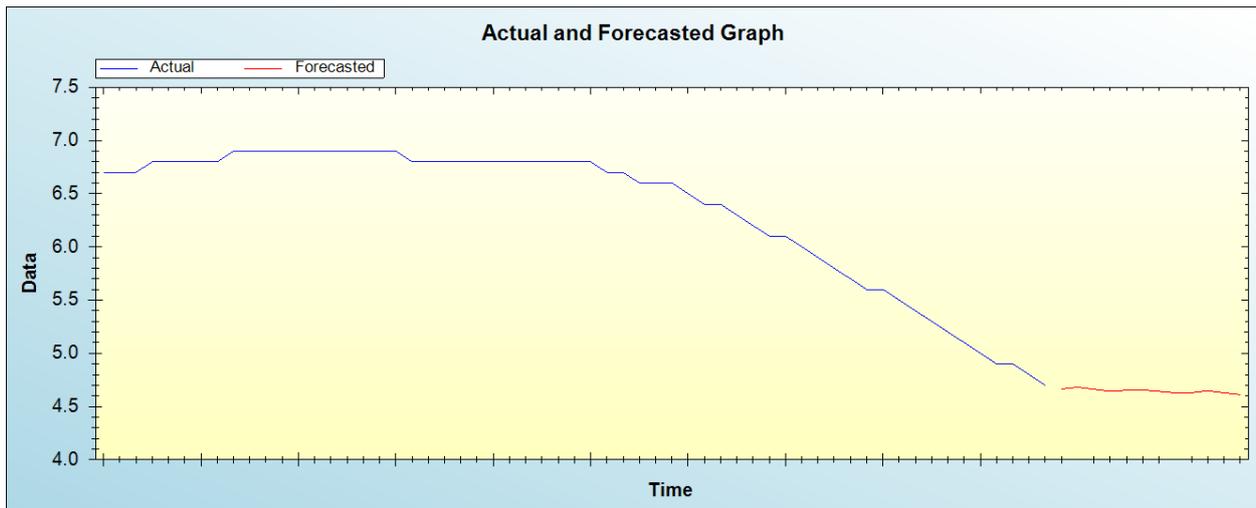


Figure 3: Out-of-sample forecast for S: actual and forecasted graph

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

Table 2: Tabulated out-of-sample forecasts

Year	Forecasts
2019	4.6639
2020	4.6816
2021	4.6621
2022	4.6423
2023	4.6530
2024	4.6549
2025	4.6426
2026	4.6293
2027	4.6301
2028	4.6481
2029	4.6293
2030	4.6121

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 South Sudan are likely to hover around 5.0 births per woman over the out-of-sample period.

#### IV. CONCLUSION & RECOMMENDATIONS

The South Sudan's health indicators are among the worst in the world. The country has high maternal, infant and child mortality rates. In this study we applied the artificial neural network approach to predict TFR in South Sudan. The findings revealed that annual total fertility rates in South Sudan are likely to hover around 5.0 births per woman over the out-of-sample period. Therefore, the South Sudanese government is encouraged to prioritize family planning services to prevent adverse maternal and child health outcomes and channel more resources towards women empowerment programs.

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