

# Time Series Forecasting Of Total Fertility Rate (TFR) In Sudan

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**Abstract** - In this research article, the ANN approach was applied to analyze TFR in 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 Sudan. The results of the study indicate that annual total fertility rates in Sudan are likely to be around 4.5 births per woman over the out-of-sample period. Therefore, the government of Sudan is encouraged to focus on improving accessibility of SRH services, create more demand for family planning services targeting the reproductive age group and scale up women empowerment program activities.

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

## I. INTRODUCTION

Sudan has an estimated population size of about 43.8 million and 34.7% of the population is urban (Worldometer, 2020). The country's total fertility rate has been declining over the years from 6.9 births per woman in 1980 to 4.4 births per woman in 2020 (Worldometer, 2020). Infant and under five mortality rates have also decreased over the years. In 2020, the country reported an infant mortality rate of 38.0 infant deaths per 1000 live births and an under five mortality rate of 56.9 deaths per 1000 live births according to Worldometer. Sudan's infant and fertility indicators are among the highest in the region. This means that the Sudanese government must channel more resources towards improving health infrastructure and employing skilled medical staff in order to avoid maternal deaths and improve child survival. There are few previous studies in the region that investigated fertility and fertility rates. Ooms et al (2020) carried out 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 showed 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. Kane et al (2016) carried out a qualitative study in the state of Western Bahr el Ghazal (WBeG) in South Sudan to explore the social norms shaping decisions about family planning among the Fertit community. Data were collected through five focus group discussions and 44 semi-structured interviews conducted with purposefully selected community members and health personnel. The study concluded that the sexual and reproductive health programmes in WBeG should work with and leverage existing and emerging social norms on spacing in their health promotion activities.

The aim of this paper is to project TFR in Sudan using an artificial intelligence approach. The results of the study are envisioned to provide an insight of the likely fertility trends in the out of sample period to facilitate planning and resource mobilization for health, education and employment sectors.

## 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 Sudan.

Data Issues

This study is based on annual total fertility rate (births per woman) in 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	0.085094
MSE	0.013968
MAE	0.099148

Residual Analysis for the Applied Model

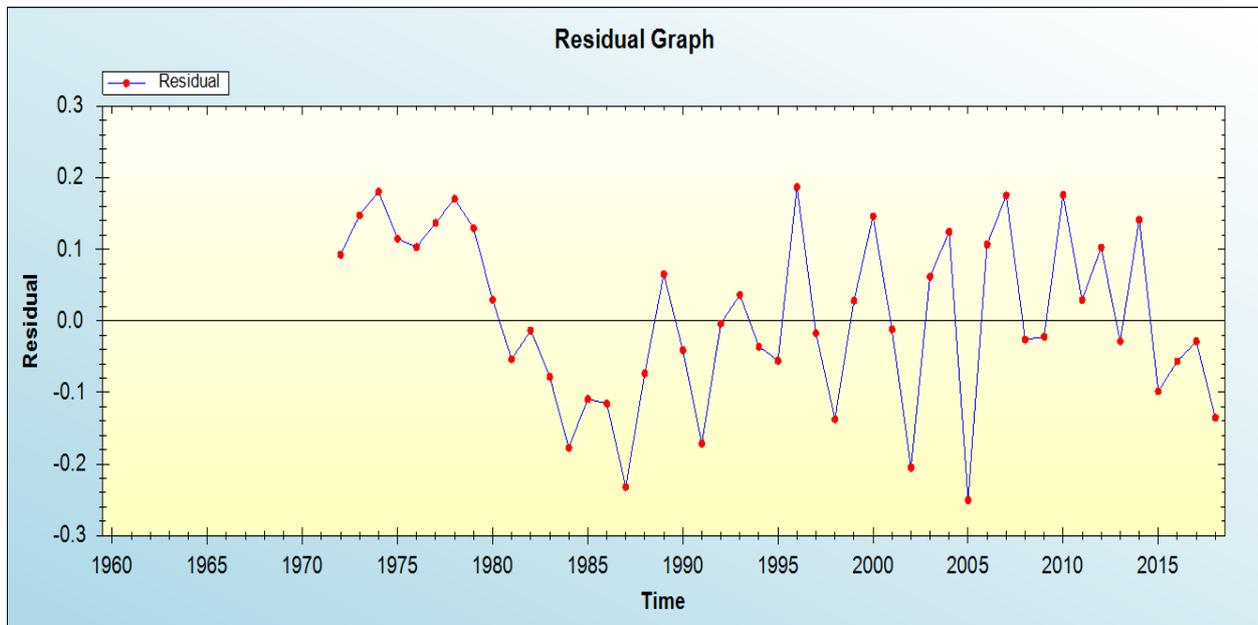


Figure 1: Residual analysis

*In-sample Forecast for S*

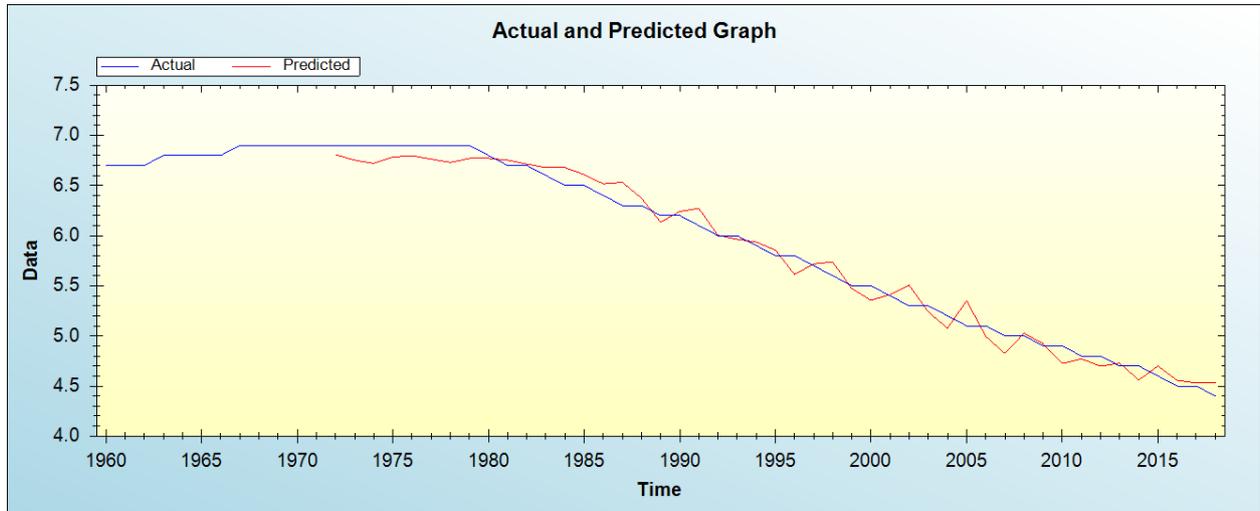


Figure 2: In-sample forecast for the S series

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

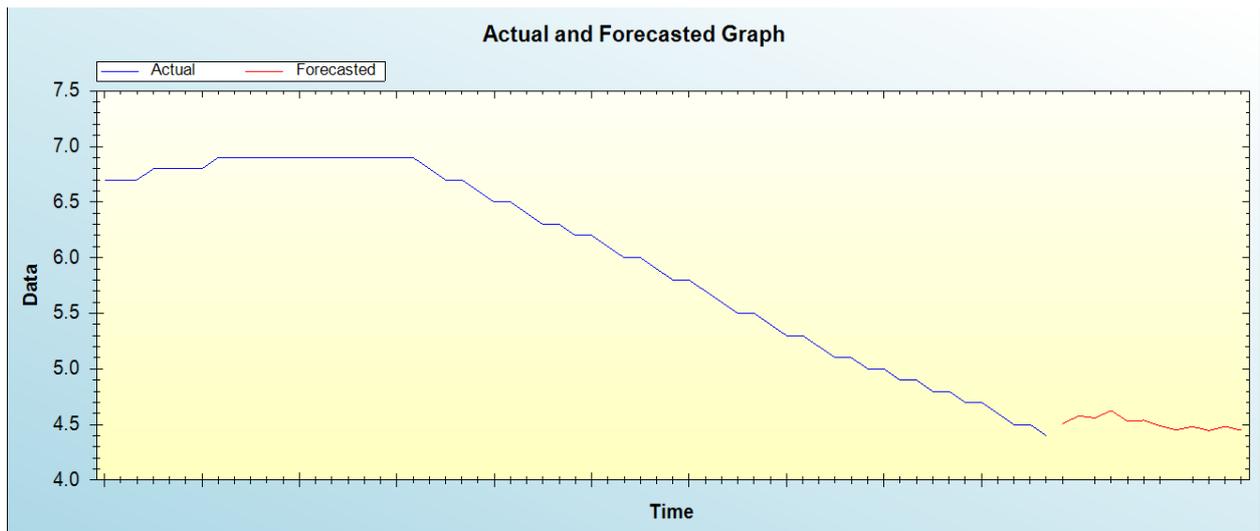


Figure 3: Out-of-sample forecast for S: actual and forecasted graph

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

Table 2: Tabulated out-of-sample forecasts

Year	Forecasts
2019	4.5081
2020	4.5773
2021	4.5588
2022	4.6253
2023	4.5279
2024	4.5367
2025	4.4880
2026	4.4517
2027	4.4807
2028	4.4452
2029	4.4834
2030	4.4476

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 Sudan are likely to be around 4.5 births per woman over the out-of-sample period.

#### IV. CONCLUSION & RECOMMENDATIONS

Total fertility rates have decreased over the past decades in Sudan although fertility rates are still high. In this paper we proposed a machine learning technique to predict total fertility rates in Sudan. The ANN model projections revealed that annual total fertility rates in Sudan are likely to be around 4.5 births per woman over the out-of-sample period. Therefore, the Sudanese government is advised to focus on improving accessibility of sexual and reproductive health (SRH) services, create more demand for family planning services and scale up women empowerment program activities.

#### REFERENCES

- [1] Worldometer (2020). Sudan demographics. <https://www.worldometers.info>

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