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Forecasting Total Fertility Rate (TFR) in Chad Using a Machine Learning Approach

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***Abstract* - In this research article, the ANN approach was applied to analyze TFR in Chad. The employed 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 Chad. The results of the study indicate that annual total fertility rates in Chad are likely to increase over the out-of-sample period. Therefore, authorities in Chad are encouraged to (1) increase demand creation activities for family planning services and improve accessibility of sexual and reproductive health (SRH) services among adolescents and young adults, and (2) continuous empowerment of women through education, labor participation and promoting women's rights.**

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

I. INTRODUCTION

Sexual and reproduction health is a fundamental human right and it was endorsed during the 1994 international conference on population and development (Barot, 2014). Many countries all over the world are rallying behind the programme of action of the 1994 international conference. Significant progress has been made in ensuring universal access to SRH services. FP 2020 countries have channeled resources towards this sustainable development goal 3 by 2030 (FP 2020, 2017a). Over the years the uptake of contraception has increased tremendously in many countries and this has contributed in part to the decline in fertility trends at global and country levels. Family planning services have resulted in positive outcomes such as reduction in maternal deaths, infant mortality, unintended pregnancies, unsafe abortion, child poverty and malnutrition (UN, 2017b). Chad's fertility rates declined from 7.4 births per woman in 2000 to 5.8 births per woman in 2020 and its IMR dropped from 186.05 infant deaths per 1000 live births in 1950 to 67.14 infant deaths per 1000 live births in 2020 (Worldometer, 2020). This paper shall mention few relevant studies since there are limited studies which have forecasted or examined fertility rates in the region. Ahinkorah et al (2020) investigated the influence of sexual violence on planned, mistimed, and unwanted pregnancies in sub-Saharan Africa (SSA). Data from the Demographic and Health Survey (DHS) of 22 countries in SSA were used in the study. Multinomial logistic regression was used to examine the effect of sexual violence on planned, mistimed, and unwanted pregnancies. The study found out that Sexual violence plays a key role in mistimed and unwanted pregnancies. It is, therefore, prudent to develop various assessment techniques to detect sexual violence in unions and refer victims to appropriate services to diminish the risk of mistimed and unwanted pregnancies. Barrow (2020) applied 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 revealed 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.

The aim of this paper is to forecast TFR in Chad using a machine learning approach. The results are expected to enlighten the government on the likely fertility trends in the out of sample period. This will assist in policy making and in responding to the future health, education and employment needs of the people in Chad.

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

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activation function. This paper applies the Artificial Neural Network (ANN) approach in predicting annual total fertility rates in Chad.

Data Issues

This study is based on annual total fertility rate (births per woman) in Chad 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	C
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	0.086428
MSE	0.006663
MAE	0.068118

Residual Analysis for the Applied Model

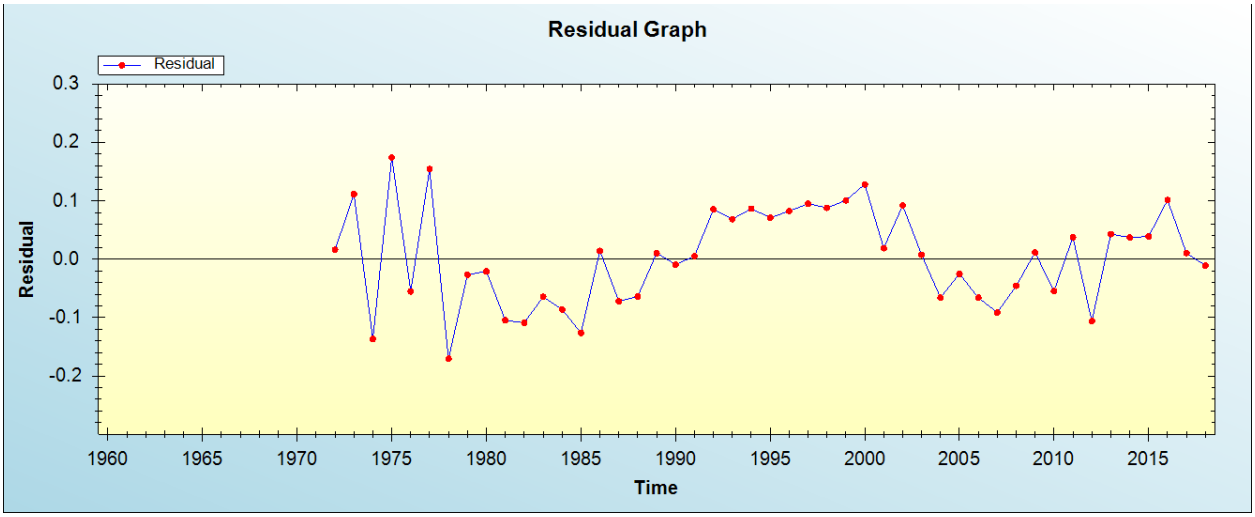

Figure 1: Residual analysis

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In-sample Forecast for C

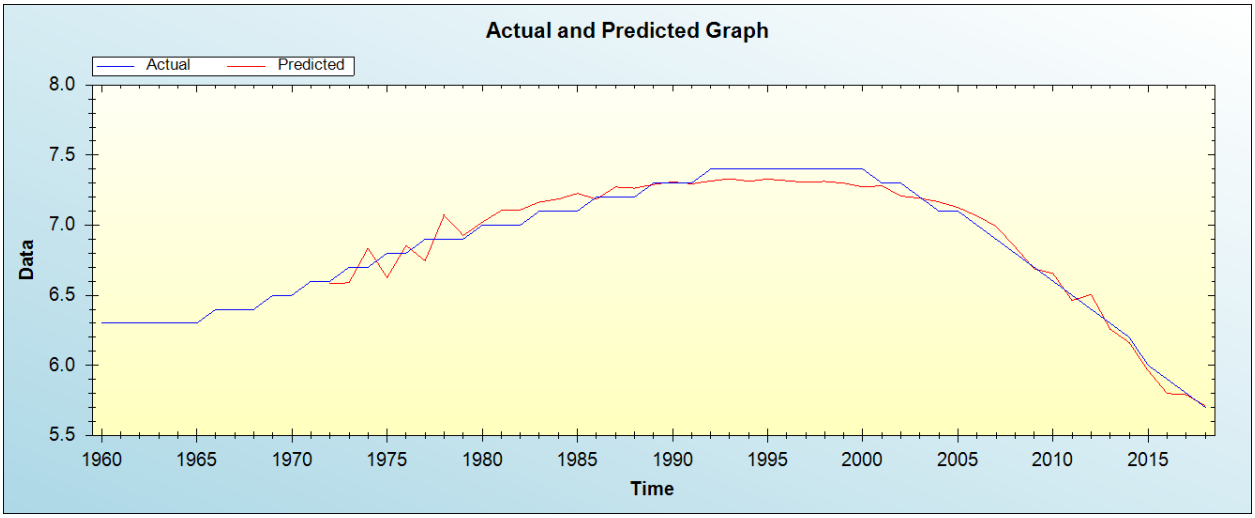

Figure 2: In-sample forecast for the C series

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

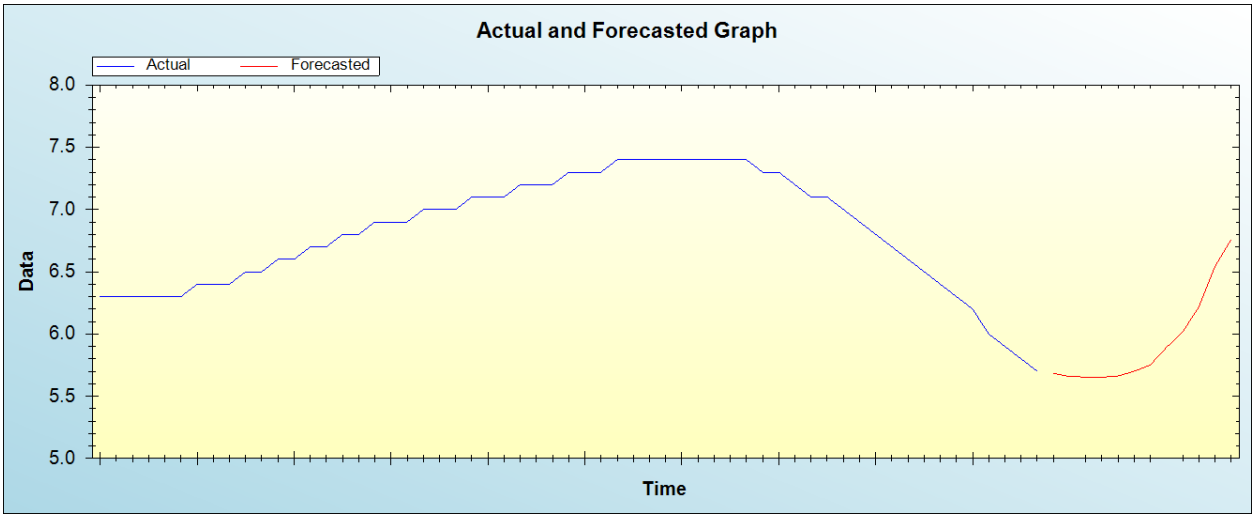

Figure 3: Out-of-sample forecast for C: actual and forecasted graph

Out-of-Sample Forecast for C: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasts
2019	5.6831
2020	5.6585
2021	5.6543
2022	5.6524
2023	5.6625
2024	5.7008
2025	5.7518
2026	5.8931
2027	6.0164
2028	6.2166
2029	6.5416
2030	6.7578

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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 Chad are likely to increase over the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

The composition of a population is largely determined by fertility. Prediction of fertility will reveal the likely composition of a population in the future. In this article we employed an artificial intelligence technique to project total fertility rate in Chad. The model projections suggest that annual total fertility rates in Chad are likely to increase over the out-of-sample period. Therefore, we encouraged the government of Chad to increase demand creation activities for family planning services and improve accessibility of sexual and reproductive health (SRH) services among adolescents and youths, continuously empower women through education, labor participation and promoting women's rights.

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