

# Forecasting Total Fertility Rate (TFR) in Cote d'Ivoire using a Machine Learning Technique

<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

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

**Abstract -** In this research article, the ANN approach was applied to analyze TFR in Cote d'Ivoire. The employed annual data covers 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 Cote d'Ivoire. The results of the study indicate that annual total fertility rates in Cote d'Ivoire are likely to rise slightly over the out-of-sample period. Therefore, the authorities in Cote d'Ivoire are encouraged to scale up demand creation for sexual and reproductive health (SRH) services and address health system challenges that hinder access to family planning services, and prioritize women empowerment programs.

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

## I. INTRODUCTION

The programme action of the international conference on population and development recognizes the sexual and reproductive health rights of both men and women. Governments must ensure equal access to safe and effective family planning methods (UN, 2019). Each individual has a right to make an informed decision on the appropriate method of family planning, decide on age of marriage, have desired number of children and child spacing (UN, 2019). According to the FP 2020: 2019-2020 annual progress report, In 2019, Cote d'Ivoire reported a contraceptive prevalence rate among all women of 22.5 %, the unmet need for contraception for married women or in union was 29.9% and there were 499 000. In 2020 the country reported a total fertility rate of 4.7 births per woman, IMR of 53.7 infant deaths per 1000 live births and under five mortality rates of 77.5 deaths per 1000 live births (Worldometer, 2020). There are limited studies which have examined or forecasted fertility rates in the region. In this paper we will only highlight relevant ones. Becquet et al (2020) described sexual and reproductive health (SRH) needs of female sex workers (FSWs) to inform the future implementation of pre-exposure prophylaxis (PrEP) for HIV prevention in this population. A cross-sectional study based on a convenience sample of 1000 FSWs aged  $\geq 18$ , not known as HIV-positive, completed a standardized questionnaire assessing sociodemographic characteristics, sexual practices, use of community health services and a priori acceptability of PrEP. Twenty-two in-depth interviews and eight focus group discussions were also conducted to document FSWs' risky practices and sexual behaviors, experiences with violence and discrimination, attitudes regarding HIV and sexually transmitted infections (STIs), and barriers to SRH service. The study concluded that SWs are still highly exposed to HIV. Furthermore, FSWs seem to face several barriers to accessing SRH. 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 and the study showed that the overall prevalence of modern CP use was 26% and ranged from 6% in Guinea to 62% in Zimbabwe. 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. Based on a randomized control trial in rural, Cote d'Ivoire, Falb et al (2014) investigated intimate partner violence (IPV) which revealed that lifetime IPV was associated with a 3.7 increase in odds of reporting reproductive coercion (95% CI: 2.4 – 5.8) compared to women who did not report such victimization.

The aim of this study is to project total fertility rate in Cote d'Ivoire using an artificial intelligence technique. The results of this paper are envisioned to highlight the likely future trends of fertility in the country. This will guide policy making and trigger an appropriate evidence based response to the future health, education and employment needs for the people in Cote d'Ivoire.

## 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 Cote d'Ivoire.

**Data Issues**

This study is based on annual total fertility rate (births per woman) in Cote d'Ivoire 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	0.069205
MSE	0.016097
MAE	0.107843

*Residual Analysis for the Applied Model*

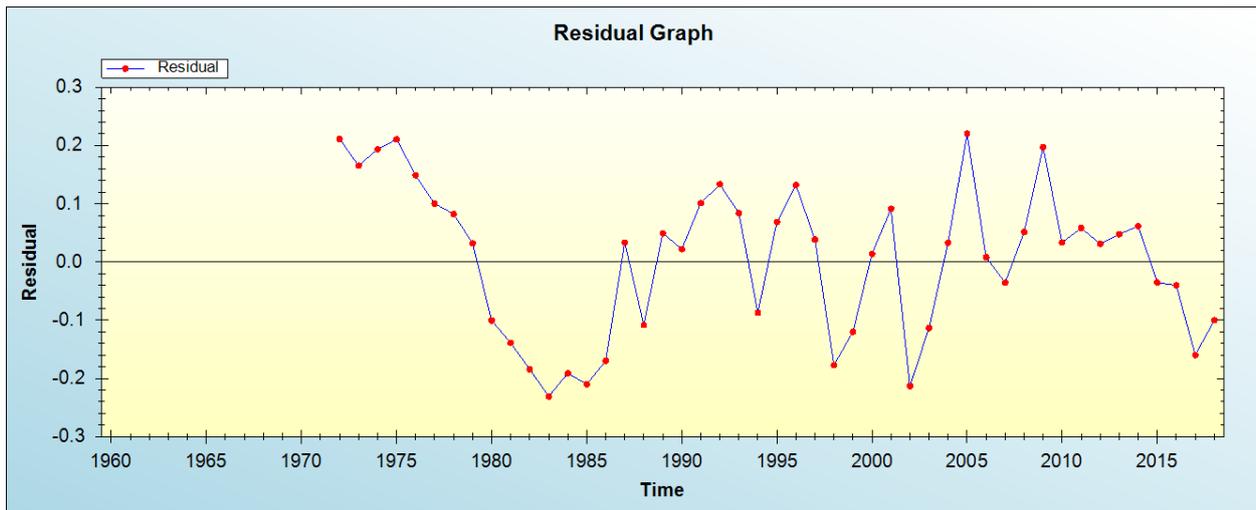


Figure 1: Residual analysis

*In-sample Forecast for C*

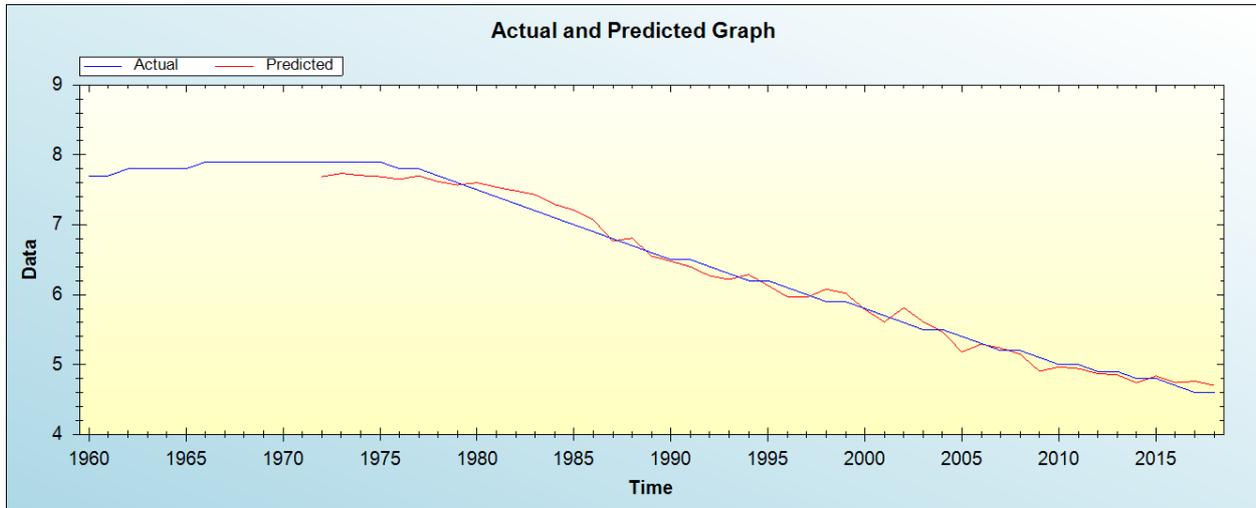


Figure 2: In-sample forecast for the C series

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

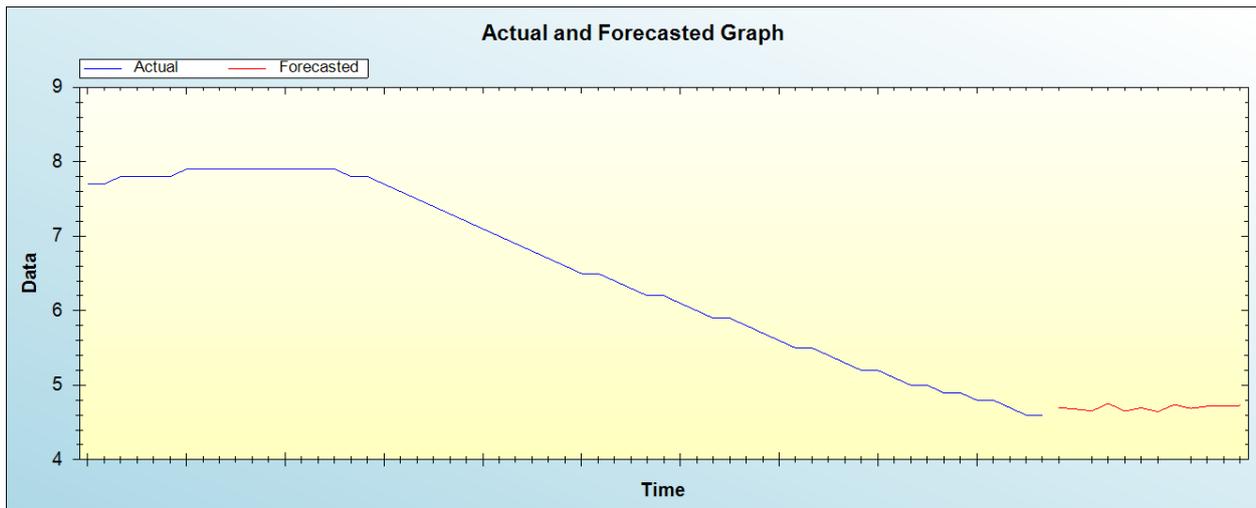


Figure 3: Out-of-sample forecast for C: actual and forecasted graph

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

Table 2: Tabulated out-of-sample forecasts

Year	Forecasts
2019	4.6991
2020	4.6804
2021	4.6561
2022	4.7543
2023	4.6537
2024	4.6959
2025	4.6459
2026	4.7389
2027	4.6893
2028	4.7182
2029	4.7191
2030	4.7280

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 Cote d'Ivoire are likely to rise slightly over the out-of-sample period.

#### IV. CONCLUSION & RECOMMENDATIONS

Adolescent girls and young women in Africa continue to experience challenges in accessing SRH services due to socio-cultural, health provider and health system challenges. In this paper we employed an artificial intelligence technique to project total fertility rate in Cote d'Ivoire. The ANN model projections revealed that annual total fertility rates in Cote d'Ivoire are likely to rise slightly over the out-of-sample period. Therefore, the government is encouraged to scale up demand creation for sexual and reproductive health (SRH) services and address health system challenges that hinder access to family planning services, and also prioritize women empowerment programs.

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