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Time Series Forecasting of Total Fertility Rate (TFR) in Kenya

[1]Dr. Smartson. P. NYONI, [2]Tatenda. A. CHIHOHO, [3]Thabani NYONI

[1]ZICHIRe Project, University of Zimbabwe, Harare, Zimbabwe
[2]Independent Health Economist, Zimbabwe
[3]SAGIT Innovation Center, Harare, Zimbabwe

***Abstract*- In this piece of work, the ANN approach was applied to analyze TFR in Kenya. 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 Kenya. The results of the study revealed that annual total fertility rates in Kenya are likely to hover around 4.0 births per woman/ year over the out-of-sample period. Therefore, the Kenyan government should focus on improving access to sexual and reproductive health (SRH) services among adolescents and young adults, and promote female education & women's rights.**

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

I. INTRODUCTION

The Kenyan government has made significant progress in addressing the challenges being faced by adolescent girls and young women, however the country still remains with high maternal and neonatal mortality (UNICEF, 2016; WHO, 2015). The nation continues to battle the dual epidemic and HIV and TB. In Kenya adolescent girls and young women are twice likely to be living with HIV when compared with male counterparts aged 15-24years (MOH Kenya, 2016). The number of teenage pregnancies is high in Kenya (Wilson et al, 2020). Among sexually active never married young women the unmet need for family planning is 74 % in the 15-19 age group and 39 % among 20-24 years age group (Sedgh, 2016; Kenya, 2014). Many adolescent girls and young women are involve d in commercial sex work putting themselves at a high risk of contracting HIV, STIs and having unintended or unwanted pregnancies. Some of the studies which have been done in Kenya have shown that for FSWs dual contraception was 38 % although consistency in condom use varied (Ochako et al, 2018; Sutherland, 2011).

Total fertility rates in Kenya have been declining from 7.5 births per woman in 1955 to 3.5 births per woman in 2020 (Worldometer, 2020). In 2020 the country recorded an infant mortality rate of 30.5 infant deaths per 1000 live births and under five mortality rate of 40 births per 1000 live births (Worldometer, 2020). There are limited studies in the country and region that have examined or focused fertility rates. Ooms et al (2020) did anassessment 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 consisted of an adaptation of the World Health Organization/Health Action International methodology, Measuring Medicine Prices, Availability, Affordability and Price Components. Price, availability and stock-out data was collected in July 2019 for over fifty lowest-priced SRHC from public, private and private not-for-profit health facilities in Kenya (n = 221), Tanzania (n = 373), Uganda (n = 146) and Zambia (n = 245). The study findings revealed that accessibility was low across the countries, with Kenya's and Zambia's public sectors having six SRHC that met the accessibility threshold, while the private sector of Uganda had only one SRHC meeting the threshold. Based on a systematic literature review, Akwara and Idele (2020) deconstructed the moral and social narratives of adolescents' and young people's sexual and reproductive health (AYSRH) in Kenya as driven by the powerful discourse and ideologies pre- and within the Millennium Development Goal (MDG) era. Their findings showed that the evolution of AYSRH policies and programmes in Kenya was gradual and largely shaped by prevailing development threats and moral and social narratives. Pre-MDG period was dominated by issue-based policies of population growth and high fertility rates, with a focus on married population with strong cultural and religious barriers to AYSRH. Wilson et al (2020) conducted a cross-sectional survey in Mombasa, Kenya to characterize sexual and reproductive health (SRH) indicators among adolescent girls and young women (AGYW) engaged in casual and transactional sexual relationships as well as sex work. The study findings revealed high need for SRH services, particularly, access to contraception and safe abortion.

The aim of this study is to project TFR in Kenya using a machine learning algorithm. The results of the study are expected to reveal the likely future trends of TFR in the country to facilitate policy formulation, planning and allocation of resources.

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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 Kenya.

Data Issues

This study is based on annual total fertility rate (births per woman)in Kenya 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	K
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	0.081237
MSE	0.043100
MAE	0.170406

Residual Analysis for the Applied Model

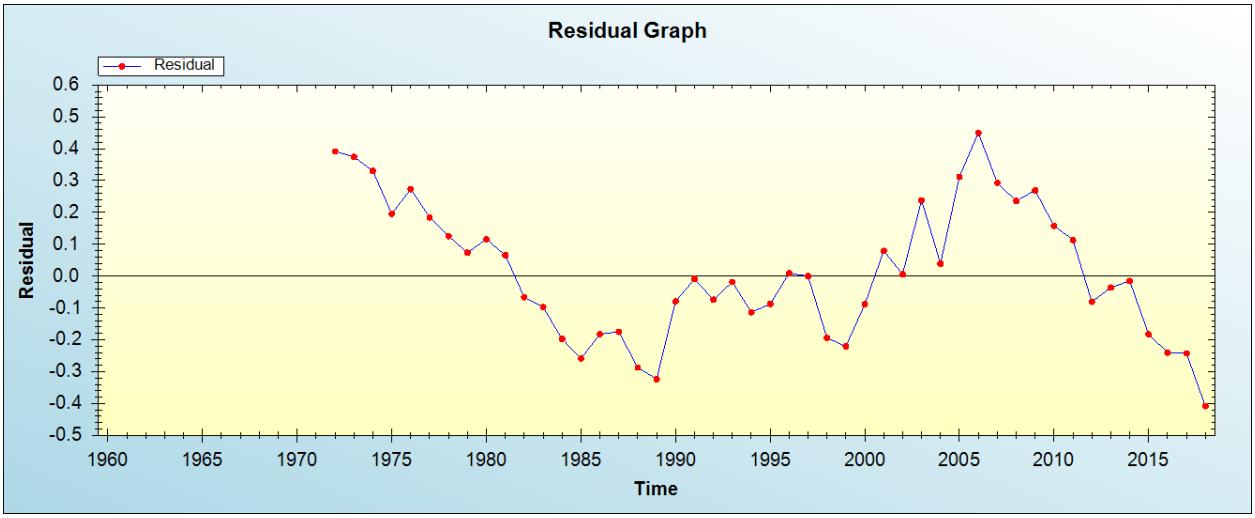

Figure 1: Residual analysis

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In-sample Forecast for K

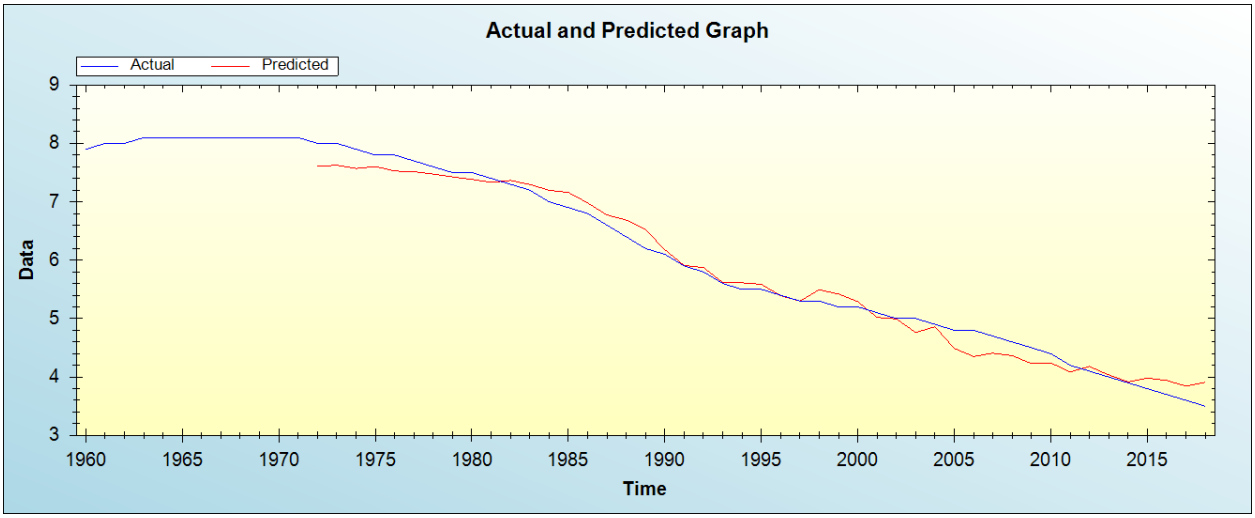

Figure 2: In-sample forecast for the K series

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

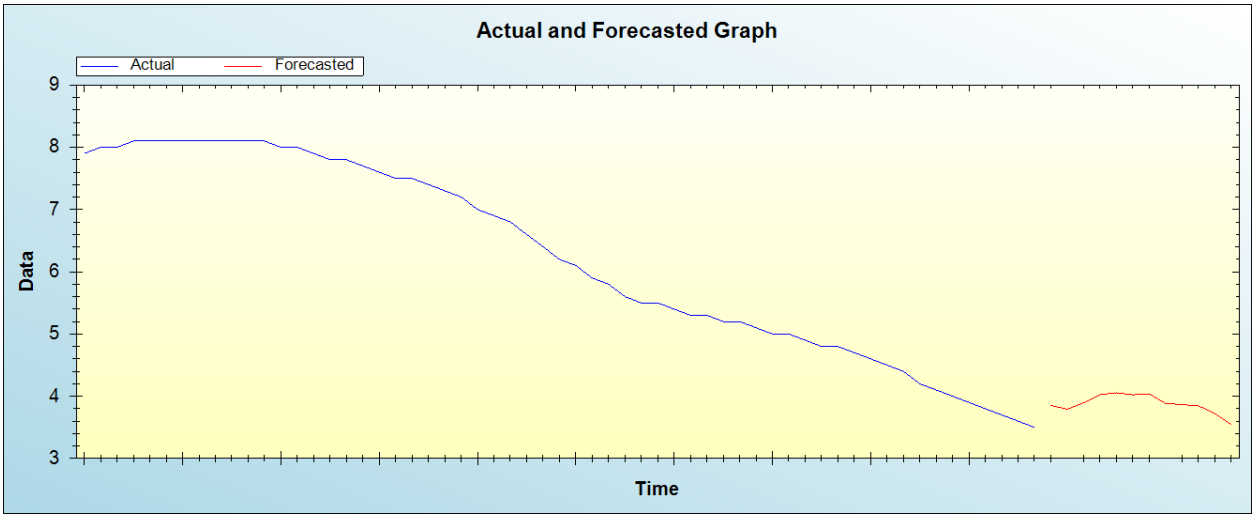

Figure 3: Out-of-sample forecast for K: actual and forecasted graph

Out-of-Sample Forecast for K: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecast
2019	3.8512
2020	3.7918
2021	3.8962
2022	4.0239
2023	4.0548
2024	4.0233
2025	4.0372
2026	3.8857
2027	3.8643
2028	3.8478
2029	3.7254
2030	3.5509

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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 Kenya are likely to hover around 4.0 births per woman/ year over the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

Kenya has witnessed a decline in fertility, infant and child mortality rates over the years, however teenage pregnancies remain high. In this study we proposed a machine learning algorithm to project TFR in Kenya. The ANN model predictions suggested that annual total fertility rates in Kenya are likely to hover around 4.0 births per woman/ year over the out-of-sample period. Therefore, the Kenyan government is encouraged to focus on improving access to sexual and reproductive (SRH) services among adolescents and youths, and promote female education & women's rights.

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