Time Series Forecasting Of Total Fertility Rate (TFR) In Tanzania

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Abstract - **In this research paper, the ANN approach was applied to analyze TFR in Tanzania. 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 Tanzania. The results of the study indicate that annual total fertility rates in Tanzania are likely to slightly decline over the out-of-sample period. Therefore, the Tanzanian government is encouraged to create more demand for family planning services, HIV testing and ART (Antiretroviral therapy) services, address adolescent challenges experienced when seeking health care services and channel more resources towards women empowerment program activities.**

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

I. INTRODUCTION

Tanzania has the second youngest population in East Africa with a median age of the population being 18 years (NBS, 2012). Many adolescents and young adults are involved in risky a sexual behavior which predisposes them to adverse reproductive health outcomes (Nkata et al, 2019). Approximately 4.7 % of adolescents aged 10-19 years are living with HIV in Tanzania (TACAIDS et al, 2008). Tanzanian teenagers are 3times more likely to get unwanted pregnancies than their regional counterparts (Japhet, 2017). Previous studies have shown that approximately 45 % of all 19 year old Tanzanian women are either pregnant or already have a child (CCBRT, 2018). In addition, adolescents aged 15-19 years have the lowest contraceptive prevalence rate and highest unmet need for family planning in East Africa (Izubara et al, 2018).

Total fertility rates in the country have been trading downwards over the past decades from 6.7 births per woman in 1955 to 4.9 births per woman in 2020 (Worldometer, 2020).The country continues to report high infant and under five mortality rates. In 2020, infant mortality rate was 34.2 infant deaths per 1000 live births and under five mortality rate was reported to be 47 deaths per 1000 live births (Worldometer, 2020). This means that the country has lot of work to do for it to further reduce infant and under five mortality by improving the quality of maternal and child health services in the country. There are few authors in the country or region which have examined fertility trends or predicted fertility rates to inform policy and decision making. Based on a qualitative study, Mesiäislehto (2021) examined how SRH services respond to the characteristics of Tanzanian adolescent females with disabilities. Authors, used the method of empathy-based stories to investigate the perceptions of 136 adolescent females with disabilities of their access to SRH services in Tanzania. The results demonstrated that discrimination affects access at different phases of care-seeking that affectionate behaviour of providers is a central enabler of access, and that for this population access relies on a collective effort. Damian et al (2020) did a qualitative thematic analysis for eight primary healthcare facilities in Kasulu, a rural district in Tanzania to explore how the underrepresentation of the youth in health facility committees, the decentralized community- and facility level healthcare decision-making forums affects youth access to sexual and reproductive health services. Their study results highlighted the need for gradual emancipatory and transformative efforts to normalize the representation of the youth and their concerns in formal community-level decision-making institutions. Nkata et al (2019) performed a scoping review to collect and analyze observational data on sexual and reproductive health behaviors among Tanzanian adolescents. Publications were identified using PubMed, Scopus, Web of Science, and Cochrane Library electronic databases from 2000 to December 2017. The study results showed that adolescents engage in high-risk sexual behaviors and experience its adverse consequences.

The aim of this paper is to predict total fertility rate in Tanzania using the multilayer perceptron neural network. The results of the study are expected to reveal the likely fertility trends in the out of sample period. This will inform policy and decision making so as to mobilize resources for the anticipated future health, education, housing and employment needs of the Tanzanian population.

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 Tanzania.

Data Issues

This study is based on annual total fertility rate (births per woman)in Tanzania 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	T
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	0.082848
MSE	0.007648
MAE	0.069048

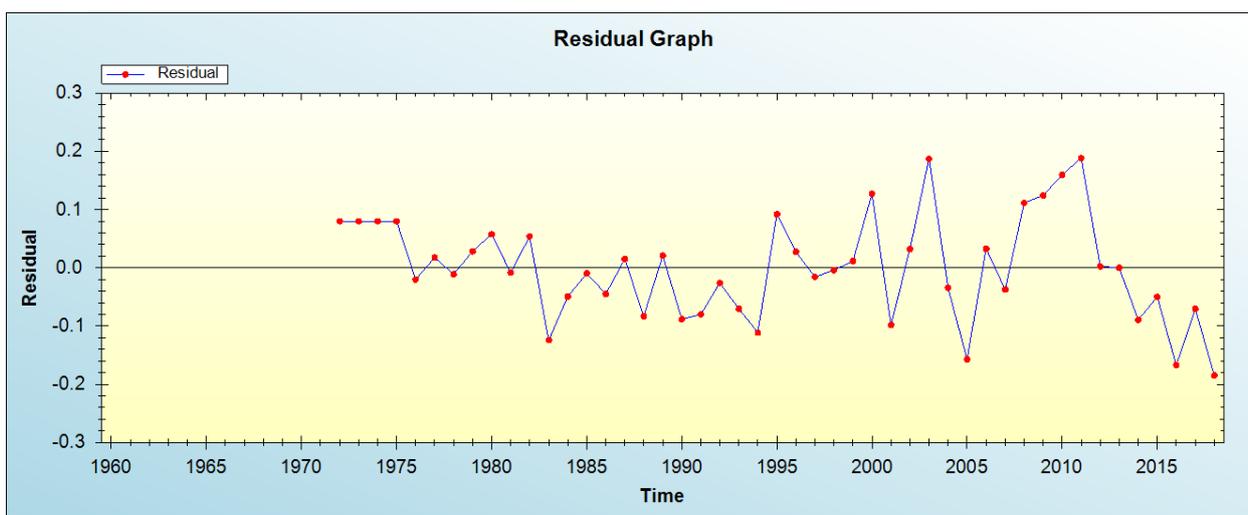*Residual Analysis for the Applied Model*

Figure 1: Residual analysis
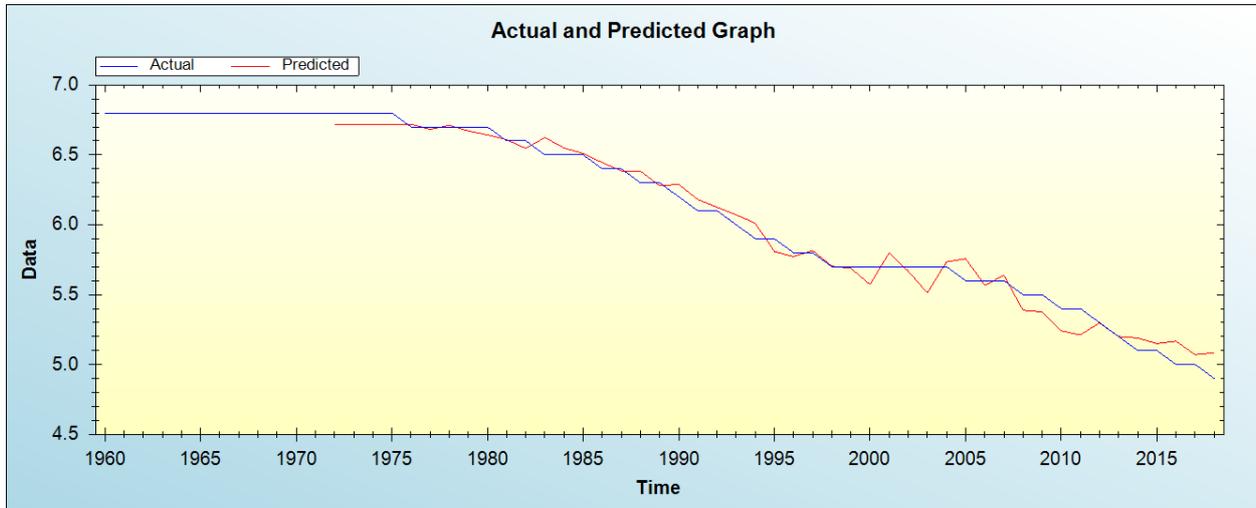
In-sample Forecast for T

Figure 2: In-sample forecast for the T series

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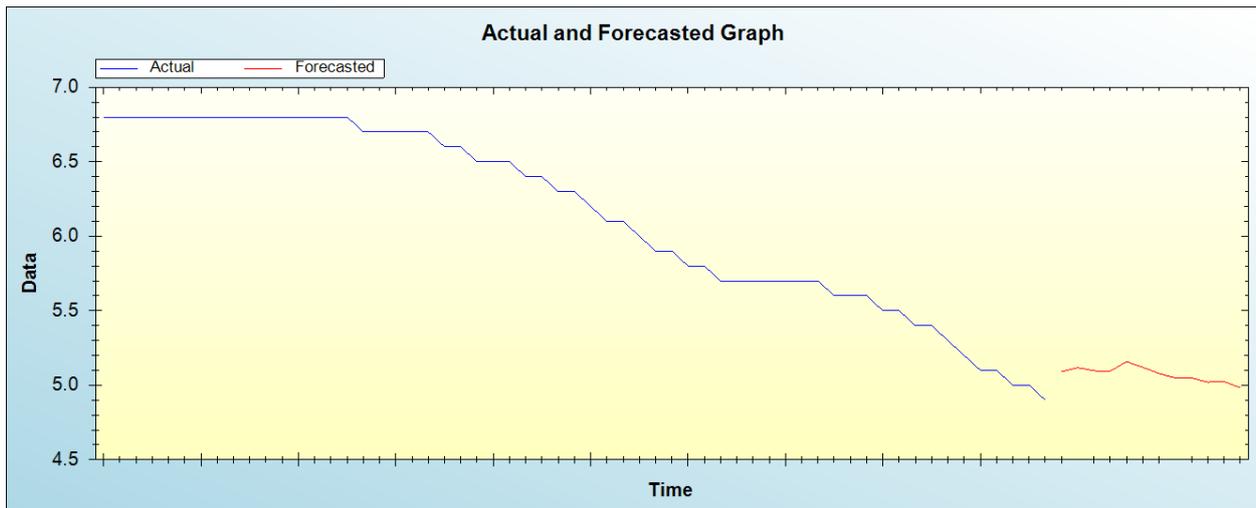

Figure 3: Out-of-sample forecast for T: actual and forecasted graph

Out-of-Sample Forecast for T: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecast
2019	5.0907
2020	5.1179
2021	5.0968
2022	5.0944
2023	5.1584
2024	5.1205
2025	5.0787
2026	5.0483
2027	5.0492
2028	5.0207
2029	5.0252
2030	4.9829

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 Tanzania are likely to slightly decline over the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

Many Tanzanian adolescents and youths are involved in risky sexual behaviors which predispose them to STIs, HIV, unwanted pregnancies, and unsafe abortions. The country has recorded a decline in total fertility rates over the years but fertility rates are still high. In this paper we applied the artificial neural network approach to predict TFR in Tanzania and the results indicate that annual total fertility rates in Tanzania are likely to slightly decline over the out-of-sample period. Therefore, the Tanzanian government is encouraged to create more demand for family planning services, HIV testing and ART (antiretroviral therapy) services, address adolescent challenges experienced when seeking health care services and channel more resources towards women empowerment program activities.

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