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

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Abstract - **In this research paper, the ANN approach was applied to analyze TFR in Lesotho. 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 Lesotho. The results of the study indicate that annual total fertility rates in Lesotho are likely to remain around 3.0 births per woman over the out-of-sample period. Therefore, the government of Lesotho should focus on improving access to sexual and reproductive health (SRH) services among adolescents and youths and promotion of women empowerment.**

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

I. INTRODUCTION

The rates of unintended pregnancies and new HIV infections among adolescent girls and young women are becoming a global concern (Aventin et al, 2021). Globally approximately 170 000 adolescents aged 10-19 years were newly infected with HIV in 2019 raising alarm in many developing countries where there is a dual epidemic of HIV and TB (UNICEF, 2020). Lesotho has the second highest HIV prevalence in the World which was estimated to be 23% among 15-49 year olds, 10% in the 15-24 year age group and 5% in men (UNAIDS, 2019). Furthermore 48% of the sexually active adolescents do not use condoms consistently (UNICEF, 2016). It is worrisome to note that 19 % of adolescent girls become pregnant by the time they reach 19 years of age (UNICEF, 2016) and 50% of inpatient deaths among females aged 15 yrs. and above are as are as a result of complications following unsafe abortions (Mosaase & Tiebere1996).

In Lesotho the modern contraceptive prevalence rate among all women was 51.3% in 2019, the unmet need for family planning among married women was 16.0 % in 2019 and demand satisfied for modern contraception in 2019 was 79 % (Lesotho FP 2020). The country has recorded a decline in fertility rates from 5.7 births per woman in 1980 to 3.2 births per woman in 2020. In 2020, infant mortality rate was 50.5 infant deaths per 1000 live births (Worldometer, 2020). In the region there are limited studies that have focused on examining fertility trends and prediction of fertility rates. Aventin et al (2021) conducted a needs assessment to inform the co-design, in consultation with local stakeholders, of adapted versions of an existing gender-transformative Relationships and Sexuality Education intervention for use in South Africa and Lesotho. This process involved consultation with separate adolescent, community and expert advisory groups and a collaboratively conducted needs assessment, which drew on focus groups with adolescents (8 groups, n = 55) and adults (4 groups, n = 22) in South Africa and Lesotho, and was informed by systematic review of the literature on the determinants of condom use among adolescents in the region. The study revealed how the intervention should be adapted, which individual- and environmental-level determinants of condom use to target, and actions for facilitating successful adoption, evaluation and implementation in the new settings. Hoffman et al (2017) examined prevalence of factors potentially associated with HIV risk, focusing on partnership characteristics and consistent condom use. Data were drawn from a representative interviewer-administered survey of 2nd–4th year students conducted during registration at a university campus in KwaZulu-Natal. The study concluded that Sexual partnership characteristics potentially place sexually active university students at high HIV risk. Lince-Deroche et al (2015) assessed young women's SRH knowledge and experiences and to determine how they get SRH information and services in Soweto, South Africa using quantitative and qualitative methods. Young women, aged 18-24, recruited from primary health clinics and a shopping mall, reported that they have access to SRH information and know where to obtain services. However there are challenges to accessing and utilizing information and services including providers' unsupportive attitudes, uneven power dynamics in relationships and communication issues with parents and community members.

The aim of this study is to forecast fertility rates in Lesotho using a machine learning technique. The results of the study are expected to highlight likely fertility trends in the out of sample period to facilitate planning and resource mobilization for the health sector, education, and employment creation.

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 Lesotho.

Data Issues

This study is based on annual total fertility rate (births per woman) in Lesotho 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	L
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	0.082618
MSE	0.015318
MAE	0.092227

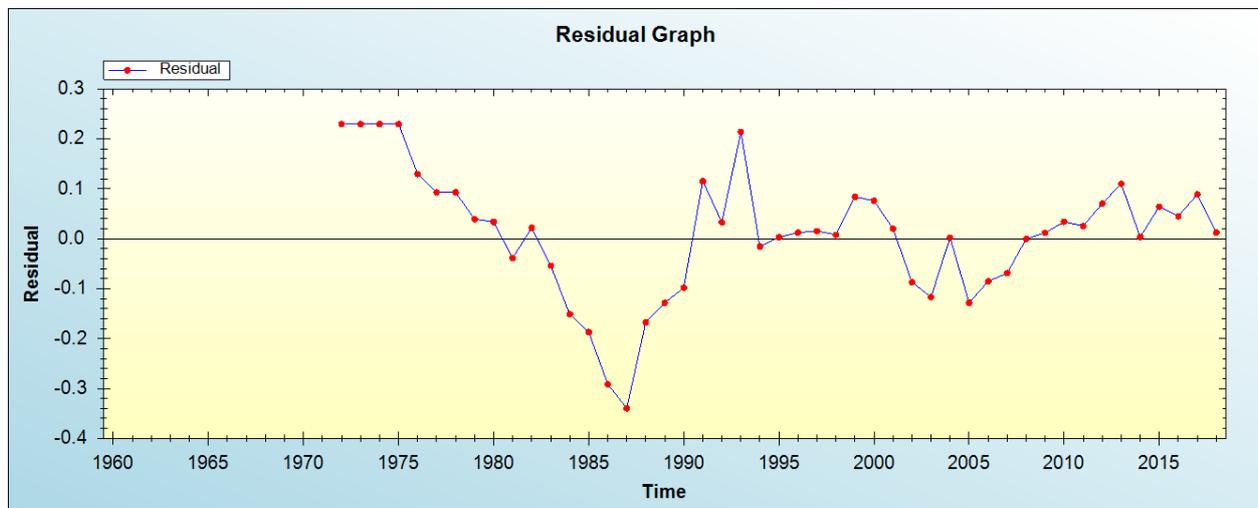*Residual Analysis for the Applied Model*

Figure 1: Residual analysis
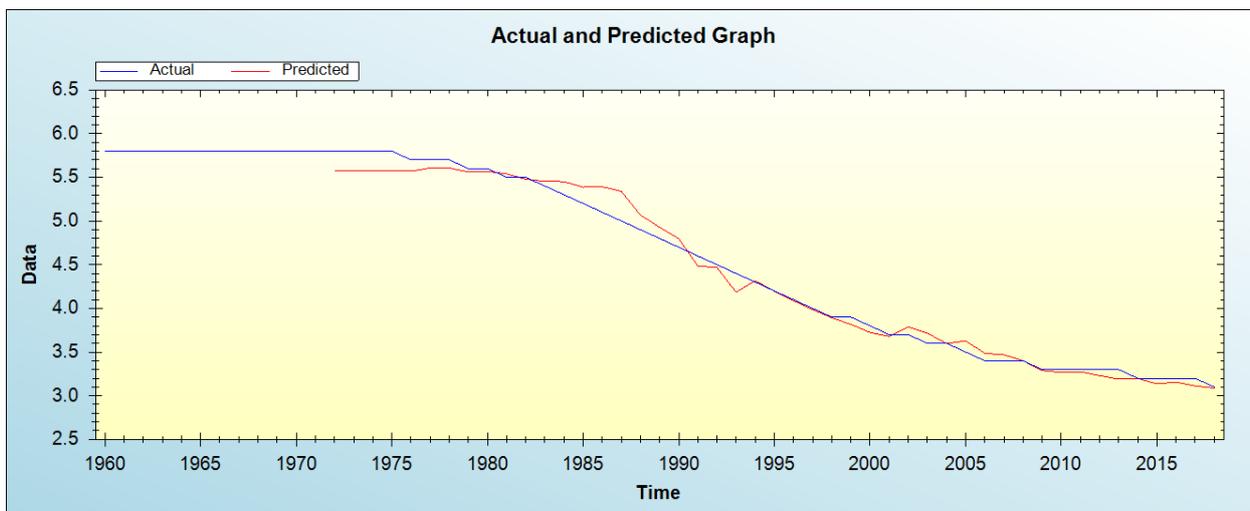
In-sample Forecast for L

Figure 2: In-sample forecast for the L series

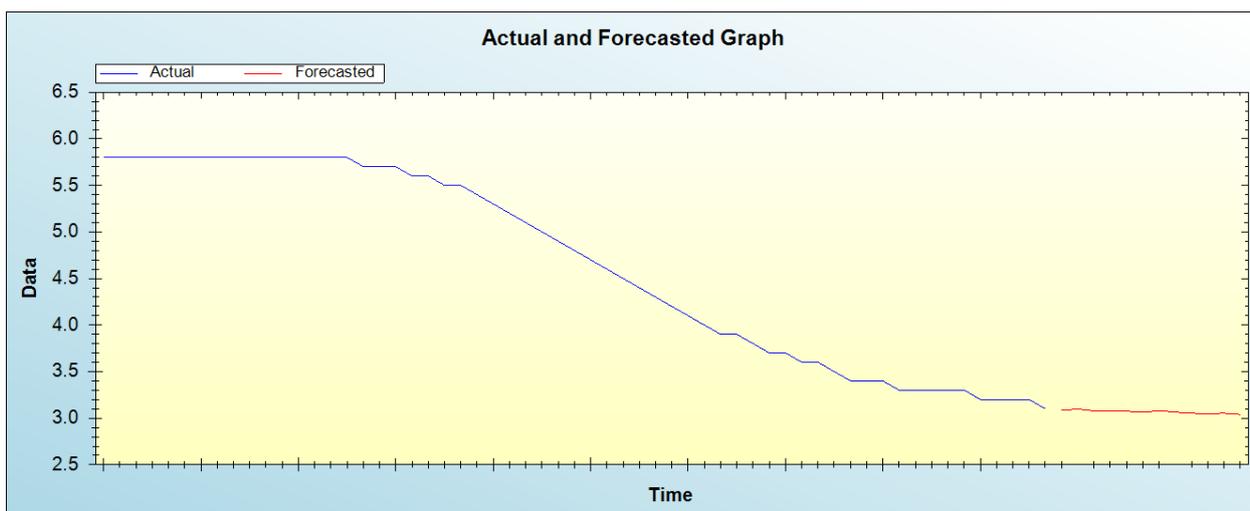*Out-of-Sample Forecast for L: Actual and Forecasted Graph*

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

Out-of-Sample Forecast for L: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasts
2019	3.0848
2020	3.0972
2021	3.0784
2022	3.0720
2023	3.0757
2024	3.0622
2025	3.0811
2026	3.0643
2027	3.0541
2028	3.0483
2029	3.0530
2030	3.0414

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 Lesotho are likely to remain around 3.0 births per woman over the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

Lesotho is one of the developing countries in the SADC region which is still facing problems of early child marriages and high numbers of teenage pregnancies. The country has recorded a decline in fertility, infant and child mortality rates. In this paper we proposed a machine learning technique to forecast TFR in Lesotho. The ANN model projected that annual total fertility rates in Lesotho are likely to remain around 3.0 births per woman over the out-of-sample period. Therefore the government of Lesotho is encouraged to focus on improving access to sexual and reproductive health (SRH) services among adolescents and youths and promotion of women empowerment.

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