Forecasting Total Fertility Rate (TFR) in the Kingdom of Eswatini

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Abstract - **In this research paper, the ANN approach was applied to analyze TFR in the Kingdom of Eswatini. 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 Eswatini Kingdom. The results of the study indicate that annual total fertility rates in Eswatini are likely to decline over the out-of-sample period. Therefore, the authorities in the Kingdom of Eswatini are encouraged to continuously focus on addressing challenges faced by adolescents and young adults in accessing family planning services as well as women empowerment.**

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

I. INTRODUCTION

Many developing countries have made significant strides in improving quality and access to maternal and child health services, however maternal mortality ratio remains high in Sub-Saharan Africa with approximately 550 maternal deaths per 100 000 live births in 2015 (WHO, 2015). Lack of quality care, unsafe abortions and poor health infrastructure are the major causes of maternal and neonatal deaths (WHO, 2017; Haddad, 2009). Several governments are committed to the 1994 International conference on Population and development (ICPD) and adopted recommendations by WHO to respond to women's sexual and reproductive health rights and needs such as health education, access to information on family planning, improved quality of prenatal, antenatal and postnatal care (Sullivan et al, 2020). Globally approximately 40 % of all pregnancies are unintended and half of them end up in abortion (Sedgh et al, 2006). Furthermore commercial sexwork is rampant in developing countries and there is lack of comprehensive knowledge on family planning services among adolescent girls and young women (Workie et al, 2019).

Eswatini Kingdom has witnessed a downward trend in fertility rates over the past four decades from 6.6 births per woman in 1980 to 3.0 births per woman in 2020 (Worldometer, 2020). The country reported a drop in infant mortality rate from 144.8 infant deaths per 1000 live births in 1950 to 34.99 infant deaths per 1000 live births in 2020 (Worldometer, 2020) reflecting the government's commitment in addressing maternal and child health problems in the country. There are limited studies in the region that have investigated fertility trends or forecasted fertility rates. Sullivan et al (2020) conducted a cross-sectional survey to assess the frequency and determinants of pregnancy and abortion among FSWs in Benin. The study revealed that one FSW out of five had at least one pregnancy during her sex work practice. Most of those pregnancies, regardless of their origin, ended with an abortion. 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 revealed 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 the Kingdom of Eswatini using an artificial intelligence algorithm. The results of the study are expected to highlight likely fertility trends in the out of sample period to facilitate policy making 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 inEswatini.

Data Issues

This study is based on annual total fertility rate (births per woman) in Eswatini 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	E
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	0.076562
MSE	0.027517
MAE	0.142621

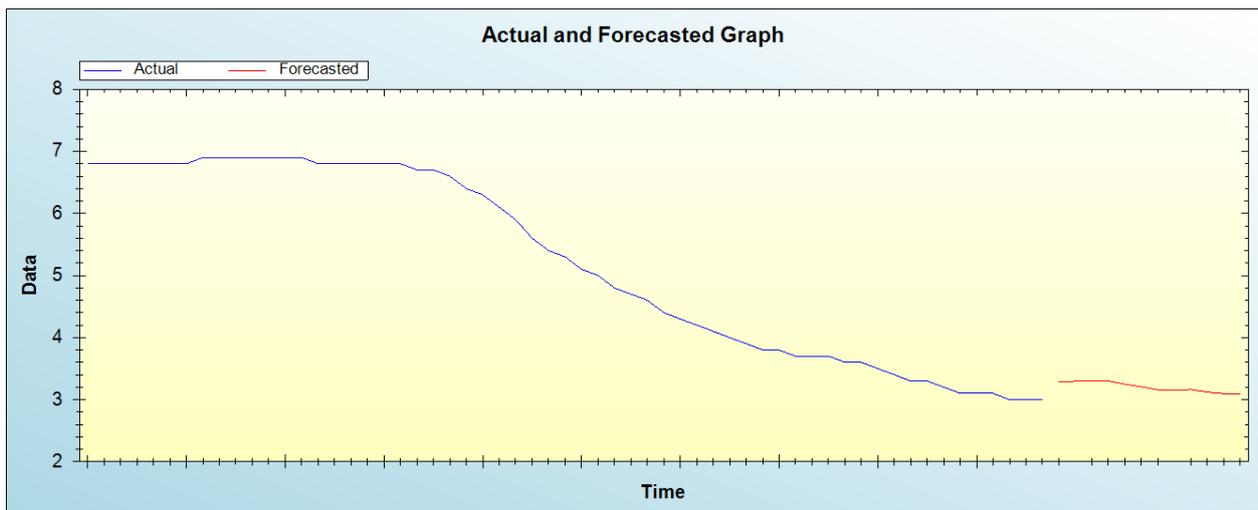*Residual Analysis for the Applied Model*
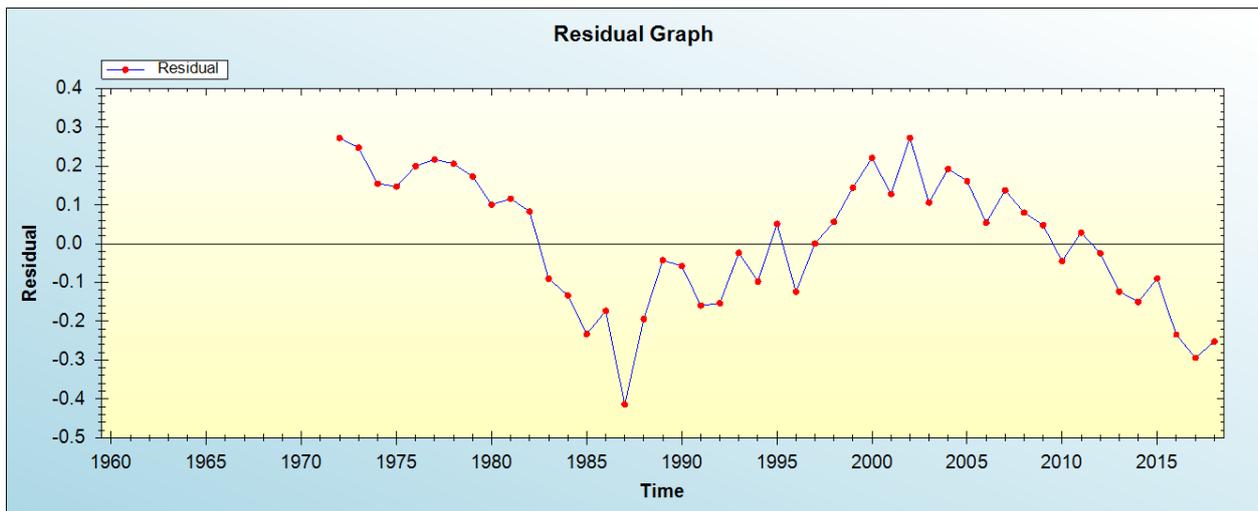
Figure 1: Residual analysis

In-sample Forecast for E
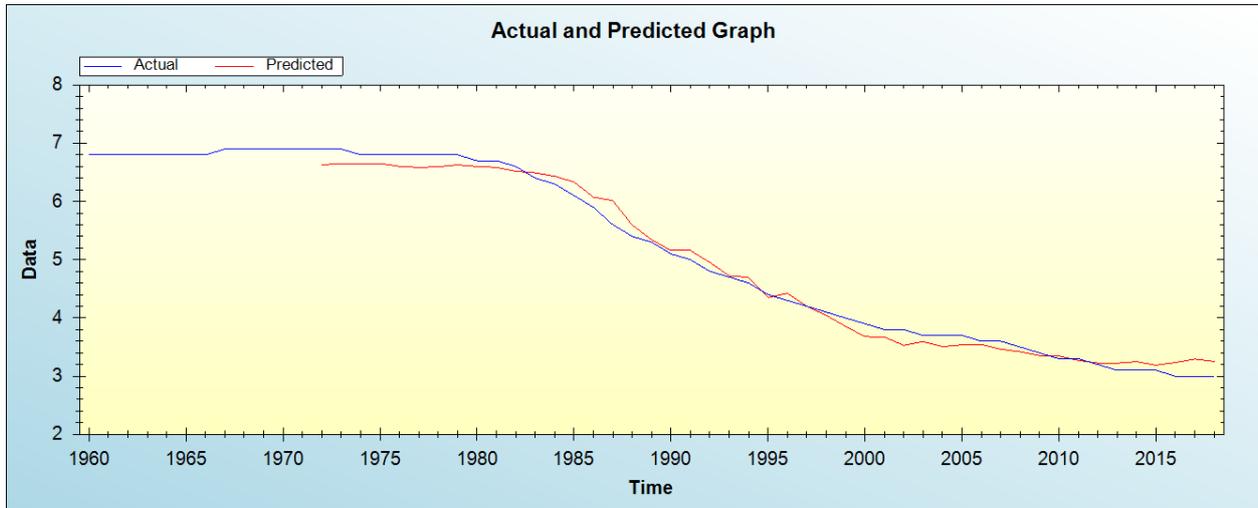
Figure 2: In-sample forecast for the E series

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

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

Out-of-Sample Forecast for E: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Years	Forecasts
2019	3.2818
2020	3.2983
2021	3.3029
2022	3.3032
2023	3.2484
2024	3.2068
2025	3.1576
2026	3.1520
2027	3.1617
2028	3.1210
2029	3.0961
2030	3.0863

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

IV. CONCLUSION & RECOMMENDATIONS

Sexual and reproductive health is a fundamental human right. Adolescents and youths across the globe must enjoy this right and contribute to economic development in their settings. In this study we applied the artificial neural network approach to project total fertility rates in Eswatini. The ANN model projections suggest that annual total fertility rates in Eswatini are likely to decline over the out-of-sample period. Therefore, the Eswatini Kingdom should continuously focus on addressing challenges faced by adolescents and young adults in accessing family planning services as well as women empowerment.

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