Machine Learning Application in Forecasting Total Fertility Rate (TFR) In Madagascar

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Abstract - **In this piece of work, the ANN approach was applied to analyze TFR in Madagascar. 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 Madagascar. The results of the study indicate that annual total fertility rates in Madagascar are likely to range from 4.17 to 4.46 births per woman over the out-of-sample period. Therefore, the government of Madagascar is encouraged to focus on improving access to SRH services among adolescents and young adults to avert undesirable sexual and reproductive health (SRH) outcomes, and promotion of women empowerment.**

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

I. INTRODUCTIION

Madagascar's population in 2018 was estimated to be around 25million with 60 % of its population under the age of 25 (CIA, 2019). The Island country has a rapidly growing population with a total fertility rate of 4.1 births per woman and recorded an infant mortality rate of 23.0 infant deaths per 1000 live births in 2020 (Worldometer, 2020). The majority (91%) of people in Madagascar live on less than 2 USD per day (Morris et al, 2014). The nation has a myriad of challenges which include regular outbreaks of plague, cholera, drought and malnutrition which make it difficult to prioritize sexual and reproductive health programs (Grant & Shoham, 2018). The health system in Madagascar is very weak and heavily depends on donor funds (Lang et al, 2018). There is inequitable access to health services across regions with 20 % regarded to be heavily isolated due to bad road network, 53% of the health centers are inaccessible as a result of seasonal flooding (Madagascar, 2015).

Sexual and reproductive health continues to be a challenge in the country. The country has a high maternal mortality ratio of 426 per 100 000 live births, a contraceptive prevalence rate of 40 % and unmet need for contraception at 18.4% (INSTAT & UNICEF, 2019; Madagascar FP 2020). Adolescent pregnancies are high with 34.7 % of girls aged 15-19 having begun child bearing (INSTAT & UNICEF, 2019). There are limited studies that have focused on examining fertility trends and prediction of fertility rates. Genus (2020) examined the determinants of trends wanted and unwanted fertility in SSA using fixed-effects regressions of country-level data. Data came from 103 DHS surveys in 25 countries in SSA with at least two DHS surveys between 1989 and 2019. The study indicated that Women's education and family planning programs are found to be the dominant determinants of fertility decline and their effects operate by reducing both wanted and unwanted fertility. A secondary analysis of the Global School-based Student Health Surveys (GSHS) datasets pooled from five SSA countries Benin, Mozambique, Namibia, Seychelles, and Tanzania were done by Shayo and Kalomo (2019). Logistic regression was applied and the results indicated that Adolescents sexual intercourse and more especially sex with multiple partners was prevalent and strongly correlated with substance use. 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 study is to project total fertility rate in Madagascar using a machine learning approach. The findings are envisioned to reveal likely fertility trends in the country in order to guide policy, planning and allocation of resources to the health sector, education and for 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 Madagascar.

Data Issues

This study is based on annual total fertility rate (births per woman)in Madagascar 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	M
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	0.077871
MSE	0.019165
MAE	0.117053

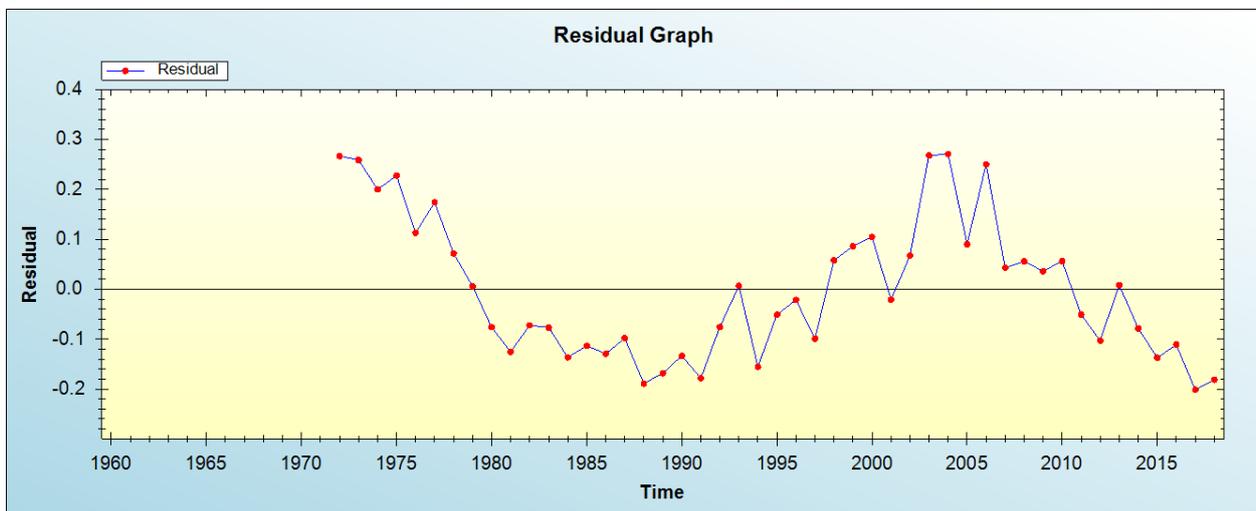*Residual Analysis for the Applied Model*

Figure 1: Residual analysis
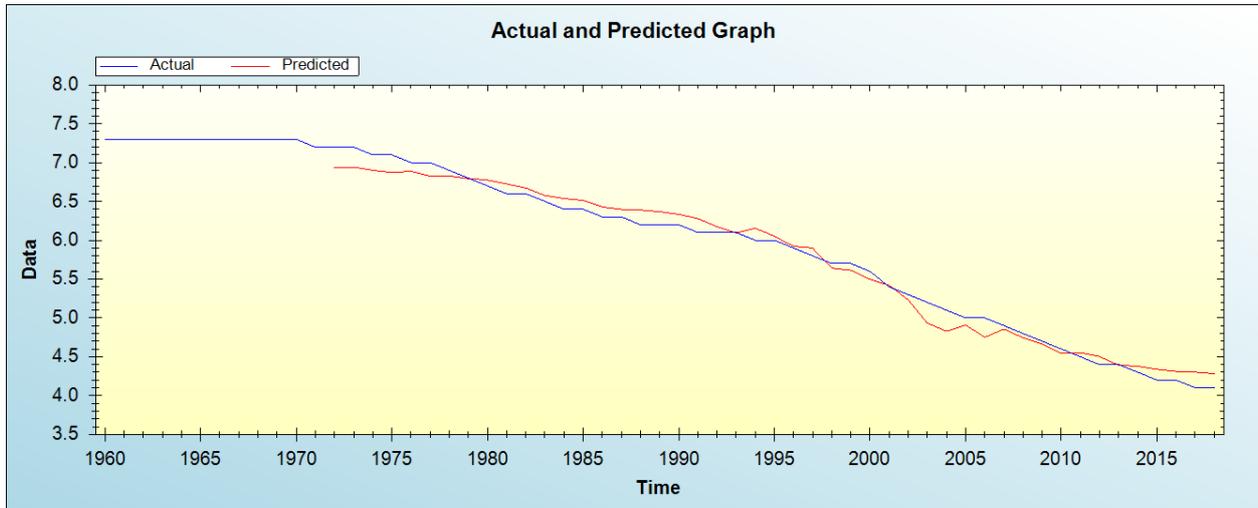
In-sample Forecast for M

Figure 2: In-sample forecast for the M series

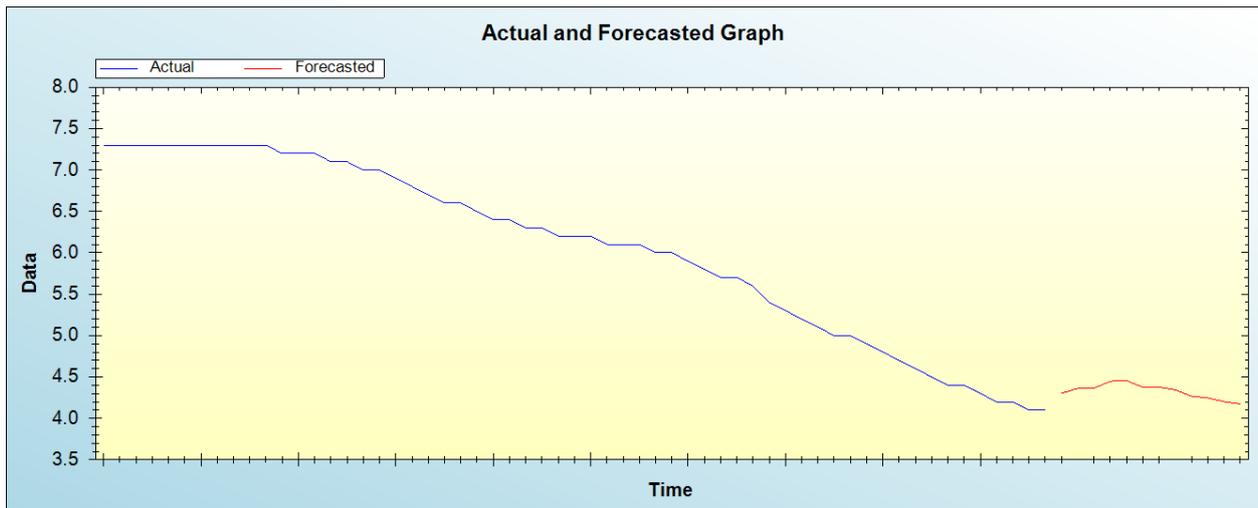*Out-of-Sample Forecast for M: Actual and Forecasted Graph*

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

Out-of-Sample Forecast for M: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Years	Forecasts
2019	4.3031
2020	4.3607
2021	4.3632
2022	4.4481
2023	4.4559
2024	4.3756
2025	4.3752
2026	4.3444
2027	4.2667
2028	4.2468
2029	4.2007
2030	4.1740

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 Madagascar are likely to range from 4.17 to 4.46 births per woman over the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

The total fertility rate in Madagascar has declined over the years, however the country continues to face many challenges which make it difficult to prioritize SRH programs. Adolescent pregnancies are still high associated with a low contraceptive prevalence and a high unmet need for family planning. In this study we propose an artificial neural network technique to forecast TFR in Madagascar. The ANN model projections revealed that annual total fertility rates in Madagascar are likely to range from 4.17 to 4.46 births per woman over the out-of-sample period. Therefore the government is encouraged to focus on improving access to sexual and reproductive (SRH) services among adolescents and young adults to avert undesirable SRH outcomes, and promotion of women empowerment.

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