Time Series Prediction of Total Fertility Rate in Rwanda

[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 - **The decline in total fertility rates in Rwanda is partly due to her successful family planning program. In this piece of work, the ANN approach was applied to analyze TFR in Rwanda. 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 Rwanda. The results of the study indicate that annual total fertility rates in Rwanda are likely to decline slightly over the out-of-sample period. Therefore, we encourage the Rwandan government to focus on improving access to sexual and reproductive (SRH) services among adolescents and young adults by addressing their challenges and promotion of women empowerment.**

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

I. INTRODUCTION

Rwanda is among the signatories of the 1994 International conference on Population and development which took place in Cairo, the Egyptian Capital. 179 countries agreed to uphold human rights and dignity including sexual and reproductive health rights all the people both men and women. There was consensus to provide universal access to sexual and reproductive health and rights especially those of adolescent girls and women who are suffering physical and sexual abuse and violation of their sexual and reproductive rights across the globe (Rwanda MOH, 2018). The Rwandan government has invested a lot in family planning services and this has resulted in a decline in Total fertility rate and mortality (Rwanda MOH, 2018).The unmet need for planning is 17 % for women in union (Rwanda, MOH, 2018).The prevalence of unwanted pregnancies is high as well as risky sexual behavior, lack of sexual and reproductive health information and a surge in new HIV infections among adolescent girls and young women in urban areas such as Kigali (R MOH, 2018; Black et al, 2015; NISR, 2015). TFR in Rwanda has been on a downward trajectory from 8.0 births per woman in 1955 to 4.1 births per woman in 2020 (Worldometer, 2020). In 2020 the country reported an infant mortality rate of 22.6 infant deaths per 1000 live births and under five mortality rate of 29.8 deaths per 1000 live births (Worldometer, 2020).

There are limited studies in the region which have examined or predicted fertility rates. Ndayishimiye et al (2020) did a descriptive cross-sectional survey between May 2018 and May 2019 in six selected cities of Rwanda using a mixed-methods approach to understand SRH services providers' viewpoints on accessibility, availability, and quality of SRH services provided to adolescents in selected cities of Rwanda. The study concluded that SRH services in Rwanda are available for the general population and are not specifically designed for adolescents and these SRH services seem to be fairly accessible to adolescents with insufficient quality as adolescents themselves do not get to be fully involved in service provision among other aspects of quality SRH as stated by the World Health Organization (WHO). Ooms et al (2020) did an assessment 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 utilized the WHO methodology: Measuring Medicine Prices, Availability, Affordability and Price Components. The study revealed that accessibility of SRHC remains a challenge. Low availability of SRHC in the public sector is compounded by regular stock-outs, forcing patients to seek care in other sectors where there are availability and affordability challenges. Coast et al (2019) examined early adolescent understandings and experiences of sexual and reproductive health (SRH) in Ethiopia and Rwanda, drawing on a multisite qualitative research study with 10- to 12-year-old and 14- to 15-year-old male and female adolescents and a range of adult participants. The authors concluded that there is need for program designers and implementers to address the role of underlying social norms in a more strategic and context-specific way to help young people navigate their sexual and reproductive lives.

The aim of this paper is to forecast TFR in Rwanda using a machine learning algorithm. The findings of this paper will reveal the likely trends of fertility rates in the out of sample period to facilitate planning, decision making and resource mobilization for 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 Rwanda.

Data Issues

This study is based on annual total fertility rate (births per woman)in Rwanda 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	R
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	0.069426
MSE	0.030125
MAE	0.141604

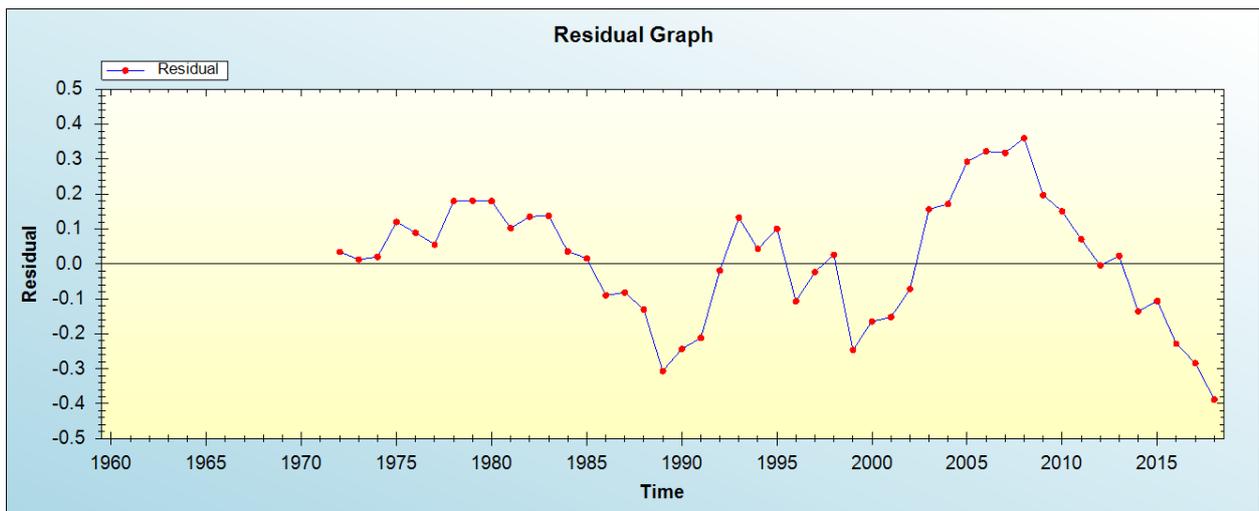*Residual Analysis for the Applied Model*

Figure 1: Residual analysis

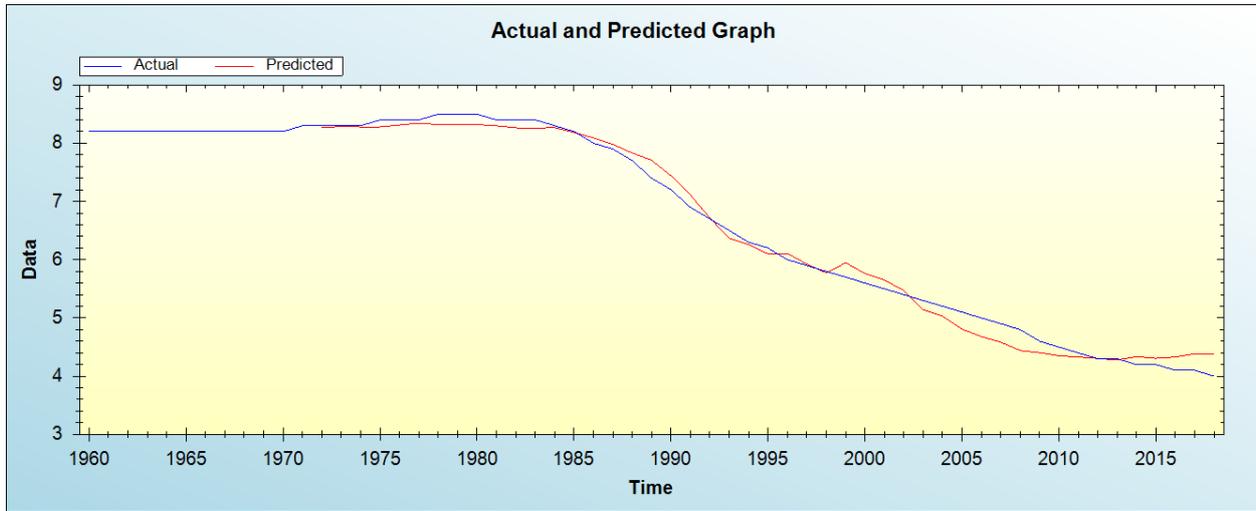*In-sample Forecast for R*

Figure 2: In-sample forecast for the R series

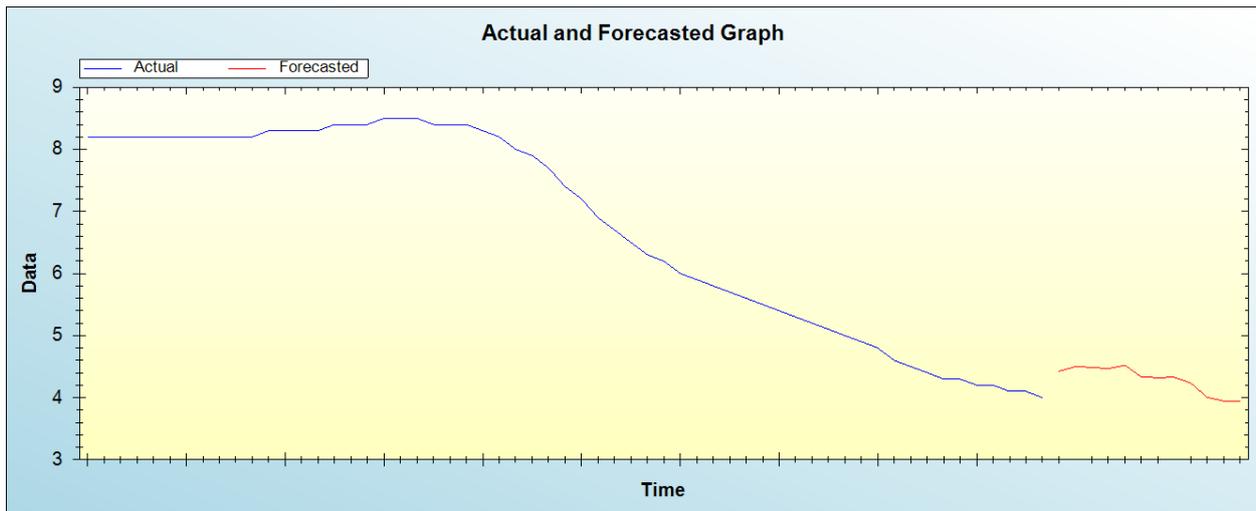*Out-of-Sample Forecast for R: Actual and Forecasted Graph*

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

Out-of-Sample Forecast for R: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasts
2019	4.4253
2020	4.5005
2021	4.4872
2022	4.4670
2023	4.5215
2024	4.3356
2025	4.3218
2026	4.3293
2027	4.2361
2028	4.0058
2029	3.9453
2030	3.9368

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

IV. CONCLUSION & RECOMMENDATIONS

Rwanda has invested a lot of resources in family planning, however teenage pregnancies are still high with an unmet need for family planning of 17%. In this study we applied a machine learning approach to predict TFR in Rwanda. The findings of this study revealed that annual total fertility rates in Rwanda are likely to decline slightly over the out-of-sample period. Therefore, the Rwandan government is encouraged to focus on improving access to sexual and reproductive health (SRH) services among adolescents and young adults by addressing challenges which they experience when seeking healthcare services and promotion of women empowerment.

REFERENCES

[1] Worldometer (2020). Guinea demographics. https://www.worldometers.info

[2] Rwanda Ministry of Health (2018). National Family Planning and Adolescent Sexual and Reproductive Health (FP/ASRH) Strategic Plan (2018–2024), pp 1-68

[3] Blake C., Elouard Y., Tropical S., Hilber AM., Tropical S., & Merten S. Adolescent and youth sexual and reproductive health survey: survey report 2014, Rwanda. Tech Rep. 2015; (July 2017).

[4] Ministry of Health (2018). National Family Planning and Adolescent Sexual and Reproductive Health (FP/ASRH) Strategic Plan (2018 –2024).

[5] NISR (2015). Rwanda Demographic and Health Survey 2014 –15 - Final Report. Rwanda: National Institute of Statistics of Rwanda (NISR); 2015. p. 640

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