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Forecasting Total Fertility Rate (TFR) In Senegal

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Abstract - In this research article, the ANN approach was applied to analyze TFR in Senegal. 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 Senegal. The results of the study indicate that annual total fertility rates in Senegal are likely to remain around 5.0 births per woman over the out-of-sample period. Therefore, the Senegalese government should prioritize creating demand for family planning services, tackling system challenges that hinder access to sexual and reproductive health (SRH) services among adolescents and young adults, and channel more resources towards women empowerment programs.

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

I. INTRODUCTION

The decline in fertility rates that has been witnessed over the past four decades in Sub-Saharan Africa has been less pronounced with TFR remaining at 5.1 births per woman compared to 2.7 births per woman in developed countries (UNDP, 2015). This is due to the uptake of contraception with the Sub-Saharan Africa reporting a modern contraceptive prevalence (m CPR) of 24% (World Bank, 2014). The unmet need for family planning remains high (Camphea et al, 2015). Senegal has a low CPR of 18.9% and a high rate of unmet need for family planning at 25.2% (Senegal, 2017; Machiyama et al, 2013). Previous studies have indicated that reasons for the unmet need for contraception include lack of access to family planning services and behavioral characteristics of women and their partners (Belohlav, 2013). Ndayishimiye et al (2020) did a descriptive crosssectional 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). 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 researchers 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. Based on a systematic review, Nkata et al (2019) examined the available published information on sexual and reproductive health among Tanzanian adolescents. The results of the study results indicated that Adolescents engage in high-risk sexual behaviors and experience its adverse consequences.

Fertility rates in Senegal have been decreasing over the years from 7.1 births per woman in 1985 to 4.7 births per woman in 2020. Infant mortality and under five mortality have also been declining over the past decades. The country recorded a decline in IMR of 127.55 infant deaths per 1000 live births in 1950 to 26.41 infant deaths per 1000 live births in 2020 (Worldometer, 2020). The aim of this study is to project TFR in Senegal using a machine learning approach. The results of the study are expected to highlight the likely fertility trends in the out of sample period. This is going to guide policy, planning and resource allocation to health, education and employment sectors.

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 Senegal.



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Data Issues

This study is based on annual total fertility rate (births per woman) in Senegal 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	S
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	0.087961
MSE	0.017408
MAE	0.111712

Residual Analysis for the Applied Model



Figure 1: Residual analysis



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In-sample Forecast for S



Figure 2: In-sample forecast for the S series

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



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

Out-of-Sample Forecast for E: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasts
2019	4.8029
2020	4.7444
2021	4.7987
2022	4.7989
2023	4.7649
2024	4.9106
2025	4.9170
2026	4.8951
2027	5.0036
2028	4.9359
2029	4.7864
2030	4.8549

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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 Senegal are likely to remain around 5.0 births per woman over the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

Senegal has experienced fertility transition over the years however; fertility rates remain high with a low contraceptive prevalence and high unmet need for family planning. In this study we applied a machine learning technique to predict total fertility rate in Senegal. The findings revealed that annual total fertility rates in Senegal are likely to remain around 5.0 births per woman over the out-of-sample period. Therefore, the Senegalese government is encouraged to prioritize creating demand for family planning services, tackling system challenges that hinder access to sexual and reproductive health (SRH) services among adolescents and young adults and channel more resources towards women empowerment program activities.

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