Projection of Total Fertility Rate (TFR) in India

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Abstract - **In this research article, the ANN approach was applied to analyze TFR in India. 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 India. The results of the study indicate that annual total fertility rates in India are likely to be around 2.3 births per woman over the out-of-sample period. Therefore, the Indian government must continue implementing its current population control policy.**

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

I. INTRODUCTION

India is the second most populous country in the world. According to the 2011 census the country has an estimated population size of 1.21 billion and it was the first country in the world to launch a National family planning programme in 1952. The goal of the family planning programme was to stabilize the population to a level consistent with its economy (FP 2020 India). The country's family planning programme has been decentralized to all the regions of the country including rural health facilities (Family planning Annual report 2015-2016). The birth control methods offered under the National family planning programme are divided into 2 groups 1) spacing methods and 2) permanent methods. Spacing methods include oral contraceptive pills, condoms, intrauterine device and injectables (Annual report 2015-16). The modern contraceptive prevalence rate for couples is 47.1% and the unmet need for family planning for couples is 21.3% (DLHS: 2007-09). The country has experienced fertility transition recording a drop of total fertility rate from 5.9 births per woman in 1955 to 2.2 births per woman in 2020 (Worldometer, 2020). India recorded an IMR of 26.6 infant deaths per 1000 live births and under five mortality of 32.9 deaths per 1000 live births in 2020 (Worldometer, 2020). In this paper we shall highlight some of the studies that have investigated fertility and other related issues. Srivastava et al (2021) proposed four flexible models, to capture the diverse age pattern of fertility, observed in the Indian states. The proposed models were compared in three ways; among themselves, with the original models and with the popular Hadwiger model. The best model was chosen by using AIC. The results of the study showed that all the four proposed models outperform their corresponding original models and the Hadwiger model. The ARIMA model was utilized by Nyoni (2019) to forecast the total population in India. The study employed annual time series data of India from 1960-2017. The optimal model ARIMA (1, 2, 3) model projected that total population in India will continue to sharply rise in the next three decades, thereby posing a threat to both natural and non-renewable resources. A similar study was done by Waseem and Yasmeen (2016) where the authors applied the ARIMA model to predict TFR in Pakistan and utilized secondary data of total fertility rates from 1984 to 2007, obtained from Pakistan Demographic Surveys (PDS). The optimal model ARIMA (0, 1, 2) projected TFR of Pakistan would decline and expected to be approximately 1.81 (average number of children per women) for the year 2022. Bandyopadhyay and Chattopadhyay (2008) applied the artificial neural network approach to predict India's population. It was found that the model performed more efficiently in predicting female population than the male population.

The aim of this paper is to forecast TFR in India using a machine learning algorithm. The results of the study are expected to reveal the likely future trends of fertility in the country. This will guide policy making and stimulate a national response to the future health, education and employment needs of the Indian population.

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 India.

Data Issues

This study is based on annual total fertility rate (births per woman) in India 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	I
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	0.220788
MSE	0.082900
MAE	0.175681

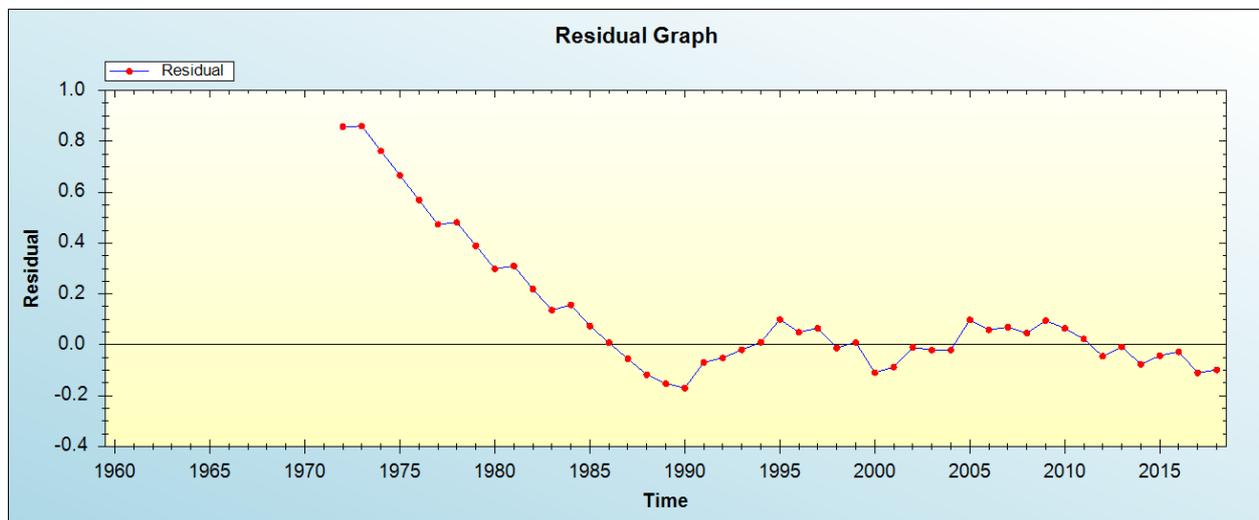*Residual Analysis for the Applied Model*

Figure 1: Residual analysis
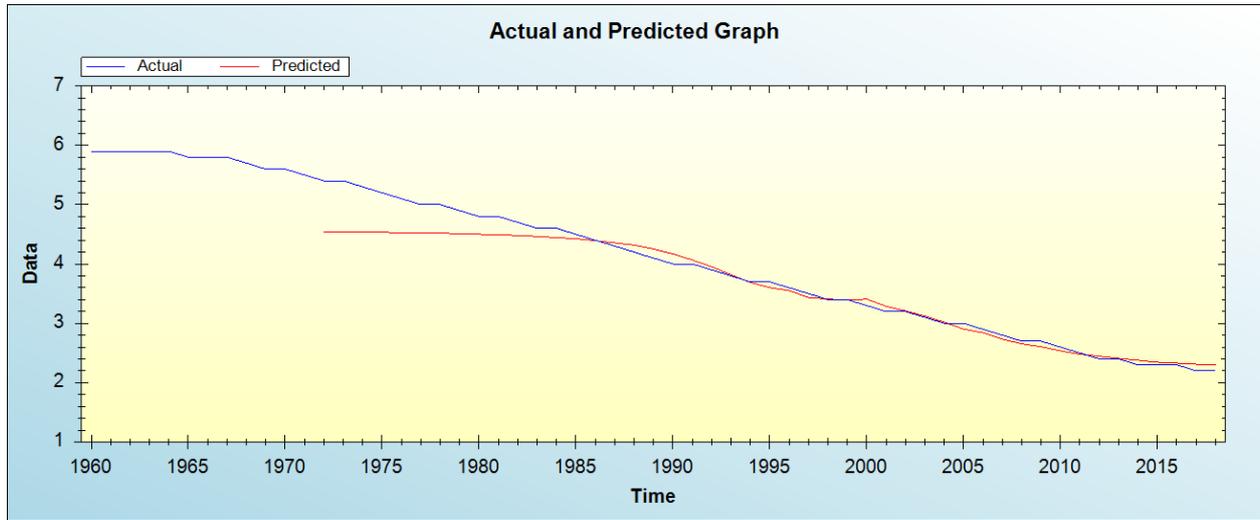
In-sample Forecast for I

Figure 2: In-sample forecast for the I series

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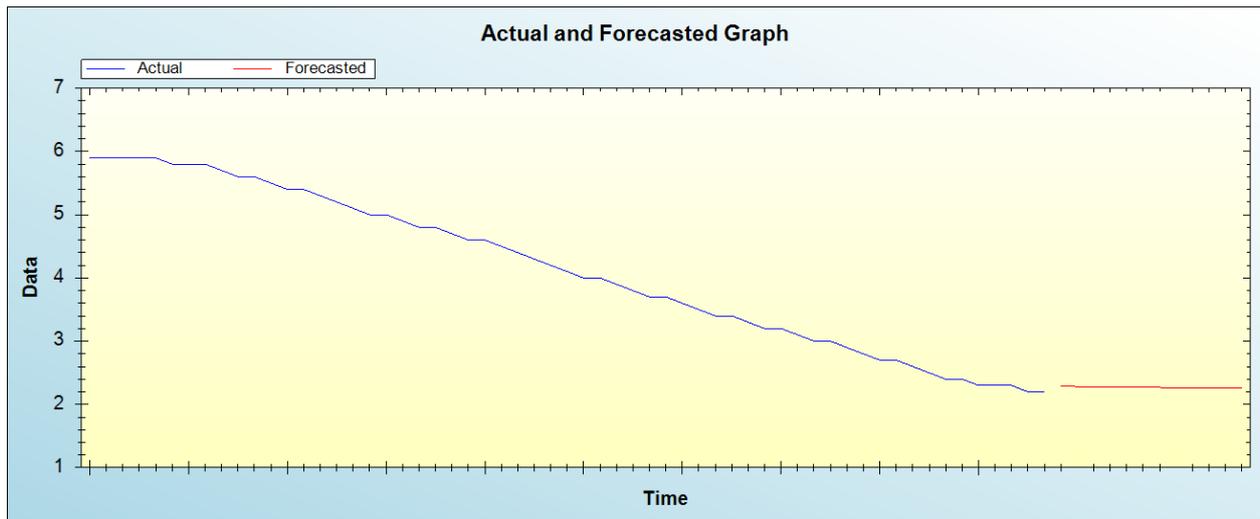

Figure 3: Out-of-sample forecast for I: actual and forecasted graph

Out-of-Sample Forecast for I: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted TFR values
2019	2.2891
2020	2.2829
2021	2.2716
2022	2.2727
2023	2.2741
2024	2.2701
2025	2.2685
2026	2.2679
2027	2.2659
2028	2.2669
2029	2.2676
2030	2.2678

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 India are likely to be around 2.3 births per woman over the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

Future population dynamics can be understood by fertility forecasting and hence in this study we apply a machine learning algorithm to project total fertility rate in India. The findings of this piece of work revealed that annual total fertility rates in India are likely to be around 2.3 births per woman over the out-of-sample period. Therefore, the Indian government should continue implementing its current population control policy.

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