Projection of Total Fertility Rate (TFR) in Indonesia Using a Machine Learning Approach

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Abstract - **In this research article, the ANN approach was applied to analyze TFR in Indonesia. 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 Indonesia. The results of the study indicate that annual total fertility rates in Indonesia are likely to be around 2.5 births per woman throughout the out-of-sample period. Therefore, the Indonesian government is encouraged to create more demand for family planning services, address challenges being experienced by adolescents and young adults and continue implementing women empowerment programs.**

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

I. INTRODUCTION

The study of human population including its composition, distribution, density, growth and its processes is known as demography (Demena, 2005). It focuses on changes in population size, composition, and distribution in space. The main demographic processes namely fertility (births), mortality (deaths) and migration are the major determinants of population size, composition and distribution. Fertility is the actual production of live births or reproductive performance of an individual or population. Fertility measures include crude birth rates (CBR), general fertility rates (GFR), age specific fertility rate, gross reproduction and total fertility rate (TFR). TFR is the major determinant of population growth and composition; therefore it is useful fertility measure to predict fertility trends of a population. Total fertility rate is the average number of children born to a woman throughout her lifetime if she were to pass through her child bearing years experiencing the current age specific fertility rates. Determinants of fertility can be categorized into demographic, socio-economic, cultural and special factors. Globally fertility trends have declined as a result of contraceptive use, female education and increased age of marriage.

Total fertility rate in Indonesia has been declining over the past decades from 5.7 births per woman in 1960 to 2.3 births in 2020. In 2020, the country recorded an infant mortality rate of 15.9 infant deaths per 1000 live births and under five mortality rate of 21.0 infant deaths per 1000 live births (Worldometer, 2020). There are few published research articles on fertility trends and other related areas in the region. Setiawan et al (2021) produced a probabilistic population projection for the provincial level in Indonesia. The base population used the base population used by Bappenas, BPS, and UNFPA Indonesia in compiling the 2015-2045 Indonesian official population projection. The study revealed that the total population of the official projection is located at the predicted interval of the Bayesian population projection, except for the Kepulauan Riau. Based on linear regression, Arbu et al (2021) investigated ASFR trends and forecasted the ASFR of India, Bangladesh, and Pakistan from 2020 to 2100. The results revealed that the change in fertility in these three countries from low stable population to high population will occur within next 40 years from 2020. Based on a cross-sectional study, Ranatunga and Jayaratne (2020), described the proportion of unplanned pregnancies, their determinants and the health outcomes of women delivering at Colombo North Teaching Hospital-Ragama (CNTH). The study revealed that inadequate pre-pregnancy preparation and antenatal care were associated with an unplanned pregnancy. Bandyopadhyay and Chattopadhyay (2008) used the artificial neural network approach to predict India's population. The study revealed that the model performed more efficiently in predicting female population than the male population.

The aim of this study is to project fertility trends in Indonesia using a machine learning technique. The results of this study are expected to reveal the likely fertility trends in the out of sample period. This will assist in policy making and trigger an appropriate response to the future health, education and employment needs of the Indonesian 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 Indonesia.

Data Issues

This study is based on annual total fertility rate (births per woman) in Indonesia 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	D
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	0.063496
MSE	0.010423
MAE	0.074057

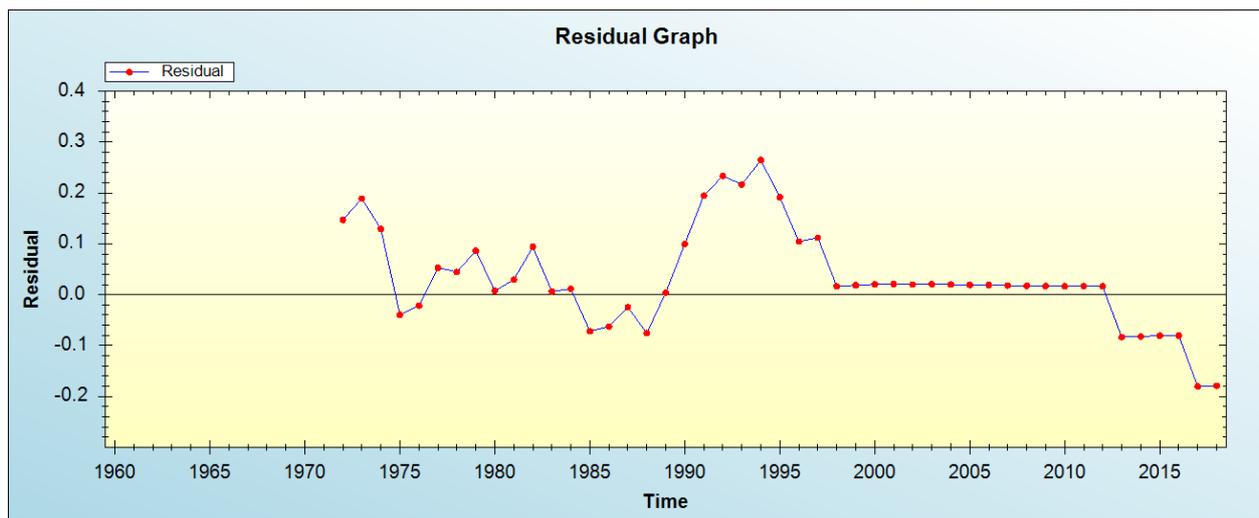*Residual Analysis for the Applied Model*

Figure 1: Residual analysis
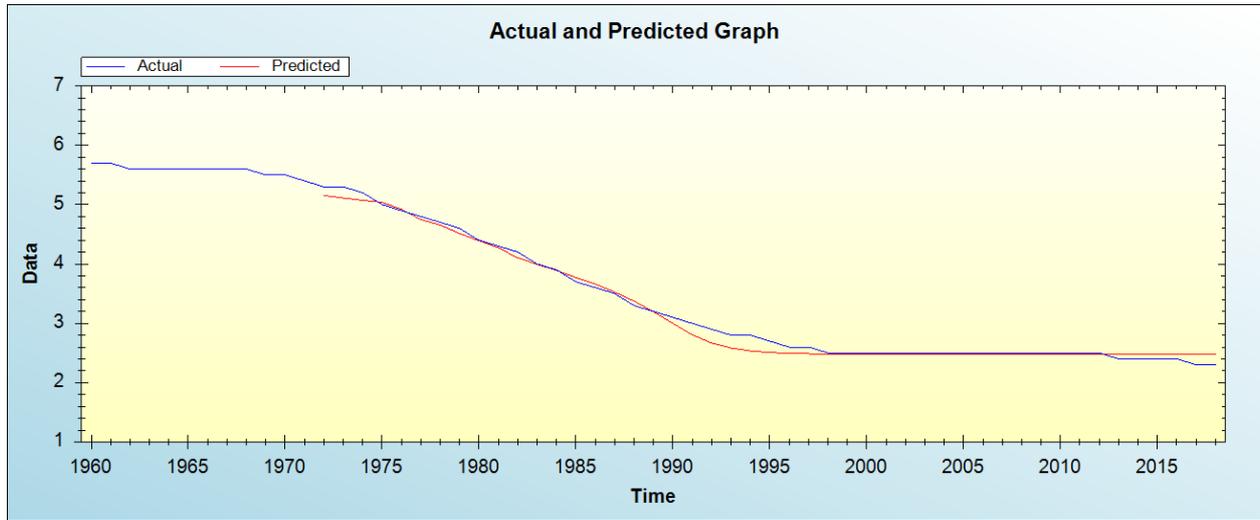
In-sample Forecast for D

Figure 2: In-sample forecast for the D series

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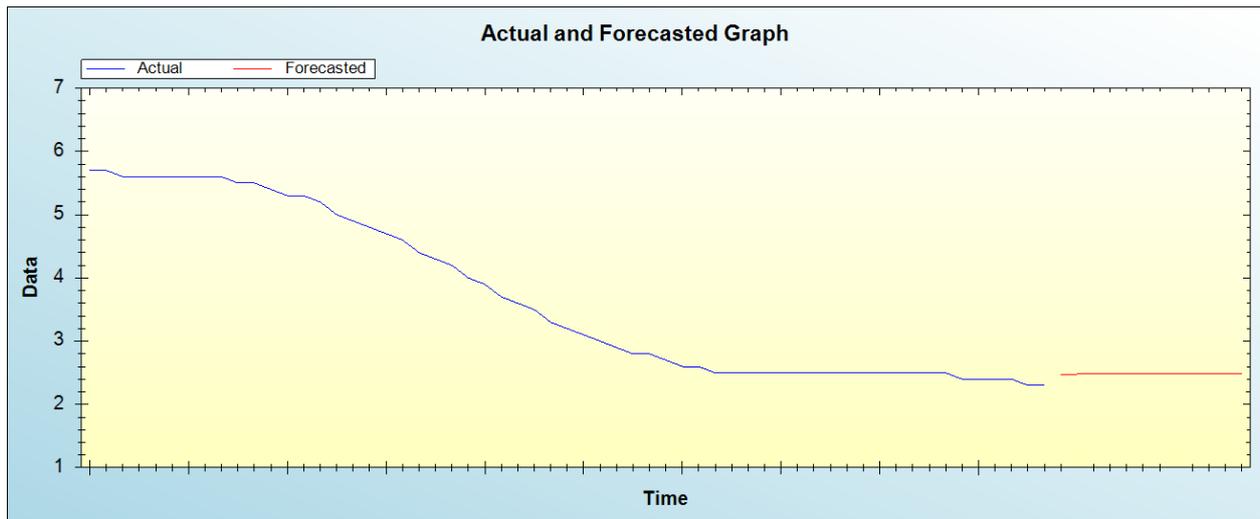

Figure 3: Out-of-sample forecast for D: actual and forecasted graph

Out-of-Sample Forecast for D: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted TFR values
2019	2.4778
2020	2.4791
2021	2.4808
2022	2.4812
2023	2.4816
2024	2.4828
2025	2.4823
2026	2.4833
2027	2.4853
2028	2.4849
2029	2.4847
2030	2.4835

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 Indonesia are likely to be around 2.5 births per woman throughout the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

Indonesia has experienced fertility transition over the past four decades and witnessed decline in infant and child mortality rates. In this paper we applied an artificial intelligence technique to project total fertility rate in Indonesia. The findings of the study have shown that annual total fertility rates in Indonesia are likely to be around 2.5 births per woman throughout the out-of-sample period. Therefore, the Indonesian government should create more demand for family planning services, address challenges being experienced by adolescents and young adults and continue to empower women.

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