Predicting Future Trends of Total Fertility Rates in Fiji Using Artificial Neural Networks

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Abstract - **This study was carried out to predict total fertility rates (TFRs) for Fiji from 2019 to 2030 by employing the Artificial Neural Networks method using Fiji data on TRFs from 1960 to 2018 obtained from World Bank Online database. The results predict that the TRFs will be almost constant for Fiji from 2019 to 2030.**

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

I. INTRODUCTION

Total Fertility Rates (TFR) play an important role in the determination of population growth hence a positive, direct relationship between the two (Gubhaju et al 2013). For policy makers to effectively plan and allocate resources to areas where maximum social benefit is to be derived there is need to have precise predictions on future fertility and population growth rates to ensure sustainable use of resources. Fiji experienced increasing population growth of 1.3%, 2.7% and 3.3% between 1901 and 1966 implying that the TRF has been increasing. The period 1966 to 2007 saw the declining in population growth rate in which the population grew by 2.1% and by 1% towards 2007.There were low fertility rates coupled with high mortality rates during this period and since 2009, Fiji has been experiencing high population growth rates due to high birth rates (Lincoln et al 2018). Prediction of future TFR for Fiji beyond the year 2021 will aid in sound population and resource allocation policies by the Fiji Authorities.

II. LITERATURE REVIEW

Given below is a summary of literature on total fertility rates:

Table 1: Literature on TFRs

Author/s (Year)	Study period	Method	Topic	Key results
Lincoln et al (2018)	15 March to 28 April 2017	-quantitative cross-sectional analysis	- Knowledge, attitudes and practices of family planning among women of reproductive age in Suva, Fiji 2017	-45.5% had good knowledge of family planning, 53.5% had moderate knowledge. - 54.2% had high level of attitude whilst 3% had poor attitude level -24.6% had poor level of practice of family planning whilst 9.5% had good level of practice
Gubhaju, Jongstra and Raikoti (2013)	1966, 1976, 1986, 1996, 2007	-own children method, Cho 1973. -Decomposition analysis technique	- Below replacement fertility of ethnic Indians in Fiji: a decomposition analysis of the components of changes in the total fertility rate	- educational attainment has a significant, negative impact on fertility -changes in marital structure have a negative impact on fertility in Fiji -marital fertility is positively related to TFR in Fiji
Kazenin &Kozlov (2020)	Multiple Indicators Clusters Survey of	Cumulative Probabilities -Regression	What factors support the early age patterns of fertility in a developing	-women education, labour market relations and family gender relations influence

	2012 and 2014	Analysis	country: Kyrgyzstan	her likelihood of becoming a mother
Hortacsu et al (2001)	2000	-ANOVA -Instrumental Variable approach	Desire for children in Turkmenistan and Azerbaijan: son preference and perceived instrumentality for value satisfaction	-Turkmens desire to have more children and ascribe greater importance to having children than Azeris. -Turkmen and Azeri men desire more sons than daughters whilst Azeri women prefer sons only
Clifford et al (2010)	2000, 2003 and 2005	Piecewise-constant hazard model	Through civil war, food crisis and drought: trends in fertility and nuptiality in Post-Soviet Tajikistan	-evidence of a fall in period fertility - strong evidence for a fall in nuptiality and fertility associated with the 1995 food crisis.
Islam (2017)	1988, 1995, 2000, 2008	-Bongaarts Aggregate Model	Rapid fertility decline in Oman: understanding the role of proximate determinants	Decline of fertility due to spacing and delaying of birth, prolonged postpartum infecund ability, increased modernisation, education and labour force participation of women in Oman
Nedoluzhko (2012)	Multiple Indicators Clusters survey of 2005 and 2006	-Poisson Regression -logistic regression model	Achieved fertility and fertility intentions among ethnic groups in Central Asia: Kyrgyzstan, Tajikistan and Uzbekistan compared	-number of children ever born and the intention to have another child appear to be negatively correlated with minority status.
Tucker (1996)	1990	Narrative analysis	Haiti: unions, fertility and the quest for survival	-most popular unions are legal marriage and setting up of a household in Haiti -more urban women use contraceptives than rural women

III. 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 Fiji.

Data Issues

This study is based on annual total fertility rate (births per woman) in Fiji 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.

IV. FINDINGS OF THE STUDY

ANN Model Summary

Table 2: ANN model summary

Variable	TFR
Included Observation	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	0.064312
MSE	0.017476
MAE	0.106523

Residual Analysis for the Applied Model
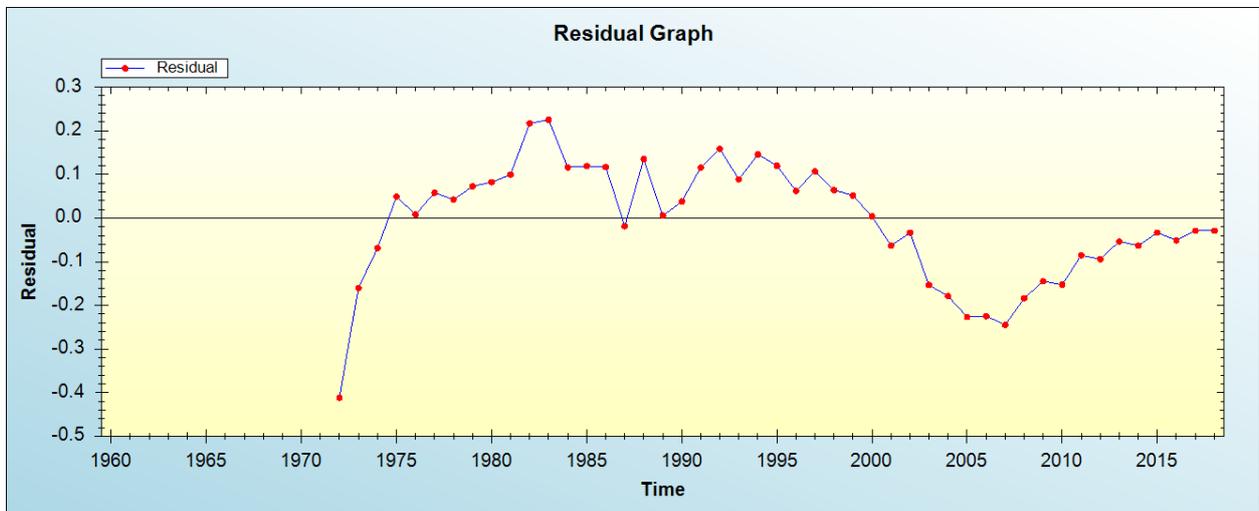
Figure 1: Residual analysis
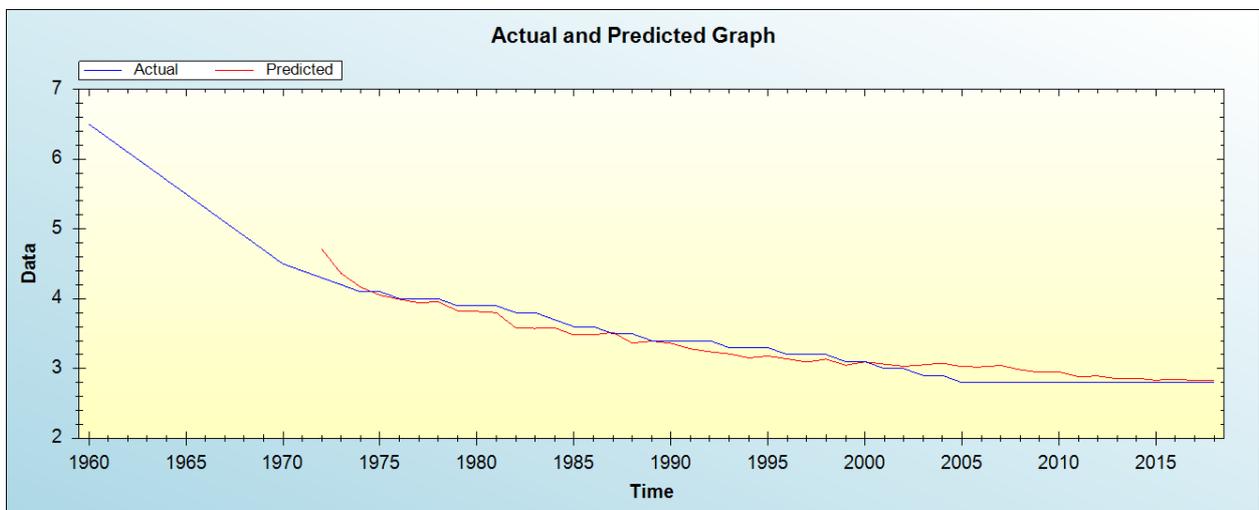
In-sample Forecast for TFR

Figure 2: In-sample forecast for the TFR series

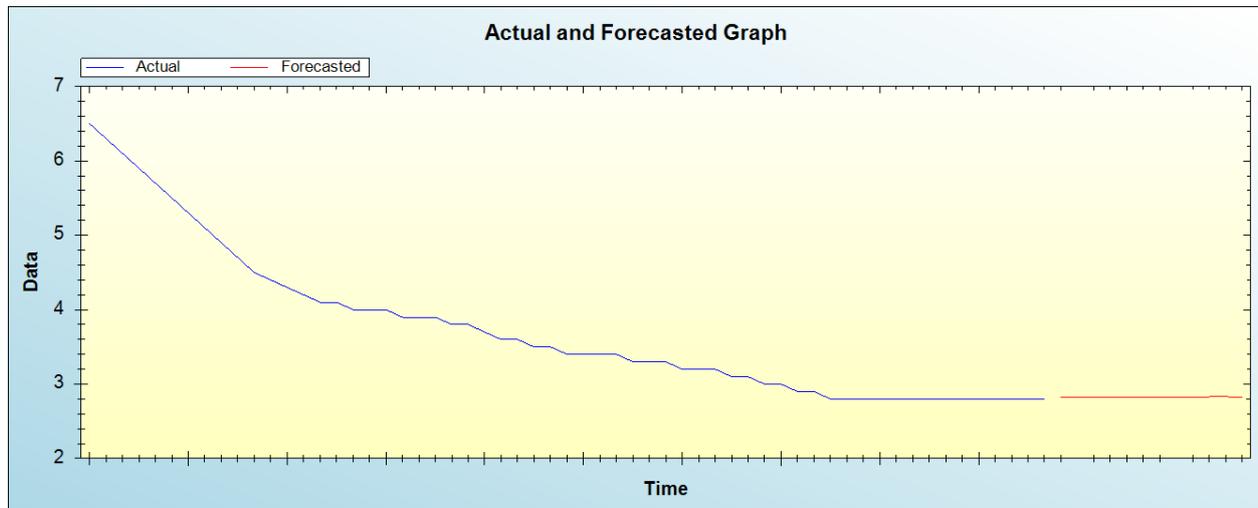*Out-of-Sample Forecast for TFR: Actual and Forecasted Graph*

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

Out-of-Sample Forecast for TFR: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Forecasted
2019	2.8290
2020	2.8258
2021	2.8222
2022	2.8229
2023	2.8228
2024	2.8231
2025	2.8279
2026	2.8276
2027	2.8281
2028	2.8302
2029	2.8312
2030	2.8257

The main results of the study are shown in table 2. 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 Fiji are likely to be almost constant over the out-of-sample period.

V. CONCLUSIONS AND RECOMMENDATIONS

The results show that TRFs for Fiji is almost constant at 2.8 live births per woman, which is above the replacement fertility rate of 2.1 as per United Nations. This implies that Fiji's population is expected to continue growing until 2030 ceteris paribus. Fiji authorities might need to come up with policies aimed at influencing population growth and for sustainable use of resources otherwise resources might continue to be insufficient to take care of the growing population.

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