

Forecasting Future Trends of Adolescent Fertility for Nepal Using Holt's Linear Method

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Abstract - This study uses annual time series data of adolescent fertility rate for Nepal from 1960 to 2020 to predict future trends of adolescent fertility rate over the period 2021 to 2030. The study utilizes Holt's linear exponential smoothing model. The optimal values of smoothing constants α and β are 0.9 and 0.2 respectively based on minimum MSE. The results of the study indicate that annual adolescent fertility will continue to decline throughout the out of sample period. Therefore, we encourage authorities in Nepal to persistently enforce laws that protect sexual and reproductive health rights of women and girls, promote girl child education, and improve access and quality of adolescent health services.

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

The entire world is currently witnessing adverse maternal and child health outcomes as a result of adolescent pregnancies (WHO, 2020; Darroch *et al.* 2015; UNFPA, 2015; UNFPA, 2013). Developing countries report the highest pregnancy rates among teenagers and this is consistent with the high morbidity and mortality among adolescents and their children being observed in these countries (Kassa *et al.* 2018; Ganchimeg *et al.* 2013; Chen *et al.* 2010; Chen *et al.* 2007; Canbas *et al.* 2005). Each year, an estimated 21 million girls aged 15–19 years living in developing regions become pregnant and approximately 12 million of them give birth (Darroch *et al.* 2016). Around 10 million of these pregnancies are unintended (UNFPA, 2015). At least 777,000 births occur in adolescent girls below 18 years of age (WHO, 2020; CBS, 2015). Moreover, 3.9 million unsafe abortions among girls aged 15–19 years occur each year, contributing to maternal mortality, morbidity and far reaching health consequences (WHO, 2020; Bajracharya, 2020).

South Asian countries including Nepal have high rates of teenage pregnancies because early marriage is common and there is a social expectation to have a child soon after marriage (Stone *et al.* 2003). Within South Asia, teenage pregnancy rate is highest in Bangladesh (35%) followed by Nepal (21%) and India (21%) (Stone *et al.* 2003). The United Nations revealed that adolescents in Nepal represent 24 percent of the country's total population. The Nepal 2016 demographic health survey (Nepal DHS-2016) reported that forty percent of women aged 20–24 years were married before the age of 18 years and seven percent were remarried before the age of 15 years. The adolescent birth rate is 88 per 1000 women, with 17 percent of adolescent girls aged 15–19 years already mothers of at least one child. The survey also highlighted that 15 percent of married adolescent girls use modern contraceptive methods and 35 percent have an unmet need for modern family planning methods. In addition, seventeen percent of adolescents aged 15-19 are already mothers or pregnant with their first child. There is a geographic variation in adolescent pregnancies with rural areas reporting higher fertility (22%) than in urban areas (13%). By province, teenage pregnancy ranges from 10% in Province 3 to 27% in Province 7. The percentage of teenagers who have started childbearing increases rapidly with age, ranging from 1% in 15 years old to 39% in 19 years old. According to the 2010–11 Nepal Adolescent and Youth Survey, approximately 33 percent of sexually active adolescent males, both married and unmarried, used a condom at last sex. Use of modern methods of contraception has remained constant in the last 10 years, and currently married adolescent girls have the highest unmet need for family planning of any age group. Several previous studies in Nepal reported that pregnancy among adolescents is associated with poverty, social status, ethnicity, and employment status (Koirala *et al.* 2021; Bajracharya, 2020; Gurung *et al.* 2020; Pradhan *et al.* 2018).

This paper applies the double exponential smoothing technique to model and forecast future trends of adolescent fertility in Nepal. The findings are expected to highlight the future burden of adolescent births in the country. This will guide policy, planning and allocation of resources to activities that reduce teenage pregnancies and early child marriages.

II.METHODOLOGY

This study utilizes an exponential smoothing technique to model and forecast future trends of adolescent fertility rate in Nepal. In exponential smoothing forecasts are generated from the smoothed original series with the most recent historical values having more influence than those in the more distant past as more recent values are allocated more weights than those in the distant past. This study uses the Holt's linear method (Double exponential smoothing) because it is an appropriate technique for modeling linear data.

Holt's linear method is specified as follows:

Model equation

$$E_t = \mu_t + \rho_t t + \varepsilon_t$$

Smoothing equation

$$L_t = \alpha E_t + (1-\alpha)(L_{t-1} + b_{t-1})$$

$$0 < \alpha < 1$$

Trend estimation equation

$$b_t = \beta (L_t - L_{t-1}) + (1-\beta)b_{t-1}$$

$$0 < \beta < 1$$

Forecasting equation

$$f_{t+h} = L_t + hb_t$$

E_t is the actual value of adolescent fertility rate at time t

ε_t is the time varying **error term**

μ_t is the time varying mean (**level**) term

ρ_t is the time varying **slope term**

t is the trend component of the time series

L_t is the exponentially smoothed value of adolescent fertility rate at time t

α is the exponential smoothing constant for the data

β is the smoothing constant for trend

f_{t+h} is the h step ahead forecast

b_t is the trend estimate at time t

b_{t-1} is the trend estimate at time t-1

Data Issues

This study is based on annual adolescent fertility rate in Nepal for the period 1960 – 2020. The out-of-sample forecast covers the period 2021 – 2030. All the data employed in this research paper was gathered from the World Bank online database.

III. FINDINGS OF THE STUDY

Exponential smoothing Model Summary

Table 1: ES model summary

Variable	E
Included Observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.200
Forecast performance measures	
Mean Absolute Error (MAE)	1.250651
Sum Square Error (SSE)	533.038708
Mean Square Error (MSE)	8.738339
Mean Percentage Error (MPE)	0.039282
Mean Absolute Percentage Error (MAPE)	1.103896

Residual Analysis for the Applied Model

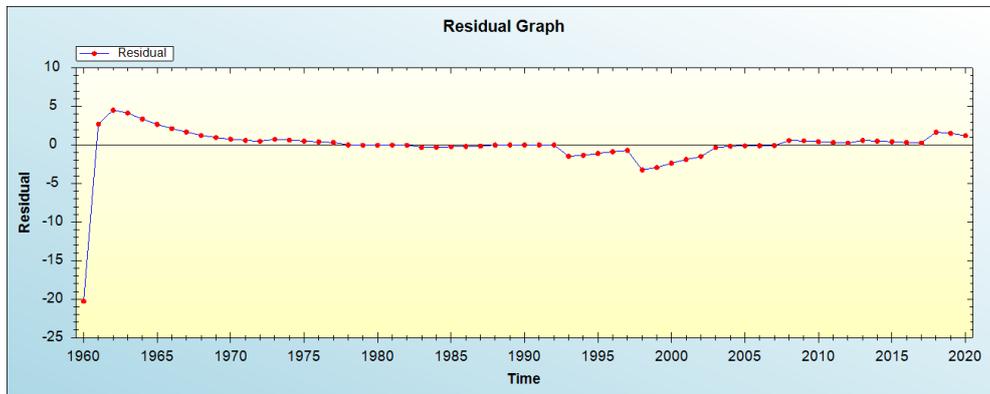


Figure 1: Residual analysis

In-sample Forecast for E

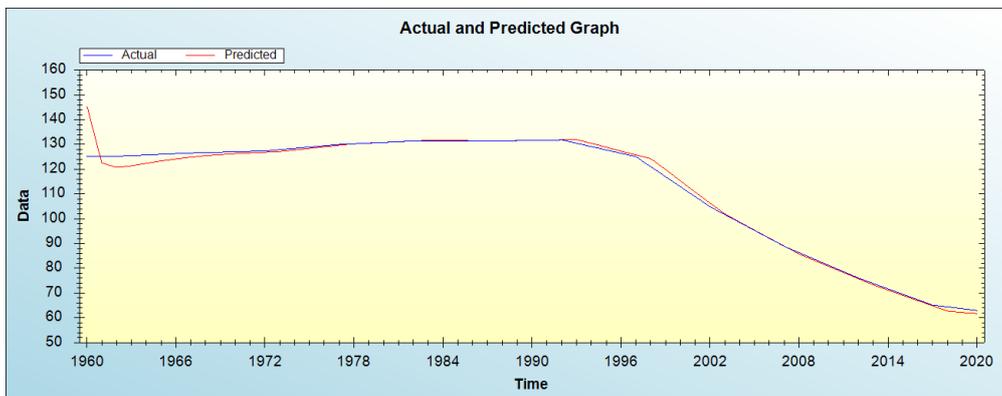


Figure 2: In-sample forecast for the E series

Actual and Smoothed graph for E series

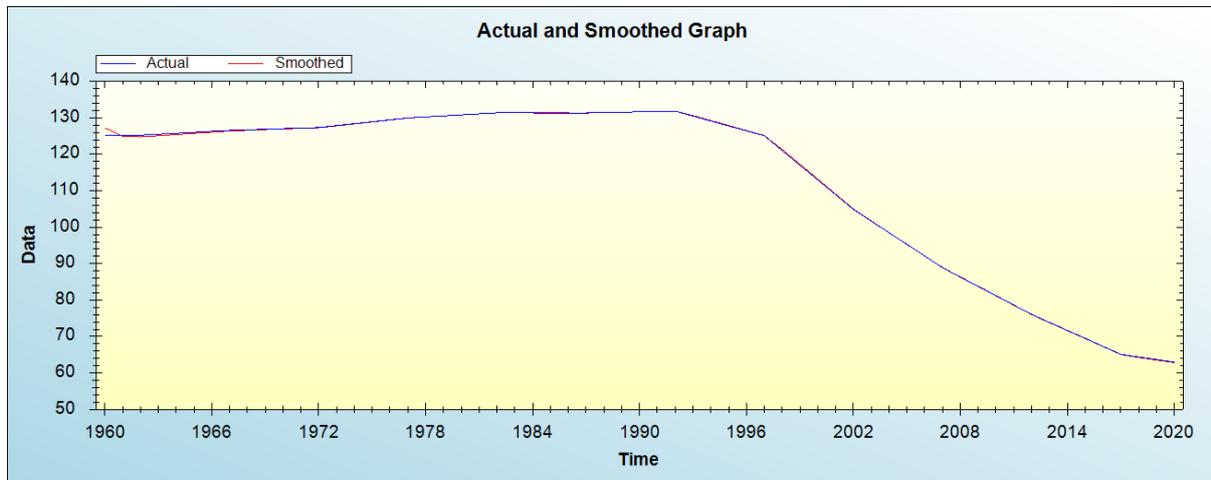


Figure 3: Actual and smoothed graph for E series

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

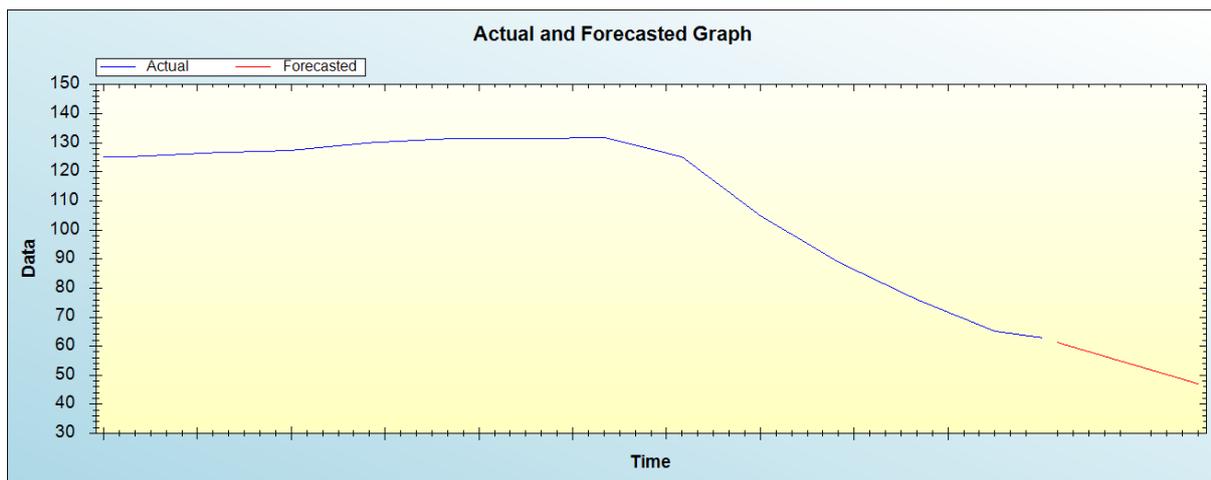


Figure 4: Out-of-sample forecast for E: actual and forecasted graph

Out-of-Sample Forecast for E: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	61.2550
2022	59.6778
2023	58.1006
2024	56.5233
2025	54.9461
2026	53.3689
2027	51.7917
2028	50.2145
2029	48.6373
2030	47.0601

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 adolescent fertility rate will continue to decline throughout the out of sample period.

IV. POLICY IMPLICATION & CONCLUSION

South Asian countries including Nepal have high rates of teenage pregnancies because early marriage is common and there is a social expectation to have a child soon after marriage. Within South Asia, teenage pregnancy rate is highest in Bangladesh followed by Nepal and India. Teenage pregnancies in Nepal can be attributed to social norms, poverty, social status, ethnicity, and employment status. Adolescent fertility steadily declined during the previous 2 decades due to increase in age at marriage, family planning services and awareness programs. This study applied the double exponential smoothing technique to forecast future trends of adolescent fertility for Nepal. The results of the study indicated that adolescent fertility will continue to decline throughout the out of sample period. Therefore, we encourage the government to persistently enforce laws that protect sexual and reproductive health rights of women and girls, promote girl child education, and improve access and quality of adolescent health services.

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Citation of this Article:

Smartson. P. NYONI, Thabani NYONI, “Forecasting Future Trends of Adolescent Fertility for Nepal Using Holt’s Linear Method” Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 7, Issue 2, pp 252-257, February 2023. Article DOI <https://doi.org/10.47001/IRJIET/2022.702041>
