

Adolescent Fertility Forecasting for Sudan Using Holt’s Double Exponential Smoothing Technique

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Abstract - This research article uses annual time series data of adolescent fertility rate for Sudan 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 0.8 respectively based on minimum MSE. The results of the study indicate that annual adolescent fertility will continue to drop and reach levels below 25 births per 1000 women aged 15-19 years by the end of 2030. Therefore, we encourage authorities in Sudan to persistently enforce laws that safeguard sexual and reproductive health rights of women and girls, promote girl child education and scale up awareness campaigns through various media platforms.

Keywords: Exponential smoothing, Forecasting, adolescent fertility rate.

I. INTRODUCTION

The 1994 International Conference on population and development held in the Egyptian Capital, Cairo, made its declaration and pledged to uphold sexual and reproductive health and rights as fundamental human rights (UN, 1995). The recognition of sexual and reproductive health rights of every individual particularly for adolescent girls and women was a significant step towards addressing gender imbalances and empowering women. The Agenda 2030 for sustainable development attended by all UN member states agreed on a clear action plan to address health problems, gender imbalances and ending child marriages especially in low-middle income counties (UN, 2020; UNICEF, 2019, WHO, 2019; UNICEF, 2018; UN, 2016; UN, 2015). The 3rd sustainable development goal focuses on ensuring good health for all at all stages of life. Target 3.1 and 3.2 are specifically designed to reduce maternal mortality to less than 70 deaths per 100 000 live births and under five mortality to at least 25 deaths per 1000 live births by 2030. The 4th SDG focuses on ensuring inclusive and equitable quality education and promote lifelong learning opportunities. By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes (UN, 2016; UN, 2015). Under the 5th sustainable development goal, the aim is to achieve gender equality and empower all women and girls. Target 5.3 aims to eliminate all harmful practices, such as child, early and forced marriage and female genital mutilation. It is therefore clear that curbing child marriage and teenage pregnancy will help in the reduction of adverse maternal and child health outcomes. On the other hand, promoting girl child education and women empowerment is critical in delaying the age at marriage and encouraging female labor participation.

In this study we propose Holt’s double exponential smoothing technique to predict future trends of adolescent fertility in Sudan. The findings are expected to depict the future burden of adolescent births and guide policy formulation and implementation to end child marriages in the country.

II. LITERATURE REVIEW

Author(s)	Topic	Objectives	Methodology	Main Findings
Gawar (2021)	What can be done about adolescent pregnancy in What can be done about adolescent pregnancy in South Sudan?	To identify the contributory factors for adolescent pregnancy in South Sudan, the effects of these pregnancies and describes some solutions and	Systematic review	The contributory factors for adolescent pregnancy in South Sudan are sociocultural where the need for dowries, forced and arranged marriages,

		recommendations		gender based violence are examples, economic and political factors
Ahinkorah et al. (2021)	Prevalence of first adolescent pregnancy and its associated factors in sub-Saharan Africa: A multi-country analysis	to determine the prevalence of first adolescent pregnancy and its associated factors in sub-Saharan Africa	A secondary analysis of cross-sectional data from Demographic and Health Surveys conducted in 32 sub-Saharan African countries between 2010 and 20	Among all adolescents, Congo experienced the highest prevalence of first adolescent pregnancy (44.3%) and Rwanda the lowest (7.2%). The odds of first adolescent pregnancy was higher with increasing age, working, being married/cohabiting, having primary education only, early sexual initiation, knowledge of contraceptives, no unmet need for contraception and poorest wealth quintile.
Gunawardena et al. (2019)	Predictors of pregnancy among young people in sub-Saharan Africa: a systematic review and narrative synthesis	To systematically review predictors of pregnancy among young people in sub-Saharan Africa.	Systematic review	The most obvious predictors included sexual coercion and pressure from male partners, low or incorrect use of contraceptives, and poor parenting or low parental communication and support
Kane et al. (2019)	‘You have a child who will call you “mama”’: understanding adolescent pregnancy in South Sudan	To give a critical account of adolescent South Sudanese girls’ reasons for and explanations of childbearing	Analytical study	Bearing a child and making one’s ‘own home’ was seen as a way to exit into the world of adults, and as a strategy towards achieving security and stability.
Yakubu & Salisu (2018)	Determinants of adolescent pregnancy in sub-	to identify factors influencing adolescent	Systematic review	High levels of adolescent pregnancies in Sub-

	Saharan Africa: a systematic review	pregnancies in sub-Saharan Africa in order to design appropriate intervention program		Saharan Africa is attributable to multiple factors. The study, however, categorized these factors into three major themes; sociocultural and economic, individual, and health service related factors as influencing adolescent pregnancies
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III. METHODOLOGY

This study utilizes an exponential smoothing technique to model and forecast future trends of adolescent fertility rate in Sudan. 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

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

Smoothing equation

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

$$0 < \alpha < 1$$

Trend estimation equation

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

$$0 < \beta < 1$$

Forecasting equation

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

K_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 period t-1

Data Issues

This study is based on annual adolescent fertility rate in Sudan 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.

IV. FINDINGS OF THE STUDY

Exponential smoothing Model Summary

Table 1: ES model summary

Variable	K
Included observations	61
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.800
Forecast performance measures	
Mean Absolute Error (MAE)	0.869661
Sum Square Error (SSE)	202.113145
Mean Square Error (MSE)	3.313330
Mean Percentage Error (MPE)	0.004179
Mean Absolute Percentage Error (MAPE)	0.725938

Residual Analysis for the Applied Model

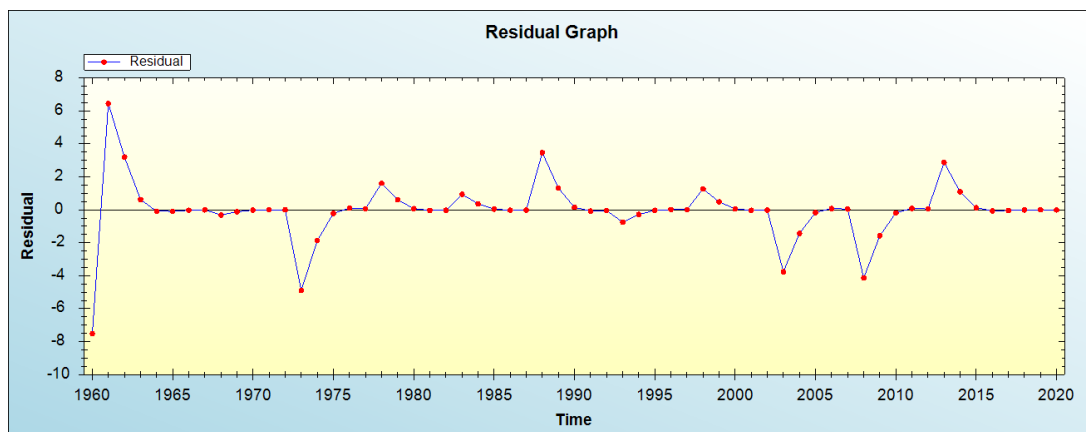


Figure 1: Residual analysis

In-sample Forecast for K

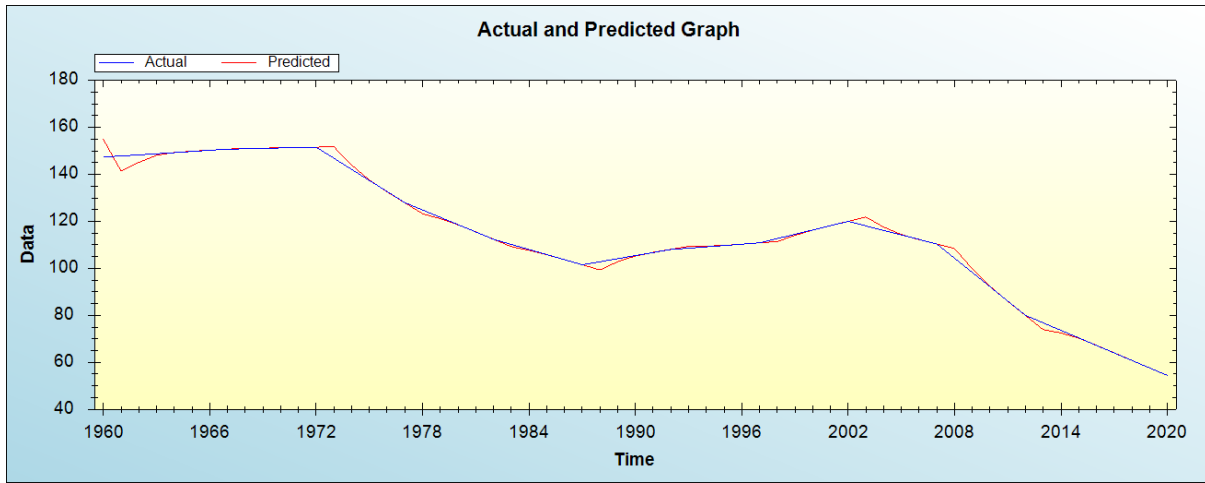


Figure 2: In-sample forecast for the K series

Actual and Smoothed graph for K series

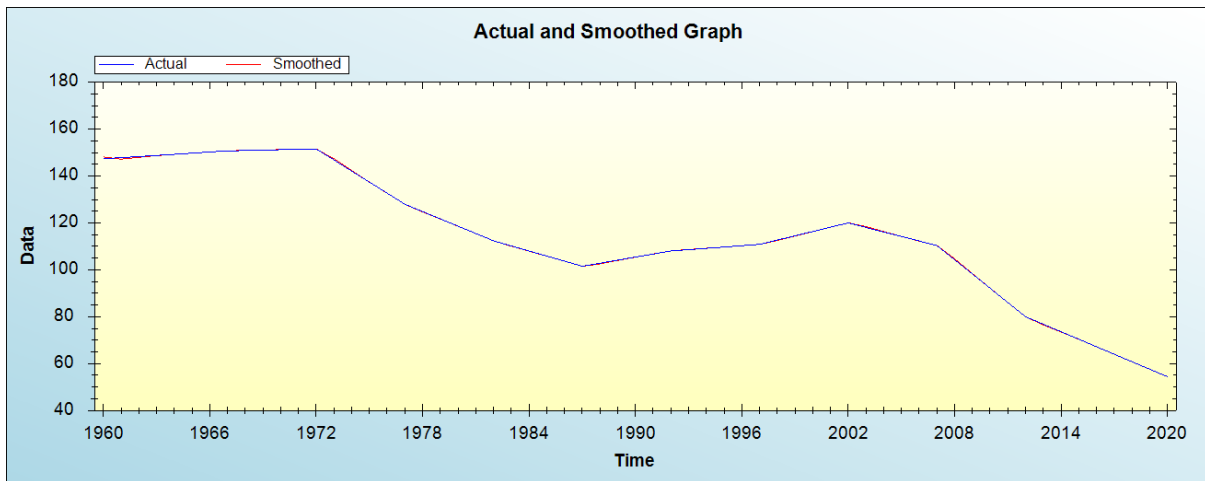


Figure 3: Actual and smoothed graph for K series

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

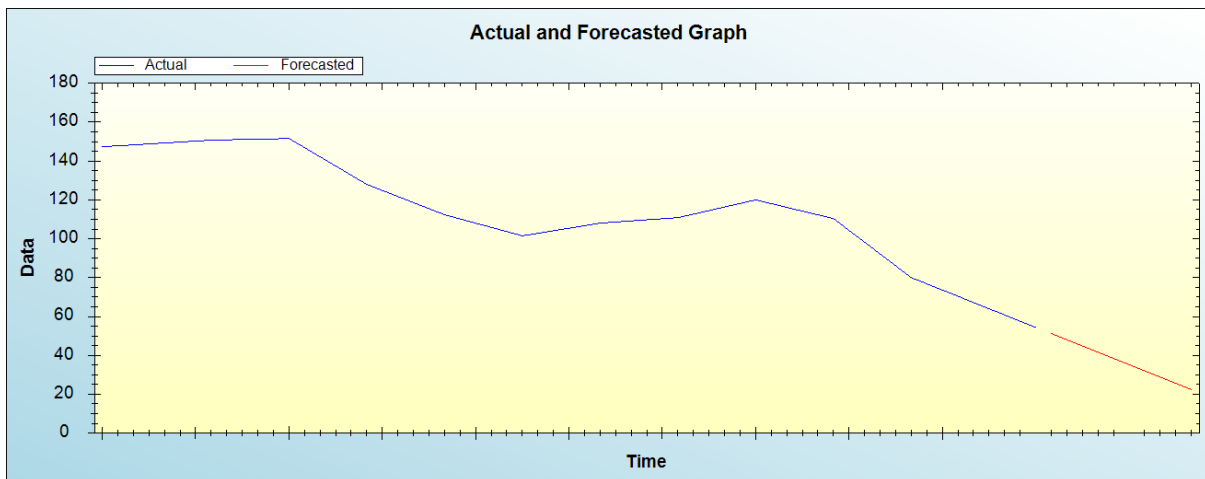


Figure 4: Out-of-sample forecast for K: actual and forecasted graph

Out-of-Sample Forecast for K: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted adolescent fertility rate
2021	51.2048
2022	48.0077
2023	44.8107
2024	41.6136
2025	38.4166
2026	35.2195
2027	32.0224
2028	28.8254
2029	25.6283
2030	22.4313

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 and reach levels below 25 births per 1000 women aged 15-19 years by the end of 2030.

V. POLICY IMPLICATION & CONCLUSION

Adolescent fertility in Sudan has been declining steadily during the previous decades as a result of multiple strategies implemented by the Sudanese government which includes ensuring availability of family planning services at all levels of healthcare. Factors such as poverty, low education level, peer pressure, social norms and inconsistent use of contraceptive methods are among the leading causes of teenage pregnancy. This study applied the double exponential smoothing technique to forecast future trends of adolescent fertility for Sudan. Study findings revealed that adolescent fertility will continue to decline and reach levels below 25 births per 1000 women aged 15-19 years by the end of 2030. Therefore, we implore the Sudanese government to persistently enforce laws that safeguard sexual and reproductive health rights of women and girls, promote girl child education and scale up awareness campaigns among communities through various media platforms.

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