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OPEN DEFECATION IN BURKINA FASO: A BOX-JENKINS ARIMA APPROACH

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ABSTRACT:

Employing annual time series data on the number of people who practice open defecation in Burkina Faso from 2000 – 2017, the study predicts the annual number of people who will still be practicing open defecation over the period 2018 – 2022. The study applies the Box-Jenkins ARIMA method. The diagnostic ADF tests show that the series under consideration is an I (1) variable. Based on the AIC, the study presents the ARIMA (2, 1, 0) model as the optimal model. The diagnostic tests further reveal that the presented model is very stable and its residuals are not only stationary in levels but also normally distributed. The results of the study indicate that the number of people practicing open defecation in Burkina Faso is still very high although it is likely to decline over the period 2018 – 2022, from 44.81% to 39.28% of the total population. The study suggested the following: [i] the government of Burkina Faso should continue to make toilets a status symbol so that people consider toilets to be "rooms of happiness". [ii] the government of Burkina Faso should create more demand for sanitation. There is need for the government of Burkina Faso to effectively deliver Water Supply and Sanitation programs at all levels. This can only happen if there is peace and security in the country. Political instability, has, over the years, delayed progress towards total sanitation and hygiene in Burkina Faso. [iii] there is need for the government of Burkina Faso to encourage a habit of systematic hand-washing, and not defecating in the open.

INTRODUCTION:

Sanitation coverage in Burkina Faso is amongst the lowest in the world. The access rate to improved sanitation is generally around 18% in urban areas and 15% in rural areas. The traditional pit latrine is common in the urban areas while open defecation is a widespread practice in rural areas (Klutse et al., 2010). Open defecation has terrible consequences for health (UNICEF, 2018), particularly, in terms of the spread of bacterial, viral and parasitic infections including diarrhoea, polio, cholera, soil-transmitted helminth, trachoma infection, schistosomiasis and hookworm and is also an important cause of child stunting (Megersa et al., 2019) and deaths (Thiga & Cholo, 2017). Therefore, it has become instructive for public health researchers and policy makers to model and forecast the number of people practicing open defecation in order to formulate policies to end open defecation. The main purpose of this study is to model and forecast the number of people practicing open defecation in Burkina Faso. This study will go a long way in examining the possibility of ending open defecation in Burkina Faso.

LITERATURE REVIEW:

Klutse et al. (2010) compared the capital expenditure and the operational and maintenance expenditure for sanitation facilities in rural and peri-urban areas in Burkina Faso and basically found that the pit latrine is not promoted in Burkina Faso, but it is the toilet used by the vast majority of those who have access to one. In Ghana, Alhassan & Anyarayor (2018) looked at the adoption of sanitation innovations introduced in Nadowli-Kaleo district in Upper West region of Ghana as part of the efforts to attain Open Defecation Free (ODF) status. Interviews were employed to collect data. The study revealed that while effective communication of innovation resulted in widespread awareness, low income levels significantly accounted for households' inability to sustain and utilize latrines. Nyoni (2019) forecasted total population in India using the Box-Jenkins ARIMA technique based on annual time series data on total population in India from 1960 to 2017. The study presented the ARIMA (1, 2, 3) model and concluded 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. Similarly, total population is also increasing in Burkina Faso and without proper sanitation and hygiene (in the midst of open defecation), that would be a time bomb in terms of disease transmission, especially cholera and faecal-related diseases. This study will adopt the ARIMA method in analyzing open defecation trends in Burkina Faso and is apparently the first of its kind in the country.

METHODODOLOGY:

3.1 The Box – Jenkins (1970) Methodology:

The first step towards model selection is to difference the series in order to achieve stationarity. Once this process is over, the researcher will then examine the correlogram in order to decide on the appropriate orders of the AR and MA components. It is important to highlight the fact that this procedure (of choosing the AR and MA components) is biased towards the use of personal judgement because there are no clear – cut rules on how to decide on the appropriate AR and MA components. Therefore, experience plays a pivotal role in this regard. The next step is the estimation of the tentative model, after which diagnostic testing shall follow. Diagnostic checking is usually done by generating the set of residuals and testing whether they satisfy the characteristics of a white noise process. If not, there would be need for model re – specification and repetition of the same process; this time from the second stage. The process may go on and on until an appropriate model is identified (Nyoni, 2018c). This approach will be used to analyze the ODF series under consideration.

3.2 The Moving Average (MA) model:

Given:

$$ODF_t = \sum_{i=1}^{q} \alpha_i \mu_{t-i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [1]$$

where μ_t is a purely random process with mean zero and varience σ^2. Equation [1] is reffered to as a Moving Average (MA) process of order q, usually denoted as MA (q). ODF is the annual number of people (as a percentage of the total population) who practice open defecation at time t, $\alpha_0 \ldots \alpha_q$ are estimation parameters, μ_t is the current error term while $\mu_{t-1} \ldots \mu_{t-q}$ are previous error terms.

3.3 The Autoregressive (AR) model:

Given:

$$ODF_t = \sum_{i=1}^{p} \beta_i ODF_{t-1} + \mu_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [2]$$

Where $\beta_1 \ldots \beta_p$ are estimation parameters, $ODF_{t-1} \ldots ODF_{t-p}$ are previous period values of the ODF series and μ_t is as previously defined. Equation [2] is an Autoregressive (AR) process of order p, and is usually denoted as AR (p).

3.4 The Autoregressive Moving Average (ARMA) model:

An ARMA (p, q) process is just a combination of AR (p) and MA (q) processes. Thus, by combining equations [1] and [2]; an

ARMA (p, q) process may be specified as shown below:

$$ODF_t = \sum_{i=1}^{p} \beta_i ODF_{t-i} + \sum_{i=1}^{q} \alpha_i \mu_{t-i} + \mu_t \ldots \ldots \ldots [3]$$

3.5 The Autoregressive Integrated Moving Average (ARIMA) model:

A stochastic process ODF_t is referred to as an Autoregressive Integrated Moving Average (ARIMA) [p, d, q] process if it is integrated of order "d" [I (d)] and the "d" times differenced process has an ARMA (p, q) representation. If the sequence $\Delta^d ODF_t$ satisfies an ARMA (p, q) process; then the sequence of ODF_t also satisfies the ARIMA (p, d, q) process such that:

$$\Delta^d ODF_t = \sum_{i=1}^{p} \beta_i \Delta^d ODF_{t-i} + \sum_{i=1}^{q} \alpha_i \mu_{t-i} + \mu_t \ldots \ldots \ldots [4]$$

where Δ is the difference operator, vector $\beta \in \mathbb{R}^p$ and $\alpha \in \mathbb{R}^q$.

3.6 Data Collection:

This study is based on annual observations (that is, from 2000 – 2017) on the number of people practicing Open Defecation [OD, denoted ODF] (as a percentage of total population) in Burkina Faso. Out-of-sample forecasts will cover the period 2018 – 2022. All the data was gathered from the World Bank online database.

3.7 Diagnostic Tests & Model Evaluation:

3.7.1 Stationarity Tests: Graphical Analysis:

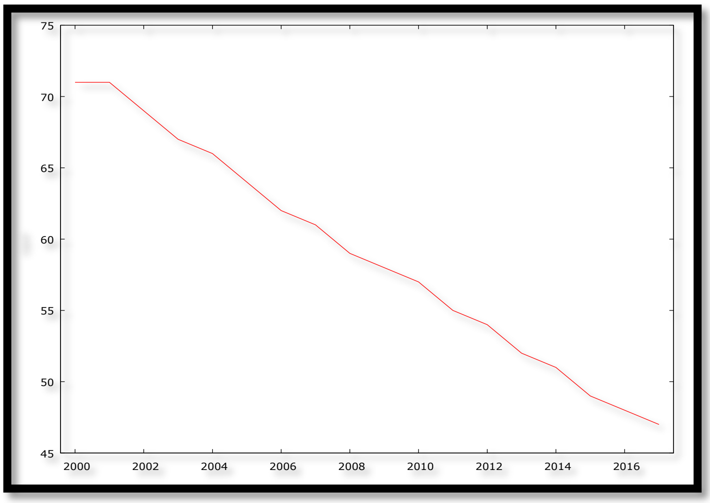

Figure 1

3.7.2 The Correlogram in Levels:

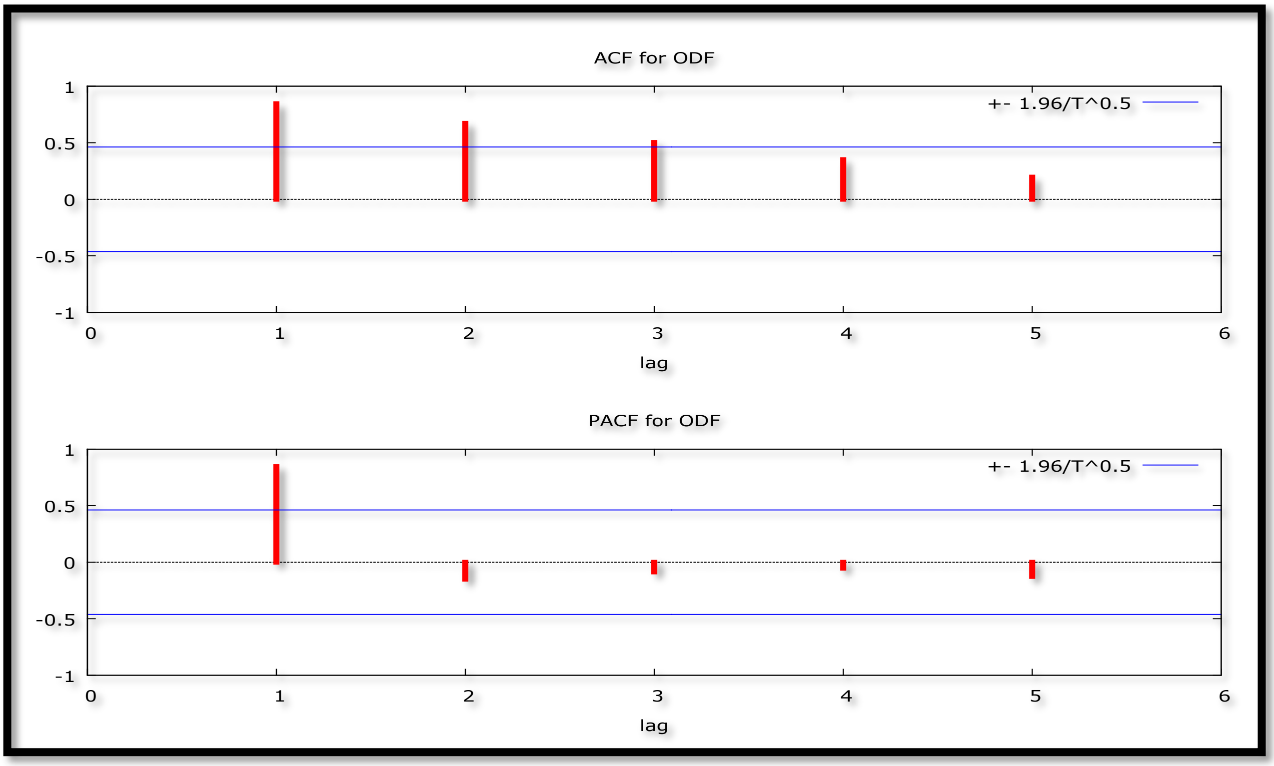

Figure 2: Correlogram in Levels

3.7.3 The ADF Test in Levels:

Table 1: with intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
ODF	-2.251387	0.1982	-3.959148	@1%	Non-stationary
			-3.081002	@5%	Non-stationary
			-2.681330	@10%	Non-stationary

Table 2: with intercept and trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
ODF	-3.794441	0.0432	-4.616209	@1%	Non-stationary
			-3.710482	@5%	Stationary
			-3.297799	@10%	Stationary

Tables 1 and 2 show that ODF is not stationary in levels as already suggested by figures 1 and 2.

3.7.4 The Correlogram (at First Differences):

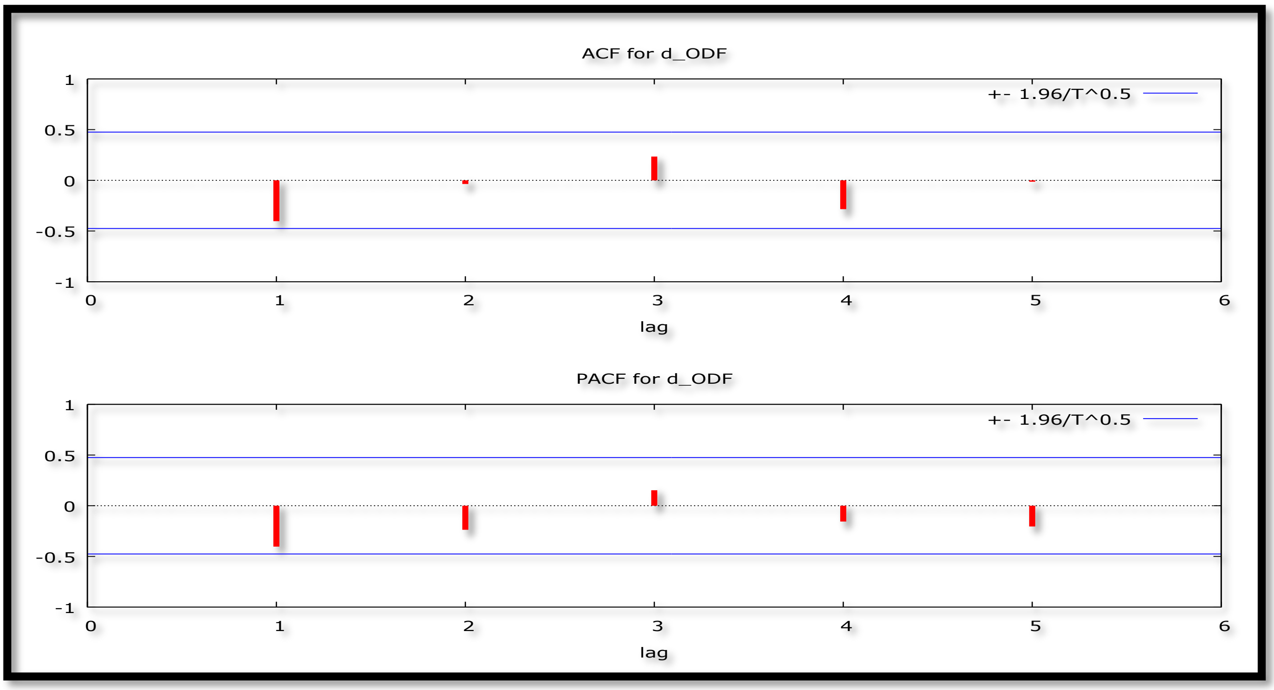

Figure 3: Correlogram (at First Differences)

3.7.5 The ADF Test (at First Differences):

Table 3: with intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
ΔODF	-7.546729	0.0000	-3.920350	@1%	Stationary
			-3.065585	@5%	Stationary
			-2.673459	@10%	Stationary

Table 4: with intercept and trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
ΔODF	-7.760920	0.0001	-4.667883	@1%	Non-stationary
			-3.733200	@5%	Non-stationary
			-3.310349	@10%	Stationary

Figure 3 as well as tables 3 and 4, indicate that ODF is an I (1) variable.

3.7.6 Evaluation of ARIMA models (with a constant):

Table 5: Evaluation of ARIMA Models (with a constant)

Model	AIC	U	ME	MAE	RMSE	MAPE
ARIMA (1, 1, 0)	32.13691	0.28069	0.050674	0.418883	0.55608	0.70103
ARIMA (2, 1, 0)	**30.38341**	0.26105	0.083349	0.43088	0.52698	0.73301
ARIMA (3, 1, 0)	31.14213	0.25557	0.083258	0.40967	0.51985	0.69682

A model with a lower AIC value is better than the one with a higher AIC value (Nyoni, 2018b) Similarly, the U statistic can be used to find a better model in the sense that it must lie between 0 and 1, of which the closer it is to 0, the better the forecast method (Nyoni, 2018a). In this research paper, only the AIC is used to select the optimal model. Therefore, the ARIMA (2, 1, 0) model is finally selected.

3.8 Residual & Stability Tests:

3.8.1 Correlogram of the Residuals of the ARIMA (2, 1, 0) Model:

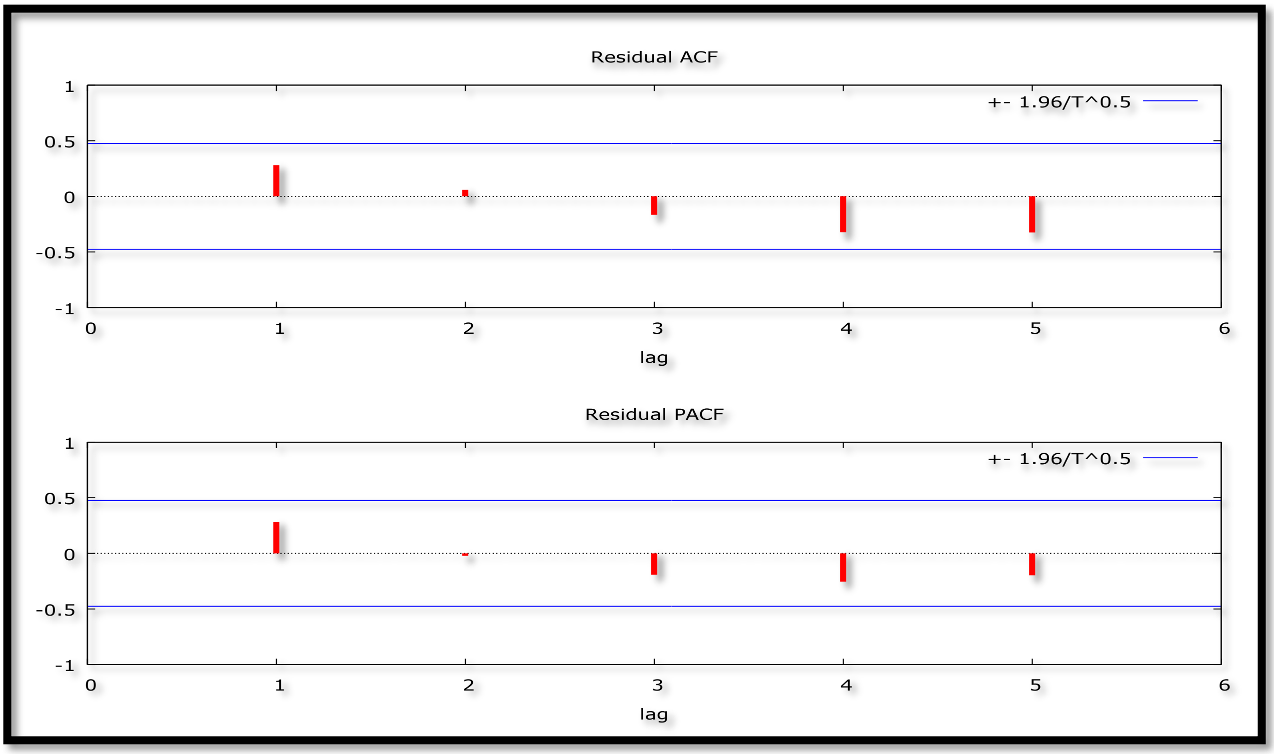

Figure 4: Correlogram of the Residuals

Figure 4 indicates that the estimated model is adequate because ACF and PACF lags are quite short and within the bands. This apparently implies that the “no autocorrelation” assumption is not violated in this study.

3.8.2 Normality Test of the Residuals of the ARIMA (2, 1, 0) Model:

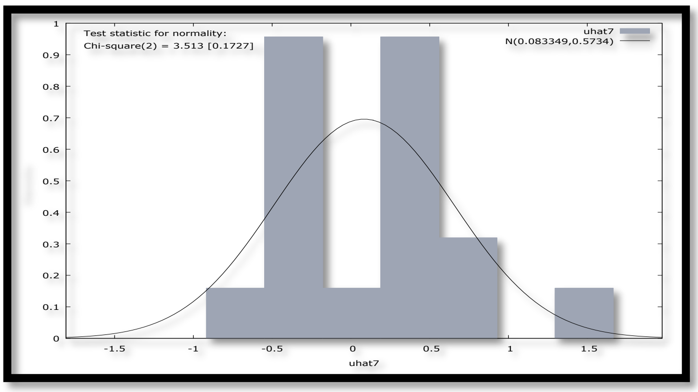

Figure 5: Normality Test

Figure 5 indicates that the residuals of the applied model are normally distributed as shown by the p-value of the Chi-square statistic which is statistically insignificant. Hence, the model is stable and suitable for forecasting the number of people practicing open defecation in Burkina Faso. This is consistent with figure 4 above and figure 5 below.

3.8.3 Stability Test of the ARIMA (2, 1, 0) Model:

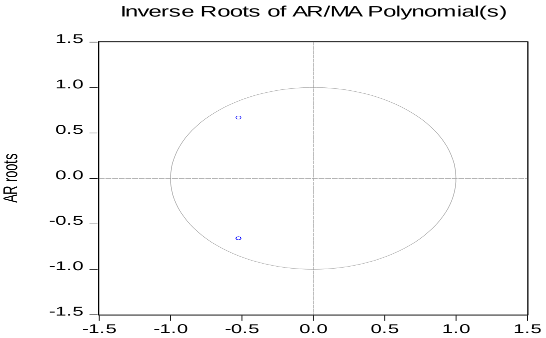

Figure 6: Inverse Roots

Since all the AR roots lie inside the unit circle, it implies that the estimated ARIMA process is (covariance) stationary; thus confirming that the ARIMA (2, 1, 0) model is really stable and suitable for forecasting annual number of people practicing open defecation in Burkina Faso.

FINDINGS:

4.1 Descriptive Statistics:

Table 6: Descriptive Statistics

Description	Statistic
Mean	58.944
Median	58.5
Minimum	47
Maximum	71

As shown in table 6 above, the mean is positive, that is, 58.944. This means that, over the study period, the annual average number of people practicing open defecation in Burkina Faso is approximately 59% of the total population. This is a warning alarm for policy makers in Burkina Faso with regards to the need to promote an open defecation free society. The minimum number of people practicing open defecation in Burkina Faso over the study period is approximately 47% of the total population, while the maximum is 71% of the total population. However, the number of people practicing open defecation in Burkina Faso has continued to decline over the years from 71% in 2000 to 47% of the total population in 2017.

4.2 Results Presentation:

Table 7: Main Results

ARIMA (2, 1, 0) Model:

Guided by equation [4], the chosen optimal model, the ARIMA (2, 1, 0) model can be expressed as follows:

$$\Delta ODF_t = -1.48018 - 0.926666\Delta ODF_{t-1} - 0.559702\Delta ODF_{t-2} \ldots\ldots\ldots\ldots\ldots\ldots [5]$$

Variable	Coefficient	Standard Error	z	p-value
constant	-1.48018	0.0460453	-32.15	0.0000***
β_1	-0.926666	0.265257	-3.493	0.0005***
β_2	-0.559702	0.233105	-2.401	0.0163**

Table 7 shows the main results of the ARIMA (2, 1, 0) model.

Forecast Graph

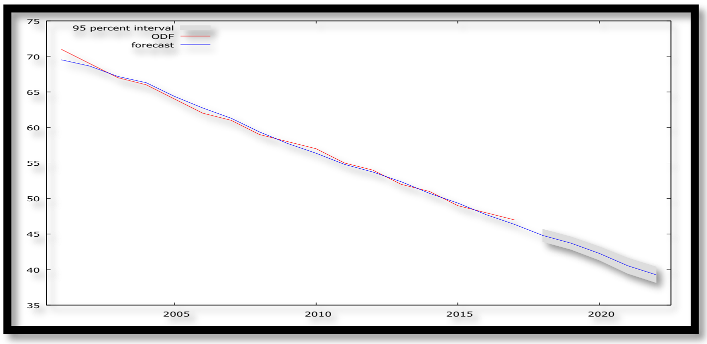

Figure 7: Forecast Graph – In & Out-of-Sample Forecasts

Figure 7 shows the in-and-out-of-sample forecasts of the ODF series. The out-of-sample forecasts cover the period 2018 – 2022.

Predicted ODF – Out-of-Sample Forecasts Only

Table 8: Predicted ODF

Year	Predicted ODF	Standard Error	Lower Limit	Upper Limit
2018	44.81	0.451	43.92	45.69
2019	43.72	0.453	42.83	44.61
2020	42.27	0.483	41.33	43.22
2021	40.54	0.557	39.45	41.63
2022	39.28	0.566	38.17	40.38

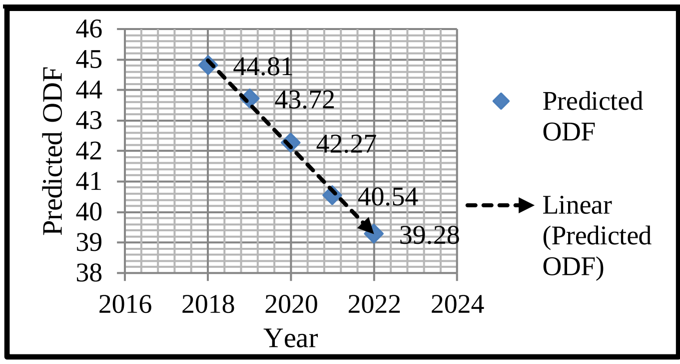

Figure 8: Graphical Analysis of Out-of-Sample Forecasts

Table 8 and figure 8 show the out-of-sample forecasts only. The number of people practicing open defecation in Burkina Faso is projected to fall from approximately 45% in 2018 to 39% of the total population by the year 2022. Open defecation is still very high in Burkina Faso and the government, through the relevant ministries, has a big role to play in order to promote an open defecation free society in Burkina Faso.

4.3 Policy Implications:

i. The government of Burkina Faso should continue to make toilets a status symbol so that people consider toilets to be "rooms of happiness".

ii. The government of Burkina Faso should create more demand for sanitation. There is need for the government of Burkina Faso to effectively deliver Water Supply and Sanitation programs at all levels. This can only happen if there is peace and security in the country. Political instability, has, over the years, delayed progress towards total sanitation and hygiene in Burkina Faso.

iii. There is need for the government of Burkina Faso to encourage a habit of systematic hand-washing, and not defecating in the open.

CONCLUSION:

The study shows that the ARIMA (2, 1, 0) model is not only stable but also the most suitable model to forecast the annual number of people practicing open defecation in Burkina Faso over the period 2018 – 2022. The model predicts a decrease in the annual number of people practicing open defecation in Burkina Faso. These results are paramount for the government of Burkina Faso, especially for future planning with regards to materializing the much needed open defecation free society.

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