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FORECASTING PORTABLE WATER SUPPLY IN IBADAN METROPOLITAN USING AUTOREGRESSIVE INTEGRATED MOVING AVERAGE MODEL

Semiu Ayinla Alayande

Research Scholar, Department of Mathematical Sciences, College of Natural Sciences, Redeemer's University, Ede, Osun, Nigeria

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ABSTRACT

The issue of supplying water that meets the demand of the population is a major problem in Ibadan city, a metropolitan town in Oyo state. Because of the fact that the supply of water by the state government does not meet the needs of the growing population. The sources of water include surface water and underground water. The surface water comes from asejire and eleyele dam, while the underground water is from boreholes. Most people have resolved to digging boreholes in their homes or buying water from water vendors in serious water crisis since the water supplied by the water works are either not available for use or not use suitable for consumption. This contributes to high cost of living and exposure to unsafe water. the result of the analysis, using the developed ARIMA model showed that water supply is set to fall, although not speedily from 34.965mgd on average from December 2019 to December 2022. This shows that adequate measures should be taken to increase water supply.

KEYWORDS: *Water, ARIMA Models, Stationarity, Augumented Dickey Fuller*

INTRODUCTION

Water is a major necessity for survival as it is used for various purpose by human beings. This includes growing of crops and raising of livestock. Industries need it for production. No human being, plant or animal can survive without it. Reports over the years have indicated that water supply is not always commensurate with demand all over the world. According to World Health Organisation (WHO), only 32% of rural population in developing countries have access to safe or portable drinking water (WHO 2010). Today, a large percentage of population in developing countries still live without adequate access to safe water supply sanitation (Dada, 2009). The daily per capita water consumption varies between 10-27 litres, with an average of 46 litres, which is below the recommended minimum requirement of 115 litres per person per day. This shortfall in water needed is due to difference in availability and supply (UNICEF, 2009). Portable water for consumption is the water fit for drinking, cooking, washing and other purposes. The issue of supplying water that meets the demand of the population is a major problem in Ibadan city, a metropolitan town in Oyo state. Because of the fact that the supply of water by the state government does not meet the needs of the growing population. Organisational bodies have been set to manage this problem of water demand. Yet, inadequate supply still persists in many places in Ibadan city especially the major areas while the water supply has been very limited in some places, others do not get at all. The total water produced to the people in the mini water works at Asejire and Eleyele water dam per day is 210,000m3 per day. Another problem is that the water supply is not even regular.

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Some common factors affecting portable water supply include electricity, demand fr water, price, poor irrigation facilities, population, climatic factors, poor level of service, poor and inadequate monitoring of water related projects and poor quality control.

Ibadan was derived from two words 'Eba Odan' meaning near savannah (Ayoade, 1979). The city is located in southwestern Nigeria between latitudes7^0 00 and 7^0 30' and between longitudes 3^0 30' and 4^0 00'. It is the capital of Oyo State. The city is located at about 127 km northeast of Lagos and 531 km southeast of Abuja. Its elevation ranges from 151 m above sea level (asl) in the valley to 278 m also on the major North- South ridge (Lloyd et al., 1987). Ibadan is located within the undifferentiated basement complex and the rock types consist of quartizes of meta-sedimentary series and migmatites complex consisting of branded gneiss and auger gneiss. Ibadan (Yoruba: Ìbàdàn) is the capital and most populous city of Oyo State, Nigeria. With a population of over 3 million, it is the third most populous city in Nigeria after Lagos and Kano; it is the country's largest city by geographical area. (National bureau of Statistics, 2016). Ibadan is continually growing in human population and this has resulted in continuous increase in water consumption demand. This situation has led to persistent water shortage in the city and its environs.

LITERATURE REVIEW

Lipac and Deligero (2012) conducted a study to examine the trends and forecast of the monthly water consumption in Davao city using statistical forecasting processes such as Autoregressive Integrated Moving Average (ARIMA) models and Multilayer perception Neutral Network (MPNN) models to analyses past data. Haque, Rahman ad Kibra (2013) conducted a study to forecast future water demand in the blue mountains water supply systems in New South Wales, Australia by developing a principal component regression model by a combination of multiple regression analysis and principal component analysis. The analysis proved that the developed principal component regression model was able to predict future water demand with a high degree of accuracy with an average relative error., Nash-Sutcliffe efficiency and accuracy and many others.

METHODOLOGY

The methodology approach here is of that of Box-Jenkins approach. This approach refers to a set of processes for identifying and estimating time series model in the class of Autoregressive Integrated Moving Average (ARIMA) models. There are five iterative steps for model building in Box-Jenkins approach for non- seasonal ARIMA models. They are:

Stationary checking, model identification, parameter estimation, diagnostic checking and forecasting.

Stationary Checking

A time series y_t is said to be stationary if it satisfies the following conditions.

(i).$E(y_t) = \mu_y$ for all y

(ii). $Var(y_t) = E[(y_t - \mu_t)]^{2} = \sigma_y^2$ for all t

(iii). $Cov(y_t, \mu_{t-k)=}\gamma_k$ for all t.

When a time series is not stationary, we can make it stationary either by ADF or Johansen's method.

Model Identification

Model identification is a process that is followed after the data has been confirmed stationary. This involves cautious identification of the models through visual inspection of both the Sample Autocorrelation and Partial Sample Autocorrelation through the use of Autocorrelation and Partial Autocorrelation function.

Parameter Estimation

For parameter estimation, we have the maximum likelihood estimators. They are those values of the parameters for which the data actually observed are the most likely; this means the values that maximise the likelihood function L. The likelihood function L is defied to be the probability of obtaining the data which is observed.

For no-seasonal Box-jenkins models, L is a function of $\mu' s$, $\gamma' s$, $\theta' s$ and σ_ϵ^2 for y_1,..., y_t.

Diagnostic Checking

Diagnostic Checking is a process that helps determine a single model that most adequately represents the data generating process. It may involve estimation of several models at initial stage. The model is finally chosen is the one that best satisfies the diagnostic checking criteria

Forecasting

This is the final stage of the model building for non-0seasonedal ARIMA models. The forecast of m-periods ahead is based on an ARMA(p,q) model, given by

$$y_{t+m} = \mu + \gamma_1 y_{t+m-1} + \cdots \gamma_{t+m-p} + \varepsilon_{t+m} - \theta_1 \varepsilon_{t+m-1} - \cdots \theta_q e_{t+m-q}$$

Data Analysis

The data presented for this study was obtained from Oyo state water corporation which is in charge of both Eleyele and Asejire water dam. The data rage from January 2005 to December 2016.the data follow the steps of Box-Jenkins method.

The firs step is to test whether the data is stationary using ADF and know it is stationary level.

Table 1

Null Hypothesis: GDP Has a Unit Root				
Exogenous: Constant				
Lag Length: 8 (Automatic - Based on SIC, maxlag=9)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller Test Statistic			-3.129612	0.0362
Test critical values:	1% level		-3.699871	
	5% level		-2.976263	
	10% level		-2.627420	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(GDP)				
Method: Least Squares				
Date: 07/19/18 Time: 16:36				
Sample (adjusted): 1990 2016				
Included observations: 27 after adjustments				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
GDP(-1)	-0.359120	0.114749	-3.129612	0.0061
D(GDP(-1))	0.868476	0.207599	4.183439	0.0006
D(GDP(-2))	0.803927	0.235448	3.414452	0.0033
D(GDP(-3))	0.498356	0.284485	1.751784	0.0978
D(GDP(-4))	0.406257	0.308848	1.315395	0.2058
D(GDP(-5))	0.950910	0.401861	2.366267	0.0301
D(GDP(-6))	0.796234	0.323250	2.463214	0.0247
D(GDP(-7))	-0.776379	0.464614	-1.671019	0.1130
D(GDP(-8))	1.402529	0.585675	2.394724	0.0284
C	299.2994	318.5672	0.939517	0.3606
R-squared	0.932979	Mean dependent var		3743.772
Adjusted R-squared	0.897497	S.D. dependent var		3353.416
S.E. of regression	1073.630	Akaike info criterion		17.07360
Sum squared resid	19595592	Schwarz criterion		17.55354
Log likelihood	-220.4935	Hannan-Quinn criter.		17.21631
F-statistic	26.29469	Durbin-Watson stat		2.138609
Prob(F-statistic)	0.000000			

Table 2: Results of ARIMA Models

	ARIMA (1,1,0)	ARIMA (1,1,3)	ARIMA (2,0,0)	ARIMA (1,1,1)	ARIMA (2,1,1)	ARIMA (2,1,3)	ARIMA (01,1)	ARIMA (2,1,2)	ARIMA (1,0,1)
AR1 S.E	0.0005 0.0985	0.7445 0.1119	0.8839 0.6957	3e-0.3	0.8922 0.0975	0.6016 0.7908		-0.0394 0.2932	0.7562 0.0755
AR2 S.E			-0.1088 0.0955		-0.1008 0.0968	0.6019 0.7908		-0.6788 0.2562	
MA1 S.E		-0.8365 0.1468		2e-0.4	-1.0000 0.0344	-0.7158 0.7899	0.0006 0.1021	-0.1125 0.2584	0.1146 0.5428
MA2 S.E		-0.0665 0.1435				-0.1752 0.7114		-0.8876 0.2584	
MA3 S.E		-0.0997 0.1305				-0.1153 0.1556			
AIC	348.55	368.45	365.69	361.95	365.48	367.44	364.35	366.87	368.59
σ^2 estimate	1.689	1.654	1.589	1.754	1.568	1.552	1.748	1.508	1.548
Log liklihood	-175.94	-176.84	-177.45	-181.92	-176.95	-176.73	-181.74	-177.16	-177.38

He above results show the R results of the analysis. In this table, we conclude that models of the original variable, ARIMA (p,0,q). To select the most suitable model to make the forecast, from the above table the lowest ARIMA is ARIMA (2,1,1) to do the forecast.

Presentation of Results

The above plot is a forecast on water to be supplied 2018. This is the final result after various steps to building ARIMA model.

Predicted Values

Table 3

Year/Month	Jan	Feb.	march	April	May	June	July	August	Sep	Oct	Nov	Dec
2019	34.366	34.493	34.613	34.706	34.775	34.852	34.862	34.668	34.899	34.919	34.519	34.629
2020	34.396	34.549	34.711	34.805	34.635	34.552	34.322	34.565	34.826	34.931	34.535	34.259
2021	34.262	34.253	34.514	34.466	34.652	34.654	34.565	34.568	34.819	34.925	34.529	34.424
2022	34.549	34.711	34.805	34.706	34.777	34.842	34.862	34.698	34.899	34.652	34.654	34.565

The Box-Jenkins methodology for non-seasonal Autoregressive Integrated Moving Average was adopted in which ARIMA model was developed to forecast water supplied to year 2022. It was found that ARIMA (2,1,1) was the best fit for the ARIMA model. Therefore, the result of the analysis, using the developed ARIMA model showed that water supply is set to fall, although not speedily from 34.965mgd on average from December 2019 to December 2022. This shows that adequate measures should be taken to increase water supply.

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