International Review of Business Research Papers
Vol.4 No. 5 October-November 2008 Pp. 231-248

FORECASTING WATER DEMAND FOR AGRICULTURAL, INDUSTRIAL AND DOMESTIC USE IN LIBYA

Fathis F. Lawgali*

This paper examines water demand for all needs to determine the future water demand for agricultural, industrial and domestic use; it uses annual data on consumption of water demand by the year 2020. The method of demand forecasting of water is based on Box –Jenkins method.By 2020, as a whole, water demands will increase to the double in Libya. So, Available water in 2020 will be less than half of water demands' which means an increase of the shortage over time. The future water demand for agriculture purposes is expected to increase. Also, it becomes the biggest consumer of water, It represents about 83%of the estimated water consumption of 2020.

Field of Research: Economics of Water Resource Management in Libya

1. Introduction

One of the serious problems that many countries are facing today is water shortage, even though there is over 70% of surface water covered the earth. Water shortage like other economic resources, it is no different from one country and part of a country into another. In the last few years, domestic water shortage has increased worldwide, increase water demand as result of, increase of the population, increase in the individual agricultural domestic and industrial demand and rising of living standard. Libya, like other countries worldwide, is no different in respect of the causes leading to the increase of water shortage and I believe that population growth and water consumption are among the areas that should be addressed by any scientific study. Large increases in water demand with very little recharge have strained Libya's groundwater resources resulting in serious declines in water levels and quality, especially along the Mediterranean coast where most of the agricultural, domestic and industrial activities are concentrated.

*Fathia .F. Lawgali is a PhD Student at Dundee Business School, University of Abertay **Dundee, Scotland, U.K.**
Email:flawgali@yahoo.com
f.lawgali@abertay.ac.uk

The future estimations of water consumption for all possible purposes indicate to total water consumption increasing from 6293.89 million cubic meters in 2006 to 12473.20 million cubic meters in 2020 with an average of compound annual rate of 4.97%. In 2020 it is expected, that the increase would be 98% of the water consumption in 2006.
So, the aims and objective of this study are to forecast the water demand for agricultural, domestic and industrial use in Libya using Box –Jenkins method.

2. The Data Sources

This study requires collecting and analysing data about the Libyan water for the period from 1975 to 2005 this data is annual data because only annual data available covering this period and information related to water demand in Libya. All reference data were collected from Libyan Authorities: General Environmental Authority; General Water Resources the Public Corporation of Water, the General People's Committee of Planning, the General People's Committee of Agriculture and the General Corporation for Investment of the Great Man- Made River Waters.

3. Literature Review

Studies and researches undertaken in recent years show, that one of the most important economic problems facing many countries of the world nowadays is the shortage of ground waters.
Water is natural resource renewable in limited quantities. Demand for water increase with time population and standard of living increase
The purpose of this section is to review the experience of researchers in the area of water demands and water resources.
Modelling of water demand consists of the search for variables that underlie or determine water demand and the determination of their relationships to water use in quantitative terms.

3.1 Review of References

The review of past studies of water demand shows a significant number of studies in various categories of water use. There is much variability in the selection of both dependent and independent variables in water use studies, even within narrowly defined individual water use sectors. Few studies were available for comparison using a single comparable set of variables. The results are often contradictory and the values of reported coefficients frequently have signs and values that fail to conform to reason or theory. The availability of studies varies from sector to sector and the differences in data and methodologies used preclude comparisons of results across individual studies.

3.1.1 Water Demand

Reviews of the empirical literature on water demand show the dominance of residential (urban) over that of rural water demand studies. Single and system demand equations with different functional forms have been employed to estimate elasticities of water demand with respect to price, income, population characteristics and composition, among others. These studies utilise time series, cross-sectional data or panel data.

Arbués *et al*. (2003) notes the absence of a general consensus regarding the methodology to analyse water demand and this has resulted in different ranges in price-elasticity estimates of water demand. Through meta-analyses of residential water demand studies, Espey *et al*. (1997) as cited by Arbués *et al*.

Attention has lately shifted to a demand-oriented approach where the price of water is used as the main instrument to regulate demand. Significant factors that explain household water demand in 8 rural communities in Madagascar.

4. Methodology

Economists define the demand for water as the relationship between water use and price, when all other factors are held constant. Demand is a negative functional relationship represented by the demand curve. This curve describes the relationship between price and water use for a single user. The demand imposed by each water user can be represented by a similar demand curve, and all such curves are expected to be negatively sloped (increased price results in decreased water use).

In general, water use relationships are in the form of mathematical equations which express water use as a mathematical function of one or more independent variables. The mathematical form (i.e., linear, multiplicative, exponential) and the selection of the right hand side or independent (explanatory) variables depend on the type and aggregation of water demand represented by the left-hand side or dependent variable.

The methodology of the study is defined as an analytical method practised to realize the study goal.

The estimates of water consumption for different purposes are calculated by using the comparative equations stated. The Box-Jenkins is used to forecast the water demand for all purposes .In addition, this study uses econometric tests for Unit Roots, Co integration to estimate this model:

4.1 The Forecasting Model

4.1.1 Water Demand Equations

$$W = W_A + W_I + W_D \quad (1)$$

Where W = total water demand, W_A, W_I, W_D = water demand for the purposes of, agricultural, industrial and domestic use, respectively

$$W_A = f\left(P_A, Y, pop, temp\right) \quad (2)$$

Where P_A, is the price of agriculture water, Y is the income, pop is the number of people and $temp$ is the temperature

$$W_D = f(P_D, Y, pop, temp) \qquad (3)$$

Where Y is income and P_D is the price of domestic water

$$W_I = f(p_I, Y, pop, temp) \qquad (4)$$

Where p_I is the price of industry water
Estimation these equations (2), (3), (4) by sector.

Substituting equations (2), (3), (4) into equation (4)

$$W = W_A + W_I + W_D \qquad (5)$$

$$W(.) = W_A(P_A, Y, pop\ , temp) + W_I(P_I, Y, pop, temp) + W_D(P_D, Y, pop, temp) \qquad (6)$$

$$W = f(P_A, P_I, P_D, Y, pop, temp) \qquad (7)$$

Estimation equation (5), Aggregate

$$W = f(P_A, P_I, P_D, Y, pop, temp) \qquad (8)$$

Estimation Equations (2), (3), (4) and (8)
To estimate total water demand, transforming equations into double log form (2), (3), (4) and (8)

I have an estimable model:

$$\ln W_A = \alpha_A + \beta_1 \ln P_A + \theta_1 \ln pop + \gamma_1 \ln Y + \psi_1 \ln temp + u_A$$

$$\ln W_I = \alpha_I + \beta_2 \ln P_I + \theta_2 \ln pop + \gamma_2 \ln Y + \psi_2 \ln temp + u_I$$

$$\ln W_D = \alpha_D + \beta_3 \ln P_D + \theta_3 \ln pop + \gamma_3 \ln Y + \psi_3 \ln temp + u_D$$

$$\ln W = \alpha + \beta_1 \ln P_A + \beta_2 \ln P_I + \beta_3 \ln P_D + \theta \ln pop + \gamma \ln Y + \psi \ln temp + u$$

Where:
α = Intercept coefficients
$\beta_1, \beta_2, \beta_3, \theta, \gamma, \psi$ = Slope coefficients
u = residual term
$\ln$ = Natural logarithm

Linear water demand functions are often chosen because of their ease of estimation. These can be derived from a quadratic utility function, but are most often presented with no formal derivation (Al- Quanibet and Johnston, 1985). The linear regression functional form is often criticized, because it implies that the change in quantity demanded in response to a price change is the same at every price level. (Billings and Day, 1989).

5. Major Findings

5.1 ARIMA Forecasting Models

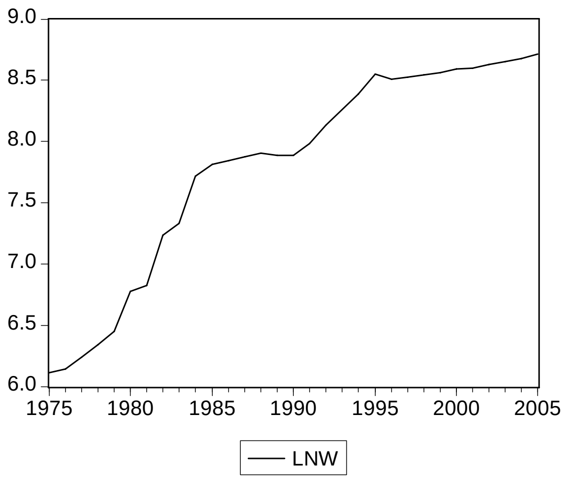
This section examines stationary and non stationary time series by formally testing for the presence of unit roots. Various Box-Jenkins Autoregressive Integrated Moving Average (ARIMA) models are estimated over the period 1975-2005 for total water demand and demand for water for agriculture, domestic and industry use.
The ARIMA models provide a useful framework to understand how the water time series is generated. Unlike univariate smoothing models which are more commonly used, the ARIMA approach requires a water time series to be tested for nonstationarity prior to undertaking estimation and forecasting. If a series is nonstationary (that is, the series has a mean and variance that are not constant over time), the series has to be differenced to transform it to a stationary series, before generating forecasts. A stationary water demand series typically provides better and more reliable forecasts.
The work of Box and Jenkins (1970) shifted professional attention in time series modelling away from stationary processes to a class of nonstationary processes and the related ideas of the order of integration necessary to obtain stationary series. Furthermore, the Box-Jenkins method is popular because of its generality since it can handle any stationary or nonstationary time series. In the identification phase, a general class of models applicable to a particular situation is examined with the aid of the sample correlograms, and autocorrelation and partial autocorrelation functions.

5.2 Testing for Stationarity

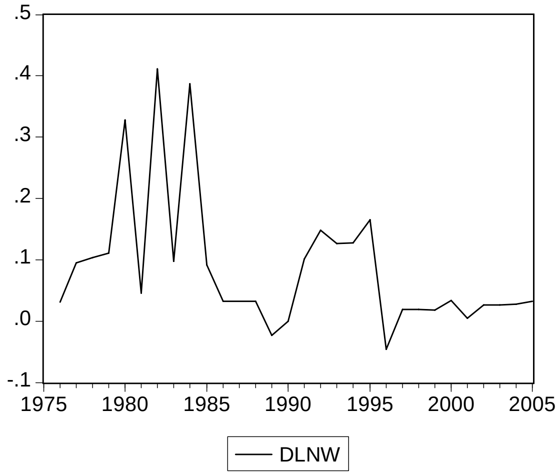
5.2.1 Graphs of Variables

The first method which can be used to check stationarity of the variables is to graph the series. The graphs of these variables in logarithm form are shown in figure (1).

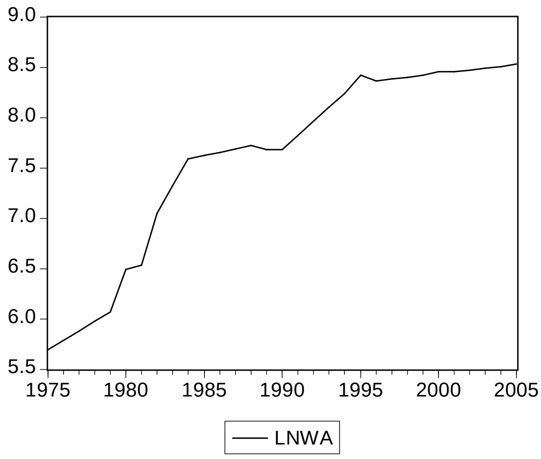
Figure (1) Graphs of the variables (in level and in first and second differences)



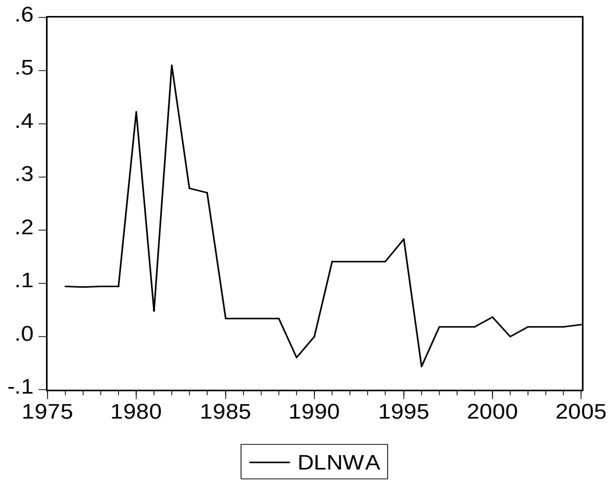
Lawgali



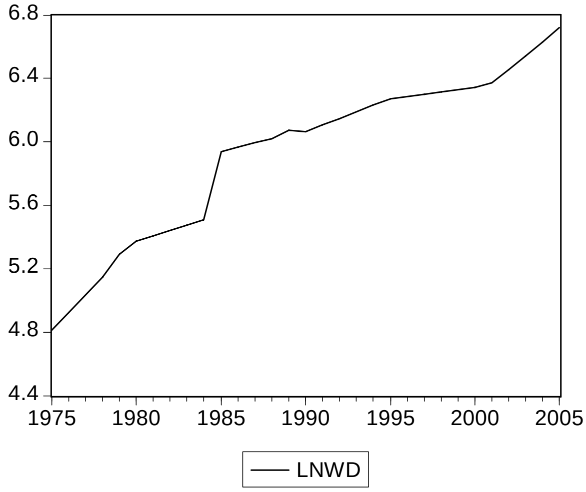
.5
.4
.3
.2
.1
.0
-.1
1975 1980 1985 1990 1995 2000 2005
DLNW

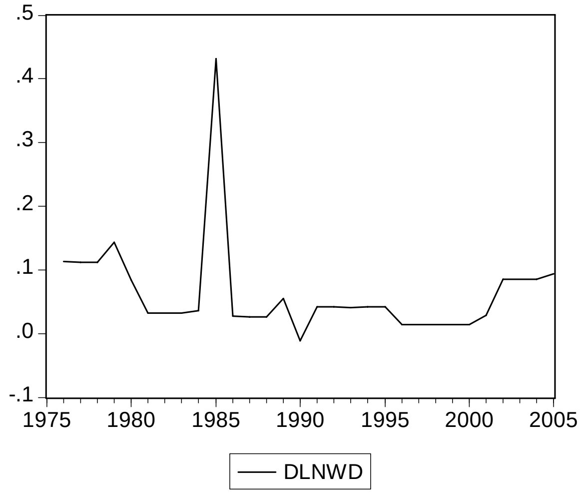


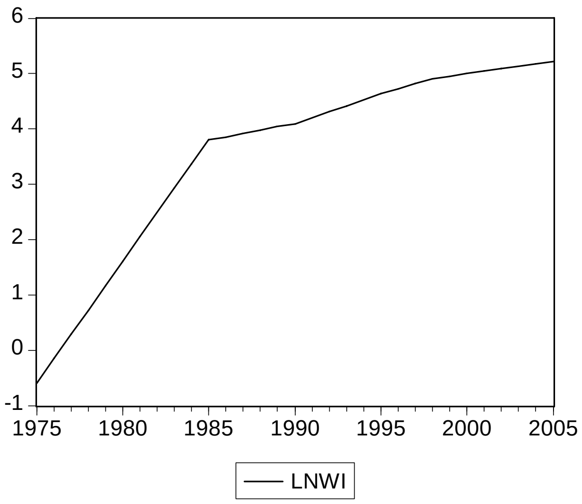
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
1975 1980 1985 1990 1995 2000 2005
LNWA

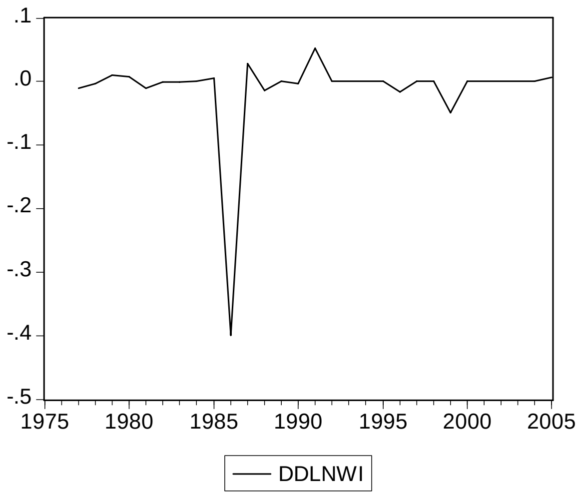


.6
.5
.4
.3
.2
.1
.0
-.1
1975 1980 1985 1990 1995 2000 2005
DLNWA









The original time series in logarithm form is checked for stationarity using the augmented Dickey- Fuller (ADF) test for unit roots.

5.2.2 The ADF-Test for Difference Versus Trend Stationarity

The restricted model assumes the time trend is zero and the series for all variables are difference stationary. As shown in tables (1), (2), (3) and (4), then the series are transformed by taking appropriate differences to render the series stationary. A detailed explanation of the test procedure is given in Gujarati (2003).

Table (1): $\ln W$

Wald Test:				
Equation: Untitled				
Null Hypothesis:	C(2)=0			
	C(3)=0			
F-statistic	3.428872		Probability	0.048313
Chi-square	6.857743		Probability	0.032424

$\Delta Y_t = \alpha_0 + \lambda t + \theta Y_{t-1} + \delta_2 \Delta Y_{t-1}$

D ($\ln W$) C Trend $\ln W$ (-1) D ($\ln W$ (-1))

$H_0 : \theta = \lambda = 0$

$F =$ 3.43 < $F_c =$ 7.24

We can not reject H_0 ,because the F-statistic is less than the 5% critical value ,then we can say that we are 95% confident that the series $\ln W$ follows a difference stationary process.

Table (2): $\ln W_A$

Wald Test:				
Equation: Untitled				
Null Hypothesis:	C(2)=0			
	C(3)=0			
F-statistic	4.717876		Probability	0.018265
Chi-square	9.435753		Probability	0.008934

$\Delta Y_t = \alpha_0 + \lambda t + \theta Y_{t-1} + \delta_2 \Delta Y_{t-1}$

D ($\ln W_A$) C Trend $\ln W_A$ (-1) D ($\ln W_A$ (-1))

$H_0 : \theta = \lambda = 0$

$F =$ 4.72 < $F_c =$ 7.24

We can not reject H_0 ,because the F-statistic is less than the 5% critical value ,then we can say that we are 95% confident that the series $\ln W_A$ follows a difference stationary process.

Table (3): $\ln W_D$

Wald Test:				
Equation: Untitled				
Null Hypothesis:	C(2)=0			
	C(3)=0			
F-statistic	1.430434		Probability	0.258117
Chi-square	2.860869		Probability	0.239205

$\Delta Y_t = \alpha_0 + \lambda t + \theta Y_{t-1} + \delta_2 \Delta Y_{t-1}$

D ($\ln W_D$) C Trend $\ln W_D$ (-1) D ($\ln W_D$ (-1))

$H_0 : \theta = \lambda = 0$

$F =$ 1.43 < $F_c =$ 7.24

We can not reject H_0 ,because the F-statistic is less than the 5% critical value ,then we can say that we are 95% confident that the series $\ln W_D$ follows a difference stationary process.

Table (4): $\ln W_I$

Wald Test:				
Equation: Untitled				
Null Hypothesis:	C(2)=0			
	C(3)=0			
F-statistic	5.0331		Probability	0.000000
Chi-square	1.0132		Probability	0.000000

$$\Delta Y_t = \alpha_0 + \lambda t + \theta Y_{t-1} + \delta_2 \Delta Y_{t-1}$$

D ($\ln W_I$) C Trend $\ln W_I$ (-1) D ($\ln W_I$ (-1))

$H_0 : \theta = \lambda = 0$

$F =$ 5.03 < $F_c =$ 7.24

We can not reject H_0 ,because the F-statistic is less than the 5% critical value ,then we can say that we are 95% confident that the series $\ln W_I$ follows a difference stationary process.

5.2.3 Unit Root Test

Another method which can be used to check stationarity of the variables is the ADF tests which are performed sequentially show that not included any lag of the differenced variable for total water demand and demand for water for agriculture is significant, and the ADF test statistics is calculated with and without time trend for water demand for, industrial, and domestic use respectively for lag length of one. Each of the calculated statistics exceeds the critical value the value of this test statistics with 5 per cent critical value, as tabulated in Mackinnon (1991), is included in table (5), so the null hypothesis of a unit root is not rejected, which implies that each of the four water demand series is non stationary in its level. Taking first differences renders each series stationary except demand for water for industry, with the ADF statistics in all cases for total water demand and demand on water for agricultural and domestic, respectively) while demand for water for industrial use, taking second difference renders it stationary being more negative than the critical value. Table (5) indicate the stationarity of all the variables.

Table (5): Unit Root Test

	Level		**First difference**	**Second difference**	
	With trend	Without trend	Without trend	Without trend	
Variable	ADF	ADF	ADF	ADF	Conclusion
$\ln W$	-0.71	-2.58	-4.51	_	I(1)
$\ln W_A$	-0.78	-2.84	-3..77	_	I(1)
$\ln W_D$	-2.19	-1.74	-3.52	_	I(1)

$\ln W_I$	-2.59	-2.91	-1.39	-3.72	I(2)

5% critical values.

Without time trend ADF-2.97

With time trend DF ADF-3.57

5.3. Estimates of the ARIMA Model

5.3.1 Using the Best Fitting Model during the Period 1975-2005

The best fitting ARIMA models are estimated separately for water demand series from 1975 to 2000 and the tests indicate that the ARIMA (3,1),(3,1),(1,1)and(1,2,1) performs well. The coefficients and all significant, and they satisfy the stationarity and invertibility conditions. It has the highest adjusted R^2 and the lowest AIC and SIC values six candidate models. The correlogram and unit root tests of the series before and, if necessary, after differencing are examined for stationarity. After empirical examination, the most appropriate models for total water demand and demand for water for agricultural , domestic and industrial use are determined as ARIMA (3,1,1), ARIMA (3,1,1), ARIMA (1,1,1) and ARIMA (1,2,1) respectively. Using the best fitting model for total water demand, demand for water for agricultural, domestic and industrial use are calculated in tables (6),(7),(8) and (9). (With absolute t-ratios in parentheses):

$$\Delta \ln W_t = \alpha_0 + \alpha_1 \Delta \ln W_{t-1} + \alpha_2 \Delta \ln W_{t-2} + \alpha_3 \Delta \ln W_{t-3} + e_t - \beta_1 e_{t-1} \quad \text{ARIMA(3,1,1)}$$

$$\Delta \ln W_{At} = \alpha_0 + \alpha_1 \Delta \ln W_{A_{t-1}} + \alpha_2 \Delta \ln W_{A_{t-2}} + \alpha_3 \Delta \ln W_{A_{t-3}} + e_t - \beta_1 e_{t-1} \quad \text{ARIMA(3,1,1)}$$

$$\Delta \ln W_{Dt} = \alpha_0 + \alpha_1 \Delta \ln W_{D_{t-1}} + e_t - \beta_1 e_{t-1} \quad \text{ARIMA(1,1,1)}$$

$$\Delta\Delta \ln W_{It} = \alpha_0 + \alpha_1 \Delta\Delta \ln W_{i_{t-1}} + e_t - \beta_1 e_{t-1} \quad \text{ARIMA (1,2,1)}$$

Table (6): d $\ln W$ (1975-2005)

	$\bar{R}^2$	AIC	SC	SIG	STAT	INV
ARIMA(3,1,1)	0.63	-2.32	-2.08	All sign	$\sum \alpha < 1$	$\sum \beta < 1$
ARIMA(3,1,2)	0.45	-1.87	-1.58	2 insign	$\sum \alpha < 1$	$\sum \beta < 1$
ARIMA(5,1,1)	0.60	-2.18	-1.84	4 insign	$\sum \alpha < 1$	$\sum \beta < 1$
ARIMA(4,1,1)	0.51	-1.95	-1.66	2 insign	$\sum \alpha < 1$	$\sum \beta < 1$
ARIMA(2,1,1)	0.25	-1.66	-1.47	2 insign	$\sum \alpha < 1$	$\sum \beta < 1$
ARIMA(1,1,2)	0.30	-1.58	-1.59	All sign	$\sum \alpha < 1$	$\sum \beta < 1$

Table (7) $d\ln W_A$ (1975-2005)

	$\overline{R}^2$	AIC	SC	SIG	STAT	INV
ARIMA(3,1,1)	0.42	-1.52	-1.30	All sign	$\sum \alpha < 1$	$\sum \beta < 1$
ARIMA(3,1,0)	0.20	-1.25	-1.05	3 insign	$\sum \alpha < 1$	………
ARIMA(4,1,1)	0.64	-1.95	-1.66	3 insign	$\sum \alpha < 1$	$\sum \beta < 1$
ARIMA(1,1,0)	0.05	-1.22	-1.13	one insign	$\sum \alpha < 1$	……….
ARIMA(1,1,1)	0.09	-1.23	-1.09	2 insign	$\sum \alpha < 1$	$\sum \beta < 1$
ARIMA(2,1,1)	0.19	-1.28	-1.09	3 insign	$\sum \alpha < 1$	$\sum \beta < 1$

Table (8) $d\ln W_D$ (1975-2005)

	$\overline{R}^2$	AIC	SC	SIG	STAT	INV
ARIMA(1,1,1)	0.50	-2.23	-2.08	All sign	$\sum \alpha < 1$	$\sum \beta < 1$
ARIMA(1,1,2)	0.07	-2.17	-1.98	One insign	$\sum \alpha < 1$	$\sum \beta < 1$
ARIMA(2,1,2)	0.16	-2.22	-1.98	2 insign	$\sum \alpha < 1$	$\sum \beta < 1$
ARIMA(3,1,2)	0.12	-2.11	-1.82	3 insign	$\sum \alpha < 1$	$\sum \beta < 1$
ARIMA(5,1,1)	-0.08	-1.80	-1.49	4 insign	$\sum \alpha < 1$	$\sum \beta < 1$
ARIMA(4,1,0)	-0.18	-1.84	-1.60	4 insign	$\sum \alpha < 1$	………

Table (9) dd$\ln W_I$ (1975-2005)

	$\overline{R}^2$	AIC	SC	SIG	STAT	INV
ARIMA(1,2,1)	0.48	-2.83	-2.69	One insign	$\sum\alpha<1$	$\sum\beta<1$
ARIMA(1,2,0)	-0.02	-2.19	-2.09	One insign	$\sum\alpha<1$	…….
ARIMA(2,2,1)	-0.02	-2.09	-1.90	2 insign	$\sum\alpha<1$	$\sum\beta<1$
ARIMA(3,2,1)	-0.04	-1.99	-1.75	3 insign	$\sum\alpha<1$	$\sum\beta<1$
ARIMA(4,2,1)	-0.06	-1.90	-1.61	4 insign	$\sum\alpha<1$	$\sum\beta<1$
ARIMA(1,2,2)	0.45	-2.75	-2.56	3 insign	$\sum\alpha<1$	$\sum\beta<1$

Where: $\overline{R}^2$ is Adjusted R-squared, AIC is Akaike info criterion, SC is Schwarz criterion, SIG is Significant, STAT is Stationary i.e. $\sum\alpha<1$, INV is Invertibility i.e. $\sum\beta<1$ and insign is insignificant

Since the specific ARIMA models that adequately describe total water demand and demand for water for agriculture, industry and domestic are given above, the fitted models used for forecasting water demand for four categories are given as follows:

Total water demand (1975-2005)

$$\Delta\ln W_t = 0.11 + 1.12\Delta\ln W_{t-1} + 0.55\Delta\ln W_{t-2} - 083\Delta\ln W_{t-3} + e_t + 1.59e_{t-1}$$

t- values (2.86) (6.29) (2.26) (4.78) (4.22)

$\overline{R}^2$=0.63 SC=-2.08 AIC=-2.32

Demand for water for agriculture (1975-2005)

$$\Delta\ln W_{At} = 0.05 + 0.89\Delta\ln W_{A_{t-1}} + 0.39\Delta\ln W_{A_{t-2}} - 0.45\Delta\ln W_{A_{t-3}} + e_t + 0.99e_{t-1}$$

t- values (3.399) (4.71) (2.44) (2.59) (9.70)

$\overline{R}^2$=0.42 SC=1.30 AIC=1.52

Demand for water for domestic use (1975-2005)

$$\Delta\ln W_{Dt} = 0.05 + 0.77\Delta\ln W_{D_{t-1}} + e_t + 0.96e_{t-1}$$

t- values (5.65) (7.76) (26.54)

$\overline{R}^2$=0.50 SC=-2.08 AIC=-2.23

Demand for water for industry (1975-2005)

$$\Delta\Delta\ln W_{It} = -0.002 + 0.55\Delta\Delta\ln W_{i_{t-1}} + e_t + 1.45e_{t-1}$$

t- values (0.29) (3.27) (6.62)

$\overline{R}^2$=0.48 SC=-2.69 AIC=-2.83

Tests for white noise residuals

Having decided to use the ARIMA (3,1,1),(3,1,1),(1,1,1) and (1,2,1) model for total water demand , demand for water for agricultural, domestic and industrial use, it is necessary to use five different tests, to determine if the residuals are white noise theses tests are **(**residual line graph, check the size of the differences between the fitted and actual values, check the residual correlogram for ARIMA (3,1,1) if white noise ,test for autocorrelation in the residuals is the Serial Correlation Lagrange Multiplier (LM), normality of the residuals and test if the series is stationary by using unit root) on it. The key tests to determine whether the estimated from the ARIMA (3, 1, 1), (3, 1, 1), (1, 1, 1) and (1, 2, 1) model are white noise.

5.4 Magnitude of Forecasting Errors (2001-2005)

With the forecast observations being demand for water for five years (2001-2005), table (10) presents the Root Mean Squared Error (RMSE) forecast accuracy measure of the ARIMA models for total water demand, demand for water for agriculture domestic and industry ,the mean absolute percentage error(MAPE) of the ARIMA model lower in both(static and dynamic). However, the static ARIMA model forecasts were better than the dynamic ARMA model forecasts, these result suggest that the ARIMA (3,1, 1), (3,1, 1), (1,1, 1) and (1, 2, 1) model performs better in forecasting total water demand, demand for water for agricultural, domestic and industrial use.

Table (10): Root Mean Squared Error (RMSE) for Five years Ex post Forecasts of the Logarithm of Demand for Water, 2001-2005

	RMSE		
	ARIMA	Static	Dynamic
$\ln W$	(3,1,1)	0.01	0.04
	(3,1,2)	0.03	0.06
$\ln W_A$	(3,1,1)	0.02	0.07
	(1,1,1)	0.05	0.07
$\ln W_D$	(1,1,1)	0.04	0.06
	(1,1,2)	0.18	0.05
$\ln W_I$	(1,2,1)	0.02	0.01
	(1,2,0)	0.2	0.02

Table (10) shows the RMSE for the fitted ARIMA (3,1, 1), (3,1, 1), (1,1, 1) and (1,2, 1) models against (3,1,2),(1,1,1),(1,1,2) and (1,2,0) models according to the forecasting. It suggests that the models which we tested to forecasting are more accurate than others during the period 2001-2005

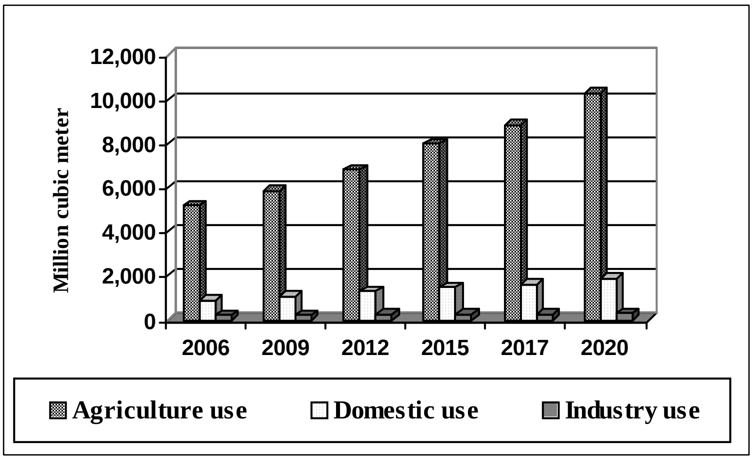
The fitted values, which are interpreted as the forecasts for the next five years, are sufficiently close to the actual values for total water demand, demand for water for agricultural, domestic and industrial use using the ARIMA models.

6. Discussion of the Results

Low RMSE for forecasting purposes is a desirable measure of forecasting fit. The RMSE for forecasting computed over the forecast range provides a measure of the ability of the model to forecast.

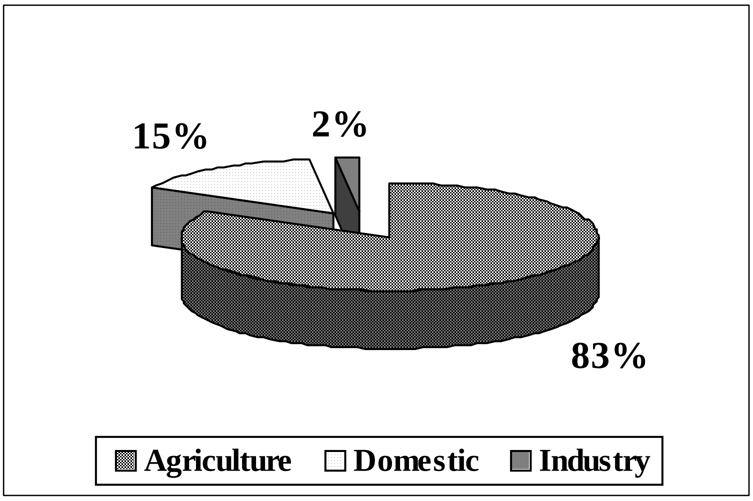
For estimation of future water consumption the equations for total water demand and demand for agricultural, domestic and industrial use have been applied. By viewing table (11) which shows the estimations of future water consumption during the period 2006 – 2020, the following could be noticed: The future estimations of water consumption for all possible purposes indicate to total water consumption increasing from 6293.89 million cubic meters in 2006 to 12473.20 million cubic meters in 2020 with an average of compound annual rate of 4.97%. In 2020 it is expected, that the increase would be 98% of the water consumption in 2006.

Figure (7.2): Water Demands in Libya, 2006-2020



Data source: table (11)

Figure (3) Water Consumption in 2020



Data source: table (11)

Agriculture will continue to be the major water consumer; it becomes the biggest consumer of water as shown in table (11) and figure (3). It represents about 83%of the estimated water consumption of 2020 of the current water demand and despite the use of pressurized irrigation techniques in practically all farming areas, application rates are still among the highest in the world. Actually, this great increase in water consumption for agricultural use will affect the water reserve. Therefore, the way to guide water consumption in the agriculture sector has to be necessarily considered.
This is mainly due to the unsuitable climatic and soil conditions. Different scenarios can be presented for the estimation of future water demand by the agricultural sector. A reasonable one is that shown in Table (11).

Table (11) Water Demands by Different Users in Libya, 2006-2020 Forecasts

Year	**Water Demand (Million Cubic Meter)**			
	Agricultural Use	**Domestic Use**	**Industrial Use**	**Total Demand**
2006	**5204.43**	**895.75**	**193.71**	**6293.89**
2007	5384.29	958.96	202.30	6545.55
2008	5601.55	1022.69	210.70	6834.94
2009	5854.41	1084.98	218.69	7158.08
2010	**6171.39**	**1147.69**	**227.24**	**7546.32**
2011	6194.89	1204.19	233.08	7632.16
2012	6803.48	1275.93	241.08	8320.49
2013	7172.95	1342.17	247.79	8762.91
2014	7564.41	1410.49	254.07	9228.97
2015	**7975.77**	**1494.92**	**259.85**	**9730.54**
2016	8405.78	1555.31	265.12	10226.21
2017	8853.87	1631.83	269.82	10755.52
2018	9320.22	1711.56	273.93	11305.71
2019	9805.61	1794.76	277.41	11877.78
2020	**10311.30**	**1881.66**	**280.24**	**12473.20**

The future water consumption for domestic purposes will increase from 895.75 million cubic meters in 2006 to 1881.66 million cubic meters in 2020 with an average of compound annual rate of 5.4% in 2020. That could be explained by the expected increase of population and their needs of water. It is worth mentioning here, that the consumed water quantity in the northern regions will depend, in addition to the groundwater, on waters obtained from desalination plants.
The water consumption of industrial uses will increase. The water quantity to be consumed for industrial purposes in 2020 is expected to be about 2% of the total water consumption. Using water for industrial purposes will rely mainly on desalinated water. In spite of the positive relation between industrial expansion and water demand, and the expected increase of water consumption during the period 2006 – 2020, the consumed quantity of industrial purposes is considered small, if compared with water quantities consumed for other purposes.
Industry consumes the least water of all sectors, with a current share of about 2%. A large number of industries depend on private sources for water supply, including desalination of seawater, as in the case of chemical, petrochemical,

steel, textile and other industries. Industry uses 2% of the Libyan water resource. Today the volume of water used by industries rises, but an increase in demand, with a rate of 2% is forecast, which increases water demand for industry to 280.24 million cubic meters in 2020.

7. Conclusions and recommendations

This study has provided the Box-Jenkins approach to modelling ARMA processes.

The use of such procedures, particularly tests for unit roots, improves the validity of using the ARIMA models for forecasting and allows the forecaster to make informed judgments at each step as the results are presented by the statistical packages. The dickey-fuller test was used test the stationarity of each individual variable. The test ADF statistic of all variables clearly not rejects the null hypothesis; this is meaning we are 95% confident that the series for all follows a difference stationarity process. Overall, this study shows that by comparing the root mean squared errors, lower post-sample forecast errors were obtained when time series methods, such as the Box-Jenkins ARIMA models, was used.

As we discussed in the previous section the biggest user of water in 2020 in Libya is agriculture (83 %) followed by domestic use (15 %) and industrial use (2 %). Large increases in water demand during the period 2006 to 2020 with very little recharge from precipitation have strained Libya's groundwater resources resulting in declines of groundwater levels and its quality, especially on Mediterranean coastal areas where most of the agriculture, domestic and industrial activities are concentrated Hirji and Ibrekk,(2001).

The growth of the population has a marked impact on the water resources of Libya as a result of increasing demand for agricultural, domestic and industry which suffered serious depletions and quality deterioration

By 2020, the population of Libya is projected to become 12.5 million In 2006, the available renewable fresh water per capita was 459 liters/day it is decreased by population growth in 2020 to 332 liters

Ground water is considered the main source for irrigation and domestic uses followed by surface water. With the current trend in water use, it is anticipated that within the next decade, Libya will have utilised all the potentially available conventional water resources.

The future water supply will strongly depend on desalination, treatment, and reuse and to a greater degree on the improvement of irrigation practices.

The most important Recommendations as follows:

- Guiding the citizens through the mass media in consumption of water in general and groundwater in agricultural areas particular. Additionally, it should be attempted to find out irrigation methods to limit unreasonable consumption of water for agricultural purposes.
- Researches and studies have to be done as soon as possible in order to find out the best methods, which could be applied for reducing the exhaustion of water for industrial and agricultural purposes.
- Issuance of water legislations in order to limit exhaustion of groundwater and organize its exploitation.

- Maintenance of the water networks indoors as well as outdoors, and imposing the use of water-meters in order to control the water consumption.
- It is necessary, that the General Corporation of Water runs periodic forecasting about available water sources and water quantities expected to be consumed, so that both the individuals as well as the establishments are well informed about the water situation.
- Paying attention to the sources of water desalination and trying to develop the technology practiced in them with the aim to reduce the costs of water desalination and enable the current desalination plants to reach the level of designed capacity, then water desalination is in fact the main everlasting source of water.
- All the institutions which work in water shortage issues in order to avoid the in crease water demand in decisions. Supporting the scientific institutions and institutes in order to increase the role of researches, education, and training. Monitoring, analyzing and forecasting variation is of prime importance to Expansion of safely cropped areas by introducing crops which are more resistant to extreme conditions and by improving methods of cultivation and water conservation. Priority has to given to the quality of agriculture productions which has to be improved, instead of cultivating more marginal lands.
- Modern technologies and approaches in agriculture and water resources management are very important to meet increasing demands and to alleviate the effects of climate change and desertification.
- Improved irrigation methods, mechanization, fertilization, plant protection and the selection of crops that use water more efficiently are important for facing water shortage.

References:

AI-Quanibet, H. and Johanton, S. 1985. Municpal demand for water in Kuwait: methodological issues and empirical results. Water Resources Research .2(2):pp. 433-438.

Arbués, F., Garcıa-Valiñas, M.Á, and Martınez-Espiñeira, R.2003.Estimation of residential water demand: a state-of-the-art review.Journal of Socio-Economics. (32): pp. 81-102.

Billings, B, and Day, M. 1989. Demand Management Factors in Residential Water Use: the Southern Arizona Experience. Journal of the American Waterworks Association .81(3).pp. 58-64.

Box, G and Jenkins, G.1970.Time Series Analysis: Forecasting and Control. San Francisco. Holden-Day

Burke, Thomas R. 1970. “A Municipal Water Demand Model for The Conterminous United States”, Water Research Bulletin, (4):pp.661-675

De Rooy, J. 1974. “Price Responsiveness of the Industrial Demand for Water”, Water Resources Research, 10(3): pp.403-406.

Dickey, D. and Fuller, W .1979.”Distribution of The Estimators for Autoregressive Time Series a Unit Root”, Journal of the American

Statistical Association, 74(366):pp.427-431.
EL- Tantawl, A. 1998b. Water Balance in Libya, Presented in the First Arabic Conference on Water and Desertification, Academy of Scientific Research, Cairo (in Arabic).
Espey, J. and Shaw, W. 1997. Price Elasticity of Residential Demand for Water: A Meta-Analysis. Water Resources Research .33(6):pp. 1369-1374.
Foster, Henry S. Jr. and Bruce R. Beattie. 1979. "Urban Residential Demand for Water in the United States", Land Economics, 55 (1): pp.43-58.
Franses, P.1998. Time Series Models for Business and Economic Forecasting. Cambridge University Press.UK.
Gujarati, D.N.2003.Basic Econometrics. 4th Edition. McGraw Hill.

Fuller, W.A .1985.Introduction to Statistical Time Series Analysis .New York: John Wiley & Sons.
General Planning Council .2006.Report of Libyan Economic and Social Indicators 1962-2000,Tripoli, Libya.
General Water Authority. 1999. Report on Water Situation in Libya [in Arabic].
Hirji, R. and Ibrekk, H. 2001. Water stressed and water scarce countries '2025 projections', Environmental and water resource management strategy series.(2). October 2001. World Ban' Environment Department' available from: http://www.waterinfogr/pages/data.htm
Johansen, S .1988."Statistical Analysis of Co-integration Vectors", Journal of Economic Dynamics and Control ,(12):pp.231-254.
Jones, Charles I. 1998.Introduction to Economic Growth. New York
Naief Al-Mutairi and Mohammed El-sakka.2002."Determinants of the Demand for Fresh Water in Kuwait: an Econometric Study", The Journal of Energy and Development.27 (2).
Omer M. Salem .1998."Water Shortage in Libya and the Needs for its Management for Sustaining the Development", Water Authority Report. Tripoli .
Patterson, K.2000. An introduction to Applied Econometrics: time series approach. Palgrave.
Phillips, P. C. and Perron , P.1988."Testing for a Unit Root in Time Series Analysis ", Biometrika, 75(2):pp. 335-346.
Phillips, P .1987."Time Series Regression with a Unit Root" ,Econometrica. 11(55):pp.277-301.
Thomas, R.1993.Introductory Econometrics: Theory and Applications.2nd Edition . UK.