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Measuring and Analyzing the Demand Function for Clean Water Consumption in the Household Sector in the City of Hit Using Johansen and ECM Models

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ABSTRACT

While the Iraq is witnessing a water crisis whose causes vary, which led to the decline of water levels of rivers and lakes in Anbar province at a large and dangerous at certain times, which leads to fluctuation and decrease the amount of supply of clean water cities in the province, the family sector represents the largest proportion of the consumption process, In fact, controlling the quantity and amount of consumption has become an imperative in light of the decrease in the amount of rain and water releases from Turkey and the amount consumed in Syria, in addition to increasing the use of water stored in the lakes to generate electricity.

Therefore, this research aims to analyze and measure the demand for clean water for the household sector and its influencing factors in Anbar governorate. The research was based on estimating the sample of the study on the method of estimating the monthly data and Using the Johansen cointegration test and the Error Correction Model (ECM), for the sample of the study. The first difference is the stability of the time series of the variables of the study. The results of the quantitative analysis show that they correspond to the theoretical equations of the economy. There is a positive correlation between the independent variables (population, temperature, electric power) on the required amount of water under study, the estimated model was adopted after it passed all standard tests.

Keywords: Water demand, Consumption function, Johansen, ECM

1- Introduction:

The significant and dangerous decline in the water levels of rivers and lakes in Anbar province at certain times has led to fluctuations and a decrease in the supply of clean water to the cities of the province. The household sector represents the largest share in the consumption process. In fact, regulating the consumption process and its quantity has become an imperative necessity in light of the decrease in rainfall, international water releases, and the increase in the quantity consumed from it in Syria, in addition to the increased use of stored water in lakes for electricity generation.

The research aims to analyze and measure the demand function for clean water in the household sector and the factors affecting it in the city of Hit. The study relied on estimating the model using monthly data for the sample during the period (1:2020-12:2022), as well as using the counteraction method to determine the existence of a long-term relationship between the study variables, after taking the first difference for the stability of the time series of the study variables. The results of the quantitative analysis showed that they are consistent with the hypotheses of economic theory, indicating a varying positive relationship between the independent variables (population, temperatures, electricity) and the quantity of water demanded in the study, The research assumes a direct relationship with statistical significance between the independent variables of the study, which are (population, temperature, electricity consumption), and the dependent variable is the quantity of water demanded in the city of Hit.

Previous Studies: (Shabbir Ahmad) 2016 and others clarified that in a sample of 1200 households in the city of Faisalabad, Pakistan, the researchers found that the percentage of household consumption of clean water is not affected by water pricing and billing, nor does household income affect the quantity of water demanded, especially after estimating the price and income elasticity of demand for water, which was found to be inelastic.

In a study by (Mansour Zarra-Nezhad) and others in 2013 to estimate the demand function for water in the Khuzestan region of southern Iran, using the cointegration method as a standard economic analysis to estimate the short-term and long-term relationship of the determinants of household water demand, the researchers concluded that the demand function for domestic water consumption in Khuzestan with respect to prices and income is inelastic. That is, water is very essential, and therefore, non-price and non-income-related factors have a weak impact on water consumption.

The researcher (Mohammad Tabieh) in 2012 and others used IV estimation techniques to analyze cross-sectional data from 1,360 households, concluding that the elasticity of demand for household water is negative and weakly responsive to price, meaning that the demand for water is insensitive to rising water prices, and that the response of low-income households to price increases is low.

Given that most previous studies and literature have found that the quantity demanded (consumed) does not respond to changes in the price (bill) of water, nor to changes in income, this is attributed to the fact that water is a very essential commodity related to human and societal life. Therefore, the researcher excluded these two variables and studied other variables that may have a greater impact on the quantity of water demanded.

The research assumes a direct relationship with statistical significance between the independent variables of the study, which are (population, temperature, electricity consumption), and the dependent variable is the quantity of water demanded in the city of Hit. This analysis contributes to the efficient management of resources, aligning with the broader goals of the green economy and sustainable development indicators in Iraq (Shallal et al., 2025). Furthermore, the quantitative approach employed here complements other applied economic studies in the Iraqi context, such as those evaluating the financial performance of the banking sector (Al-Anezi et al., 2021).

2- The theoretical aspect: Factors affecting the consumption of clean water:

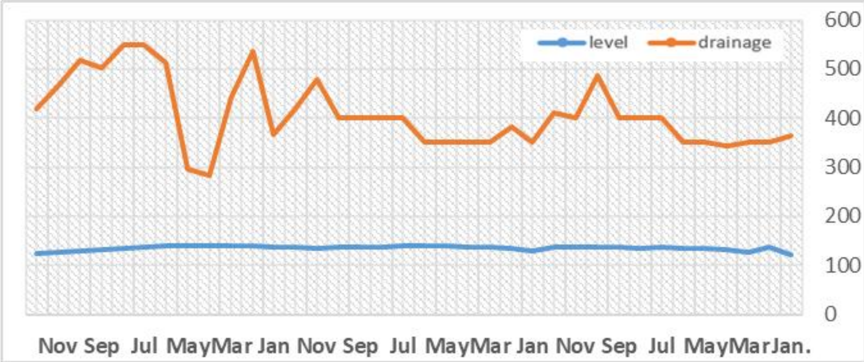
One of the most important sources of life is water, as Allah Almighty said (And We made from water every living thing), and it is one of the most abundant resources available on the surface of the earth and beneath it. The increasing demand for clean water is a given due to the rise in the world population, the spread of industry, the increase in the standard of living, the expansion of irrigated agricultural land, and other factors. The rate of individual water consumption is an indicator of their standard of living, as the water consumption rate in developing countries is lower than that in developed countries. Below is an overview of the main factors affecting water consumption. (Al-Qadi and Al-Juhari, 2006: 5)

2-1 Sources of water:

The scarcity of potable water has been a major concern and anxiety for humanity. If we look at the state of water in the world, we notice that about 71% of the earth's surface is covered by water, while the fresh water available in rivers and lakes for human use does not exceed 1%. According to United Nations statistics, there are more than one billion people who do not have access to safe drinking water, with the number of environmental refugees rising to (25) million annually, as their migration is linked to factors such as desertification and drought. Therefore, the United Nations has given special attention to this issue by designating March 22 as World Water Day to alert the world to the dangers resulting from neglecting the water issue and what it may lead to in terms of wars and future disasters. (Al-Maqadima, 2015: 22).

Despite the desert nature of Al-Anbar Governorate, where the city of Hit is located, it is distinguished by hosting one of the most important and sweetest rivers in the world (the Euphrates River), from which three lakes emerge: (Lake Haditha, Al-Razzazah, and Al-Habbaniyah). However, the Euphrates River has witnessed a decrease in its levels, reaching up to 50% this summer due to the reduced water releases from Syria, the low water inflows from sources and reservoirs, rising temperatures, and some encroachments on the river's course in several areas of Al-Anbar cities. Additionally, there are reasons that have led to the low levels of the Euphrates River, including the presence of drinking water networks in Al-Anbar cities, many of which have aged, resulting in leaks, along with wastefulness and a lack of guidance and regulation in water usage.

This research will focus on Lake Haditha as it is the main resource affecting the Euphrates River before its flow enters the city of Hit. Figure (1) below illustrates the water level and monthly discharge of Lake Haditha for the years 2020 to 2022:



- **Source: Prepared by the researcher based on data from the field interview with the Haditha Dam management on 4/2/2024.**

Figure (1) Average monthly water level and discharge of Haditha Lake

We observe from the above figure that the water level of Haditha Lake was well controlled and managed despite fluctuations in international water releases. However, the discharge of water into the Euphrates River and from it to the city of Hit was variable due to several reasons, including the actual need for water for various uses of the river, as well as the increased discharge used for electricity generation. This is particularly noticeable in the hot summer months when the amount of discharge into the river increases for electricity generation and domestic and agricultural use. The lowest recorded discharge was in April 2020, with a volume of (m3/h 284.5), while the highest discharge of water occurred in August and September of the same year, reaching (m3/h 550) due to high temperatures in the summer and increased domestic use, in addition to electricity generation.

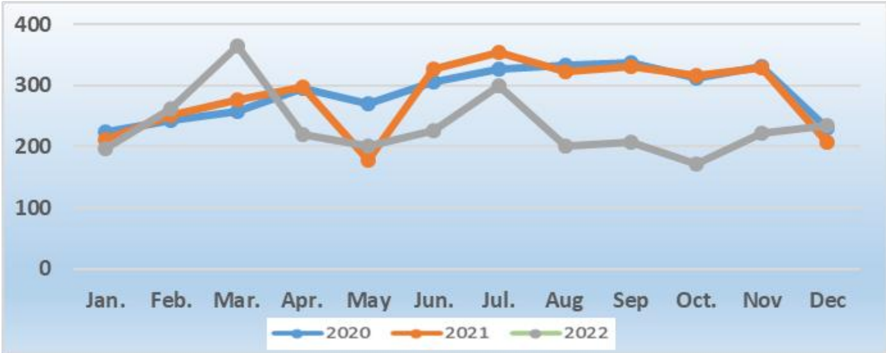
The water level and discharge in Haditha Lake and Dam affect two important factors in our research:

A- The amount of electricity generated by the dam based on the lake, which supplies the city of Hit with electricity for its projects and water complexes, thereby affecting the number of operating hours of the water complexes per day.

B- It affects the water level in the river on which the water complexes and projects are located. A decrease in the river's water level may lead to some of these projects being out of service due to the low flow of the river.

2-2 Water Supply:

The water supply in the city of Hit and its surrounding areas and villages for domestic use depends on the number of operating hours of the water complexes and projects in the city, which in turn relies on the availability of electrical power. Therefore, the researcher collected data on the operating hours of the city and its surrounding areas with electrical power to calculate the amount of water supplied to the residents in the city sample of the research, Figure (2) below shows the number of operating hours of the city and the water pumping complexes powered by electricity to operate and pump clean water to the residential units and citizens in the city of Hit and its surrounding areas and villages during the study period.

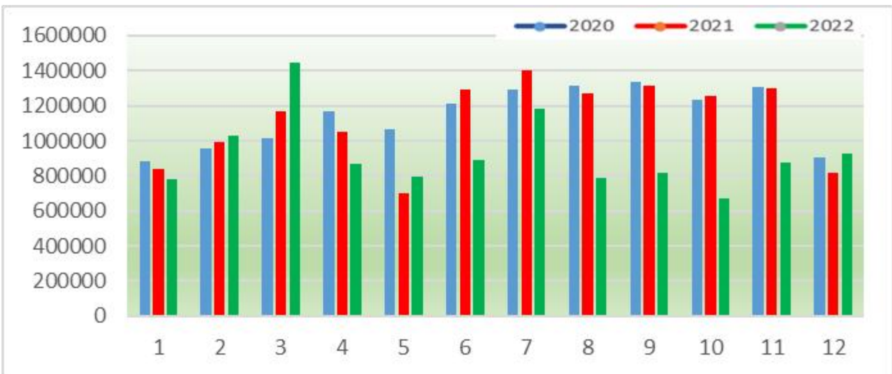


- Source: Prepared by the researcher, based on the field visit to the Hit Electricity Department on 3/1/2023

Figure (2) Number of operating hours of water pumping stations

The residents of the city of Hit rely on pumps (projects/complexes) based on the Euphrates River to supply households in the city. There are (21) twenty-one clean water projects and complexes that supply the city of Hit and its districts and villages for domestic use.

The compensation (operating additional supply hours for water complexes relying on diesel generators in addition to national electricity) begins to meet the increasing demand during the hot months from May to September, at an operating rate of three hours daily. When calculating the monthly operating hours for the water complexes and projects in the city of Hit and multiplying them by the daily production capacity of these complexes, we will obtain the quantity of clean water supplied to the city monthly, which represents the volume of water demand. The monthly supply capacity for all stations can be obtained (the required quantity of water in the city) by summing the daily production capacity of all stations, which is (3950 m3/h), multiplied by the monthly operating hours, as shown in the following figure (3):

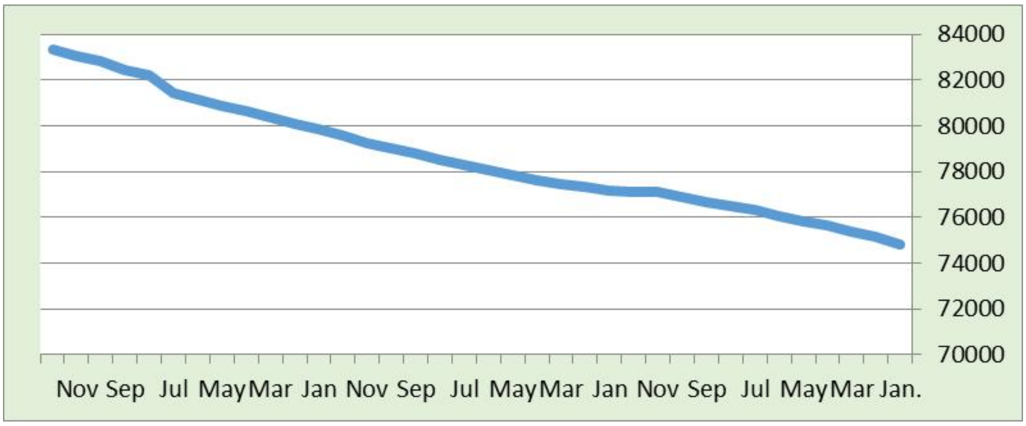


- Source: Prepared by the researcher, based on the data from the field visit to the Hit Water Department on 7/2/2023

Figure (3) The quantity of clean water supplied (required) (m3/month)

2-3 Population: The population size is one of the most important factors influencing the demand for clean water. According to the economic theory, there is a direct relationship between population growth and water demand. It is evident that as the population increases, their needs for clean water for various household uses also increase (Ta'ani et al., 2015:71).

From the figure below, we observe the continuous growth in the population of the city of Hit and its suburbs, which necessitates an increase in the demand for clean water for various uses. Therefore, we expect that the population growth rate will be an important variable with statistically significant implications in the water demand function. The population growth rate of the city is illustrated in the figure below:



- Source: Prepared by the researcher, based on the field visit to the Supply Department of Hit and the Health Department of Hit on 7/2/2023

Figure (4) Population Growth in the City of Hit

2-4 Per Capita Water Consumption Rate: The per capita water consumption rate (individual share of water) is considered one of the indicators of individual welfare due to the importance of water for human use. After determining the population size in the city of Hit and the amount of water required, the per capita water share can be calculated by dividing the amount of water required in the city of Hit by its population. The share of clean water per capita in the city of Hit can be represented in the following graph, which illustrates the fluctuation of the average per capita water share monthly, depending on temperature variations and the amount of energy supplied to the city and its water stations.

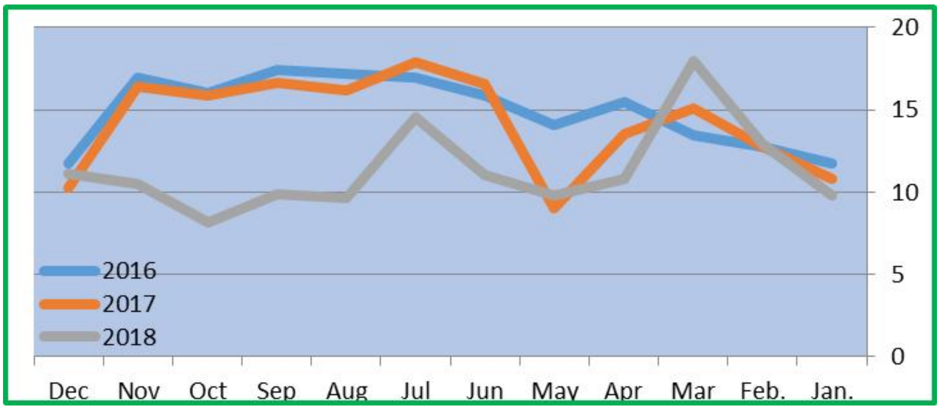


Figure (5) Average per capita share of clean water for the city of Hit (m^3/month)

From the previous figure, we can see that the per capita share of clean water in the city of Hit ranges between (8.2) m^3 per month and (18.1) m^3 per month, with an average monthly individual consumption of (13.05) m^3. This significant increase in monthly clean water consumption in the city of Hit is attributed to several reasons, the most important of which are the following:

1- The city's location on the banks of the Euphrates River, which encourages residents to consume unlimited amounts of water.

2- Weak awareness and increased excessive water use by residents.

3- Numerous breaks in the old and even new water networks that supply the city.

4- The use of clean water for purposes other than drinking, including washing cars, irrigating gardens, and industrial purposes, etc.

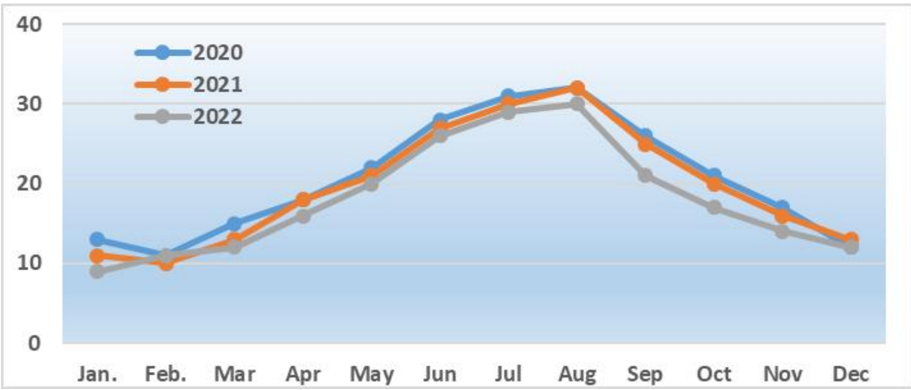
5- Significant violations of the official water network, leading to irresponsible use of clean water.

6- Weak official and supervisory bodies regarding water consumption and water bill collection.

2-5 Temperature: The variation in temperature affects water in two ways: (1) When surface water in seas, oceans, lakes, and rivers is exposed to direct sunlight, leading to significant evaporation and loss, and a decrease in water levels in rivers and lakes. (2) There is an increased household need and demand for water for drinking and various domestic uses, leading to a significant rise in water demand during the summer, which is characterized by its length and high temperatures, especially in Anbar Province, which includes the city of Hit and is considered a hot desert province.

Due to the destruction and damage of all meteorological stations in the city of Hit and its surroundings, it was impossible to obtain recorded temperature data for the city. Therefore, the researcher resorted to the internet and through the international meteorological site that provides weather conditions and temperature updates. The average temperatures for the city of Hit are shown in Figure (6).

It is certain that the average temperatures in summer were higher than those in winter, as Iraq has a seasonal continental climate characterized by hot, dry summers and cold, rainy winters. Thus, the highest average temperature was observed in summer (August) of 2022, where the temperature reached 32 degrees Celsius, compared to the lowest average temperature recorded in winter (January), which was 9 degrees Celsius.



Source: Meteorological website, at the following electronic site:
https://www.accuweather.com/ar/iq/hit/206745/month/

Figure (6) Average temperatures for the city of Hit

The clear variation in temperatures during the winter and summer seasons of the year undoubtedly affects the amount of clean water required and consumed by the residents of the city of Hit and its surroundings and villages during the years 2020-2022, and this is what we will attempt to prove in the final section of this research.

3- Quantitative aspect and standard analysis

3-1 Model construction: Based on the theoretical framework and previous studies, the model was described as follows:

Table (2) Description of the model variables

Variables	Code	Type
Water demand	W	Dependent
Population	N	Independent
Temperature	H	Independent
Electrical energy	E	Independent

-Source: Prepared by the researcher

3-2 Stationary of Time Series: Most economic and financial time series exhibit unstable random behavior, and the task of econometrics is to determine the most appropriate trend form in the data (Ravindrana et al., 2011, 78). A time series is considered stable if its values fluctuate around a constant mean with a constant variance over time. This condition means that the means for all periods have the same value, meaning:

A. Stability of average values over time

$$E(y_t) = M \quad \text{... (1)}$$

B. Stability of variance over time

$$Var(y_t) = \sigma^2 \quad \text{... (2)}$$

C. The variance between two series does not depend on the actual time period of variance, but rather on the variance constant (k) between the two periods:

$$COV(y_1 . y_2) = E[(y_1 - M)(y_2 - M)] = \gamma_k \quad \text{... (3)}$$

The stationarity of the time series at the original level, the first difference, or both determines the model used to measure and estimate the relationship or effect between the time series. There are several methods for this test, including the following:

3-1-1 Augmented Dickey-Fuller (ADF) unit root test: The stationarity of the time series under study was tested using the Augmented Dickey-Fuller (ADF) test, as shown in the table below. The mathematical formula can be shown as follows:

- Without a fixed limit and general direction

$$\Delta y_t = B_1 y_{t-1} \sum_{i=1}^{p} \lambda_i \, \Delta y_{t-i} + e_t \quad \text{... (4)}$$

- With a fixed limit and no general direction:

$$\Delta y_t = B_0 + B_1 y_{t-1} + B_1 y_{t-1} \sum_{i=1}^{p} \lambda_i \, \Delta y_{t-i} + e_t \quad \text{... (5)}$$

- With a fixed limit and general direction:

$$\Delta y_t = B_0 + B_{1t} + \sum_{i=1}^{p} \lambda_i \, \Delta y_{t-i} + e_t \quad \text{... (6)}$$

Table (3) Results of (ADF) unit root test for the difference

Variables	Without a constant		With constant and direction		Without a constant or direction	
	t-Statistic	Prob.	t-Statistic	Prob.	t-Statistic	Prob.
Y	1.9036	0.0261	-3.4622	0.0005	-0.3612	0.004
N	5.3233	0.000	-5.8473	0.000	-1.5657	0.000
H	1.635	0.000	-1.9864	0.004	0.3227	0.0007
E	1.0913	0.008	0.3046	0.0012	-1.7745	0.018

-Source: Prepared by the researcher using Eviews10

3-1-2 Phillips-Perron (PP) Unit Root Test: The stability (Stationary) of the time series under study was tested using the Phillips-Perron (PP) test as shown in the table below, and the mathematical formula for the (PP) test is as follows:

$$\Delta Z_t = \phi + (\rho - 1)Z_{t-1} + \gamma(t - \frac{T}{2}) + \psi\Delta Z_{t-i} + e_{3t} \quad)7(...$$

The PP test is used because it has better and more accurate testing capability than the ADF test, especially when the sample size is small, and in cases of conflicting and inconsistent results from the ADF test.

Table (4) Results of (PP) unit root test at the first difference

variables	Without a constant		With constant and direction		Without a constant or direction	
	t-Statistic	**Prob.**	**t-Statistic**	**Prob.**	**t-Statistic**	**Prob.**
Y	**-3.8462**	**0.000**	**-3.6681**	**0.0042**	**-2.4165**	**0.000**
N	**-5.6713**	**0.000**	**-5.7551**	**0.0001**	**-2.2442**	**0.0054**
H	**-1.6502**	**0.0021**	**-1.4244**	**0.000**	**0.6803**	**0.0009**
E	**-0.9835**	**0.0004**	**-0.4443**	**0.0036**	**1.8734**	**0.0016**

Source: Prepared by the researcher using Eviews10

From the above tables, we notice that the time series data for the study variables have become stable, and we can move on to the next step, which is testing for the existence of co-integration among the study variables and estimating the multiple linear regression equation between the dependent variable and the independent variables.

3-2 Co-integration Methodology: To analyze time series in econometrics for two or more time series, it is necessary to ensure the stationarity of the time series and then verify the existence of co-integration among the time series. It is said that there is co-integration between two or more variables if they share the same direction (Bachrach & Vaughan, 1994: 22), meaning if they have a long-term equilibrium relationship. Among the most famous methods are the Engle-Granger method and the Johansen method.

After conducting unit root tests for the variables under study, it was found that the variables are integrated of order one I(1), It is also necessary to know and determine the number of optimal time delay periods for a single time interval as in the following equation equation when estimating the (ECM) model:

$$\Delta y_t = B_0 + B_1 y_{t-1} + B_2 y_{t-1} + \sum_{i=1}^{p} \lambda_i \Delta y_{t-i} + U_t \quad ... \quad (8)$$

or for two time delay periods as in the equation:

$$\Delta y_t = B_0 + B_1 y_{t-1} + B_2 x_{t-1} + B_1 y_{t-1} \sum_{i=1}^{p} \lambda_i \, \Delta y_{t-i} + B_1 +_{t-1} \sum_{i=1}^{p} \lambda_i \, \Delta x_{t-i} + U_t \quad \ldots \ (9)$$

Therefore, the regression equation will be estimated as shown in the table below:

Table (5) Results of Variable Estimation

Dependent Variable: W				
Method: Least Squares				
Date: 03/26/23 Time: 13:56				
Sample: 2020M01 2022M12				
Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	399139.5	981640.7	0.406605	0.6870
E	4418.424	479.4217	9.216153	0.0000
H	5754.07	4187.718	1.37403	0.0090
N	5.63266	11.85152	0.47527	0.0078
R-squared	0.80772	Mean dependent var		1067403
Adjusted R-squared	0.789694	S.D. dependent var		328044.2
S.E. of regression	150438.1	Akaike info criterion		26.78493
Sum squared resid	7.24E+11	Schwarz criterion		26.96088
Log likelihood	-478.129	Hannan-Quinn criter.		26.84634
F-statistic	44.80811	Durbin-Watson stat		2.262643
Prob(F-statistic)		0.000000		

- Source: From the researcher's work based on the output of the Eviews10.

The following regression equation can be written:

$$WQ_d = 399139.5 + 5.6327N + 5754.07H + 4418.424E + u_i \quad \ldots (10)$$

The table above indicates the following:

1- The values of all independent variables in the model, represented by (population N, temperatures H, electric energy E), are statistically significant at a significance level of (5%), as there was a positive effect of all independent variables on the dependent variable, which is the quantity of clean water demanded.

2- The value of the coefficient of determination for the model reached (81%), and this value indicates that the independent variables included in the model contribute to explaining (81%) of the variations in the dependent variable, while the remaining percentage (11%) is attributed to other factors not included in the model. The results can be interpreted as follows:

3- After estimating the co-integration relationship among the model variables, the researcher arrived at the above multiple linear regression equation, from which the following can be inferred:

- An increase in the population by one individual leads to an increase in the required amount of clean water by (5632) five thousand six hundred and thirty-two liters per month.

- A rise in temperature by one degree will result in an increase in the required amount of clean water by (5754) five thousand seven hundred and fifty-four liters per month.
- An increase in the city's electricity supply by one hour will lead to an increase in the city's supply of clean water by (4418) four thousand four hundred and eighteen liters per month.
- It is necessary first to estimate the optimal lag periods between the variables, and Table (6) shows the tests for optimal lag periods, indicating that the best lag period is two periods.

Table (6) Tests for Optimal Lag Periods

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-186.288	16.69719	21354540	19.71455	19.76426	19.72297
1	-152.462	60.53061	674751.2	16.25919	16.35861	16.27602
2	-149.831	4.431164*	569375.9*	16.08751*	16.23663*	16.11275*
* indicates lag order selected by the criterion						

- Source: Prepared by the researcher using Eviews10

After conducting the relationship between the study variables and testing for unit roots in the residuals of this test, which showed that the residuals are non-stationary, it is not possible to use the error correction model. Therefore, we resort to the Johansen method within the VAR model framework. This method is considered better than the first method because it allows for the determination of the mutual effect between the variables under study, which is not present in the Engel-Granger method. Since the time series of the study variables are integrated of the first order, we will test for the existence of a long-term equilibrium among them by examining the co-integration among the model variables using the Johansen method. The following table shows the results of the co-integration test for the study variables:

Table (7) Results of the Johansen Co-integration Test

Unrestricted Co-integration Rank Test (Trace)				
	Trace		0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.71456	89.53746	47.85613	0.0000
At most 1 *	0.482176	46.91086	29.79707	0.0002
At most 2 *	0.408847	24.5348	15.49471	0.0017
At most 3 *	0.177932	6.661687	3.841466	0.0098
Trace test indicates 1 co-integrating eqn(s) at the 0.05 level				
	Max-Eigen		0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.71456	42.6266	27.58434	0.0003
At most 1 *	0.482176	22.37606	21.13162	0.0333
At most 2 *	0.408847	17.87311	14.2646	0.0129
At most 3 *	0.177932	6.661687	3.841466	0.0098
Max-eigenvalue test indicates 1 co-integrating eqn(s) at the 0.05 level				

Source: Prepared by the researcher using Eviews10

The results in Table (7) show the co-integration test using the Johansen method, where we find that there is a long-term co-integration relationship between water demand and the influencing factors in the city of Hit during the study period, according to the Trace Test, which was equal to (89.53746), greater than the critical value of (27.58434) at a significance level of (5%). Therefore, the null hypothesis will be rejected and the alternative hypothesis accepted. As for the Maximum Eigenvalues Test, which was equal to (42.6266), it is also greater than the critical value of (27.58434) at a significance level of (5%). Consequently, the null hypothesis will also be rejected and the alternative hypothesis accepted. This confirms the existence of a co-integration and a long-term equilibrium relationship between the independent variables and the dependent variable of the study.

Graphical representation of residual stability:

This test is used to ensure that the residuals in the model estimated according to the Johansen Co-integration test are stationary and that the model does not suffer from autocorrelation issues. This indicates the presence of co-integration, which allows for the estimation of the Error Correction Model (ECM), as illustrated below:

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |* . |	. |* .	1	0.148	0.148	0.5923	0.442
.**| . |	***| .	2	-0.319	-0.348	3.4711	0.176
. | . |	. |* .	3	-0.042	0.085	3.5234	0.318
. | . |	. *| .	4	-0.006	-0.146	3.5243	0.474
. *| . |	. | .	5	-0.060	-0.020	3.6419	0.602
. | . |	. | .	6	0.061	0.042	3.7688	0.708
. *| . |	.**| .	7	-0.135	-0.233	4.4394	0.728
. *| . |	. | .	8	-0.102	0.027	4.8436	0.774
. *| . |	.**| .	9	-0.083	-0.256	5.1332	0.823
. *| . |	. *| .	10	-0.149	-0.149	6.1253	0.805
. | . |	. *| .	11	-0.039	-0.118	6.1986	0.860
. | . |	.**| .	12	0.000	-0.221	6.1986	0.906

- **Source: Prepared by the researcher using Eviews10**

Figure (7) Graphical representation of residual stability

3-3 ECM Error Correction Results:

After ensuring that the study variables are cointegrated and that there is a long-term equilibrium relationship between the required amount of clean water and the influencing variables, according to Engle-Granger, the variables that achieve cointegration reflecting the long-term equilibrium relationship should be represented in an Error Correction Model (ECM), which means it is possible to test and estimate the relationship in the short and long term between the study variables. Therefore, the Error Correction Model should be estimated using the two-step Engle-Granger method, and the short-term model will be estimated by introducing the estimated residuals from the long-term regression as a lagged independent variable for a second time period.

Table (8) Results of Estimating the Error Correction Model

Dependent Variable: DW
Method: Least Squares
Date: 03/29/23 Time: 00:18
Sample (adjusted): 2020M02 2022M12

Included observations: 35 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1555.562	89774.16	0.017327	0.0063
DH	6109.814	9689.217	0.630579	0.0129
DN	5.058282	333.3101	0.015176	0.0080
DE	4180.029	561.7737	7.440770	0.0000
U(-1)	-0.215478	0.102874	-2.094581	0.0027
R-squared	0.651834	Mean dependent var		2629.571
Adjusted R-squared	0.618140	S.D. dependent var		370802.4
S.E. of regression	229136.6	Akaike info criterion		27.62923
Sum squared resid	1.63E+12	Schwarz criterion		27.80699
Log likelihood	-479.512	Hannan-Quinn criter.		27.69060
F-statistic	19.34599	Durbin-Watson stat		1.083414
Prob(F-statistic)	0.000000			

-

Source: Prepared by the researcher using Eviews10

The error correction model equation can be written as follows:

DW=1555.5616+6109.8141*DH+5.0583*DN+4180.0290*DE-0.21*U(-1)

We notice from the results of the estimation above the significance of the model indicated by the F-value, which reached (19.346) and is significant at the 5% level. Through the probability value (prob.), the Durbin-Watson statistic (D.W) of (1.08) indicates that the estimated model does not suffer from autocorrelation issues. We also observe that the short-term error term does not equal the long-term equilibrium value. Therefore, in the short term, there is a partial correction through the error correction term or adjustment coefficient, adjusting the actual value of the error term towards the equilibrium value. This coefficient measures the imbalance in different periods and corrects it towards the equilibrium value. The negative sign of the error term indicates the long-term equilibrium relationship and the speed of adjustment of the error term, which is (-0.12).

3-4 Standard Tests:

To ensure the validity of the results of the estimated multiple regression model and cointegration and to verify their integrity and adherence to the conditions of the OLS method to avoid misleading results, we must check the conditions of the previous method. We use the following standard tests:

3-4-1 Autocorrelation: The issue of autocorrelation arises when there is a correlation between the values of the random variable in the studied time series. The existence of this problem was tested using the Serial Correlation LM test (James L. Powell, 3), which resulted in a value of (1.8745) with a probability of (0.2214). This value is greater than (0.05), indicating acceptance of the null hypothesis, which assumes that there is no autocorrelation within the bounds of random error, as shown in the table below:

Table (9) Results of the Autocorrelation Test

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	1.874541	Prob. F(1,20)	0.2214

Obs*R-squared	1.954326	Prob. Chi-Square(1)	0.1762

Source: Prepared by the researcher using Eviews10 software -

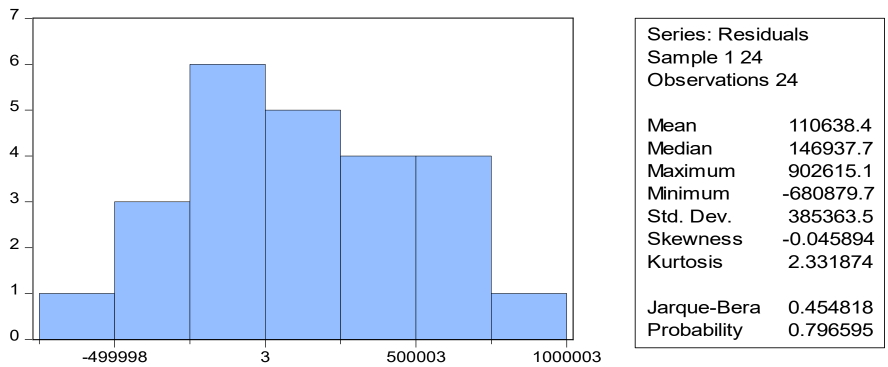
3-4-2 Homoscedasticity: To ensure there is no heteroscedasticity among the independent variables in the model, the Autoregressive Conditional Heteroskedasticity (ARCH) test was used, which resulted in a value of (0.0026) with a probability of (0.9215). This value is greater than (0.05), indicating acceptance of the null hypothesis, which assumes no multicollinearity among the independent variables in the model, as shown in the table below:

Table (10) Results of the Multicollinearity Test

Heteroskedasticity Test: ARCH			
F-statistic	0.002578	Prob. F(1,21)	0.9215
Obs*R-squared	0.006542	Prob. Chi-Square(1)	0.9764

- Source: Prepared by the researcher using Eviews10

3-4-3 The normal distribution of random error bounds: The histogram of the random error bounds is drawn, in addition to using the Jarque-Bera test to test the random error bounds. The results indicate that the p-value of the test is (0.7966), which is greater than the level of (0.05). Therefore, we will accept the null hypothesis which states that the random error bounds follow a normal distribution, as shown in the following figure:



- Source: Prepared by the researcher using Eviews10

Figure (7) Histogram of the normal distribution of random error bounds

Based on the previous tests, it can be said that the estimated regression model meets the required conditions; therefore, it is considered a good model and can be relied upon to interpret the results.

4. Conclusions

After reviewing the summary of the theoretical framework of the study and estimating the monthly water demand function, the researcher reached the following results:

There is a significant problem with the misuse of water in the study area, attributed to several factors, including:

- The city's location on the banks of the Euphrates River, which encourages residents to consume water without limits.
- Weak awareness and increased excessive water use by residents.
- Many breaks in the old and even new water networks that supply the city.
- The use of clean water for purposes other than drinking, such as washing cars, irrigating gardens, and industrial purposes.
- Significant violations of the official water network, leading to irresponsible use of clean water.
- Weak official and regulatory bodies overseeing water consumption and the collection of water bills.
- The average water consumption per person in the study area is (13.05) m3/month, which is a very high average compared to the global average.
- An increase in the population by one individual leads to an increase in the required amount of clean water by (5632) five thousand six hundred and thirty-two liters per month.
- A one-degree increase in temperature will increase the required quantity of clean water by 5,754 liters per month. Increasing the city's electrical power supply by one hour will increase the city's clean water supply by 4,418 liters per hour.

Resources:

1. Al-Muqaddamah, T. I. (2015). *Estimating the demand function for household water consumption in the Gaza Strip: An* applied *study for the period 2009-2013* [Master's thesis, Islamic University of Gaza]. IUG Library. https://library.iugaza.edu.ps/
2. Al-Anezi, W. H., Mohammed, M. T., & Asaad, B. (2021). The impact of financial liberalization on the value of the bank: An applied study on private Iraqi banks for the period 2011-2017. *Webology, 18*(SI03), 195–213. https://doi.org/10.14704/WEB/V18SI03/WEB18108
3. Shallal, A. A. H., Asaad, B. M., Aljebory, A., & Aldulaim, H. (2025). Impact of green economy on the sustainable development indicators in Iraq. In *Springer Proceedings in Business and Economics*. Springer. https://doi.org/10.1007/978-981-96-4116-1_27
4. Al-Qadi, A. F., & Al-Jawhari, W. (2006). The impact of some factors on household water consumption in Jordan. *Dirasat: Agricultural Sciences, 33*(1). https://journals.ju.edu.ps/DirasatAgri/article/view/1000
5. Salman, A. Z., Al-Karablieh, E., & Haddadin, M. (2012). The residential water demand function in Amman-Zarka Basin in Jordan. *Wulfenia Journal, 19*(10).

https://www.researchgate.net/publication/259266839_The_Residental_Water_Demand_Function_in_Amman-_Zarka_Basin_in_Jordan

6. Powell, J. L. (n.d.). *Models, testing, and correction of serial correlation*. Department of Economics, University of California, Berkeley. https://eml.berkeley.edu/~powell/e240b_sp06/sernotes.pdf
7. Bachrach, M., & Vaughan, W. J. (1994). *Household water demand estimation*. Inter-American Development Bank. https://doi.org/10.18235/0011616
8. Ramasamy, R., & Helmi, M. H. M. (2011). Chaotic behavior of financial time series: An empirical assessment. *International Journal of Business and Social Science, 2*(3), 195–201. https://www.researchgate.net/publication/228958100_Chaotic_Behavior_of_Financial_Time_Series-An_Empirical_Assessment
9. Ahmed, S., Mustafa, U., & Khalid, M. (2016). *Analysing household water demand in urban areas: Empirical evidence from Faisalabad, the industrial city of Pakistan*. International Growth Centre (IGC). https://www.theigc.org/sites/default/files/2016/08/Ahmed-et-al-2016-Final-Report.pdf
10. Shallal, A. A. H., Asaad, B. M., Aljebory, A., & Aldulaim, H. (2025). Impact of green economy on the sustainable development indicators in Iraq. In S. Kot, B. Khalid, & A. ul Haque (Eds.), *New Challenges of the Global Economy for Business Management* (pp. [Page Numbers]). Springer. https://doi.org/10.1007/978-981-96-4116-1_27
11. Taani, R. A. (2015). Water uses and their effects on sources and treatment methods: A case study/Jordan. *Assiut University Bulletin for Environmental Researches, 18*(1). https://www.researchgate.net/publication/309762302_Water_Uses_and_Their_Negative_Impacts_on_Water_Resources_and_Treatment_Methods_A_Case_StudyJordan