

# Analyzing the Effectiveness of Modern Irrigation Methods in Iraq

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## ABSTRACT

Iraq is one of the countries that have water scarcity problem. Many reasons have made this problem to be more complex. The modern irrigation methods have used as one solution to the water problem in Iraq. This paper investigates the effectiveness of modern irrigation methods in Iraq. The paper tests the impact of using modern irrigation methods on the amount of water used for irrigation. The study uses Liner Regression Model (LRM) as a statistical estimation model. The study data were taken from the ministry of water resources, and the ministry of agriculture in Iraq.

This study uses weekly time series data from 2000 - 2010. The results show that using modern irrigation methods in Iraq has negative and insignificant impact on the total amount of irrigation water. The results shows that temperature (climate effect) has positive and significant impact on total irrigation water. The results shows that stored water has positive and significant impact on irrigation water.

**Keywords**— Irrigation, Method, Iraq, Liner Regression Model, Water Resources Management

## I. INTRODUCTION

The modern irrigation methods have introduced as an engineering solution to the water problem in Iraq. This paper aims to analyze the effectiveness of modern irrigation methods in Iraq. The importance of this paper is to statistically test the impact of using modern irrigation methods on the amount of water used for irrigation. The contribution of this paper is to help Iraqi policy maker evaluate the program of using modern irrigation systems in agriculture, [1].

Before starting, it is important to discuss the water problem in Iraq. The water shortage or water scarcity in Iraq is one of the serious problems that started few decades ago. This problem become worse because of high population growth rate, and big climate change (high temperature for long time). In addition, the pollution of some water sources, and the water resources policies of neighbor countries are other reasons of water scarcity in Iraq, [2].

The problem of water scarcity is usually happened in dry areas. The climate change resulting from

global warming has increased this problem. Since Iraq is one of the countries that are located in dry areas, it is more likely to have the water scarcity problem. In fact, in the recent years, many signs of the water scarcity problem in Iraq were identified. For example, the lack of water supply due to the behavior of neighboring countries. In addition, there are very old and limited water management strategies used in Iraq. Therefore, Iraqi authority must respond seriously and immediately to these challenges to obtain sustainable water availability, [3].

Despite the many advanced innovations and technologies in the field of water resources management (WRM), Iraq and some other countries in this still do not use them. Iraq still use only traditional techniques such as artificial lakes and dams to manage it water resources. It is known that the Tigris River and the Euphrates River are the main water resources in Iraq. Most of water used in Iraq especially for irrigation is from these rivers, [4].

The scarcity of water resources in Iraq is not a new problem. This problem was identified since the seventies of the last century. It started when Turkey, Iran and Syria established projects to store the water of the upper Tigris and Euphrates rivers. They were constructing dams, reservoirs and irrigation projects on the course of the two rivers in their lands without consulting the downstream state (Iraq). Iraq has tried repeatedly over the twenty years to negotiate with those countries to reach solutions through diplomatic means in order to preserve its water rights. However, it did not succeed in that because the Turkish side was not corporate, and because of the Iraqi-Iranian war, [1].

All of these factors enforced Iraqi governments to find solutions to the water problem especially in agriculture, which is the main economic activity in Iraq. Many government agencies and private organizations in Iraq were working on special program to that encourage farmers to use modern irrigation methods, [5].

## II. SOURCES OF IRRIGATION WATER IN IRAQ

There are three main sources of irrigation water in Iraq. The first source is the water of the Tigris and Euphrates rivers and their tributaries. The second source is the rain water. The third source is the ground water.

**2.1. The Tigris and Euphrates Rivers**

The water of the Tigris and Euphrates rivers is considered as the main source of water that used for irrigation purposes in Iraq. Recently, the quality of water of the Euphrates has changed due to the decrease in the amount of water reaching Iraq. The decrease was from 14 billion m<sup>3</sup> to 9 billion m<sup>3</sup>. That decrease was happened because of the dam reservoirs in Turkey (Keban and Ataturk) and the Tabqa reservoir in Syria.

The salinity of the Euphrates increased dramatically from 300 to 400 parts per million (about 0.5 decisiemens /m). While it has currently exceeded (1.1 decisiemens /m), and arrived at the city of Nasiriyah to (4.5 decisiemens/m). Despite the increasing risks of salinity in the water of the Euphrates River, the water still in good quality to be used in irrigation, [6].

The negative impacts on Iraq's water resources are expected to intensify upon the completion of the huge irrigation projects that Turkey is establishing in the southwest region (Southwest Anatolia Project). In general, the tangible changes in the quality of the Tigris and Euphrates waters in relation to the increase in salinity are due to:

1. Decrease the amount of water coming into these rivers in Iraq.
2. Operating large storage projects on them and the consequent increase in evaporation.
3. Changing the system of controlling and investing their waters.

**2.2. The Rain Waters**

The rainwater is another source of irrigation water in Iraq. The rain in Iraq is limited and the rain season is very short. However, big agriculture areas in Iraq depend on rainwater for irrigation. The big problem is that different Iraqi governments have not adopted good plans and strategies for the sustainable development of rainwater management, [7].

There is a need for development that achieves the best results in collecting rainwater and reducing its waste. That can be more important with the expectation of future water scarcity that Iraq may suffer in the future.

Many studies indicated that there is no clear strategic plan for an integrated management of rainwater resources. In addition, there is lack of cooperation between the Iraqi authorities to solve this problem. For example, there is no cooperation between the governmental and official institutions such as the Ministry of Water Resources, Agriculture, Environment, Health, Industry, Municipalities, and others. Even their work is concerned with reviving, maintaining and preserving natural and industrial water sources, they do not cooperate.

The water harvesting in Iraq could add thousands of cubic meters to irrigation water resources. However, there is no clear national strategic plan that can effectively

manage rainwater resources. According to the Ministry of Water Resources in Iraq, in the previous five years, Iraq suffered from a great water scarcity that led to the desertification of thousands of agricultural areas. There was no enough water storage to irrigate these vast areas of orchards and summer crops. Therefore, the governorates must pay more attention to solve the shortage in irrigation water especially in the hot summer season. In addition, they must adopt new techniques and technologies in rainwater harvesting operations, [8].

For example, one possible solution is reducing the waste of rainwater. Rainwater can be stored by fixing the engineering problems in most of old dams and reservoirs. Developing these dams and reservoirs can help reducing the water waste and distributing the water in an optimal manner. That will lead to investing the rainwater in various uses without wasting thousands of cubic meters. Table (1) shows the average rainfall in Iraq.

**Table 1:** Rainfall rates and quantities in Iraq  
**Source:** Ministry of water resources in Iraq

Rainfall Rate (mm/year)	Rainfall quantity (million m <sup>3</sup> )	Rainfall Areas (1000 km <sup>2</sup> )	Rainfall Areas (%)
Less than 100	4.7	99	22
100 – 300	54	282	62
300 – 600	20.7	48	11
600 – 1000	7	9	2
More than 1000	12.8	13	3
<b>Total</b>	<b>99.8</b>	<b>450</b>	<b>100</b>

**2.3 Ground Water**

Ground water is the water stored under the surface of the earth. The geological formations that store water are called reservoirs (Aquifers). Studies indicate the existence groundwater with good quality is found mostly in the western plateau of Iraq. It is found in relatively deep wells and its quantities are small. The depth of the wells in these areas is between 50 - 450 m. The production rate of these wells is about 80 - 400 liters / minute, [9].

The dissolved salts in the groundwater in Iraq is between 0.5 - 4.6 decisiemens/m. The utilization of groundwater in Iraq is still limited. There is currently (13174) machine dug wells and (4000) hand dug wells.

The annual productivity of these wells is about one billion m<sup>3</sup>.

The renewable groundwater reserve in Iraq is about 2.3 billion m<sup>3</sup>. The underground storage in the desert is about 200 billion m<sup>3</sup>, which big part of it still not invested. Reserves of groundwater are distributed over 30 basins, most of which are located in the northern and central region, and another percentage of them in the Western Sahara region.

### III. THE AGRICULTURE IN IRAQ

The previous section discussed the water resources that are used for irrigation in Iraq. These water resources represent water supply or the water available for irrigation. However, it is important to discuss the other side, which is the demand side. That can help better understand the irrigation water problem, and why new irrigation technologies are become essential. Therefore, it is important to review the agriculture in Iraq, which represents the irrigation water demand side, [10].

The agricultural in Iraq is considered as the oldest known agricultural in the world. Many evidences and studies have indicated the natural and human conditions for the establishment of agriculture are available in Iraq. For example, Iraq has appropriate climate, fertile soil, abundant water and agricultural labor. All of these factors make agriculture the main activity of the population

Most studies indicate that the available agriculture area in Iraq is about 48000 km<sup>2</sup> of the total Iraqi lands, which is about 175000 km<sup>2</sup>. The agriculture area in Iraq has about 16000 km<sup>2</sup> is located in the region that depends on rainfall in irrigation. About 32000 km<sup>2</sup> is located in the region that depends on rivers and lakes in irrigation. However, the actual agriculture area used in Iraq is about 26000 km<sup>2</sup>. Only 15000 km<sup>2</sup> is used in the region that depends on rainfall in irrigation, and 11000 km<sup>2</sup> is used in the region that depends on rivers and lakes.

The agriculture in Iraq is primarily a winter cultivation. The summer cultivation is limited, and it usually located in the northeastern region of Iraq. The summer cultivation area is less than a quarter of the area of the winter cultivation. The most prominent crops grown are food grains that occupy more than 91% in 1952-1953 compared to 81% in 2003. That includes wheat and barley, which used to occupy 83% of the total area of cultivated land in 1952-1953, compared to 78.1% in the year in 2003. These crops vary from year to year in area and production, depending on the variation in rain and surface water. In addition, they vary depends on the extent of exposure to agricultural pests, the extremes of temperature, and the state of floods, [11].

The agricultural sector in Iraq suffers from a serious and dangerous situation. This situation requires the

government agencies to pay more attention to this sector and find solutions to its problems. Agriculture in Iraq is one of the most important elements of Iraqi economy. However, the agricultural sector in Iraq have been neglected for a long time. As a result, this sector suffers now from many complex problems that are hard to solve.

The problems of Iraqi agriculture sector can be summarized as following, [12]:

1. The scarcity of water and the state of desertification that has generated in large areas as a result of the climate changes such as global warming that contributed to the lack of rainfall.
2. The negative impact of water policies practiced by the neighboring countries where the waters of the Iraqi rivers originate. These polices have greatly affected the amount of water reaching Iraq.
3. Most Iraqi farmers started searching for other jobs that rather than farming. This trend occurred because of many reasons that the farmer does not bear alone.
4. The lack of modern agricultural technologies and equipment that supports the farmer in the agricultural processes. That negatively affects the size and quality of the production.
5. The lack of modern chemical fertilizers, and if they are available, they are given at high and unsupported prices.
6. Failure to provide good seeds for farmers, which negatively affects the productivity of agricultural crops in terms of quantity and quality.
7. The lack of government's support to the farmers. For example, there is no or very limited training programs and financial support programs.
8. Failure to protect local agricultural products from competition from their counterparts imported from neighboring countries
9. The lack of agricultural engineering and skilled workers, which negatively affects the entire agricultural production process.
10. The inconsistency of different laws. For example, there is inconsistency between agriculture land laws, and property laws.
11. The lack of regular drainage networks that help in land reclamation and reduce the level of salinity.
12. The use of old methods of irrigation for orchards and fields, which led to salinity of the soil and insufficient water for it.
13. High fuel prices and transportation fees for agricultural products from the farmer to the wholesale markets, which causes an increase in the prices of agricultural crops.

Based on the above list of problems, the Iraqi government must take actions to change the situation.

Fixing these problems can lead the agriculture in Iraq to take its role in supporting the Iraqi economy. That is, the agriculture sector can limit the size of imports and reduce the unemployment in Iraq.

Developing comprehensive strategic plans for the advancement of the agricultural in Iraq is primarily the responsibility of the ministries of planning, agriculture and water resources, in cooperation with local governments.

One of the important actions that Iraqi government must take is adopting of modern technology in the agricultural sector. The adopting of modern agricultural mechanization can save effort and time. In addition, it can help ensuring the quality of the agricultural crop produced and increasing its quantity.

#### IV. MODERN IRRIGATION TECHNIQUES IN IRAQ

The Ministry of Agriculture in Iraq was adopted a program of using modern irrigation methods starting in 1991. The actual implementing of that program was in 2000 under the direct supervision of Iraqi government. The important reason for adopting this program was to cover the shortage in the availability of food. Iraq had to increase the production of grains and wheat specifically through increasing the area planted and the productivity lands, [13].

Since the water resources available for agriculture are limited, it had become necessary to think about using modern technologies in agriculture. The goal is to increase the cultivated area and increase productivity with the same amount of water was used by traditional irrigation methods. This program had been seriously considered after the agreement of the oil-for-food program. That is because this agreement introduced new opportunities for importing sprinkler and drip irrigation systems.

The program has the following three types of modern irrigation methods:

##### 1. *Sprinkler Irrigation Method*

Sprinkler irrigation is defined as the method of irrigation in which water is pumped into a network of pipes of different diameters. These pipes end with fixed holes or rotating sprinklers from which water comes out into the air in the form of drops that fall on the ground like rain.

Sprinkler irrigation was invented during the fifties, as perforated tubes were used to irrigate fields. The water pumped into these tubes with pressure, and exited from the holes spread along the tube in a form similar to fountains. After many developments of this method, tubes with holes at specific distances were used, on which smaller tubes were installed. The small tubes carry sprinklers at the end, which is known today as the solid system or semi-solid system.

Then, the center pivot irrigation system was used for the first time in 1952. It was a self-propelled system, and then it became the most acceptable system by farmers in the sixties of the last century. The next development of that system was the linear system. This system can cover the corners of fields that have square or rectangular shape and cannot be covered by the use of the pivot irrigation system.

Sprinkler irrigation has some important features that make it very useful. It can significantly reduce water losses compared to traditional surface irrigation methods. The water transport efficiency reaches 100% due to the use of pipes to transport water from the source to the field. In addition, it can reduce to the water losses absorbed by the jungle plants that grow in the transportation channels. It allows farmers to control the amount of water given by the spray method and preventing the other sources of losing water.

Sprinkler irrigation can be used in undulating lands without the need for the leveling and modification processes, which can reduce additional costs. It also can be used as a means of supplemental irrigation in areas where rain is not guaranteed by using wells water in those areas.

##### 2. *The Center Pivot Sprinkler Irrigation Method*

A center pivot sprinkler or continuous moving sprinkler irrigation system was invented in 1952. It is less expensive than semi-stationary and drip irrigation systems. The length of the device must not be less than 400 meters in order for the axial device to be economical. The pivot irrigation device is designed with high level of technology and it is expected to advance the irrigation systems. It has wide and multiple capabilities to irrigate lands of irregular and wavy shapes. It has great ability to distribute water, fertilizers and pesticides in a homogeneous manner.

##### 3. *The Drip Irrigation System*

The drip irrigation system is a type of irrigation systems that can save water dripping water slowly to the plants' roots. This type of irrigation systems is usually used to place water directly on the plants' root zone and reduce water evaporation.

#### V. THE EFFECTIVENESS OF MODERN IRRIGATION METHODS IN IRAQ

This section tests the impact of using modern irrigation methods in Iraq on the amount of water used for irrigation.

##### 5.1 *The Methodology*

This study tests the effectiveness of modern irrigation methods in Iraq. The study tests the impact of modern irrigation methods in Iraq on the amount of water used for irrigation. The study estimates the effects of

factors that can affect irrigation water including modern irrigation methods, water consumption, climate, and stored water, [14]. The study uses Linear Regression Model (LRM) as a statistical estimation model. The study uses R programming to do the estimation.

The LRM is statistical method to modeling the relationship between two or more variables. One of them is the response variables (dependent variable). The other variables are the explanatory variables (independent variables). With one explanatory variable, the model is called simple linear regression. With more than one explanatory variable, the model is called multiple linear regression. In this model, the relationships are modeled using linear predictor functions whose unknown model parameters are estimated from the data. The LRM is used here because the models that depend linearly on their unknown parameters are easier to fit than models that are non-linearly related to their parameters and because the statistical properties of the resulting estimators are easier to determine, [83].

**5.2 The Model and the Variables**

The model used in this study is:

$$Y = \beta_0 + \alpha_1 X_1 + \gamma_1 Z_1 + \epsilon_i \dots \dots \dots (1)$$

Where the variable (Y) is the variable that represents the amount of irrigation water (dependent variable). That irrigation water in this case is the amount of irrigation water that used from different resources including the stored water. The variable (X) represents one of the independent variables. The variable (X) in this case is the amount of irrigation water that used through the modern irrigation methods. The variable (Z) is the set of other factors, or independent variables, such as evaporated water, and stored water. The climate change (Z1) or the evaporation is measured by the average whether temperatures. Finally, the stored water (Z2) is measured by the average change in the water level of irrigation water storages. The (β, α, and γ) represent the model parameters. The (εi) represent the error.

**5.3 The Data**

All the data were taken from the ministry of water resources, and ministry of agriculture in Iraq. This study uses weekly time series data from 2000 -2010. The data started from the year of 2000 when the modern irrigation methods program started. The data ends at 2010 because of missing data. The total observation is 480 records. Table (2) shows the descriptive statistics of the data.

**Table 2: The descriptive statistics of the data**

Variable description	Average weekly irrigation water (million m <sup>3</sup> )	Average weekly irrigation used by modern irrigation methods (1000 m <sup>3</sup> )	Evaporation, Average weekly temperature (Celsius degree)	The average weekly level of stored water (meter)
Variable symbol	Y	X	Z1	Z2
Max value	55	10	50	7
Min value	15	1	20	1
Mean	37	4	35	3
Total Observations	480	480	480	480

**5.4 The Study Results**

The results of this study are shown in table (3). The results show that using modern irrigation methods in Iraq has negative and insignificant impact on the total amount of irrigation water. That is, even using modern irrigation reduces the total amount of irrigation water; its impact is not significant. The results shows that temperature (climate effect) has positive and significant impact on total irrigation water, which is expected. That is, when the weather temperature increases, the irrigation water used increases.

The results shows that stored water has positive and significant impact on irrigation water. That is, when the reduction in water level at the water storages, the irrigation water will be reduced.

Based on these results, Iraqi policy maker should take action to fix any problem in the program of using modern irrigation methods and adopt strategic plan to use more of them.

**Table 3: The study results**

Variable	Estimated parameter	P value
Intercept	47.87***	0.002
X	-0.004	0.344
Z1	0.190**	0.021
Z2	0.052**	0.040

Significant code: 1% \*\*\*, 5% \*\*, 10% \*

## VI. CONCLUSION

Iraq has a serious water problem that identified since the seventies of the last century. Many reasons have led this problem to be more complex. For example, Turkey, Iran and Syria established many projects to store the water of the upper Tigris and Euphrates rivers, which reduce water, reached Iraq.

The modern irrigation methods have introduced as an engineering solution to the water problem in Iraq. This paper analyzes the effectiveness of modern irrigation methods in Iraq. The paper statistically test the impact of using modern irrigation methods on the amount of water used for irrigation. The contribution of this paper is to help Iraqi policy maker evaluate the program of using modern irrigation systems in agriculture.

The Ministry of Agriculture in Iraq was adopted a program of using modern irrigation methods starting in 1991. The program started at the year of 2000 under supervision of Iraqi government. The important reason for adopting this program was to cover the shortage in the availability of food. Iraq had to increase the production of grains and wheat specifically through increasing the area planted and the productivity lands.

The study uses Liner Regression Model (LRM) as a statistical estimation model. The study uses R programming to do the estimation. All the study data were taken from the ministry of water resources, and the ministry of agriculture in Iraq. This study uses weekly time series data from 2000 -2010.

The results show that using modern irrigation methods in Iraq has negative and insignificant impact on the total amount of irrigation water. The results shows that temperature (climate effect) has positive and significant impact on total irrigation water. The results shows that stored water has positive and significant impact on irrigation water.

In general, Iraqi policy maker develop the program of using modern irrigation methods and adopt strategic plan to use more of them. That may help solve the water scarcity problem in agriculture.

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