Improving the Cultivated Area for the Ramadi Irrigation Project By Using Water Evaluation and Planning Model (WEAP)

Abu Baker A. Najm*, Isam M. Abdulhameed**, Sadeq O. Sulaiman***
abubaker_ded@uoanbar.edu.iq  isambayati@uoanbar.edu.iq  sadeq.sulaiman@uoanbar.edu.iq

* ** *** Dams and Water Resources Department, College of Engineering, University of Anbar
** Manager of Upper Euphrates Developing Center, University of Anbar

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**ABSTRACT**

In this study, the water evaluation and planning WEAP model was used to improve the Ramadi irrigation project with 28342 hectares and annual budget 326 million m³/year for the period (2018-2019). The results showed the total water used was 111.5 million m³/year and equalled 34.2% of Ramadi irrigation budget. The annual production was 39.3 million Kg/year for Ramadi irrigation, and total economic returns 16.04 million $/year. The study proposal two scenarios to improve the cultivated area. The first scenario increased water volume of the current year from 111.5 million m³/year to 272.12 million m³/year, which caused increased in annual productivity from 39.3 million Kg/year to 144.57 million Kg/year, and economic return rose from 16.04 million $/year to 65.25 million $/year. The second scenario record increased in annual production for the current year from 39.3 million Kg/year to 192.27 million Kg/year and economic return from 16.04 million $/year to 86.79 million $/year when using additional pumps for project 2, 3 and project 5. Also, the convey losses increased from 16.72 million m³/year for the current year to 48.47 million m³/year when applying the second scenario, which equals 15% from the water budget of Ramadi irrigation.

Keywords: Improve cultivated area; Improve economic returns; Ramadi irrigation project; WEAP-model

https://rengj.mosuljournals.com
Email: alrafidain_engjournal@umosul.edu.iq

============================================================================= 1. INTRODUCTION

Water is an integral part of the ecosystem; it is a natural resource that cannot be recycled. It has a social and economic significance according to the quality and quantity of the available water [1]. The water demand divides into agricultural, domestic and industrial demand. Agriculture has the largest water share in the various regions of the world about 70% to 90% in arid and semi-arid regions [2]. The population increase requires providing more amount of water with food to meet local demands.

Due to the limited water resources, it was necessary to achieve water management ensures supply the water demands for the population [3,21]. By raising the efficiency of crops production and saving more water amount (García et al., 2020).

The Euphrates River considers the main water resource to meet the water demands for agriculture within the study area. The water imports of the Euphrates River are shared between Anbar Governorate and the others of Iraqi governorates.

The reducing in water imports of Euphrates River leads to reducing the cultivated area of study area. At the same time, a population growth about 2% according to Anbar Statistics Directorate, requires more water supply with more available food.

The Ramadi irrigation project is 28342 hectares with an annual budget 326 million m³/year, with a few cultivated area. It represents 35% of winter crops, 3.46% of summer crops and 0.39% permanent crops, and this leads to necessary to increase the cultivated area to achieve more economics returns with food for
population instead of imports crops from outside governorate or country.

Some programs appeared during past periods, which use to evaluate water consumption of crops as CROPWAT and SIM DUAL program. These programs deal with field, and there was necessary to find system deal with all water resource elements [5]. The water evaluation and planning WEAP model comes as a development of these programs, with different tools and methods. It uses assumptions and means to improve the water management of the region. The WEAP model was one of best programs, which have a set of options and features necessary for water management [6].

2. MATERIALS AND METHODS

2.1 Study area

The study area located between 33 ° 26' 84 " N to 33 ° 22'15.46" N Latitude and 43 ° 35'36.63 "E to 42 ° 57'59.50" E longitude with elevation 53 m above the sea level as shows in Figure 1. It extends from Abu Tayban west of Ramadi on the right Euphrates River and to end at Al-Malahma to the left of the Euphrates River, east of Ramadi.

![Figure 1. Map of the study area](image)

Ramadi city has an important strategic by location on 108 Km west of Baghdad and considers capital of Anbar Governorate. It bordered by Salah Al-Din Governorate from the north and northeast, Karbala Governorate from the south and southwest and Hit District from the west [7]. The study area has several water bodies as Tharthar Lake to the north and Habbaniyah Lake to the east of Ramadi city whose use during water shortages periods while Razazah Lake uses for flood protection. Al-Warar stream to the west of Ramadi uses to transport water from the Euphrates River by Al-Warar regulator to Habbaniyah Lake by Al-Warar stream.

2.2 Irrigation sector

The Ramadi irrigation project has five irrigation projects as in Figure 1. Each project content several agricultural districts.

Euphrates River is the main source to supply water requirements of crops for each project by pumps establish on the banks of the River. The cultivated area for each irrigation project represented by winter crops as wheat, barley, and Bersame with summer crops as sweet pepper, potato spring, cucumber, sesame, sunflower, tomato, and watermelon, also trees as palm, grap, olives, and citrus in addition to others crops as in Table 1.

![Table 1. Cultivated area for each project](image)

2.3 Climates conditions

The climate of study area is arid and semi-arid, with limited amount of rainfall not enough in meeting the water requirement of crops [9]. The study area characterized by the length of the summer season that extends from March to the beginning of October with high temperatures as in Figure 2. The wind differs according to the regions that come from it, where the wind passes...
through the water bodies is characterized by moderate temperatures and high humidity, while the wind that comes from desert areas is characterized by high temperatures and low humidity [10]. The daily climate data of study area collected from Iraqi Meteorological Organization and Seismology, 2019.

Figure 2. Daily Climate Data from (2018-2019)

2.4 WEAP modelling process

The WEAP model calculates Reference Evapotranspiration (ET₀) by using Penman-Monteith equation [11], which assumes the reference surface is green grass with 12 cm high and 70 s/m resistant with an albedo of 0.23 according to the following:

\[
ET_0 = \frac{0.408(\Delta + \gamma \frac{900}{T_{mean} + 273} U_2 (e_s - e_a))}{\Delta + \gamma (1 + 0.34 U_2)} \tag{1}
\]

Where ET₀ represents the reference evapotranspiration (mm day⁻¹), Rn represents net radiation at the surface of the crop (MJ m⁻² day⁻¹), G represents the density of the soil heat flux (MJ m⁻² day⁻¹), T represents average temperature of the daily air at a height of 2m (°C), U2 represents the speed of wind at 2m height (m s⁻¹), es represents the vapor pressure of the saturation (kPa), ea represents the actual vapor pressure (kPa), e_s - e_a saturation vapor pressure deficit (kPa), D represents the curve of the slope vapor pressure (kPa °C⁻¹), and γ represents the psychometric constant (kPa °C⁻¹).

The model was provided by Characteristics of crops as planting and harvesting, Basal crop coefficient, depletion factor of the crop, and maximum height as in Figure 3 [11]. The daily climate conditions as precipitation, temperature, wind speed, humidity, and elevation above sea level, latitude and longitude of the study area as in Figure 4. The climate conditions effects on the planting and harvesting of crops, which divided into a summer and winter crops with tress. Also, the climate data used to correct values of Basal crop coefficient (Kcb) and depletion factor of the crops that taken from FAO-56 [11].

The Dual-Kc is the approach uses by WEAP model, which considers more complicated than the simple approach, where the crop coefficient (Kc) divided into the "Basal" crop coefficient (Kcb) and the (Kc) coefficient represent the evaporation from the soil [12] as in Figure 3. The total crop Evapotranspiration (ETc) calculates as the result of multiplying the reference Evapotranspiration (ET₀) by the sum two coefficients (Kcb +Kc) according to the following equation: [13]

\[
ET_c = (K_{cb} + K_c)ET_0 \tag{2}
\]

However, this equation requires adjusted values of (Kcb) that take from FAO-56 by equation (3), while the daily values (Kc) coefficient by using daily water balance for topsoil layer as in equation (5).

\[
K_{cb} = K_{cb} (Tab) + [0.04(U_2 - 2) -0.004(RH_{min} - 45)] \left( \frac{h}{3} \right)^3 \tag{3}
\]

Where Kcb (Tab) represents the standard Kcb value taken from FAO-56 for stage mid and end stage, U₂ (m/s) represents the average of wind speed during mid or last stage, and h represents height of the crop during the stage , which calculated by equation (4).

\[
h_i = \frac{K_{cbi}}{K_{cb\text{ mid}}} h_{\text{max}} \tag{4}
\]
Where \( h_i \) represents crop height on day \( i \) in (m), \( K_{cbi} \) represents the crop basal coefficient on day \( i \), \( K_{cbmid} \) represents the crop basal coefficient at the mid stage, and \( h_{max} \) represents the height of crop at mid stage in (m).

The water balance was applied for topsoil layer to calculate the daily depletion as following: [11]

\[
D_{ei} = D_{e,i-1} - (P_i - R_{Oi}) - \frac{h_i}{F_w} + E_i + T_{ew,i} + D_{P_{ei}}
\]  

(5)

Where \( D_{e,i-1} \) represents the cumulative depletion depth at the end of previous day \( i-1 \) in (mm), \( D_{ei} \) represents the cumulative depletion depth at the end of day \( i \) in (mm), \( P_i \) represents Precipitation on day \( i \) in (mm), \( R_{Oi} \) represents the amount that exceeds the infiltration of soil and causes runoff on a day \( i \) in (mm), \( E_i \) represents the irrigation depth on day \( i \) that infiltrates the soil (mm), \( E_i \) represents the evaporation on day \( i \) (i.e., \( E_i = K_e \cdot E_{T_0} \)) (mm), \( T_{ew,i} \) represents the depth of transpiration from the exposed and wetted fraction of the soil surface layer on day \( i \) (mm), \( D_{P_{ei}} \) represents the deep percolation loss from the topsoil layer on day \( i \) if soil water content exceeds field capacity (mm), \( F_w \) represents the surface of the soil moistened by rain or irrigation (0.01 – 1), and \( F_{ew} \) represents the exposed soil and wetted which be subjected to solar radiation (0.01 – 1).

Irrigation used to supply water in a suitable time when the amount of rainfall is not enough to meet the water requirement. Irrigation provides according to characteristics of crops, climate conditions during the growth period, soil texture and the irrigation efficiency [15].

In optimal irrigation, WEAP model supplies the water to crops before exceeding the readily available water (RAW), which represents the amount of water that use by crop without any stress. RAW equals the total available water (TAW) multiply by depletion factor of crop during growth stage.

\[
TAW = 1000 (\theta_{FC} - \theta_{WP}) Z_r
\]

(6)

Where \( TAW \) represents the total available water in soil (mm), \( \theta_{FC} \) represents the water content at field capacity in \( m^3 m^{-3} \), \( \theta_{WP} \) represents the water content at wilting point in \( m^3 m^{-3} \), and \( Z_r \) represents the effective rooting depth in (m).

\[
RAW = P \cdot TAW
\]

(7)

Where RAW represents the readily available water, \( P \) represents the depletion factor of crop, and \( TAW \) represent the total available water. The total amount of water with irrigation losses can calculated by the following formula: [16]

\[
d_g = \frac{d_n}{E_a}
\]

(8)
Where $d_g$ represents the gross irrigation in (mm), $d_n$ represents the net water requirement of crop in (mm), and $E_a$ represents application efficiency.

### 2.4.2 Yield module and its parameter

The productivity of crops under surface irrigation method (Kg/ha) was taken from Central Statistical Organization, Iraq 2018 [17], with the unite price for each crop as in Table 2. The marketing value of crops, calculating by WEAP model multiply cultivated area by the yield productivity with the unit price as in the following formula:

$$ MV = Y_a \times \text{Area} \times \text{Price} $$

Where $MV$ represent total market value of crop ($), $Y_a$ represents actual yield in (Kg/ha), Area represents cultivated area in (ha), Price represents unit market price of crop in ($/kg).

Water productivity of crops define as the ratio between crop yields (Kg /ha) on the total water applied during the crop season, by irrigation and rainfall [18]. Water productivity of crops can be calculated by using the following formula: [19]

$$ WP = \frac{Y_a}{TWU} $$

Where $Y_a$ the yield of crop (Kg/ha), and $TWU$ represents the total water applied, which include effective rainfall and losses of irrigation method with net depth irrigation of crop in (m$^3$).

### Table 2. Yield of crops in central of Iraq, with unite price [17]

| Crops         | Surface (Kg / ha) | Price ($ / Kg) |
|---------------|-------------------|----------------|
| Wheat         | 2779              | 0.363          |
| Barley        | 1419              | 0.309          |
| Maize         | 5444              | 0.467          |
| Cucumber      | 10056             | 0.434          |
| Eggplants     | 16264             | 0.433          |
| Kidney beans  | 5020              | 1.188          |
| Potato Spring | 26983             | 0.476          |
| Sesame        | 893               | 1.499          |
| Sunflower     | 2226              | 0.725          |
| Sweet Pepper  | 8710              | 0.518          |
| Tomato        | 26866             | 0.393          |
| Watermelon    | 19225             | 0.348          |
| Berseem       | 12441             | 0.359          |
| Broad bean    | 5802              | 0.516          |
| Cauliflower   | 8632              | 0.388          |
| Potato autumn | 26983             | 0.476          |

### 3. Results and discussion

The results showed the total reference evaporation, which calculated by using Penman-Monteith Equation was 1745 mm / year.

It was increasing from March with 104 mm/month to reach a peak value at July with 266 mm /month while was decreasing during the period from September with 189 mm/month to reach the minimum value at December with 43 mm /month as shown in Figure 5. The increase in irrigation water requirements in summer due to hot months, for example the wheat crop evapotranspiration ($ETc$) was 43 mm and 103mm for initial and development stage. The mid stage that extend from February until mid-April was record 282 mm with 146 mm for end stage until harvesting at mid-May as in Figure 6.
the differences in (TAW) lead to different (RAW) of Ramadi irrigation projects. The (RAW) depends on total available water (TAW) with depletion factor of crop (p) during the growth stage.

The water requirements of each project in Figure 8 were calculated according to the cultivated area with the water requirement of crops for each project as in Table 3.

In November, Strategic crops wheat and barley with winter crops begins cultivation, therefor there was water requirements 8.6 million m$^3$ during this month by multiplying gross irrigation depth by irrigated area. The water demand decline to 1.8 million m$^3$ for December where the months is cold and the evaporation is minimum and rainfall contributes in irrigation. The water supply was increasing during March and April with 20.8 million m$^3$ and 22 million m$^3$ respectively as in Figure 8, where winter and summer crops need more water demand with increasing (ET$_{c}$) and low depletion factor of crops. In May, the water supply started the decline with the harvesting of strategic crops wheat and barley until reaching the minimum water supplied in August 0.5 million m$^3$.

The Total water supply represents the total water provoked from river to each project included the field efficiency 55% and the conveyance efficiency of lined canal 85% [8] as in Table 4.

Table 3. Gross irrigation depth of crops in (mm)

| Crops       | Pro.1 | Pro.2 | Pro.3 | Pro.4 | Pro.5 |
|-------------|-------|-------|-------|-------|-------|
| Wheat       | 790   | 758   | 621   | 787   | 758   |
| Barley      | 632   | 658   | 669   | 645   | 671   |
| Maize       | 1707  | 1795  | 1789  | 1792  | 1727  |
| Cucumber    | 1401  | 1402  | 1411  | 1445  | 1400  |
| Eggplants   | 1161  | 1218  | 1216  | 1233  | 1135  |
| Kidney beans| 778   | 819   | 800   | 821   | 779   |
| Potato Spring| 1470  | 1441  | 1449  | 1476  | 1415  |
| Sesame      | 1625  | 1582  | 1628  | 1621  | 1619  |
| Sunflower   | 1647  | 1718  | 1625  | 1699  | 1646  |
| Sweet Pepper| 1752  | 1768  | 1758  | 1755  | 1750  |
| Tomato      | 1519  | 1570  | 1527  | 1591  | 1554  |
| Watermelon  | 1544  | 1571  | 1539  | 1602  | 1488  |
| Berseem     | 1070  | 1097  | 1074  | 1034  | 1021  |
| Broad bean  | 553   | 588   | 554   | 592   | 555   |
| Cauliflower | 1026  | 1016  | 967   | 999   | 983   |
| Potato autumn| 712   | 769   | 713   | 701   | 704   |
| Citrus      | 3309  | 3399  | 3420  | 3429  | 3303  |
| Grap        | 2389  | 2452  | 2361  | 2526  | 2454  |
| Olives      | 2511  | 2762  | 2618  | 2832  | 2539  |
| Palm        | 3688  | 3681  | 3644  | 3713  | 3719  |

Table 4. Total water supply from river for each project in (million m$^3$) / year

| Project | Pumps (m$^3$/s) | Volume without losses | Field losses | Convey losses | Water supply |
|---------|----------------|-----------------------|--------------|---------------|--------------|
| Pro.1   | 3.3            | 5.00                  | 4.09         | 1.6           | 10.7         |
| Pro.2   | 2.16           | 9.06                  | 7.41         | 2.91          | 19.4         |
The different in water requirement of projects in Table 4 related to cultivated area for each project as in Table 1. The largest water supply was to project 4 and project 5 with 38.5 million $/year and 26.5 million $/year respectively. It related to the largest area, which was 8250 ha and 11250 ha for project 4 and project 5 with cultivated area of winter and summer crops 58% with 4.5% for project 4 and 44% with 3.18% for project 5 as in Table 1.

The amount of water used in production in Table 5, represented the sum of gross irrigation depth of crop with the effective rainfall, and the result multiply by cultivated area of crop.

### Table 5. Total water used in production in (million m$^3$/year)

| Crops          | Pro.1 | Pro.2 | Pro.3 | Pro.4 | Pro.5 |
|----------------|-------|-------|-------|-------|-------|
| Wheat          | 8.71  | 15.33 | 12.24 | 27.16 | 16.36 |
| Barley         | 0.96  | 2.21  | 1.59  | 5.93  | 0.63  |
| Maize          | 0.66  | 1.81  | 1.14  | 4.27  | 3.85  |
| Cucumber       | 0.04  | 0.12  | 0.08  | 0.31  | 0.23  |
| Eggplants      | 0.03  | 0.10  | 0.07  | 0.26  | 0.20  |
| Kidney beans   | 0.02  | 0.07  | 0.04  | 0.17  | 0.13  |
| Potato Spring  | 0.04  | 0.12  | 0.08  | 0.32  | 0.26  |
| Sesame         | 0.04  | 0.13  | 0.09  | 0.34  | 0.27  |
| Sunflower      | 0.05  | 0.14  | 0.09  | 0.36  | 0.29  |
| Sweet Pepper   | 0.05  | 0.16  | 0.11  | 0.40  | 0.34  |
| Tomato         | 0.04  | 0.13  | 0.09  | 0.33  | 0.27  |
| Watermelon     | 0.04  | 0.13  | 0.09  | 0.34  | 0.26  |
| Berseem        | 0.04  | 0.06  | 0.04  | 0.48  | 0.40  |
| Broad bean     | 0.02  | 0.04  | 0.02  | 0.29  | 0.24  |
| Cauliflower    | 0.03  | 0.05  | 0.04  | 0.42  | 0.33  |
| Potato autumn  | 0.02  | 0.04  | 0.02  | 0.28  | 0.25  |
| Citrus         | 0.11  | 0.11  | 0.16  | 0.25  | 0.32  |
| Grap           | 0.08  | 0.08  | 0.12  | 0.18  | 0.24  |
| Olives         | 0.08  | 0.09  | 0.12  | 0.20  | 0.27  |
| Palm           | 0.12  | 0.12  | 0.18  | 0.27  | 0.37  |

In table 5, the total water used in production represent the sum of gross irrigation of crop with effective rainfall, product by the cultivated area of crop within project. The water productivity was different between irrigation projects as in Table 6 due to different soil texture of each project, which caused different in water supply and then differ in water productivity.

### Table 6. Water productivity of crops (kg / m$^3$)

| Crops       | P.1   | P.2   | P.3   | P.4   | P.5   |
|-------------|-------|-------|-------|-------|-------|
| Wheat       | 0.28  | 0.27  | 0.28  | 0.28  | 0.31  |
| Barley      | 0.19  | 0.16  | 0.17  | 0.18  | 0.17  |
| Maize       | 0.30  | 0.30  | 0.29  | 0.29  | 0.30  |
| Cucumber    | 0.75  | 0.67  | 0.63  | 0.68  | 0.74  |
| Eggplants   | 1.33  | 1.30  | 1.29  | 1.31  | 1.40  |
| Kidney beans| 0.50  | 0.57  | 0.75  | 0.59  | 0.69  |
| Potato Spring| 1.75 | 1.83 | 1.88 | 1.75 | 1.77 |
| Sesame      | 0.05  | 0.08  | 0.06  | 0.06  | 0.07  |
| Sunflower   | 0.20  | 0.14  | 0.13  | 0.14  | 0.14  |
| Sweet Pepper| 0.60  | 0.50  | 0.45  | 0.50  | 0.47  |
| Tomato      | 1.75  | 1.69  | 1.67  | 1.67  | 1.70  |
| Watermelon  | 1.25  | 1.23  | 1.11  | 1.18  | 1.27  |
| Berseem     | 1.00  | 1.00  | 0.98  | 1.00  |       |
| Broad bean  | 1.00  | 0.75  | 1.00  | 0.76  | 0.75  |
| Cauliflower | 1.00  | 0.80  | 0.75  | 0.76  | 0.82  |
| Potato autumn| 4.00 | 3.25 | 4.00 | 3.61 | 3.44 |
| Citrus      | 0.09  | 0.09  | 0.13  | 0.12  | 0.13  |
| Grap        | 0.50  | 0.50  | 0.50  | 0.44  | 0.46  |
| Olives      | 0.63  | 0.56  | 0.67  | 0.60  | 0.59  |
| Palm        | 0.25  | 0.25  | 0.28  | 0.26  | 0.24  |

The total production for current year was 39.3 million Kg/year with economic returns 16.04 million $/year as in Table 7. The total water supply from river was 111.5 million m$^3$/year, represented by gross irrigation with conveyance losses 16.72 million m$^3$/year. The conveyance losses did not used in production due to water productivity includes water applied in field with the effective rainfall.

The total water supply from river was 111.5 m$^3$/year, and equal 34.2% from water budget from Euphrates, which was 326 million m$^3$/year. The economic returns from project 4 and 5 were largest compare with others projects, and the reason related to large cultivated area of these projects compare with other projects as in Table 1. Although, the few cultivated area for project 4 and 5, but it was the large plants with crops. There for the total economics returns were 5.58 with 4.47 million $/year on respectivly.

### 3.1 Improve cultivated area
The water budget for the irrigation project was 326 million m³/year and the amount of water used in irrigation was 111.5 million m³/year with all losses. The per cent of unused water was 65.8%. Therefore, there was necessary to improve the cultivated area according to achieve more production with more economic returns.

### 3.1.1 First scenario

Improving the cultivated area for Table 1 was without added addition new operation pumps for projects with evaluate the annual production and economic returns.

Table 8. The percent of Increasing in cultivated area of projects

| Projects | Winter crops | Summer crops | Tress |
|-----------|--------------|--------------|-------|
|          | Wheat        | Barley       | Other | Maize | Other |                   |
| Pro.1     | +4%          | +15%         | +25%  | +2%   | +20%  | +4%               |
| Pro.4     | +10%         | ----         | +24%  | +1%   | +15%  | +2%               |
| Pro.5     | +30%         | +5%          | +7%   | +2%   | +5%   | +3%               |

The increasing in cultivated area in Table 8 based on the Priority of saving water. For example, the barley crop needs gross irrigation depth 632mm/year and 672 mm/year for project 1 and 5 respectively, therefore, the increased was 35% and 5% for project 1 and 5 respectively. As well for wheat crop, it needed gross irrigation 821mm and 758mm for project 3 and 5 respectively, therefore, it increased by 30% for project 5.

The cultivate area in Table 8 did not increased for Project 2 and 3 due to the pumps did not enough to cultivate more crops. This required increased pumps for project to coverage all demand during all months, where the Unsatisfied occurred during hot motts with increased crops water requirements. The water discharge of pumps of project 1, 2, 3, 4, and 5 were 3.3, 2.16, 2.14, 8.2, and 8.8 m³/s respectively.

Table 9. Total cultivated area of Ramadi irrigation project by scenario 1 after Improving

| Area (ha) | Cultivated area after applied First scenario |
|-----------|---------------------------------------------|
|           | Winter crops % | Summer crops % | Perennial crops % |
| Pro.1     | 3667           | 71.6           | 23.7            | 4.34          |
| Pro.2     | 2675           | 66.2           | 6.5             | 0.47          |
| Pro.3     | 2500           | 58             | 4.5             | 0.75          |
| Pro.4     | 8250           | 78.2           | 19.18           | 2.34          |
| Pro.5     | 11250          | 60.1           | 10.29           | 3             |
| Sum       | 28342          | 67.7           | 13.4            | 2.6           |

The addition cultivated area as in Table 9 leads to increased irrigation volume by 144%. from 111.5 million m³/year to 272.12 million m³/year, the economic returns increased by 307% from 16.04 million $/year to 65.24 million $/year as in Table 10. The water unused reach 54 million m³/year, which equal 17% from water budget and to uses it, require more pumps for projects.

Table 10. Total Production and economic return in (million)

| Projects | Total water supply with losses (m³) | Production (Kg/year) | Total returns ($/ year) |
|----------|-------------------------------------|----------------------|------------------------|
| Project 1| 362.18                              | 28.83                | 13.33                  |
| Project 2| 267.52                              | 6.42                 | 2.56                   |
| Project 3| 16.49                               | 5.09                 | 2.05                   |
| Project 4| 94.78                               | 60.94                | 27.4                   |
| Project 5| 94.55                               | 43.29                | 19.9                   |

= 272.12, 144.57, 65.25

| Projects | Total water supply with losses (m³) | Production (Kg/year) | Total returns ($/ year) |
|----------|-------------------------------------|----------------------|------------------------|
| Project 1| 362.18                              | 28.83                | 13.33                  |
| Project 2| 267.52                              | 6.42                 | 2.56                   |
| Project 3| 16.49                               | 5.09                 | 2.05                   |
| Project 4| 94.78                               | 60.94                | 27.4                   |
| Project 5| 94.55                               | 43.29                | 19.9                   |

3.1.2 Second scenario

In this scenario was added new pumps to use all water budget of Ramadi irrigation project. The pumps increased from 2.16 to 3.16 m³/s, 2.14 to 3.14, and from 8.8 to 10.8 for project 2, 3, and 5 respectively.

Table 11. The percent of Increasing in cultivated area of projects under second scenario

| Projects | Winter crops | Summer crops | Tress |
|----------|--------------|--------------|-------|
|          | Wheat        | Barley       | Other | Maize | Other |                   |
| Pro.1    | +4%          | +15%         | +25%  | +2%   | +20%  | +4%               |
| Pro.2    | ----         | +20%         | +24%  | +1%   | +15%  | +2%               |
| Pro.3    | ----         | +10%         | +24%  | +1%   | +15%  | +2%               |
| Pro.4    | +10%         | +20%         | +24%  | +1%   | +15%  | +2%               |
| Pro.5    | +30%         | +10%         | +17   | +2%   | +5%   | +3%               |

Table 12. Production of projects with economic return in (million)

| Projects | Total water supply with losses (m³) | Production (Kg) | Total returns ($/ year) |
|----------|-------------------------------------|-----------------|------------------------|
| Project 1| 362.18                              | 28.83           | 13.33                  |
| Project 2| 267.52                              | 14.65           | 6.21                   |
| Project 3| 26.56                               | 14.21           | 6.25                   |
| Project 4| 94.78                               | 60.94           | 27.4                   |
| Project 5| 128.68                              | 73.64           | 33.60                  |

Table 13. Total cultivated area of project by second scenario after Improving

| Cultivated area after applied second scenario |
4. Conclusion

1. The water used for Ramadi irrigation project represent 34.2% from Ramadi irrigation budget from Euphrates River.

2. Despite of, the total water requirement increased by 144% from 111.5 m³/year to 272.12 m³/year, the economic returns increased by 307% from 16.04 million $/year to 65.24 million $.

3. When using addition pumps for project 2 and project 3 by 1 m³/s and 2 m³/s for project 5 on respectively, the economics returns increased by 441% from 16.04 million $/year to 86.79 million $/year.

4. The convey loss increased from 16.72 million m³/year to 48.47 million m³/year, when applied second scenario.

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|     | Area (ha) | Winter crops % | Summer crops % | Perennial crops % |
|-----|----------|----------------|----------------|------------------|
| Pro.1 | 3667     | 71.6           | 23.7           | 4.34             |
| Pro.2 | 2675     | 86.2           | 11.5           | 0.47             |
| Pro.3 | 2500     | 68             | 22.5           | 0.75             |
| Pro.4 | 8250     | 78.2           | 19.18          | 0.34             |
| Pro.5 | 11250    | 75.1           | 10.29          | 3.34             |
| Sum  | 28342    | 76             | 15.8           | 2.1              |
تحسين المساحة المزروعة لمشروع الرمادي الاروائي باستخدام نموذج تخطيط وتقييم المياه (WEAP)

أبو بكر أحمد نجم

صفاء عليوي سليمان

عثمان عبد الحميد

سليمان سالم

sadeq.sulaiman@uoanbar.edu.iq

isambayati@uoanbar.edu.iq

abubaker_ded@uoanbar.edu.iq

جامعة الانبار، كلية الهندسة، قسم السدود والموارد المائية

 مدير مركز حوض اعالي الفرات - جامعة الانبار

المتخص

في هذه الدراسة تم استخدام نموذج تخطيط وتقييم المياه (ويب) لتحسين المساحة المزروعة لمشروع الرمادي الاروائي بمساحة 28342 هكتار وحصة مائية سنوية 326.5 مليون م3. أظهرت النتائج أن إجمالي المياه المستخدمة بلغ 111.5 مليون م3 بالسنة وهو مايعادل 34.2٪ من الحصة المائية المخصصة للمشروع الاروائي. حيث بلغ الإنتاج السنوي 39.3 مليون كغم /السنة للمشروع مع عائد اقتصادي 16.04 مليون دولار /سنة. اقترحت الدراسة سيناريوهين لتحسين المساحة المزروعة. أدى السيناريو الأول إلى زيادة حجم المياه المستخدمة للعام الحالي من 111.5 مليون م3 /سنة إلى 272.12 مليون م3 /سنة، حيث أدى إلى زيادة الإنتاجية السنوية من 39.3 مليون كغم /سنة إلى 144.57 مليون كغم /سنة، وكذلك ارتفاع العائد الاقتصادي من 16.04 مليون دولار إلى 65.25 مليون دولار في السنة. سجل السيناريو الثاني زيادة في الإنتاج السنوي من 39.3 مليون كغم /سنة إلى 192.27 مليون كغم /سنة مع زيادة العائد الاقتصادي من 16.04 مليون دولار /سنة إلى 86.79 مليون دولار /سنة. عند استخدام مضخات إضافية للمشروع 2 و 3، مما زادت خسارة النقل من 16.72 مليون م3 لصالح العام الحالي إلى 48.47 مليون م3 /السنة عند تطبيق السيناريو الثاني، وهو ما يعادل 15٪ من الحصة المائية لمشروع الرمادي الاروائي.

الكلمات الدالة: تحسين المساحة المزروعة، تحسين العائدات الاقتصادية، مشروع الرمادي الاروائي، نموذج ويب