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

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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 m^3*/ year for the period (2018-2019). The results showed the total water used was 111.5 million* m^3*/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* m^3*/year to 272.12 million* m^3*/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 loss increased from 16.72 million* m^3*/year for the current year to 48.47 million* m^3*/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

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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 m^3/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.

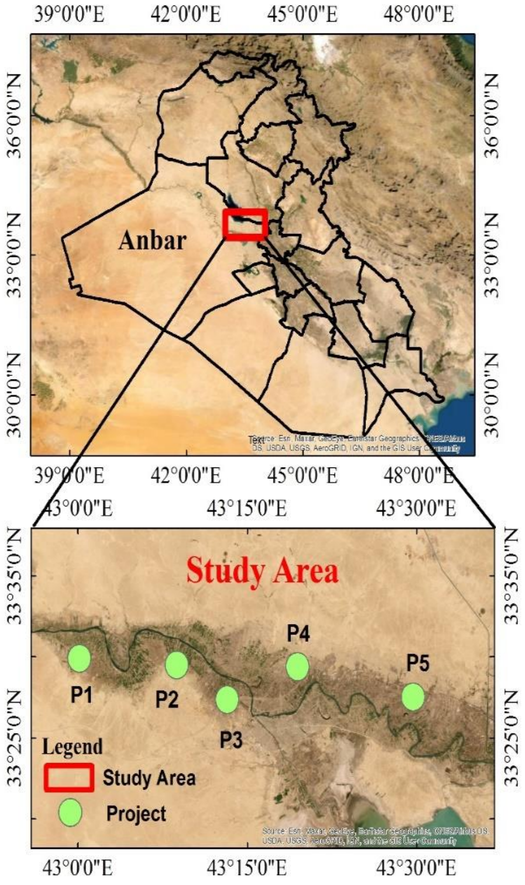

Figure 1. Map of the study area

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.

The surface irrigation considers the main method uses in each irrigation project with high water losses about 45% that are not usable for agricultural again. The conveying channels in each irrigation project are lined with losses about 15% [8]. The cultivated area in Table 1 was taken from Irrigation Directorate of Anbar, 2019.

Table 1. Cultivated area for each project

Project	Area (ha)	Cultivated area		
		Winter Crops %	summer Crops %	Perennial crops %
Projec1	3667	27.6	1.7	0.34
Projec2	2675	66.2	6.5	0.47
Projec3	2500	58	4.5	0.75
Projec4	8250	44.2	3.18	0.34
Project5	11250	18.1	3.29	0.34
Sum	28342	35	3.46	0.39

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.

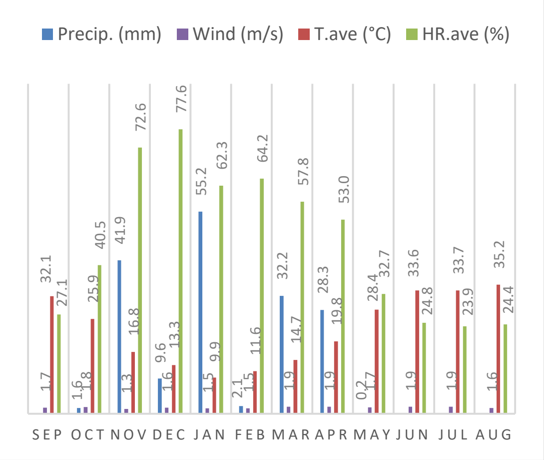

Figure 2.Daily Climate Data from (2018-2019)

2.4 WEAP modelling process

The WEAP model calculates Reference Evapotranspiration (ET_0) 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:

$$ET_0 = \frac{0.408\Delta\,(R_n - G) + \gamma\,\frac{900}{T_{mean}+273}\,U_2\,(e_s - e_a)}{\Delta + \gamma\,(1 + 0.34\,U_2)} \qquad (1)$$

Where ET_o represents the reference evapotranspiration (mm day^{-1}), R_n 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}), ,e_s represents the vapor pressure of the saturation (kPa), e_a 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 g 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 (K_{cb}) and depletion factor of the crops that taken from FAO-56 [11].

The Dual-K_c is the approach uses by WEAP model, which considers more complicated than the simple approach, where the crop coefficient (K_c) divided into the "Basal" crop coefficient (K_{cb}) and the (K_e) coefficient represent the evaporation from the soil [12] as in Figure 3. The total crop Evapotranspiration (ET_c) calculates as the result of multiplying the reference Evapotranspiration (ET_0) by the sum two coefficients (K_{cb} +K_e) according to the following equation: [13]

$$ET_c = (K_{cb} + K_e)ET_0 \qquad (2)$$

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

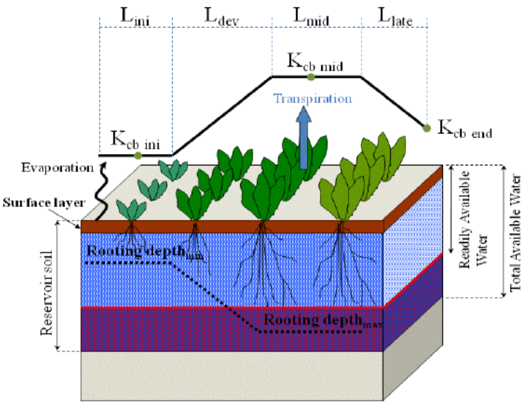

Figure 3. Growth stages of crop [14]

$$K_{cb} = K_{cb}\,(Tab) + [0.04(U_2 - 2) - 0.004(RHmin - 45)](\frac{h}{3})^3 \qquad (3)$$

Where K_{cb} (Tab) represents the standard K_{cb} value taken from FAO-56 for stage mid and end stage, U_2 (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).

$$h_i = \frac{K_{cbi}}{K_{cb\ mid}} h_{max} \qquad (4)$$

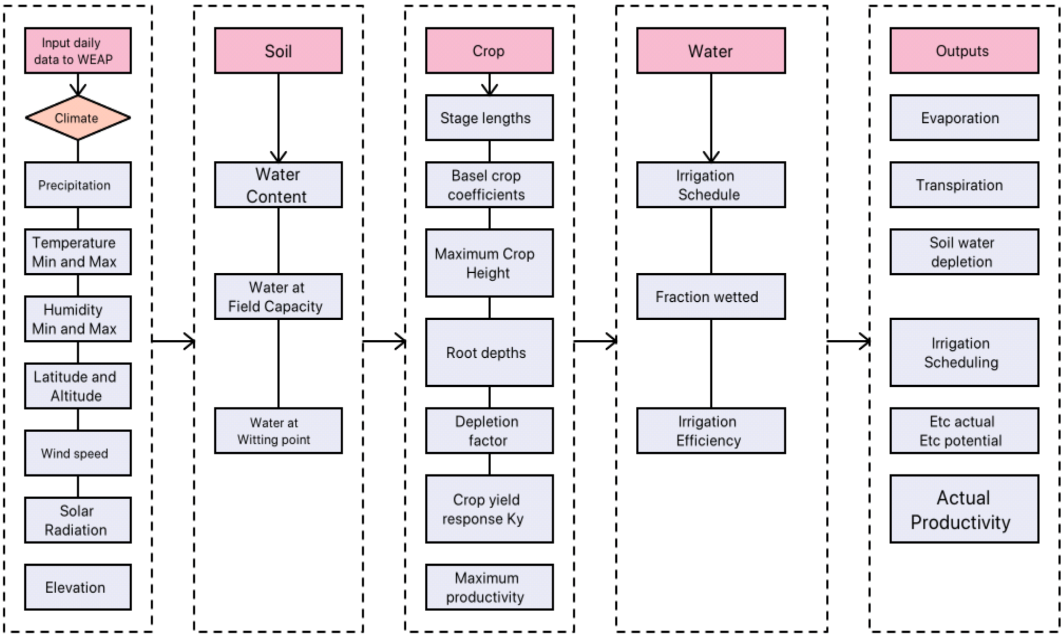

Figure 4.Steps represent the process of WEAP-model

Where hi represents crop height on day i in (m),K_{cbi} represents the crop basal coefficient on day i, $K_{cb\ mid}$ 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]

$$D_{e,i} = D_{e,i-1} - (P_i - RO_i) - \frac{I_i}{f_w} + \frac{E_i}{f_{ew}} + T_{ew,i} + DP_{e,i} \qquad (5)$$

Where $D_{e,i-1}$ represents the cumulative depletion depth at the end of previous day i-1 in (mm), $D_{e,i}$ 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), represents the irrigation depth on day i that infiltrates the soil (mm), E_i represents the evaporation on day i (i.e., $E_i = K_e$ ET_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), $DP_{e,i}$ 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).

2.4.1 Irrigation supplied

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.

$$TAW = 1000\ (\theta_{FC} - \theta_{WP})Z_r \qquad (6)$$

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

$$RAW = P\ TAW \qquad (7)$$

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]

$$d_g = \frac{d_n}{E_a} \qquad (8)$$

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:

$$MV = Y_a * Area * Price \qquad (9)$$

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]

$$WP = \frac{Y_a}{TWU} \qquad (10)$$

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
Citrus	4004	1.257
Grap	11800	0.713
Olives	17211	1.257
Palm	9872	1.022

3. Results and discussion

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

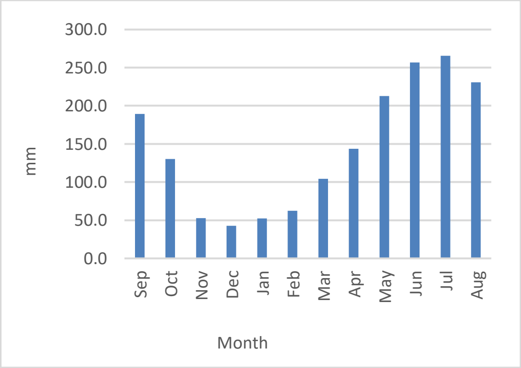

Figure 5. Monthly reference evapotranspiration

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 (ET_c) 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.

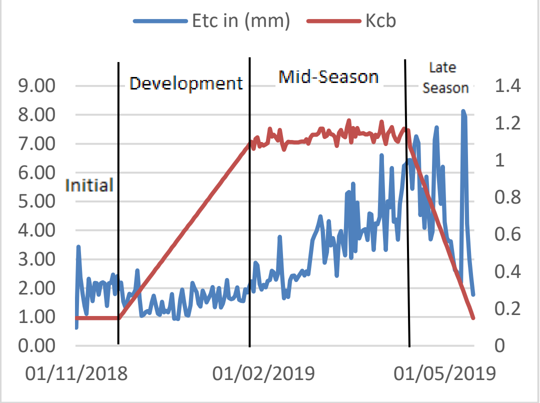

Figure 6.Wheat crop evapotranspiration (ET_c) for project1

The water supplied to crop before exceed the readily available water (RAW), to avoid water stress during the growth season of crops and achieve optimal irrigation as in Figure 7. Where 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.

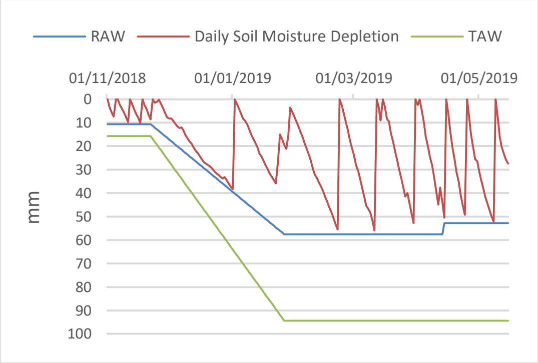

Figure 7. Daily soil depletion with total and readily available water of wheat within project1

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.

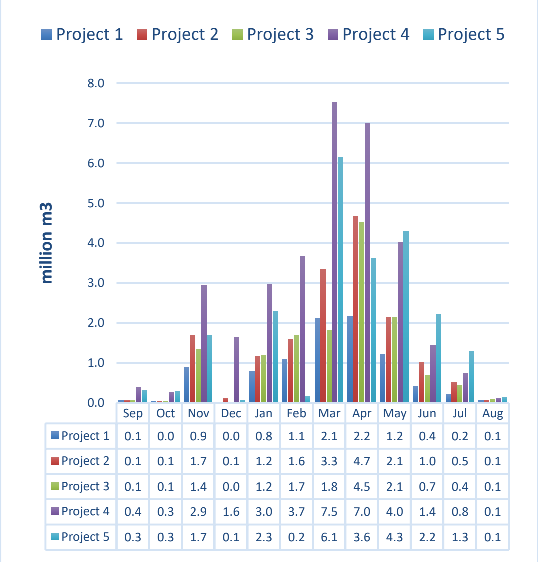

Figure 8. Water requirement for each project (with feild losses)

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

Crops	Pro.1	Pro.2	Pro.3	Pro.4	Pro.5
Wheat	780	758	821	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	1154
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	558
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

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

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

Pro.3	2.14	7.71	6.31	2.47	16.5
Pro.4	8.2	18.00	14.72	5.77	38.5
Pro.5	8.8	12.39	10.14	3.97	26.5
Sum	24.6	52.15	42.67	16.72	111.5

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 m^3/year and 26.5 million m^3/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	0.83
Maize	0.66	1.81	1.14	1.42	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 diffren in water productivity.

Table 6. Water productivity of crops (kg / m3)

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	0.30	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	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

Table 7. Total Production and economic return in (million)

Projects	Production (Kg/year)	Total returns ($/ year)
Project 1	3.4	1.37
Project 2	6.4	2.56
Project 3	5.1	2.05
Project 4	13.8	5.58
Project 5	10.5	4.47
Sum	39.3	16.04

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 larges plants with crops. There for the total economics returns were 5.58 with 4.47 million $/year on respectivitly.

3.1 Improve cultivated area

The water budget for the irrigation project was 326 million m^3/ year and the amount of water used in irrigation was 111.5 million m^3 / 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

	Winter crps			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 respectivitly. 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 moths 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 m^3/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 m^3/year to 272.12 million m^3/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 m^3 /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 (m^3)	Production (Kg/year)	Total returns ($/ year)
Project 1	46.92	28.83	13.33
Project 2	19.37	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
Sum	272.12	144.57	65.25

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 m^3/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

	Winter crps			Summer crops		Tress
	Wheat	Barley	Other	Maize	Other	
Pro.1	+4%	+15%	+25%	+2%	+20%	+4%
Pro.2	-----	-----	+20%	-----	+5%	-----
Pro.3	-----	-----	+10%	-----	+18%	-----
Pro.4	+10%	------	+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 (m^3)	Production (Kg)	Total returns ($/ year)
Project 1	46.92	28.83	13.33
Project 2	26.20	14.65	6.21
Project 3	26.56	14.21	6.25
Project 4	94.78	60.94	27.40
Project 5	128.68	73.64	33.60
Sum	323.14	192.27	86.79

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

		Cultivated area after applied second scenario

	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

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 m^3/year to 272.12 m^3/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 m^3/s and 2 m^3/s for project 5 on respectively, the economics return increased by 441% from 16.04 million $ /year to 86.79 million $ / year.

4- The convey loss increased from 16.72 million m^3/year to 48.47 million m^3/year, when applied second scenario.

REFERENCES

[1] Á. F. Morote, J. Olcina, and M. Hernández, “The use of non-conventional water resources as a means of adaptation to drought and climate change in semi-arid regions: South-eastern Spain,” Water (Switzerland), vol. 11, no. 1, 2019, doi: 10.3390/w11010093.

[2] J. M. Martínez-Paz, F. Gomariz-Castillo, and F. Pellicer-Martínez, “Appraisal of the water footprint of irrigated agriculture in a semi-arid area: The Segura River basin,” PLoS One, vol. 13, no. 11, pp. 1–20, 2018, doi: 10.1371/journal.pone.0206852.

[3] UNESCO, “Water for a sustainable world,” United Nations world water Dev. Rep., p. 122, 2015.

[4] I. F. García et al., “Trends and challenges in irrigation scheduling in the semi-arid area of Spain,” Water (Switzerland), vol. 12, no. 3, pp. 1–26, 2020, doi: 10.3390/w12030785.

[5] Z. Gu, Z. Qi, R. Burghate, S. Yuan, X. Jiao, and J. Xu, “Irrigation Scheduling Approaches and Applications: A Review,” J. Irrig. Drain. Eng., vol. 146, no. 6, p. 04020007, 2020, doi: 10.1061/(asce)ir.1943-4774.0001464.

[6] J. Sieber and D. Purkey, “Ser uide,” Environment, no. August, p. 343, 2011, [Online]. Available: http://www.weap21.org/WebHelp/index.html.

[7] S. L. M Al Dulaimy, "Water resources in the Ramadi district and their importance in agricultural production" thesis is submitted to the Council of the College of Education for Humanities in Anbar University , 2018.

[8] G.Popescu and A. Jean-Vasile “Agricultural Management Strategies in a Changing Economy“, Hershey: IGI Global, 2015 p. 439. ISBN 978-1466675216. DOI 10.4018/978-1-4666-7521-6.

[9] N. Adamo, N. Al-Ansari, V. K. Sissakian, S. Knutsson, and J. Laue, “Climate Change: Consequences on Iraq’s Environment,” J. Earth Sci. Geotech. Eng., vol. 8, no. 3, pp. 1792–9660, 2018.

[10] J. L. Hatfield et al., “Climate impacts on agriculture: Implications for crop production,” Agron. J., vol. 103, no. 2, pp. 351–370, 2011, doi: 10.2134/agronj2010.0303.

[11] R.G.Allen, L.S.Pereira, , D.Raes, , M.Smith, Crop evapotranspiration: guide-lines for computing crop water requirements. In: FAO Irrigation and Drainage Paper No. 56. FAO, Rome, Italy, 300 pp. 1998.

[12] R. G. Allen et al., “FAO-56 Dual Crop Coefficient Method for Estimating Evaporation from Soil and Application Extensions,” no. February, pp. 2–13, 2005.

[13]R. Awal, H. Habibi, A. Fares, and S. Deb, “Estimating reference crop evapotranspiration under limited climate data in West Texas,” J. Hydrol. Reg. Stud., vol. 28, no. March, p. 100677, 2020, doi: 10.1016/j.ejrh.2020.100677.

[14] M. Jabloun and A. Sahli, “WEAP-MABIA Tutorial,” no. January, p. 97, 2012.

[15] K. Chartzoulakis and M. Bertaki, “Sustainable Water Management in Agriculture under Climate Change,” Agric. Agric. Sci. Procedia, vol. 4, pp. 88–98, 2015, doi: 10.1016/j.aaspro.2015.03.011.

[16] M. Brouwer, C., K. Prins, Heibloem, “Irrigation Water Management: Irrigation Scheduling,” Train. Man., no. 4, p. 66, 1989, [Online]. Available: ftp://ftp.fao.org/agl/aglw/fwm/Manual4.pdf.

[17] Central Statistical Organization Iraq. Agricultural crop productivity reports for 2018. From http://www.cosit.gov.iq/ar/agri-stat/veg-prod

[18] R. Flach, R. Skalský, C. Folberth, J. Balkovič, K. Jantke, and U. A. Schneider, “Water productivity and footprint of major Brazilian rainfed crops – A spatially explicit analysis of crop management scenarios,” Agric. Water Manag., vol. 233, no. May 2019, p. 105996, 2020, doi: 10.1016/j.agwat.2019.105996.

[19] T. A. Paço, P. Paredes, L. S. Pereira, J. Silvestre, and F. L. Santos, “Crop coefficients and transpiration of a super intensive Arbequina olive orchard using the dual Kc approach and the Kcb computation with the fraction of ground cover and height,” Water (Switzerland), vol. 11, no. 2, 2019, doi: 10.3390/w11020383.

[20] S. O. Sulaiman, G. Al-Dulaimi and H. Al Thamiry, "Natural Rivers Longitudinal Dispersion Coefficient Simulation Using Hybrid Soft Computing Model," 2018 11th International Conference on Developments in eSystems Engineering (DeSE), Cambridge, United Kingdom, 2018, pp. 280-283, doi: 10.1109/DeSE.2018.00056.

[21] S.O.Sulaiman, A.H.Kamel, K.N.Sayl, et al. Water resources management and sustainability over the Western desert of Iraq. Environ Earth Sci 78, 495 (2019). https://doi.org/10.1007/s12665-019-8510-y

تحسين المساحة المزروعة لمشروع الرمادي الاروائي باستخدام نموذج تخطيط وتقييم المياه (WEAP)

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الملخص

فى هذه الدراسة تم استخدام نموذج تقييم وتخطيط المياه (ويب) لتحسين المساحة المزروعة لمشروع الرمادي الاروائي بمساحة 28342 هكتار وحصة مائية سنوية 326 مليون م3/ بالسنة. أظهرت النتائج أن إجمالي المياه المستخدمة بلغت 111.5 مليون م3/بالسنة وهو مايعادل 34.2٪ من الحصة المائية المخصصة للمشروع الاروائى. حيث بلغ الإنتاج السنوى 39.3 مليون كغم /بالسنة للمشروع مع عائد اقتصادى 16.04 مليون دولار / بالسنة. اقترحت الدراسة سيناريوهين لتحسين المساحة المزروعة. أدى السيناريو الأول إلى زيادة حجم المياه المستخدمة للعام الحالي من 111.5 مليون م3 / سنويًا إلى 272.12 مليون م3 / سنويًا ، حيث أدى إلى زيادة الإنتاجية السنوية من 39.3 مليون كغم / سنويًا إلى 144.57 مليون كغم/سنويا ، وكذلك ارتفاع العائد الاقتصادى من 16.04 مليون دولار الى 65.25 مليون دولار فى السنة. سجل السيناريو الثانى زيادة فى الإنتاج السنوى من 39.3 مليون كغم / إلى 192.27 مليون كغم / بالسنة مع زيادة العائد الاقتصادى من 16.04 مليون دولار / سنوياً إلى 86.79 مليون دولار / سنوياً عند استخدام مضخات إضافية للمشروع 2 و 3 والمشروع 5. كما زادت خسارة النقل من 16.72 مليون م3/ بالسنة للعام الحالى إلى 48.47 مليون م3 / بالسنة عند تطبيق السيناريو الثاني ، وهو ما يعادل 15٪ من الحصة المائية لمشروع الرمادي الاروائي.

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