Predicting Water Duty of Cultivation Farmlands in Babylon Governorate

تخمين المقنن المائي للأراضي الزراعية في محافظة بابل

Ali Hassan Hommadi
Engineer in ministry of water resource
Have on MSc degree in water resource

Abstract

In order to get perfect irrigation system and reduce waste in water of irrigation projects and control water scarcity which become one of hard problem in Iraq so have to predicting water duty for each project spatially in Babylon governorate and generally in Iraq governorates through calculating crops consumptive and cropping patterns to crops which planted and turn estimating the crops water duty after that calculating water duty of projects in order to be the delivery of water required to truly the field. The water duty can be defined as the crop need of water either field or farm turn out in field. The water duty includes crops evapotranspiration (ET_c) in addition to crop consumptive (CU); the crop consumptive was very small compare with crop evapotranspiration by 1% therefore it can be neglected and the water duty depending on crop evapotranspiration only.

The water duty considers from main determinants in design and operation of irrigation projects, also in best irrigation schedule of crops and represent less the amount of water was supposed to add to fill the shortage that getting from crops evapotranspiration to various the crops and various growing stages. The units of water duty was (m^3/s/hectare) or (l/s/hectare) or (m^3/s/don.) and in Egypt calculate (m^3/Acres). In research depending on ministry of irrigation 1983 and data of 1971-2000 also data 2014-2017get on water duty of Eskandaria / between two river was 1.43 l/s/ha because rising of temperature in present time while water duty used 0.91 l/s/ha. The water duty in Musiab project was 1.05 l/s/ha while used 0.91 l/s/ha but in center of Babylon project was 1.04 l/s/ha while used 0.91 l/s/ha. The increasing of water duty in Eskandaria, Musiab and Center of Babylon governorate was 57%,16% and 14%, respectively. In research depending on Italy studies in ministry of water resource, 2014 get on water duty of Eskandaria / between two river was 1.98 l/s/ha while water duty used 0.91 l/s/ha. The water duty in Musiab project was 1.33 l/s/ha while used 0.91 l/s/ha but in center of Babylon project was 1.3 l/s/ha while used 0.91 l/s/ha. The increasing of water duty in Eskandaria, Musiab and Center of Babylon governorate was 118%,47% and 43%, respectively. The increasing because rising in temperature during the current years. The water duty in drip irrigation was the best from surface irrigation by half or less from amount of irrigation supplied therefore we recommend using trickle irrigation as the best method to water rationing and fill the shortage.

Keywords: crops, crop evapotranspiration (ETc), reference evapotranspiration (ETo), water duty, Temperature.

الخلاصة

للحصول على نظام ري مثالي وتقليل الهدر بالماء لمشاريع الري والسيطرة على الشحة المائية الحاصلة في البلد لذلك يستوجب تخمين المقنن المائي لكل مشروع في محافظة بابل خاصة وفي باقي محافظات العراق عامة من خلال حساب الاستهلاك المائي والكثافة الزراعية للمحاصيل المزروعة و حساب المقنن المائي للمحاصيل وبعدها يتم حساب المقنن المائي للمشاريع لكي يتم ايصال المياه المطلوبة فعلا للحقل. يمكن تعريف المقنن المائي بانه احتياج المحصول للماء ويحدد اما بالحقل او عند المنفذ الحقلي. يشمل المقنن المائي تبخر النتح للمحاصيل بالإضافة الاستهلاك المائي له الذي يكون قليل جدا مقارنة بمعامل التبخر نتح كنسبة 1% من تبخر نتح. لذلك يكمن ان نهمله ونعتمد على تبخر نتح فقط لتخمين المقنن المائي. يعد المقنن المائي من المحددات الدقيقة في تصميم وتشغيل مشاريع الري وكذلك في اعداد الجدولة لري المحاصيل وانه يمثل اقل كمية مياه

يفترض اضافتها لسد النقص الحاصل من التبخر النتح للمحاصيل ولمختلف مختلف مراحل نمو المحصول. تكون وحداته (م^3/ثانية/هكتار) او(لتر/ثانية/هكتار) او(م^3/ثانية/دونم) وفي مصر (لتر/فدان). في هذا البحث تم الحصول على مقنن مائي اعتمادا على وزارة الموارد المائية في 1983 وبيانات في 2014 -2017 وكذلك 1971-2000 لمشروع الاسكندرية/ ما بين النهرين وكان 1.43 لتر/ثا/هكتار بينما المستخدم 0.91لتر/ثا/ هكتار وحصلنا لمشروع المسيب 1.05 لتر/ثا/هكتار بينما المستخدم 0.91لتر/ثا/ هكتار وكذلك لمشاريع المركز كان 1.04 لتر/ ثا/هكتار بينما المستخدم 0.91لتر/ثا/ هكتار. نسبة الزيادة في كمية المقنن المائي في المشروع الاسكندرية، مشروع المسيب وفي مشاريع المركز كانت 57%، 16% و14%، على التوالي. سبب الزيادة بسبب ارتفاع درجة الحرارة في السنوات الحالية. كان المقنن المائي في الجداول الاخيرة للري بتنقيط افضل بكثير من الري السيحي بنصف او اقل من الكمية المجهزة فنوصي باستخدام الري بتنقيط كطريقة افضل لتقنين المياه وسد النقص.

1. Introduction

The water duty various from region to other depending on climate conditions which include weather of temperature, relative humidity, sun radiation and number of hour day and wind speed. Also depending on latitude, longitude and altitude(topographic region) that help in estimating the water duty at all region and reduce the waste so rationing of water to fill the lack of water scarcity. Searching on crops that consumptive on less water and have less crop evapotranspiration to reduce the water used. The crops require a lot of water for growing, but the quantity deferent depending on a seasonal basis and a daily basis. Using rate changes depending on stages of growth. It is important to understand the range of water use by crops to better manage the crops, particularly when crops are being irrigated **Searcher[1]**. The term duty means the area of land that can be irrigated with unit volume of irrigation water at special time. The duty is defined as the area of land expressed in hectares that can be irrigated with unit discharge was 1 m^3/s. **Searcher[2]** was analyzed the difference of crops needing in the region, and then to assess these requirements in the light of the crop structure of the region and the size of water losses, and efficient use of irrigation water. Selection the best mathematical models to estimate the water consumption depending on climatic conditions of the region. Methods for scheduling irrigation are important aspects of good crop and plant management. Irrigation scheduling process is concerned with amount and time of irrigation. Time Domain Reflect meter (TDR) is utilize to measure soil moisture in the root zone **Searcher[3]**. **Searcher[4]** shown the water shortage and increase demand for water in agriculture and other sectors forced the need to adoption of irrigation strategies from open field to a greenhouse using high irrigation efficiency such as trickle irrigation system.

2. MATERIALS AND METHODS

Meteorological data

The meteorological data are very necessary to estimate water duty including temperature (maximum and minimum), relative humidity, net radiation, wind speed, hours of solar brightness, atmospheric pressure, effective rainfall and vapor pressure. Some other factors that affect crop evapotranspiration are method of irrigation, type of planting (in greenhouse or free field), method of cultivation(vertical or horizontal), using of fertilizer and pesticide, type of soil, depth of root zone, distance between crops and rows, crop density and cropping patterns and type of crops, which were calculated from many formulas such as Penman-Monteith equation and Blaney-Criddle formula that depending on principal weather information and from necessary to know the longitude, latitude and altitude of region. Figure (1) shown the map of work at page 22.

Reference evapotranspiration

The evapotranspiration rate from a reference surface, not short of water, is called the reference evapotranspiration (ETo), The surface of grass reference crop. The reference evapotranspiration studies, the evaporative demand of the atmosphere are depending on crop type, crop development and

management practices. ETo values measured or calculated at various sites or in various seasons.
ETo is depending on a climatic parameter and can be computed from weather data. The FAO Penman-Monteith method used to determine ETo(**Searcher[5]**).
There are three methods to depend on monthly data on previous years as follows.

1- Taking the average years to each month to get monthly data at one year then calculate ET_o each month
2- Calculate ET_o each month from years then applied statically distribution each month and assumed return interval at five years which find monthly ET_o at one year that consider best method in side engineering.
3- Taking value of ET_o directly from weather metrological and calculated ET_o

Crop evapotranspiration

The crop evapotranspiration under standard conditions (ET_c) defined the evapotranspiration from crops that was free from disease, best fertilizer crops, grown in large fields, under best soil water conditions. The quantity of water that evapotranspiration loss from the planted field can be named crop water requirement. the crop evapotranspiration and crop water requirement are identical, crop water requirement refers to the quantity of water that needs to be supplied, while crop evapotranspiration refers to the quantity of water that is lost through evapotranspiration. The irrigation water requirement also includes water to leach of salts. Crop evapotranspiration can be calculated from climatic by Penman-Monteith approach. ratios of ET_c/ET_o, called crop coefficients (K_c), ET_c in equation(1) of **FAO 56 (Searcher[5]).**

Crop coefficient

The crop coefficient (K_c) depending on type of crops, growing stages and changing depending on minimum relative humidity(RH_{min}), wind speed and temperature and determine to crop coefficient of center zone of Iraq in ministry of irrigation, 1983. K_c is calculated by the reference crop evapotranspiration, ET_o and ET_c crop evapotranspiration:

$ET_c = K_c\ ET_o$ ……..(1)

where ET_c crop evapotranspiration [mm d^{-1}],
K_c crop coefficient [dimensionless],
ET_o reference crop evapotranspiration [mm d^{-1}].
Also for large field and more crops, crop density is introduced to **Eq.(1)** as

$ET_c = K_c\ ET_o * Pc$ ……...(2)

Pc crop intensity taking from national center of Ministry of water resource.

Cropping patterns and intensity of crops

To estimate the water duty it must know type of crops and crop intensity and cropping patterns therefore it can be defined the crop intensity as percent of area of crops dividing on total area that planting may be calculated to one years, one season, multi season, two season (winter and summer together) and ranging from 100-300%.

Water duty

The water duty Can be defined is continuous discharge (liter/s or m^3/s) dividing on area(hectare or donam) and the units write as (l/s/ha or $m^3/s/ha$, $m^3/s/d$ (donam),….)

Type of irrigation

The type of irrigation is very important to determine irrigation efficiency, distribution efficiency and wetted percent that represent wetted area dividing to total area then estimate the water duty to any type of irrigation by irrigation efficiency. In Iraq irrigation projects assumed irrigation efficiency of surface irrigation was 65 % but sprinkler and trickle irrigation was 90 %-80 % by ministry of irrigation, 1983. In modern irrigation the irrigation efficiency in subsurface drip irrigation is 95 %**(Searcher[6])**.

Effective rain fall

The rainfall in study area of Iraq is very small and it was neglected in this work . if calculated take the average of rainfall to many years and months and takes the value of effective rainfall was 50%-70% from total rainfall will be small compare with consumptive use and losses in deep percolation and evapotranspiration.

Blanney-Criddle formula:

This formula gives an estimation of the mean monthly values of ET_O, which is stated as

$ET_O = p\,(0.46\,T_{mean} + 8.13)$ ----------(3)

Modified Blanny-Criddle Formula

Blaney-Criddle formula is a relatively simple method for calculating evapotranspiration; it is ideal when only air temperature and daylight hour data arc
available for a site. The formula is:
(Sammis et a1.,2011).

$ETo = 32+(1.8TP)/ 3.94$……(4)

Where:
T:Mean daily temperature in ^oC, and
P : Dayli ght (%).

Penman-Monteith equation

The equation of FAO Penman-Monteith for calculating ET_o take in consideration numbers of climatic parameters related to the ET_o process (air temperature, net radiation, wind speed and vapor pressure deficit) that can be expressed as follows **(Searcher[5]) and used by (Searcher[7]and Searcher[8])**

$$ET_o = \frac{0.408\Delta(R_n-G)+\gamma\frac{900}{T_{mean}+273}u_2(e_s-e_a)}{\Delta+\gamma(1+0.34u_2)} \quad \text{..... (5)}$$

Where:
$\boldsymbol{ET_o}$= reference evapotranspiration (mm/day),
$\boldsymbol{R_n}$= net radiation at the crop surface (MJ/m^2.day),
G= soil heat flux density (MJ/ m^2.day). As the immensity of the day or the ten day soil heat flux underneath the herb reference surface is comparatively small, it may be neglected and thus: G ≈ 0 FAO (**Searcher[5]),**

$\boldsymbol{T_{mean}}$= mean daily air temperature at 2m height (^oC),
$\boldsymbol{u_2}$= wind speed at 2m height (m/s),
$\boldsymbol{e_a}$= actual vapor pressure (kPa), $e_a = 0.6108exp\left(\frac{17.27T_{mean}}{237.3+T_{mean}}\right)$,
$\boldsymbol{e_s}$= saturation vapor pressure (kPa), $e_s = \frac{e(T_{max})-e(T_{min})}{2}$,
VPD= saturation vapor pressure deficit (kPa), $VPD = e_s - e_a$
Δ= slope vapor pressure curve (kPa/^oC), $\Delta=\frac{4098\left[0.6108\,exp\left(\frac{17.27\,T_{mean}}{T_{mean}+237.3}\right)\right]}{(T_{mean}+237.3)^2}$,
$\boldsymbol{\gamma}$= psychometric constant (kpa/^oC), $\gamma = \frac{c_p\,P}{\varepsilon\lambda}$,
$\boldsymbol{c_p}$= specific heat at constant pressure, 1.013×10^{-3}(MJ/kg.°C),
P= atmospheric pressure (kPa), $P = 101.3\left(\frac{293-0.0065\,z}{293}\right)^{5.26}$,
z=elevation above sea level (m), z of Baghdad is 32m,
$\boldsymbol{\varepsilon}$=ratio molecular weight of water vapor/dry air = 0.622, and
λ=Latent heat of vaporization (MJ/kg), $\lambda = 2.501 - (2.361\times10^{-3})T_{mean}$.

Kharrufa Formula

Kharrufa (1985) derived aformula through correlating ET/P and T in the form of:

$ETo = 0.34\ P\ Ta^{1.3}$……(6)

Where:-

P= percent of total day time hours for the period used (daily or monthly), and

Ta = mean temperature in C^{o}

3. RESULTS, CALCULATION AND DISCUSSIONS

This work applied to the water duty of Babylon governorate irrigation projects as applied example will calculate water duty depending on metrological data of ET_o from metrological data of 2017 in Mohanawia metrologic data staion of ministry of Agriculture and taking of crop coefficient once from ministry of irrigation, 1983 and other once from Italic-Iraq study (strategic study ,2014). Also taking of crop intensity (PC) from Ministry of Water Resource, 2017. The work in Babylon governorate at altitude 32 ° N, and longitude 44º E approximately as average latitude 30 m elevation of land from average of sea surface and depending on metrologic data from ministry of agriculture and other data of 1971-2000 and data of 2014-2017. Calculate the ETc depindin on eq.(2).

Table(1) The crop coefficient (Kc) of crops from **ministry of irrigation, 1983 (Searcher[13])** to winter crops.

Crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wheat	1.00	0.90	0.75	0.65	0.55	---	---	---	---	---	0.55	0.80
Barley	0.95	0.85	0.70	0.50	0.35	---	---	---	---	0.45	0.75	1.00
Other crops as average	1.06	0.92	0.77	0.50	0.30	---	---	---	---	0.35	0.60	0.95

Table(2) The crop coefficient (Kc) of crops from ministry of irrigation, 1983 to summer crops.

Crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maize &sorghum	---	---	---	0.30	0.55	0.95	0.90	0.60	---	---	---	---
Rice	---	---	---	0.55	0.90	1.15	0.80	0.45	---	---	---	---
Other crops as average	0.54	0.57	0.54	0.63	0.64	0.75	0.69	0.65	0.53	0.52	0.53	0.61

Table(3) The reference evapotranspiration from metrologic data of almuhanawia village in Sadat Alhindia township Metrologic station (ministry of agricultural, 2014-2017 Searcher[14]).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aver.
ET_o mm/day	1.52	2.37	3.26	4.71	6.30	8.72	8.56	6.30	5.45	3.41	2.21	1.35	54.24	4.52
ET_o mm/month	47.12	66.36	101.06	141.3	195.3	261.6	265.36	195.3	163.5	105.71	66.3	41.85	1650.84	137.57

Table(4) The reference evapotranspiration from metrologic data of almuhanawia village in Sadat Alhindia township Metrologic station at average of (1971- 2000).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	Aver.
ET_o mm/day	1.50	1.9	2.88	3.70	5.11	6.13	6.13	5.88	4.29	2.88	1.71	1.73	43.84	3.65
ET_o mm/month	46.50	53.2	89.28	111	158.41	183.9	190.03	182.28	128.7	89.28	51.3	53.63	1337.51	111.459167

Table(5) The cropping pattern and crop intensity of crops in winter planning of irrigation was taken from Ministry of Water Resource, 2017

Crops	Wheat	Barley	Other	Total
Between two river	57%	5.74%	36.30%	99%
Musaib	101.3%	5.30%	13.44%	120%
Center /Babylon	68.67%	22.02%	9.36%	100%

Table(6) The cropping pattern and crop intensity of crops in summer planning of irrigation was taken from Ministry of Water Resource, 2017

Crops	Maize& sorghum	Rice	Other	Total
Between two river	73.36	0%	29.98%	103%
Musaib	31.25%	0%	23.67%	55%
Center /Babylon	36.38%	3.18%	33.86%	73.4%

Table(7) The cropping pattern and crop intensity at two season

Crop intensity	Between two river	Musaib	Center /Babylon
Summer	103%	55%	73.4%
Winter	99%	120%	100
Total of two season	202%	175%	173.4%

The average crop intensity of Babylon governorate was 183% in years

The water duty equal to crop evapotranspiration in farm turn out that calculate from crop evapotranspiration of crops dividing on irrigation efficiency.

Determining the type of crops and calculating the Kc from pancol, 1982 and strategic study,2014, also depending on ministry of water resource on cultivation plan and cropping intensity as show in table (4), table (5) and table (6).

Determine the high water duty was determined in table(9) to table (11) as depending on water duty at four study (ministry of irrigation 1982 and strategic 2014, 1971 to 2000 and 2014 to 2017) of three regions in Babylon governorate in reclaimed land.

4. CONCLUSIONS

Using the metrological data at increasing temperature seasons to calculate the changing of water duty because increase of temperature and crop intensity because of the abuses on cultivation plan. The work was done in Babylon governorate on three projects and calculate the percent of crop patterns, ETo, ETc and water duty to conclude on :

1- The water duty of center of Iraq among the river (AL-Esqandria canal), Musaib canal and center of Babylon (Kifil project) as doing was $1m^3/s/4400mish$ (0.91 l/s/ha) to $1m^3/s/4440mish$ (0.9 l/s/ha) in the reclaimed land.
2- In recent time found the water duty depending on ministry of irrigation (English study 1982) through the area study was 1.43 l/s/ ha, 1.05 l/s/ ha and 1.04 l/s/ ha among two rivers which (AL-Esqandria canal), Musaib canal and center of Babylon (Kifil project), respectively. Whereas by drip irrigation the water duty become 0.52 l/s/ ha, 0.38l/s/ha and 0.38l/s/ha ha among two rivers which (AL-Esqandria canal), Musaib canal and center of Babylon (Kifil project), respectively.
3- The water duty adopted by ministry of water resource 2014(strategic study) through the area study was 1.98 l/s/ ha, 1.33 l/s/ ha and 1.3 l/s/ ha in among two river (AL-Esqandria canal), Musaib canal and center of Babylon (Kifil project), respectively. Whereas by drip irrigation the water duty become 0.786 l/s/ ha, 0.48l/s/ha and 0.47 l/s/ha ha among two rivers which (AL-Esqandria canal), Musaib canal and center of Babylon (Kifil project), respectively.
4- The water duty through 1971-2000 in the area study was 1.01 l/s/ ha, 0.85 l/s/ ha and0.84 l/s/ ha in among two river (AL-Esqandria canal), Musaib canal and center of Babylon (Kifil project), respectively. Whereas by drip irrigation the water duty become 0.37 l/s/ ha, 0.31l/s/ha and 0.31 l/s/ha ha among two river (AL-Esqandria canal), Musaib canal and center of Babylon (Kifil project), respectively.
5- The water duty through 2014-2017 in the area study was 1.3 l/s/ ha, 1.06 l/s/ ha and1.05 l/s/ ha in among two river (AL-Esqandria canal), Musaib canal and center of Babylon (Kifil project), respectively. Whereas by drip irrigation the water duty become 0.47 l/s/ ha, 0.38 l/s/ha and 0.37 l/s/ha ha among two river (AL-Esqandria canal), Musaib canal and center of Babylon (Kifil project), respectively.
6- The wetted percent between 0.33-0.66 assume as average 0.5 and irrigation efficiency of surface or traditional irrigation assume 65% and drip irrigation 90%.

5. RECOMMENDATIONS

1- Calculation new water duty to all Iraq governorates depending on increase the temperature and decrease the relative humidity because of reduction in precipitations and increasing of temperature, also decrease the water supply from neighbor countries which the rivers stems from them.

2- Calculation the water duty at whole five years because of climate changing and do not depend on constant water duty.

3- Calculation new water duty to all Iraq governorates depending on drip irrigation and modern irrigation.

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Table(8) The water duty at two season of crops @ministry of irrigation and drainage 1982

								Water duty of ETc mm/month								
			Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
season	Crops pattern		ET_omm/ month	47.12	66.36	101.06	141.3	195.3	261.6	265.36	195.3	163.5	105.71	66.3	41.85	1650.84
		Crop intensity														
Winter	Wheat			26.8584	34.04268	43.20315	52.35165	61.22655	0	0	0	0	0	20.78505	19.0836	257.5511
	Barley			2.569454	3.237704	4.060591	4.05531	3.923577	0	0	0	0	2.730489	2.854215	2.40219	25.83353
	Other crops			18.13083	22.16159	28.24728	25.64595	21.26817	0	0	0	0	13.43046	14.44014	14.43197	157.7564
Summer	Maize &sorgom			0	0	0	31.0973	78.79964	182.3143	175.2013	85.96325	0	0	0	0	553.3758
	Rice			0	0	0	0	0	0	0	0	0	0	0	0	0
	Other crops			0	0	16.37172	26.7057	37.4976	58.86	54.92952	38.0835	25.9965	0	0	0	258.4445
			SUM	47.55869	59.44197	91.88274	139.8559	202.7155	241.1743	230.1308	124.0467	25.9965	16.16094	38.07941	35.91776	1252.961
			SUM/0.65	73.16721	91.44918	141.3581	215.1629	311.8701	371.0373	354.0474	190.8412	39.99462	24.86299	58.5837	55.2581	1927.633
			L/S/HA	0.27	0.38	0.53	0.83	1.16	1.43	1.32	0.71	0.15	0.09	0.22	0.21	7.20
IF DRIP USE AVERpw=50%(66-33%) (w.d of surface*0.65/0.91)*0.5= 0.517 , percent increasing 57%																

Table (8) Cont.

								Water duty of ETc mm/month								
			Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
season	Crops pattern		ET_omm/ month	47.12	66.36	101.06	141.3	195.3	261.6	265.36	195.3	163.5	105.71	66.3	41.85	1650.84
		Crop intensity														
Winter	Wheat			47.73256	60.50041	76.78034	93.03899	108.8114	0	0	0	0	0	36.93905	33.91524	457.718
	Barley			2.372492	2.989518	3.749326	3.74445	3.622815	0	0	0	0	2.521184	2.635425	2.21805	23.85326
	Other crops			6.712904	8.205281	10.4585	9.49536	7.874496	0	0	0	0	4.972598	5.346432	5.343408	58.40898
Summer	Maize &sorgom			0	0	0	13.24688	33.56719	77.6625	74.6325	36.61875	0	0	0	0	235.7278
	Rice			0	0	0	0	0	0	0	0	0	0	0	0	0
	Other crops			0	0	12.91729	21.0708	29.58561	46.44054	43.33939	30.04788	20.51124	0	0	0	203.9127
			SUM	56.81796	71.69521	103.9054	140.5965	183.4615	124.103	117.9719	66.66663	20.51124	7.493782	44.9209	41.4767	979.6208
			SUM/0.65	87.41224	110.3003	159.8545	216.3023	282.2485	190.9278	181.4952	102.564	31.55575	11.5289	69.10908	63.8103	1507.109
			L/S/HA	0.33	0.46	0.60	0.83	1.05	0.74	0.68	0.38	0.12	0.04	0.26	0.25	5.63
IF DRIP USE AVERpw=50%(66-33%) (w.d of surface*0.65/0.90)*0.5=0.381 , percent increasing 16%																

Table (8) Cont.

								Water duty of ETc mm/month								
			Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
season	Crops pattern		ET_omm/ month	47.12	66.36	101.06	141.3	195.3	261.6	265.36	195.3	163.5	105.71	66.3	41.85	1650.84
		Crop intensity														
Winter	Wheat			32.3573	41.01247	52.04843	63.06996	73.76188	0	0	0	0	0	25.04052	22.99072	310.2813
	Barley			9.857033	12.4206	15.57739	15.55713	15.05177	0	0	0	0	10.4748	10.94945	9.21537	99.10354
	Other crops			4.675058	5.714392	7.283596	6.61284	5.484024	0	0	0	0	3.46306	3.723408	3.721302	40.67768
Summer	Maize &sorgom			0	0	0	15.42148	39.07758	90.41158	86.88417	42.63008	0	0	0	0	274.4249
	Rice			0	0	0	2.471337	5.589486	9.566712	6.750758	2.794743	0	0	0	0	27.17304
	Other crops			0	0	18.47821	30.14183	42.32229	66.43332	61.99712	42.98358	29.34138	0	0	0	291.6977
			SUM	46.88939	59.14746	93.38763	133.2746	181.287	166.4116	155.632	88.4084	29.34138	13.93786	39.71337	35.92739	1043.358
			SUM/0.65	72.13753	90.9961	143.6733	205.0378	278.9031	256.0179	239.4339	136.0129	45.14059	21.44287	61.09749	55.2729	1605.166
			L/S/HA	0.27	0.38	0.54	0.79	1.04	0.99	0.89	0.51	0.17	0.08	0.23	0.21	5.99
	PERCENT OF INCRESING			0.14	14%											

IF DRIP USE AVE. pw=50%(66-33%)‹(w.d of surface*0.65/0.90)*0.5=0.376 , percent increasing 14%

Table(9) The water duty at two season of crops @ strategic study of ministry of water resource 2014.

								Water duty of ETc mm/month								
			Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
season	Crops pattern		ET_omm/ month	47.12	66.36	101.06	141.3	195.3	261.6	265.36	195.3	163.5	105.71	66.3	41.85	1650.84
		Crop intensity														
Winter	Wheat			27.93	44.26	67.97	94.23	70.13	0.00	0.00	0.00	0.00	0.00	26.45	20.04	27.93
	Barley			2.87	4.46	6.84	7.54	5.04	0.00	0.00	0.00	0.00	0.00	1.18	1.47	2.87
	Other crops			0.00	0.00	11.74	28.72	56.01	94.01	81.88	38.99	24.33	6.52	0.00	0.00	0.00
Summer	Maize &sorgom			0.00	0.00	0.00	73.60	146.14	239.89	225.81	110.32	0.00	0.00	0.00	0.00	0.00
	Rice			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Other crops			9.61	14.93	25.47	25.01	25.19	0.00	0.00	21.68	21.58	20.93	12.93	7.78	9.61
			SUM	40.41	63.64	112.02	229.11	302.51	333.90	307.69	170.99	45.92	27.45	40.56	29.29	40.41
			SUM/0.65	62.17	97.91	172.34	352.47	465.41	513.69	473.37	263.06	70.64	42.24	62.40	45.06	62.17
			L/S/HA	0.23	0.40	0.64	1.36	1.74	1.98	1.77	0.98	0.27	0.16	0.23	0.17	0.23

IF DRIP	USE AVERpw=50%(66-33%)	(w.d of surface*0.65/0.91)*0.5=	0.716 , percent increasing 118%

Table (9) Cont.

								Water duty of ETc mm/month							
			Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
season	Crops pattern	Crop intensity	ET_omm/ month	47.12	66.36	101.06	141.3	195.3	261.6	265.36	195.3	163.5	105.71	66.3	41.85	1650.84
Winter	Wheat			49.64	78.65	120.80	167.47	124.64	0.00	0.00	0.00	0.00	0.00	47.01	35.61	49.64
	Barley			2.65	4.11	6.32	6.96	4.66	0.00	0.00	0.00	0.00	0.00	1.09	1.35	2.65
	Other crops			0.00	0.00	4.35	10.63	20.74	34.81	30.31	14.44	9.01	2.42	0.00	0.00	0.00
Summer	Maize &sorgom			0.00	0.00	0.00	31.35	62.25	102.19	96.19	46.99	0.00	0.00	0.00	0.00	0.00
	Rice			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Other crops			7.58	11.78	20.09	19.73	19.88	0.00	0.00	17.10	17.03	16.51	10.20	6.14	7.58
			SUM	59.87	94.55	151.56	236.15	232.16	136.99	126.51	78.53	26.04	18.93	58.30	43.11	59.87
			SUM/0.65	92.11	145.46	233.17	363.31	357.17	210.76	194.63	120.82	40.06	29.12	89.70	66.32	92.11
			L/S/HA	0.34	0.60	0.87	1.40	1.33	0.81	0.73	0.45	0.15	0.11	0.33	0.26	0.34
IF DRIP USE AVERpw=50%(66-33%) (w.d of surface*0.65/0.90)*0.5=0.48 , percent increasing 47%																

Table (9) Cont.

								Water duty of ETc mm/month								
			Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
season	Crops pattern	Crop intensity	ET_omm/ month	47.12	66.36	101.06	141.3	195.3	261.6	265.36	195.3	163.5	105.71	66.3	41.85	1650.84
Winter	Wheat			33.65	53.32	81.89	113.53	84.49	0.00	0.00	0.00	0.00	0.00	31.87	24.14	33.65
	Barley			11.00	17.10	26.26	28.94	19.35	0.00	0.00	0.00	0.00	0.00	4.53	5.62	11.00
	Other crops			0.00	0.00	3.03	7.41	14.44	24.24	21.11	10.05	6.27	1.68	0.00	0.00	0.00
Summer	Maize &sorgo m			0.00	0.00	0.00	36.50	72.47	118.96	111.98	54.71	0.00	0.00	0.00	0.00	0.00
	Rice			0.00	0.00	0.00	0.00	6.83	9.82	10.46	7.45	5.72	0.00	0.00	0.00	0.00
	Other crops			10.85	16.85	28.74	28.23	28.44	0.00	0.00	24.47	24.36	23.62	14.59	8.79	10.85
			SUM	55.50	87.26	139.92	214.59	226.02	153.02	143.56	96.68	36.35	25.31	50.99	38.55	55.50
			SUM/0.65	85.38	134.25	215.26	330.14	347.73	235.42	220.86	148.74	55.93	38.93	78.44	59.30	85.38
			L/S/HA	0.32	0.55	0.80	1.27	1.30	0.91	0.82	0.56	0.22	0.15	0.29	0.23	0.32
	PERCENT OF INCRESING			0.14	14%											
IF DRIP USE AVE. pw=50%(66-33%)‹(w.d of surface*0.65/0.90)*0.5=0.47 , percent increasing 43%																

Table(10) The water duty at two season of crops through 30 years from 1971 to 2000

								Water duty of ETc mm/month							
			Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
season	Crops pattern		ET_omm/ month	48.67	67.83	106.95	145.8	196.54	237.9	249.86	221.34	164.4	106.33	61.8	46.81	1654.23
		Crop intensity														
Winter	Wheat			26.505	27.2916	38.1672	41.1255	49.66154	0	0	0	0	0	16.08255	24.45528	223.2887
	Barley			2.535645	2.595628	3.58727	3.1857	3.182457	0	0	0	0	2.306102	2.208465	3.078362	22.67963
	Other crops			17.89227	17.76667	24.95465	20.1465	17.25085	0	0	0	0	11.34302	11.17314	18.49431	139.0214
Summer	Maize &sorgom			0	0	0	24.42888	63.91527	128.1636	125.4654	80.23236	0	0	0	0	422.2055
	Rice			0	0	0	0	0	0	0	0	0	0	0	0	0
	Other crops			0	0	14.46336	20.979	30.41472	41.3775	39.33621	35.5446	20.4633	0	0	0	202.5787
			SUM	46.93292	47.6539	81.17248	109.8656	164.4248	169.5411	164.8016	115.777	20.4633	13.64913	29.46416	46.02795	1009.774
			SUM/0.65	72.20448	73.31369	124.8807	169.024	252.9613	260.8324	253.5409	178.1184	31.482	20.99866	45.32947	70.81223	1553.498
			L/S/HA	0.27	0.30	0.47	0.65	0.94	1.01	0.95	0.67	0.12	0.08	0.17	0.27	5.80
IF DRIP	USE AVERpw=50%(66-33%)			(w.d of surface*0.65/0.91)*0.5=				0.37	, percent increasing 10%							

Table (10) Cont.

								Water duty of ETc mm/month								
			Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
season	Crops pattern		ET_omm/ month	48.67	67.83	106.95	145.8	196.54	237.9	249.86	221.34	164.4	106.33	61.8	46.81	1654.23
		Crop intensity														
Winter	Wheat			47.1045	48.50244	67.83048	73.08795	88.25813	0	0	0	0	0	28.5818	43.46175	396.827
	Barley			2.341275	2.39666	3.312288	2.9415	2.938506	0	0	0	0	2.129328	2.039175	2.84239	20.94112
	Other crops			6.624576	6.578074	9.239409	7.4592	6.387091	0	0	0	0	4.199731	4.136832	6.847478	51.47239
Summer	Maize &sorgom			0	0	0	10.40625	27.22672	54.59531	53.44594	34.1775	0	0	0	0	179.8517
	Rice			0	0	0	0	0	0	0	0	0	0	0	0	0
	Other crops			0	0	11.41159	16.55243	23.99721	32.64685	31.03627	28.04469	16.14554	0	0	0	159.8346
			SUM	56.07035	57.47717	91.79377	110.4473	148.8077	87.24216	84.48221	62.22219	16.14554	6.329059	34.7578	53.15162	808.9269
			SUM/0.65	86.26208	88.42642	141.2212	169.919	228.9349	134.2187	129.9726	95.72645	24.8393	9.737014	53.47354	81.77172	1244.503
			L/S/HA	0.32	0.37	0.53	0.66	0.85	0.52	0.49	0.36	0.10	0.04	0.20	0.32	4.65
IF DRIP USE AVERpw=50%(66-33%) (w.d of surface*0.65/0.90)*0.5=0.31 , percent increasing -6%																

Table (10) Cont.

								Water duty of ETc mm/month								
			Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
season	Crops pattern		ET_omm/ month	48.67	67.83	106.95	145.8	196.54	237.9	249.86	221.34	164.4	106.33	61.8	46.81	1654.23
		Crop intensity														
Winter	Wheat			31.93155	32.8792	45.98143	49.54541	59.82908	0	0	0	0	0	19.37524	29.46218	269.0041
	Barley			9.727335	9.957444	13.76162	12.2211	12.20866	0	0	0	0	8.846755	8.472195	11.80933	87.00443
	Other crops			4.613544	4.581158	6.434588	5.1948	4.448153	0	0	0	0	2.924813	2.881008	4.76878	35.84684
Summer	Maize &sorgom			0	0	0	12.11454	31.69626	63.55768	62.21962	39.78808	0	0	0	0	209.3762
	Rice			0	0	0	1.94139	4.533694	6.725223	4.834363	2.608427	0	0	0	0	20.6431
	Other crops			0	0	16.32431	23.6783	34.32808	46.70141	44.39747	40.11801	23.09624	0	0	0	228.6438
			SUM	46.27243	47.4178	82.50195	104.6955	147.0439	116.9843	111.4515	82.51451	23.09624	11.77157	30.72844	46.04028	850.5184
			SUM/0.65	71.18835	72.95046	126.9261	161.0701	226.2214	179.9759	171.4638	126.9454	35.53268	18.1101	47.27453	70.8312	1308.49
			L/S/HA	0.27	0.30	0.47	0.62	0.84	0.69	0.64	0.47	0.14	0.07	0.18	0.27	4.89
	PERCENT OF INCRESING			0.-07	-7%											
IF DRIP USE AVE. pw=50%(66-33%)،(w.d of surface*0.65/0.90)*0.5=0.31 , percent increasing -7%																

Table(11) The water duty at two season of crops from 2014 to 2017.

								Water duty of ETc mm/month								
			Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
season	Crops pattern		ET_omm/ month	48.67	67.83	106.95	145.8	196.54	237.9	249.86	221.34	164.4	106.33	61.8	46.81	1654.23
		Crop intensity														
Winter	Wheat			27.7419	34.79679	45.72113	54.0189	61.61529	0	0	0	0	0	19.3743	21.34536	264.6137
	Barley			2.653975	3.309426	4.297251	4.18446	3.948489	0	0	0	0	2.746504	2.66049	2.686894	26.48749
	Other crops			18.72724	22.65251	29.89359	26.4627	21.40321	0	0	0	0	13.50923	13.46004	16.14243	162.2509
Summer	Maize &sorgom			0	0	0	32.08766	79.29996	165.7973	164.9676	97.42501	0	0	0	0	539.5775
	Rice			0	0	0	0	0	0	0	0	0	0	0	0	0
	Other crops			0	0	17.3259	27.5562	37.73568	53.5275	51.72102	43.1613	26.1396	0	0	0	257.1672
			SUM	49.12312	60.75872	97.23787	144.3099	204.0026	219.3248	216.6886	140.5863	26.1396	16.25573	35.49483	40.17468	1250.097
			SUM/0.65	75.57403	93.47496	149.5967	222.0153	313.8502	337.4227	333.3671	216.2866	40.21477	25.00882	54.60743	61.8072	1923.226
			L/S/HA	0.28	0.39	0.56	0.86	1.17	1.30	1.24	0.81	0.16	0.09	0.20	0.24	7.18
IF DRIP USE AVERpw=50%(66-33%) w.d of surface*0.65/0.91)*0.5= 0.47 , percent increasing 48%																

Table (11) Cont.

								Water duty of ETc mm/month								
			Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
season	Crops pattern		ET_omm/ month	48.67	67.83	106.95	145.8	196.54	237.9	249.86	221.34	164.4	106.33	61.8	46.81	1654.23
		Crop intensity														
Winter	Wheat			49.30271	61.84061	81.25526	96.00201	109.5023	0	0	0	0	0	34.43187	37.93482	49.30271
	Barley			2.450535	3.055742	3.967845	3.8637	3.645817	0	0	0	0	2.535971	2.45655	2.48093	2.450535
	Other crops			6.933723	8.387044	11.06804	9.79776	7.924493	0	0	0	0	5.001763	4.983552	5.976701	6.933723
Summer	Maize &sorgom			0	0	0	13.66875	33.78031	70.62656	70.27313	41.50125	0	0	0	0	0
	Rice			0	0	0	0	0	0	0	0	0	0	0	0	0
	Other crops			0	0	13.67014	21.74184	29.77345	42.2332	40.80788	34.05427	20.62414	0	0	0	0
			SUM	58.68697	73.2834	109.9613	145.0741	184.6263	112.8598	111.081	75.55552	20.62414	7.537734	41.87197	46.39245	58.68697
			SUM/0.65	90.28764	112.7437	169.1712	223.1909	284.0405	173.6304	170.8939	116.2393	31.72945	11.59651	64.41842	71.37301	90.28764
			L/S/HA	0.34	0.47	0.63	0.86	1.06	0.67	0.64	0.43	0.12	0.04	0.24	0.28	0.34
IF DRIP USE AVERpw=50%(66-33%) (w.d of surface*0.65/0.90)*0.5=0.381 , percent increasing 16%																

Table (11) Cont.

								Water duty of ETc mm/month								
			Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
season	Crops pattern		ET_omm/ month	48.67	67.83	106.95	145.8	196.54	237.9	249.86	221.34	164.4	106.33	61.8	46.81	1654.23
		Crop intensity														
Winter	Wheat			33.42169	41.92097	55.08192	65.07856	74.23021	0	0	0	0	0	23.34093	25.71554	33.42169
	Barley			10.18128	12.69574	16.48527	16.05258	15.14734	0	0	0	0	10.53624	10.20627	10.30756	10.18128
	Other crops			4.828843	5.840977	7.7081	6.82344	5.518843	0	0	0	0	3.483371	3.470688	4.162345	4.828843
Summer	Maize &sorgom			0	0	0	15.9	39.3	82.22	81.81	48.3	0	0	0	0	0
	Rice			0	0	0	2.550042	5.624975	8.700003	6.356438	3.167375	0	0	0	0	0
	Other crops			0	0	19.55517	31.10176	42.591	60.41471	58.37579	48.71472	29.5029	0	0	0	0
			SUM	48.43181	60.45769	98.83046	137.519	182.4381	151.3353	146.5414	100.1962	29.5029	14.01961	37.01789	40.18545	48.43181
			SUM/0.65	74.51048	93.01184	152.0469	211.5677	280.6739	232.8236	225.4483	154.148	45.38907	21.56863	56.9506	61.82377	74.51048
			L/S/HA	0.28	0.38	0.57	0.82	1.05	0.90	0.84	0.58	0.18	0.08	0.21	0.24	0.28
	PERCENT OF INCRESING			0.14	14%											
IF DRIP USE AVE. pw=50%(66-33%)،(w.d of surface*0.65/0.90)*0.5=0.37 8, percent increasing 15%																

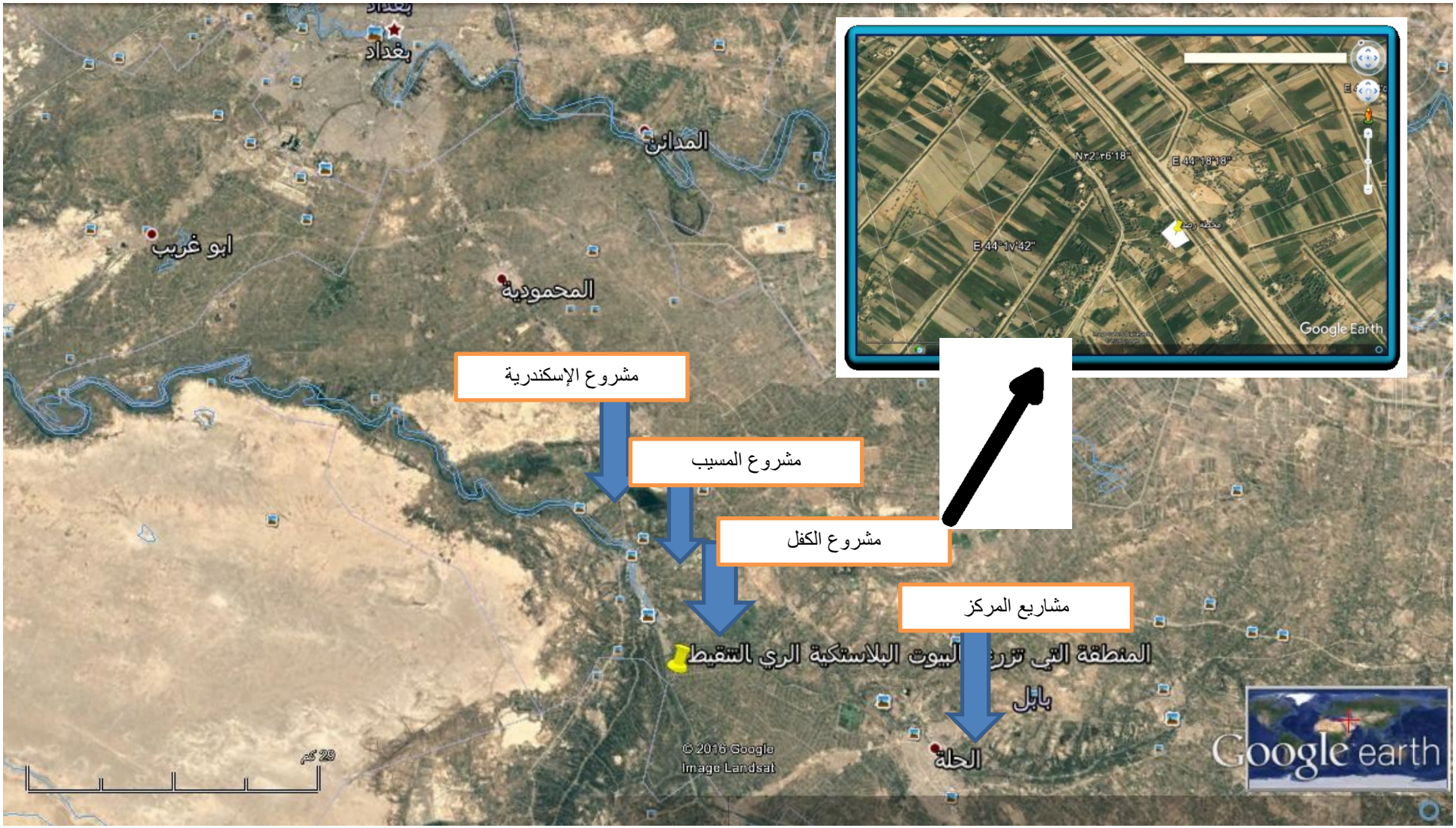

Figure (1) the map of work by Google earth was reclaimed.