https://doi.org/10.26682/csjuod.2023.26.2.21
Journal of University of Duhok., Vol. 26, No.2 (Pure and Engineering Sciences), Pp 216-230, 2023
4th International Conference on Recent Innovations in Engineering (ICRIE 2023) (Special issue)

EFFECT OF POPULATION GROWTH ON THE WATER DUTY OF THE IRRIGATED LANDS WITHIN A PART OF THE CENTRAL DISTRICT OF KERBALA CITY: ALIHNEIDIYAH RIVER AS STUDY CASE

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(Accepted for Publication: November 27, 2023)

ABSTRACT

The rivers, channels, canals, and other water ways convey and distribute the water to the irrigation field networks. Distribution of water for irrigation purposes subjects to a principle called as "The water duty". This principle is important to satisfy a justified distribution of water for the irrigation projects, and affected by many variables. One of these variables may be the urban growth within the agricultural lands. So, perhaps it needs an annual evaluation to make the water distribution plan on irrigation projects works correctly. The present study views the urban growth that take a place on the green areas which irrigate from a part of AliHneidiyah river in Karbala city, Republic of Iraq, for the distance surrounded by the stations (0+000) and (4+000), to choose between keeping up the current water duty or re-calculate it depending on the last change in space of the green zone within the studied area. The cadastral maps and satellite images are used to determine the areas irrigated from the river inside the study area, and the change that happens in the nature use of these areas. The results of this study shows that the urban growth has an inverse proportion to the green zones, and that impose to modify the water duty calculated and water shares to keep an equalibirium status during the scarcity seasons.

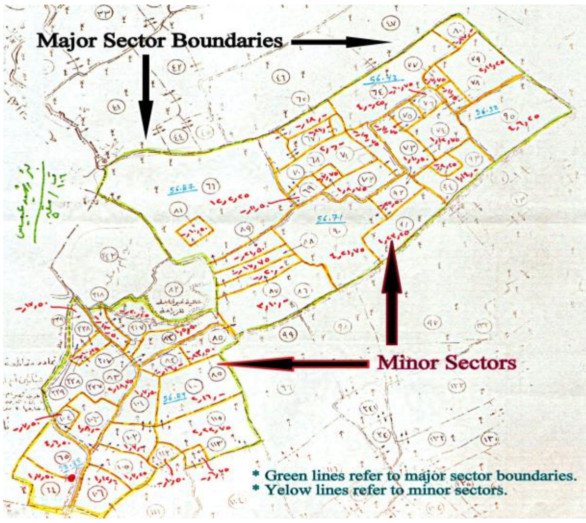
KEYWORDS: Urban Growth; Scarcity; Water Duty; Water Shares; Irrigation projects

1. INTRODUCTION

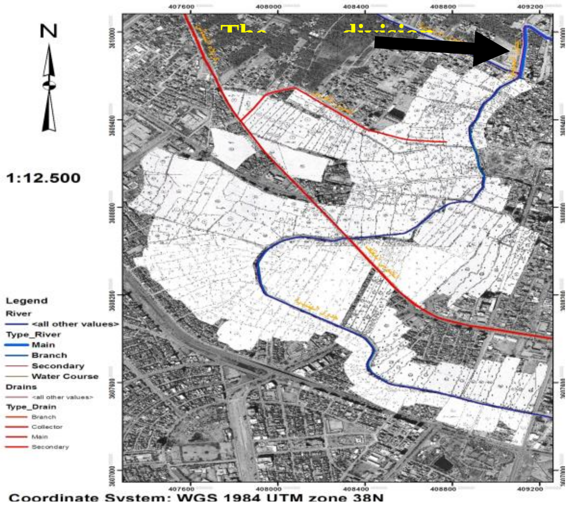
During the last five years, Iraq tested serious problems to face the reduction in water quantities supplied by the upstream countries of the Tigris and Euphrates Rivers [1]. This reduction reverberated on the preparation and management of the irrigation plans for the two seasons, winter and summer. Besides, the drought period increased and took a long time to finish during the summer season. All these events affected on the agricultural production of the farms and orchards, whereas the area of green zones in the regions around cities were minimized and changed in use from the agricultural to the other uses in the last twenty years [2, 3, and 4]. This is an indication that should be taken in mind in distributing of the water for the waterways that feeding these lands, and depending the use of groundwater as a role for the remaining areas in the present [5 and 6], as well as using the cancelled water shares to restore the areas that suffer from desertification due to the minimized incoming water [7]. Besides, using of correct, smart, and precise techniques in resetting of water shares to the reclaimed ones [8 and 9]. Using of Geographic Information System, GIS, and the remote sensing technology in the present time consider as an effect skill for spatial description because of the valuabe potential offers that provide to help diagnose various problems in multiple scientific fields, whereas it is an effective tool for the evaluation of the distribution of public services to urban residential regions, rural regions and others, and re-evaluating the random distribution of these services within city districts [10] by using many criteria including river streams, rainfall, slope, and vegetation index ... etc [11]. GIS is also used for estimating the rainfall-runoff erosive factor of the wide range watersheds for different formative terrain [12]. In addition, the effective contribution to assessing the quality of surface water such as rivers and their tributaries by monitoring the concentrations and distribution of many elements and compounds, studying the physical properties of the rivers such as water transparency, salinity, electrical conductivity, and analyzing the results to build a network of databases are all can be studied by the GIS [13 and 14]. The urban growth represented by the use of modern housing units with their concepts of construction (adding construction materials to the rural environment) and formative (introducing the modern architectural to the character of housing and rural buildings) leads to distorting and changing the reality of the formation in the housing fabric of the rural settlement, where the green areas begins to recede, and replaced by the residential areas gradually [15]. This change truly affects the water structures that serve these agricultural lands, such as natural and lined channels, and resulting in neglecting and lacking of use. Another phenomenon is clearly activated, which is the phenomenon of water percolation into the soil face that surrounding these waterways, which definitely leads to the decrease of the water shares that waters the areas located in the tail regions of the river [16]. The current study views the reduction that take place in the green lands for both sides of the AliHneidiyah River/the central district of Kerbala city (a part length equal to 4 km), and make a decision about the water duty the remaining green areas included by the study area.

2. DESCRIPTION OF STUDY AREA

Both of Al-Huseiniyah River, AliHneidiyah River, and their districts, major and minor sectors were defined and described precisely by [3 and 4]. Figures 1 and 2 and table 1 explain these terms.



Fig(1):- A part of a certain cadastral map views a major sector within a certain district, and the minor sectors



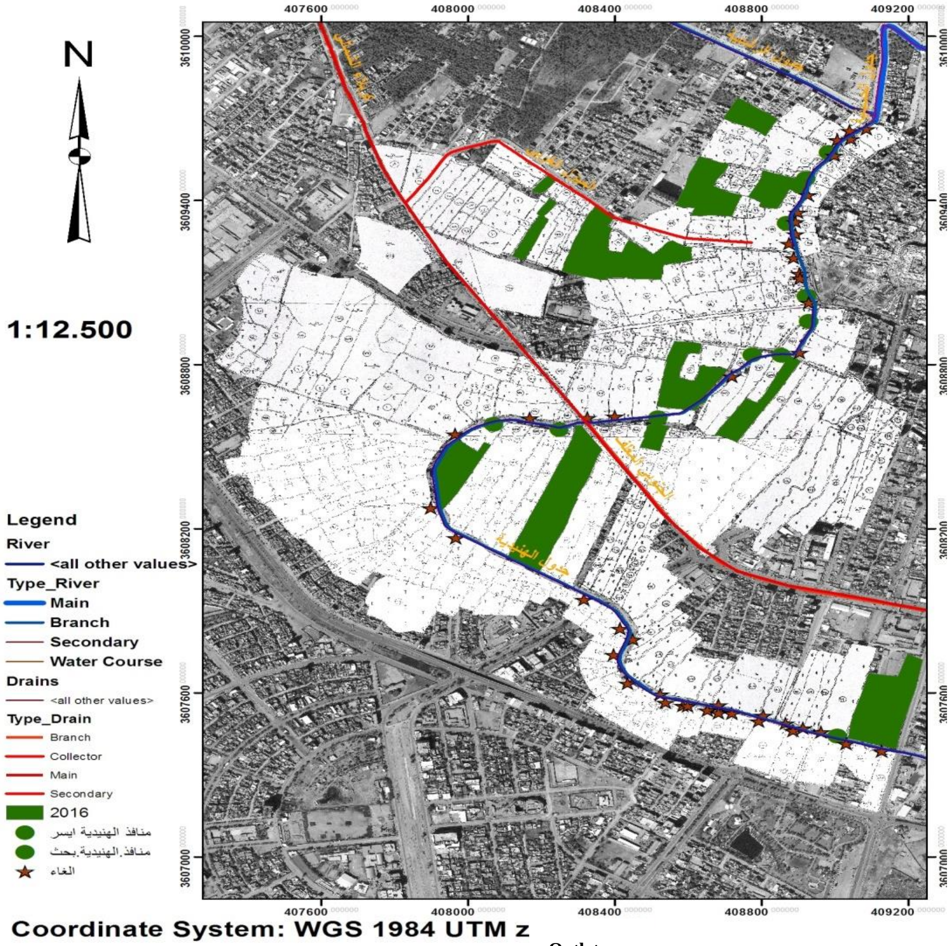
Fig(2):- The study area of AliHneidiyah river including the division point of Al-Huseiniyah river at the upper right corner [17,

Whereas the study region is surrounded by the coordinates [407300 – 409300] East, [3607000 – 3610000] North, and the river flows inside this region for a distance of 4 km from the "division point" located previously in figure 2, which provides the water demands for the field outlets, 26 on the right side and 25 on the left side, see figure 3.

The outlets provide the water courses to irrigate the farms and orchards there. Table 2 lists the details of major and minor sectors, besides the field outlets included by the study area.

Table(1):- Details of the major sectors that irrigated by AliHneidiyah River [3, 4, and 19].

Major sector number	Area (m^2)	Land type	
		Farm (m^2)	Orchard (m^2)
5	45,675	-	45,675
6	1,792,398	-	1,792,398
7	4,200	-	4,200
22	89,975	-	89,975
24	1,183,825	150,000	1,033,825
40	7,144,897	3,553,200	3,591,697
43	1,239,030	296,800	942,230



Outlets

Fig.(3):- The field outlets of AliHneidiyah river within the study area, (Year 2016 satellite image) [17, 18, and 21].

Table (2):- Details of the active spaces that irrigated by AliHneidiyah River [3, 4, 17, 18, and 19].

Outlet number	Active region number	Major sector number	Minor sectors number	Total area of active space (m^2)	Outlet discharge (l/s)
X01	RS01	6	1	2,575	1.00
X02	RS02	6	2 and 3	17,125	1.50
X03	RS03	6	4 to 7	36,750	3.50
X04	RS04	6	8 to 22, and 192	31,275	5.50
X05	RS05	6	23, 26 to 32, and 220	71,505	7.00
X06	RS06	6	33 to 36, 38, 45, 46, and 48 to 65	275,000	12.00
		22	10 to 18, 98, 99, 224, and 227		
X07	RS07	6	37	11,000	1.00

X08	RS08	6	39	1,150	1.00
X09	RS09	6	40	350	1.00
X10	RS10	6	147(Portion2)	9,843	2.00
X11	RS11	22	47, 66 to 70, 118, 140(Portion2) to 147(Portion 1), 194, and 195	94,775	9.30
X12	RS12	6	148	4,000	1.00
X13	RS13	6	120, 149 to 152, 172, and 173	24,200	2.30
X14	RS14	6	121 and 154	22,625	2.30
X15	RS15	6	153	15,100	1.25
X16	RS16	6	71 to 74	41,300	4.00
X17	RS17	6	75 to 78, 81, and 174 to 199	40,650	4.00
X18	RS18	6	79, 80, 85, 200, and 201	799,895	35.00
X19	RS19	6	83 to 100, 196 to 198, and 219	252,025	25.00
X20	RS20	6	101 and 102	61,175	6.00
X21	RS21	6	103 to 109	63,975	6.30
X22	RS22	6	110 and 111	14,275	1.25
X23	RS23	6	113	5,800	1.25
X24	RS24	6	114 to 117	32,000	1.25
X25	RS25	6	167	8,450	1.00
X26	RS26	6	175	5,075	1.00
X27	RS27	6	176	4,825	1.50
X28	RS28	6	177	11,275	1.00
X29	RS29	6	178	6,375	1.00
X30	RS30	6	119 and 179	9,200	1.00
X31	RS31	6	218	2,750	1.00
X32	RS32	6	180	16,775	1.50
X33	RS33	6	181	7,650	1.25
X34	RS34	6	182 and 183	26,725	
Y01	LS01	5	1 and 5	8,400	1.00
		7	160		
Y02	LS02	5	3	4,125	1.00
Y03	LS03	5	6, 13, and 14	6,375	1.00
Y04	LS04	5	15 and 16	6,450	1.00
Y05	LS05	5	72	2,025	1.00

Y06	LS06	6	24	3,300	1.00
Y07	LS07	6	25	4,700	1.00
Y08	LS08	6	158 to 160, 204, and 205	62,715	6.30
Y09	LS09	6	157, 202, and 230	23,850	2.30
Y10	LS10	6	156	11,100	1.00
Y11	LS11	6	164 to 166, 168 to 171, 208, 225, and 238	109,725	10.80
Y12	LS12	6	155, 209 to 211, and 217	13,700	1.25
Y13	LS13	6	122 to 125, 200 to 207, 212, and 216	144,875	14.30
		24	115 to 118, 198, and 199		
Y14	LS14	6	126, 128, 214, and 215	34,175	3.30
Y15	LS15	6	129, and 132 to 139	63,600	6.30
Y16	LS16	6	127, 130, and 131	17,975	1.80
Y17	LS17	24	114	21,000	1.00
Y18	LS18	24	109 (Portion 1), and 110 to 112	37,675	1.00
Y19	LS19	24	108	10,275	1.00
Y20	LS20	24	109 (Portion 2)	7,500	1.00
Y21	LS21	24	105	26,950	2.50
Y22	LS22	24	104	8,000	1.00
Y23	LS23	24	120	5,200	1.00
Y24	LS24	24	72	11,900	1.00
Y25	LS25	24	58 to 60, 69, and 211	75,475	7.50

Note1 : The letter (X) in the outlets column refers to the outlets on the right side of AliHneidiyah River.

Note2 : The letter (Y) in the outlets column refers to the outlets on the left side of AliHneidiyah River.

Note3 : The letter (RS) in the effective regions column refers to the areas on the right side of AliHneidiyah River.

***Note4** : The sign (LS) the effective regions column refers to the areas on the left side of AliHneidiyah River.*

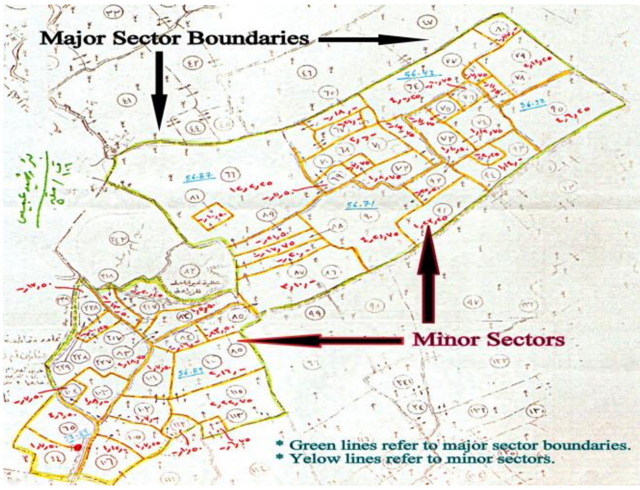


Fig.(1)A part of a certain cadastral map views a major sector within a certain district, and the minor sectors contained inside it [20].

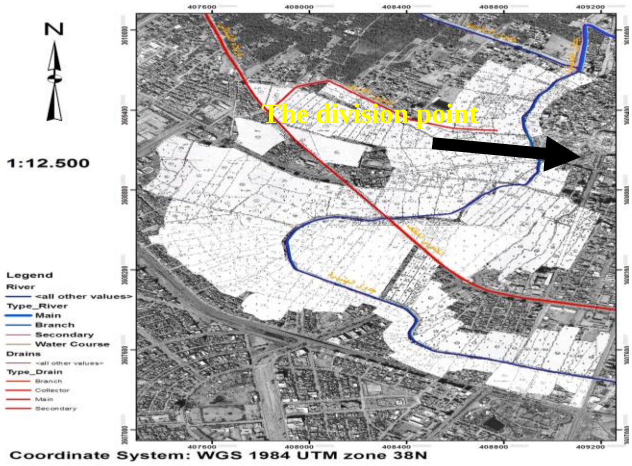


Fig.(2):- The study area of AliHneidiyah views a including the division point of Al-Huseiniyah river at the upper right corner [17, 18, and 21].

Figures 4, 5, 6, and 7 view the satellite images of the study area for the years 2002, 2007, 2013, and 2017 after projecting it on a part of the cadastral map 9192lApril/1971 by using of GIS techniques.

3. THE WATER DUTY

The term "water duty" can be defined as the continuous discharge applied to irrigate a certain unity area [22]. Equation (1) explains this term mathematically.

$$W.D. = Q/A \qquad (1)$$

Whereas as W.D. is the abbreviation of the term (L/T), Q is the applied discharge (L3/T), and A is the irrigated area (L2). This term depends on many variables such as "the soil type", "the type of plant", "temperature of air", "the regional evapotranspiration", and "the soil salt concentration". For that, the soils that consist the farms and orchards of the central district of Karbala city, and the plants grow on it were studied carefully during the last five decades of the left century, and it was found that the best value of the water duty for these soils and plants was equal to 1.00 (m3/s) for every 12,000 mishara (for farms and open field), and 1.00 (m3/s) for every 4,000 mishara (for orchards). Whereas the mishara is a unit area equal to 2500 m2.

4. ANALYSIS AND DISCUSSION

Figures 4, 5, 6, and 7 in respective order, refer to a noticeable reduction in the whole area of the green zone with time for the study area because of the human multiple activities of life, that change the nature of land use from agricultural to other uses. Table 3 lists the areas of the active spaces of the green zones, which appear in each satellite image viewed, whereas all active spaces were plotted and calculated by a GIS program [21], and this table also confirm this figure. [3 and 4] were plotted the relationship between the percentage ratio of the remain agricultural lands and the time, in years, see figure 8. According to their plot, the whole green zone of the studied area has an inverse proportion to the time, and equation (2) describes this relationship.

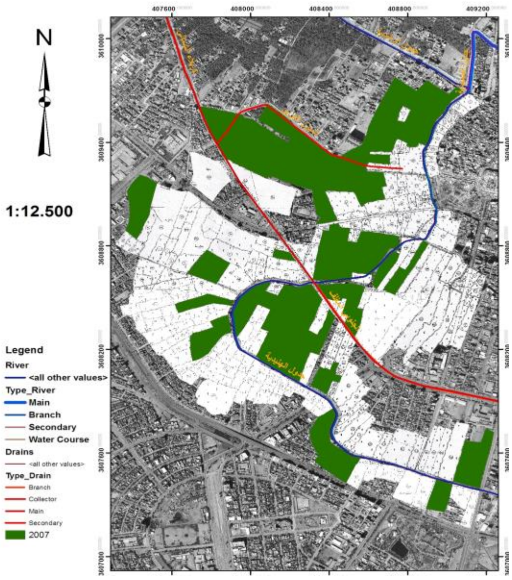


Fig.(5):-The satellite image of the year 2007 for the area [17, 18, and 21].

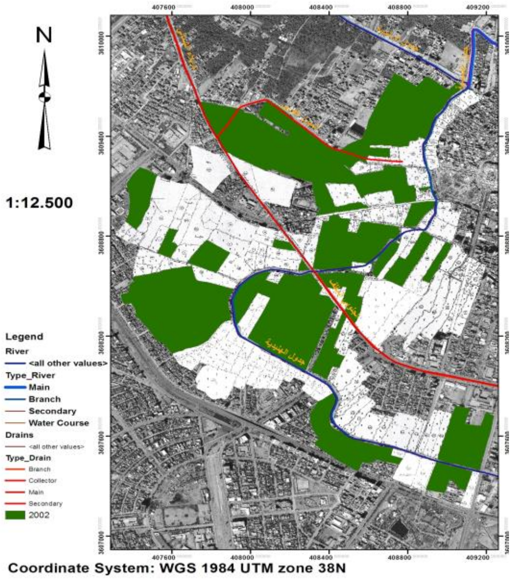


Fig.(4):-The satellite image of the year 2002 for the study area [17, 18, and 21].

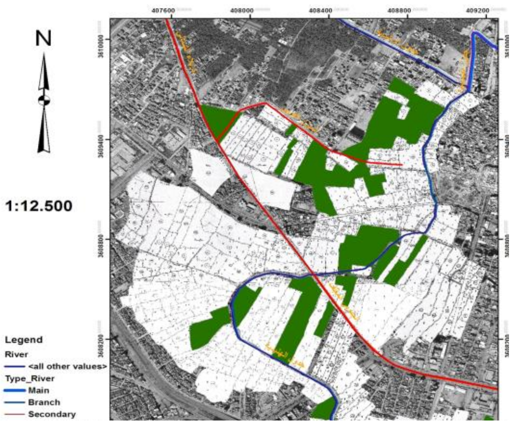


Fig.(6):-The satellite image of the year 2013 for the area [17, 18, and 21].

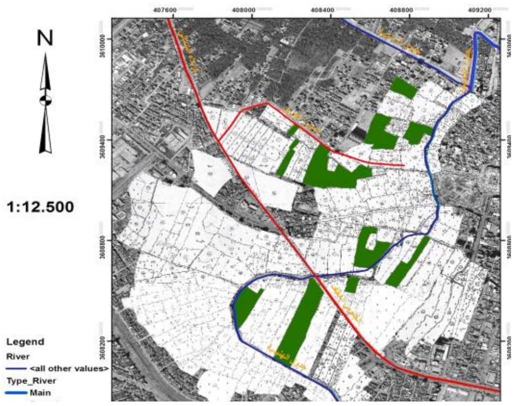


Fig.(7):-The satellite image of the year 2016 for the study area [17, 18, and 21].

Table (3):-Details of the active spaces within each satellite image for the study area [3, 4, 17, 18, 19, and 21].

Year	Active space number	Area (m^2)	% of the total study area
2002	A01/2002	186750.0	0.09883
	A02/2002	28187.2	0.01491
	A03/2002	10512.5	0.00556
	A04/2002	61272.0	0.03243
	A05/2002	66646.7	0.03527
	A06/2002	423784	0.22429
	A07/2002	93647.7	0.04956
	A08/2002	188036.0	0.09952
	A09/2002	74275.4	0.03931
	A10/2002	35831.9	0.01896
	A11/2002	10103.6	0.00535
	A12/2002	23094.9	0.01222
	A13/2002	11335.8	0.00600
	A14/2002	1021.6	0.00054
	A15/2002	13952.9	0.00739
	A16/2002	2172.2	0.00115
	A17/2002	4745.1	0.00251
	A18/2002	26994.1	0.0143
	Total	**1,262,364**	**66.810%**
2007	B01/2007	15961.7	0.00845
	B02/2007	33325.9	0.01763
	B03/2007	14570.0	0.00771
	B04/2007	162448	0.0860
	B05/2007	39254.2	0.02077
	B06/2007	391869	0.20740
	B07/2007	94043.9	0.04977
	B08/2007	4718.7	0.00250
	B09/2007	22876.2	0.01211
	B10/2007	35785.9	0.01894
	B11/2007	14881.8	0.00788
	B12/2007	4.7	0.00000
	B13/2007	27548.9	0.01458
	B14/2007	48965.3	0.02592
	B15/2007	16215.0	0.00858

	B16/2007	11313.6	0.00599
	Total	**933782.8**	**49.423%**
2013	C01/2013	182743	0.0967
	C02/2013	25198.2	0.01333
	C03/2013	2318.3	0.00123
	C04/2013	7555.4	0.00400
	C05/2013	54683.9	0.02894
	C06/2013	27522.5	0.01457
	C07/2013	4917.0	0.00260
	C08/2013	15913.2	0.00842
	C09/2013	10876.9	0.005757
	C10/2013	11342.9	0.00600
	C11/2013	54722.1	0.02896
	C12/2013	19386.5	0.01026
	C13/2013	9164.4	0.00485
	C14/2013	39219.8	0.02076
	C15/2013	11003.6	0.00582
	Total	**476567.7**	**25.219%**
2016	D01/2016	15965.8	0.00845
	D02/2016	5114.5	0.00271
	D03/2016	49136.5	0.02600
	D04/2016	19315.8	0.01020
	D05/2016	39101.1	0.02070
	D06/2016	25101.1	0.01330
	D07/2016	45230.1	0.02394
	D08/2016	7434.1	0.00393
	D09/2016	2257.6	0.00119
	D10/2016	23015.4	0.01218
	D11/2016	12347.3	0.00654
	D12/2016	10134.5	0.00536
	Total	**254153.8**	**13.450%**

***Note1** : In each satellite image, the names and values of the active spaces differ according to the appearance in the taken image.*

(The percentage ratio of the remain agricultural lands) = **-0.038** (Time) + **77.49** $R^2 = 0.998$ (2)

By fixing the value of the water duty for the reason that mentioned above, and applying the "part time irrigation scheduling" on AliHneidiyah River due to the scarcity phenomena, which is (two days gate opening by 5 days gate closing during each week of the scarcity season stating from Thursday, 9:00 PM to Saturday 9:00 PM).

W.D.(Central district/Karbala city) = 1.00 m^3/s/4000 mishara = 1.00 $m^3/s/10{,}000{,}000\ m^2$ (for orchards).

W.D.(Central district/Karbala city) = 86,400.00 $m^3/day/10{,}000{,}000\ m^2 = 0.00864\ m^3/day/m^2$.

For satellite image of the year 2002 (figure 4), the total area irrigated by AliHneidiyah River was 1,262,364 m2. For this area the, the fixed value of the water duty, and applying the minimum value of discharge for the river, (0.5 m3/s), during the summer season, (Scarcity season), it can be noticed that :-

1.00 m3/s/10,000,000 m^2 = 0.5 m3/s/ (X)

X = 5,000,000 m^2.

0.5 $m^3/s/5{,}000{,}000\ m^2 = Q/1{,}262{,}364\ m^2$

Q = 0.126 m^3/s.

According to these results, the study area needs about 25% of the minimum value of the applied discharge to get full irrigation trial during the year 2002, (which is not a drought year), and that is equal to 6 hours from each day of the present scheduling.

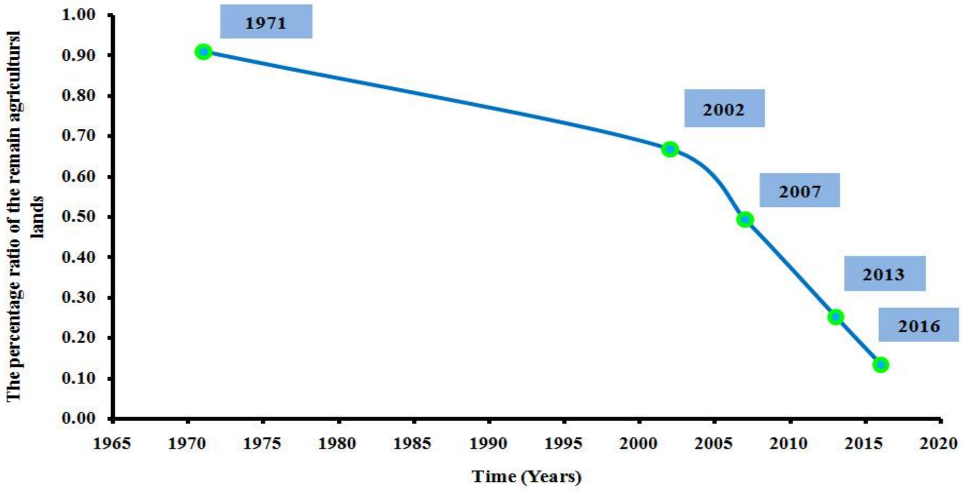


Fig (8):- The relationship between the percentage ratio of the remain agricultural lands and the time (years) [3 and 4].

According to these results, the study area needs about 25% of the minimum value of the applied discharge to get full irrigation trial during the year 2002, (which is not a drought year), and that is equal to 6 hours from each day of the present scheduling.

While for the year 2016, the total area was reduced to about 254,154 m2, which is approach to 21% of the area of the year 2002, and by applying all conditions that mentioned above the time required to get full irrigation trial is about 1.5 hours from each day of the present scheduling. Table 4 lists the scheduling of the field outlets of AliHneidiyah River during this phenomena for the year 2016.

Table(4):-Details of the active spaces (orchards) remained within the satellite image for the year 2016.

Year	Active space number	Active space area (m^2)	The total area after merging the nearby spaces (m^2)	The proposed new outlet discharge (l/s)	The scheduling time	
					From	to
	D01/2016	15965.8 (LS)	15965.8	1.6	9:00 PM	9:12 PM
	D02/2016	5114.5 (LS)	5114.5	1.0	9:12 PM	9:15 PM
2016	D03/2016	49136.5 (LS)	49136.5	5.0	9:15 PM	9:50 PM
	D04/2016	19315.8 (LS)	19315.8	2.0	9:50 PM	10:05 PM
	D05/2016	39101.1 (LS)	39101.1	4.0	10:05 PM	10:30 PM
	D06/2016	25101.1 (RS)	25101.1	2.5	10:10 PM	10:30 PM
	D07/2016	45230.1 (RS)	54921.8	5.5	9:26 PM	10:10 PM
	D08/2016	7434.1 (RS)				
	D09/2016	2257.6 (RS)				
	D10/2016	23015.4 (RS)	23015.4	2.0	9:10 PM	9:26 PM
	D11/2016	12347.3 (RS)				
	D12/2016	10134.5 (RS)	10134.5	1.0	9:00 PM	9:10 PM

5. VIEW POINT

Figures 4, 5, 6, and 7, and tables 3 and 4 give a general vision that despite the damages that occurred by the urban growth, and its effect on the agricultural sector represented by reducing the spaces of farms and orchards in special case, and minimizing the vegetation cover and the contribution in the climate changes in general case adding to the scarcity phenomena, but this situation can serve to increase the investment in countries by use of the out-of-agriculture-activity lands for urban growth in multiple fields, and that may be help to revive the desert lands and strive the desertification phenomena by activation of new reclamation projects out there utilizing the remain amounts of water left from the areas like the study area. The following mathematical expression may help to simplify the idea of the current study.

Urban growth	**α**	**1/ Agriculture, Vegetation cover, Climate change, ….**	**α**	**Scarcity**	**α**	**1/ Water duty**	**α**	**Population**

6. CONCLUSIONS

The urban growth of cities lead to increase in population, and that is a series problem faces the agriculture and water resources fields with the activation of scarcity phenomena during the Summer season. The water duty was found to serve and control the water-soil relationship that control the agricultural process at the end, and its evaluation is important to keep this equity of these variables. From the current study the following points can be concluded :

1- Increasing the urban growth will reduce agricultural activities by reducing the green zones within cities. So, the proportion between these variables is inverse.

2- Reducing the agricultural lands imposes a necessity to modify the value of water duty and the irrigation scheduling for the remain ones.

3- Even during the dry seasons, there is enough amount of water for multiple uses if it controlled using precise and practical methods like the "closed irrigation" or "Pipe irrigation" which is applied successfully in the lands of the north district of the city.

4- A percentage of 21% of the applied water duty and minimum water discharge was enough to irrigate areas within 1.5 hours of the selected scheduling day.

5- The Geographic Information System is being a good and helpful technique for evaluation and make decisions of water related subjects. River, Fig.4, is a very important one in Iraq; it branched upstream of Alhindya barrage with long of 102 km. Then it branched to two laterals which are AdDaggaarah and AdDiwanyah that are 64 km and 124 km respectively. It provides three provinces in the middle Euphrates that are Babylon, AdDiwanyah and AsSemawa. The discharge of it is different during cultivated seasons and even with highest release in last two years which is around 170 m3/s; so it is not possible to run all laterals together. The Babylon province alone needs discharge of more than 150 m3/s which is for agriculture, human needs and fish breeding. In this study; therefore GA will be implemented in Babylon district only.

Recommendations

The following recommendations may contribute in solutions for the study case :

1-Activation and commitment of the urban planning principles ordered by countries and this can be done by :

a-Separation between the agricultural lands and that used for multiple human activities.

b-Keeping up the vegetation cover by applying a monitoring program to reduce consequences of the climate change phenomena and its global effect on the different environments.

c-Evaluation of some water parameters used, like re-calculation of the water duty after updating the soil-water data of the study area.

2-Using of some hydraulic techniques to improve the water control process during the scarcity seasons to keep the water shares in equilibrium status as possible as it can, like the pervious structures that work as multi-function structures [23, 24, 25, and 26] without a series human efforts.

3-Facing the desertification phenomena utilizing of the remain water shares of the urban new growth cities to active reclamation project and revive the desert lands side by side with the ground water.

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