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Evaluation of Elaj Irrigation Project in Babil Governorate

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ABSTRACT

Climate change causes water shortage (water scarcity) in addition to the dams built by neighboring countries, which caused a lack of Iraq's water share. Therefore, evaluating the irrigation system requires considering its suitability, adequacy, and efficiency. Irrigation is considered adequate when it maintains water availability within the root zone, and if the amount to be added is determined, irrigation efficiency becomes possible by avoiding water loss. Babil Governorate is considered one of the agricultural governorates in the country that depends on its irrigation from Shatt Al-Hilla. The study area is the Elaj project. Three fields were selected for the project (B_1, B_2, and B_3). These fields are located at the project's beginning, middle and end. The evaluation was based on the field measurements of water contents before and after watering during the growing season. Also, the root zone of each plant during the growing season is measured to give more accurate calculations. Accordingly, application efficiency, conveyance efficiency, distribution efficiency, storage efficiency, water productivity efficiency, and water use efficiency were calculated in the project. The application efficiency for the selected fields ranged between (33 to 39) % in B_1, (32 to 38) % in B_2, and (32 to 39) % in B_3. The application efficiency in all fields increased by about 6% during the third watering period between (22/3/2021 to 4/4/2021) due to the low water level in Shatt Al-Hilla during maintenance work that lasted more than a month. The efficiency of the scheme [ηs%] in the project is 32.3%. This value is low and reflects the reality of irrigation in the Babil. Therefore, improvements must be made to the irrigation system.

Keywords: irrigation; efficiency of the scheme; water losses; watering number; water productivity.

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تقييم مشروع علاج الاروائي في محافظة بابل

***منتظر محمد الموسوي**
طالب ماجستير
وزارة الموارد المائية - مديرية الموارد المائية في بابل

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الخلاصة

ادت التغيرات المناخية و السدود التي أقامتها دول الجوار الى نقصان واضح في حصة العراق المائية , وعليه توجب أجراء تقييم لنظام الري الحالي والنظر في مدى ملاءمته وكفاءته وكفايته حيث يعتبر الري مناسبًا عندما يحافظ في توافر المياه داخل منطقة جذر النبات وإن تم تحديد الكمية المراد إضافتها فتصبح كفاءة الري ممكنة عن طريق تجنب فقد المياه . تقع منطقة الدراسة في محافظة بابل حيث تعتبر المحافظة من المحافظات الزراعية في البلاد والتي تعتمد في اروائها على شط الحلة وعليه تم اختيار مشروع اروئي هو مشروع علاج وتم اختيار ثلاث حقول في مشروع علاج ورمزت (B1وB2وB3) في بداية ووسط ونهاية كل المشروع . اعتمد في التقييم على القياسات الميدانية للمحتوى الرطوبي قبل وبعد الري خلال موسم النمو وكذلك التصاريف الداخلة للحقول و كما تم قياس عمق منطقة الجذر للنباتات خلال موسم النمو لإعطاء حسابات أكثر دقة.

تراوحت كفاءة التطبيق (الري) في الحقول المختارة داخل منطقة الدراسة. في مشروع علاج فكانت تتراوح بين 33 إلى 39 ٪ في الحقل B_1 وبين 32 إلى 38 ٪ في B_2 وبين 32 إلى 39 ٪ في B_3 ولوحظ زيادة كفاءة التطبيق في جميع الحقول بنحو 6٪ خلال الرية الثالثة ضمن الفترة بين (2021/3/22 وحتى 2021/4/4) بسبب انخفاض منسوب مياه شط الحلة أثناء أعمال الصيانة التي استمرت فيه لأكثر من شهر.

كانت كفاءة الكلية لنظام [ηs]٪ في مشروع علاج هي 32.3٪ . وكانت القيم متدنية وتعكس واقع الري في محافظة بابل. مما يتطلب إجراء تحسينات في نظام الري. أن قيمة كفاءة استخدام المياه وبوحدات (Kg/m^3) كانت متدنية في جميع الحقول المختارة ضمن المشروع ففي مشروع علاج كانت القيم منخفضة وتتزايد باتجاه مؤخر القناة وتراوحت بين 1.33 عند نهاية المشروع و 1.22 عند بدايته . كانت الإنتاجية الاقتصادية للمياه (EWP) في الحقول B_1 و B_2 و B_3 هي (680.3 و 815.2 و 897.4) (دينار\ م3) على التوالي. نلاحظ ان اعلى قيمة للإنتاجية اقتصادية المياه في الحقل B_3 ضمن مشروع علاج ويشير ذلك الى أن زيادة استهلاك المياه لا تعني دائمًا إنتاجية أعلى ؛ بدلاً من ذلك ، فإن المفتاح هو الاستفادة المثلى من المياه وتوفير المياه اللازمة للنبات في تاريخ ووقت الري المناسبين.

الكلمات الرئيسية: الري , كفاءة انتاجية المياه , خسائر المياه الري , كفاءة المخطط , رقم الرية .

1. INTRODUCTION

Water scarcity and global climate change are issues that most countries are dealing with current days. In the case of Iraq, the country is currently experiencing a catastrophic water scarcity due to river sources and rainfall. This problem will likely become more significant in the future, especially since the outflow of the Tigris and Euphrates rivers is expected to decrease with time. To address this issue, effective and timely steps must be taken, as well as a strategic vision for water management achieved through research, development, and enhancement of agricultural systems, as well as innovative water-saving techniques, methods, and procedures **(Al-Ansari, 2013)**. Several decades ago, water was sufficiently available to meet the needs of the various sectors. Gradually year after year, due to increased water overuse, human requirements, increased pollution, and may be due to climate alteration, water has become a scarce source and presents a serious problem presently. This problem will worsen as the population grows, so increasing the efficiency of water use for food production will be significantly important. Global freshwater use averages about 70 % for food and fiber production, 20 % for industry, and 10 % for municipal and domestic consumption **(Smucker et al., 2015)**. The Iraqi Ministry of Water Resources' strategy is to save and preserve water by technical methods. So, water should be conserved by increasing the efficiency of water application systems. Improving the irrigation water efficiency, increasing grain yield, and then increasing the profits by different systems is one of the economically practicable alternatives in overcoming the water shortage, especially in coarse and medium soil textures and in non-irrigated lands **(Ismail and Ozawa 2007)**. The poor on-farm water management comes from excesses and inadequate resource allocation that permits non-optimum and untimely water delivery and plant water uptake. Putting it otherwise, inadequate irrigation schedule, non-uniform on-farm water distribution, inaccurate length of irrigation, etc., are some of the causes of poor on-farm water management. Farmers lack sound information on on-farm water management, notably on how much to irrigate and when to irrigate (since they prefer to over-irrigate as long as the water is available), resulting in water shortages and disputes in other sections of the schemes. This also implies that on-farm water management exerts direct costs on scheme-level performance. That is, enhancing resource use efficiency and bringing additional area under irrigation **(Yusuf et al. 2004).** Surface irrigation technologies such as border, flood, and furrow irrigations have been used for decades, and farmers have simply adapted procedures and established crop requirements. It is necessary to assist them in developing an optimal design as well as effective administration and operation of water application to the fields to achieve the highest potential output while conserving water. Compared to the high cost of power in micro-irrigation technologies, which require less know-how from the average farmer for automation and operation, the furrow irrigation method is more important **(Shirazi et al., 2014)**. **(Kibret et al., 2021)** claim that Water productivity per unit of irrigated area, production per unit of irrigated area, output per unit of water supply, and production per unit of water consumption were 1.0, 0.95, 0.41, 1.5, and 4881.40 USD/ha, correspondingly. Due to water shortages and irrigation system overruns, there was an unequal water distribution **(Haymale et al., 2020)**. Duty or obligation measurement of water consumption and flow from the beginning and endpoints of irrigation canals is included to estimate the transmission efficiency of conventional irrigation systems. More than 23% of the water was observed as losses of deep penetration, evaporation, and overflow over the water quota. According to **(Jabeen et al., 2021)**, the findings showed that varying amounts of irrigation significantly influenced wheat grain production and overall water use. When the varied irrigation levels were compared, the high quantity of actual irrigation in semi-arid regions resulted in lower WUE and wheat grain yield. Soil moisture management and efficient water use are the two most essential factors in boosting agricultural water efficiency in the region. **(Sajid et al., 2022)** assessed various parameters. The irrigation performance (application and conveyance efficiency) and water availability from the field to the Mungi Distributary canal level were analyzed, and water delivery in the canal network, cotton field soil moisture content, and canal and groundwater quality were monitored. The crops' actual evapotranspiration was estimated using the Aqua Crop model. In this research, the conveyance efficiency was found to be > 90% for minor distributaries, 70 to 89 % for watercourses, and about 75% for field ditches per kilometer. The main objective of this research is to study and evaluate the irrigation system in two types of irrigation projects, one based on a lined canal and the other on an earth canal. The evaluation depends on the fieldwork during a season to find the canal's conveyance efficiency, application efficiency, distribution efficiency, storage efficiency, water use efficiency, and water productivity efficiency within the randomly selected fields within the study area. It gives the solutions to any problems that may arise.

METHODOLOGY AND PROCEDURE

EXPERIMENTAL FIELDWORK.

2. AREA OF STUDY

Babil Governorate is considered one of the agricultural governorates in the country whose irrigation depends on organized irrigation. The total irrigated area is (1668807) dounm. The Babil governorate irrigation directorate supervises all agricultural lands and their irrigation sources, which include Shatt Al-Hilla, with a length of 101 km. The study area is located in Babil Governorate within (The al-Hilla - Al-Diwaniyah) project branching off from the right side of Shatt Al-Hilla, which is of the partial agricultural reclamation projects, one of which is a lined canal (named Elaj Canal), as shown in **Fig. 1.** Due to the low water levels in Shatt Al-Hilla, pumps were installed on most of the main canals that are located on Shatt al-Hilla. So, the canal is the main source of water supply either by pumping or directly from the Shatt Al-Hilla by gravity, as shown on the map.

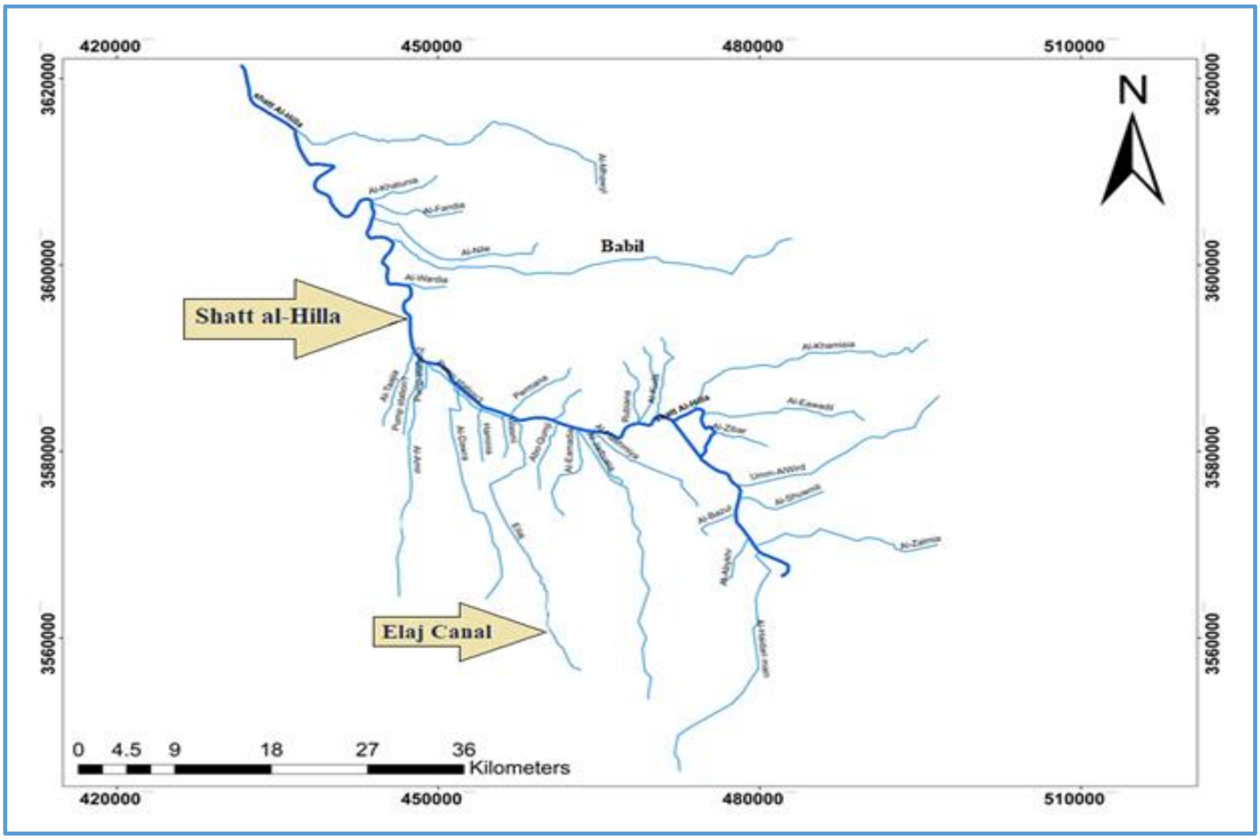


Figure 1. Shatt Al-Hilla and their branches.

3. SELECTED FARMS IN THE IRRIGATION PROJECT

Three fields were selected within the study area, the fields (B1, B2, and B3) at the beginning, middle, and end of the canal. To obtain as accurate as possible the efficiency of irrigation. The coordinates of the farms are listed in **Table 1** and shown in **Fig. 2.**

Table 1. Coordinates of the selected farms in the project.

	Channel name	Fields selected	Station Km	UTM Coordinates(m)	
				Easting	Northing
1	**Elaj Canal**	**B_1**	02+150	455774	3582448
2		**B_2**	06+650	878545	2437835
3		**B_3**	13+350	764455	0147435

Each field was divided into three parts to ensure the representation and accuracy of measurements. The irrigation in all fields is by pumping, and the moisture content was measured before and after each watering, knowing the field requirements and the quantity of losses from them during the irrigation process, and diagnosing the places of the defect.

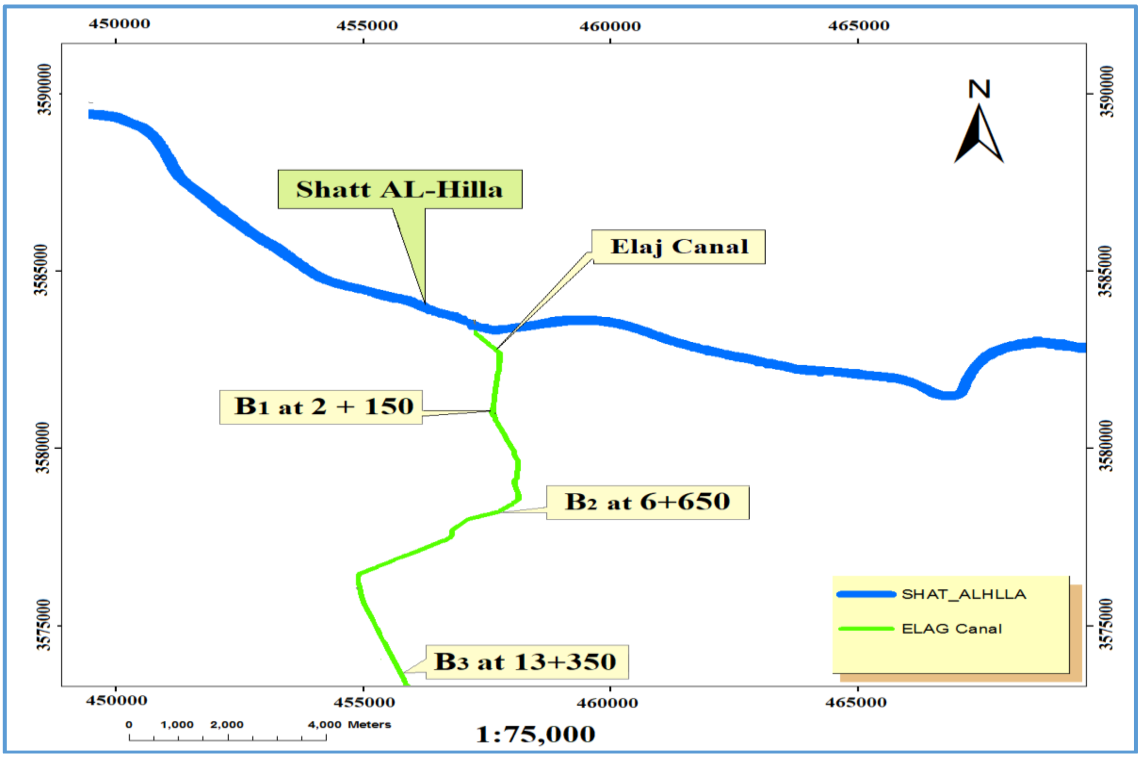


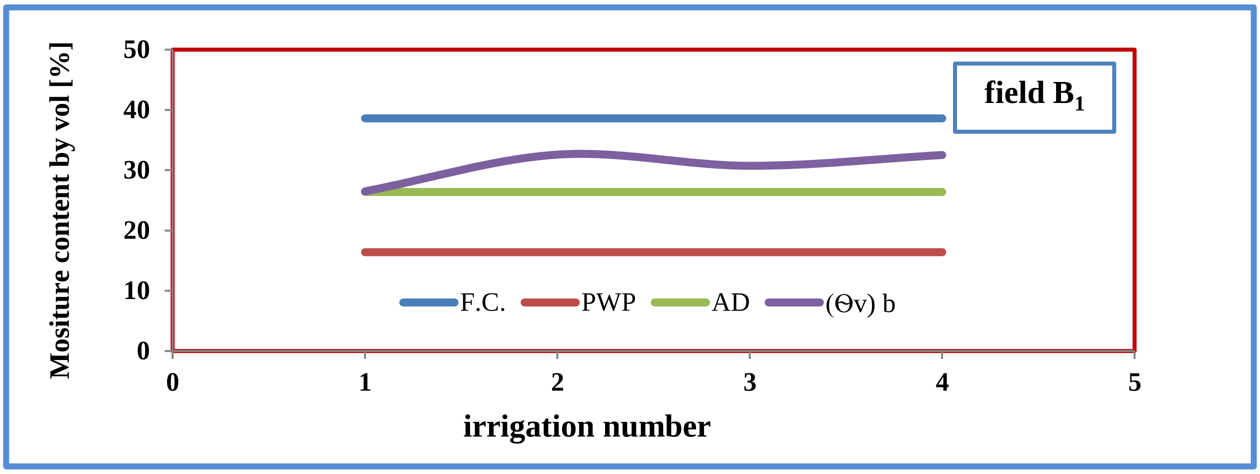
Figure 2. Selected fields within the study area.

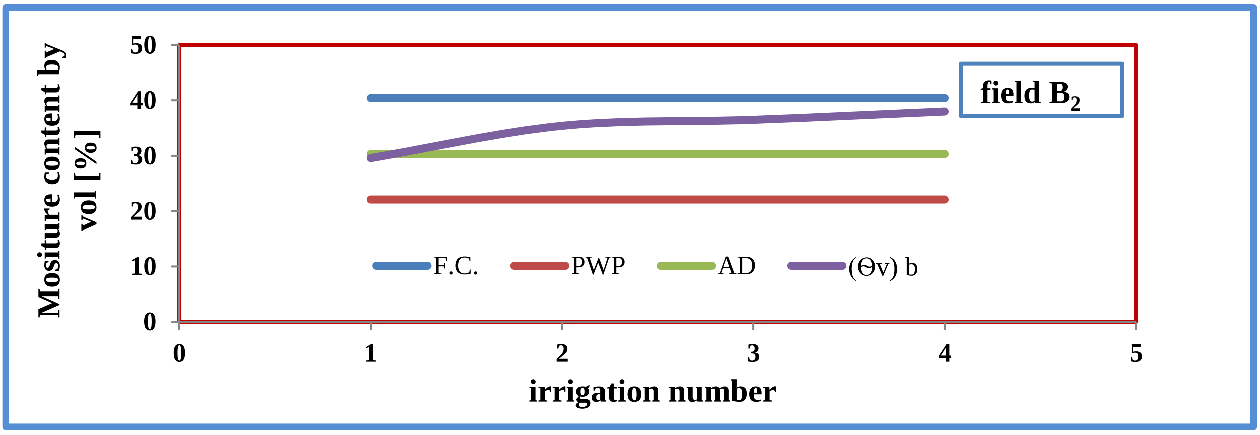
4. ROOT ZONE DEPTH OF CROPS IN THE FIELDS

In this study, the winter wheat was selected and planted on December 20, 2020, as seeds, while the harvest time was on May 10, 2021, when the whole plant became dry and yellow. The total number of days in the growing season was 140 days. Soil moisture content was measured and recorded on site. This content was measured within the root zone during the growing season before and after water application (as far as possible) from January 24, 2020, to May 10, 2021, for different root depths. **Fig. 3** shows the moisture content before and after each watering during the season in the project. The root was measured before each water application in the selected fields as much as possible, with the results compared with the FAO.

5. DEPTH OF APPLIED WATER IN THE FIELD

Soil samples were taken according to the age of the plant and depth of the root zone throughout the study period, before each and after the irrigation process, to calculate the moisture content of the selected field soils. The gravimetric method was used to calculate water content at different depths, which depend on root zone depth according to plant age, and root zone depth; the sample was dried at 105˚C. as shown in **Fig. 3 and Fig. 4** where the two figures are included watering number, soil moisture content before irrigation, field capacity, permanent wilting point, and available water for fields Depth of applied water, existing water content and water losses in each watering number of project Elaj





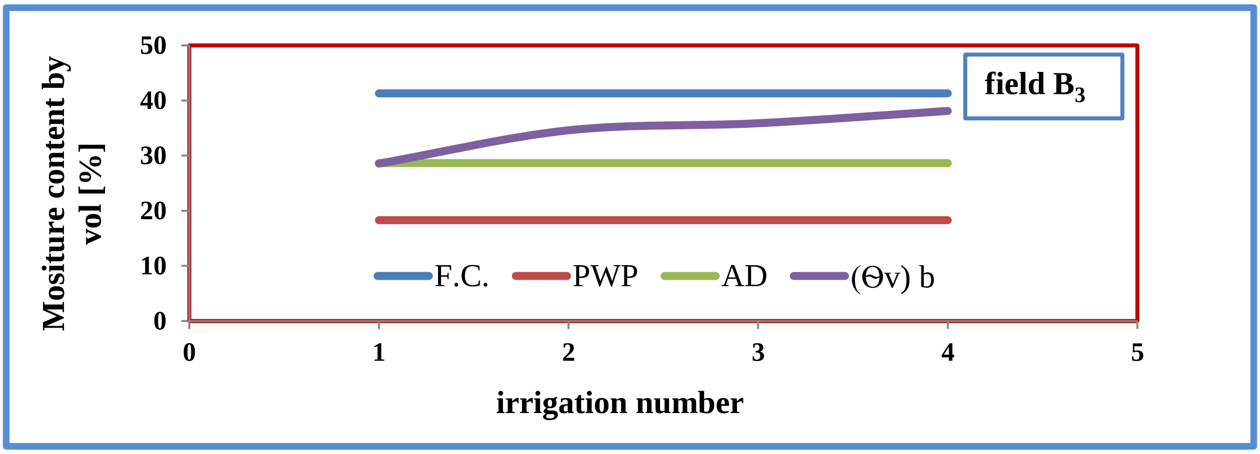


Figure 3. Watering number, soil moisture content before irrigation, field capacity, permanent wilting point, and available water for fields (B_1, B_2, and B_3) on the Elaj project.

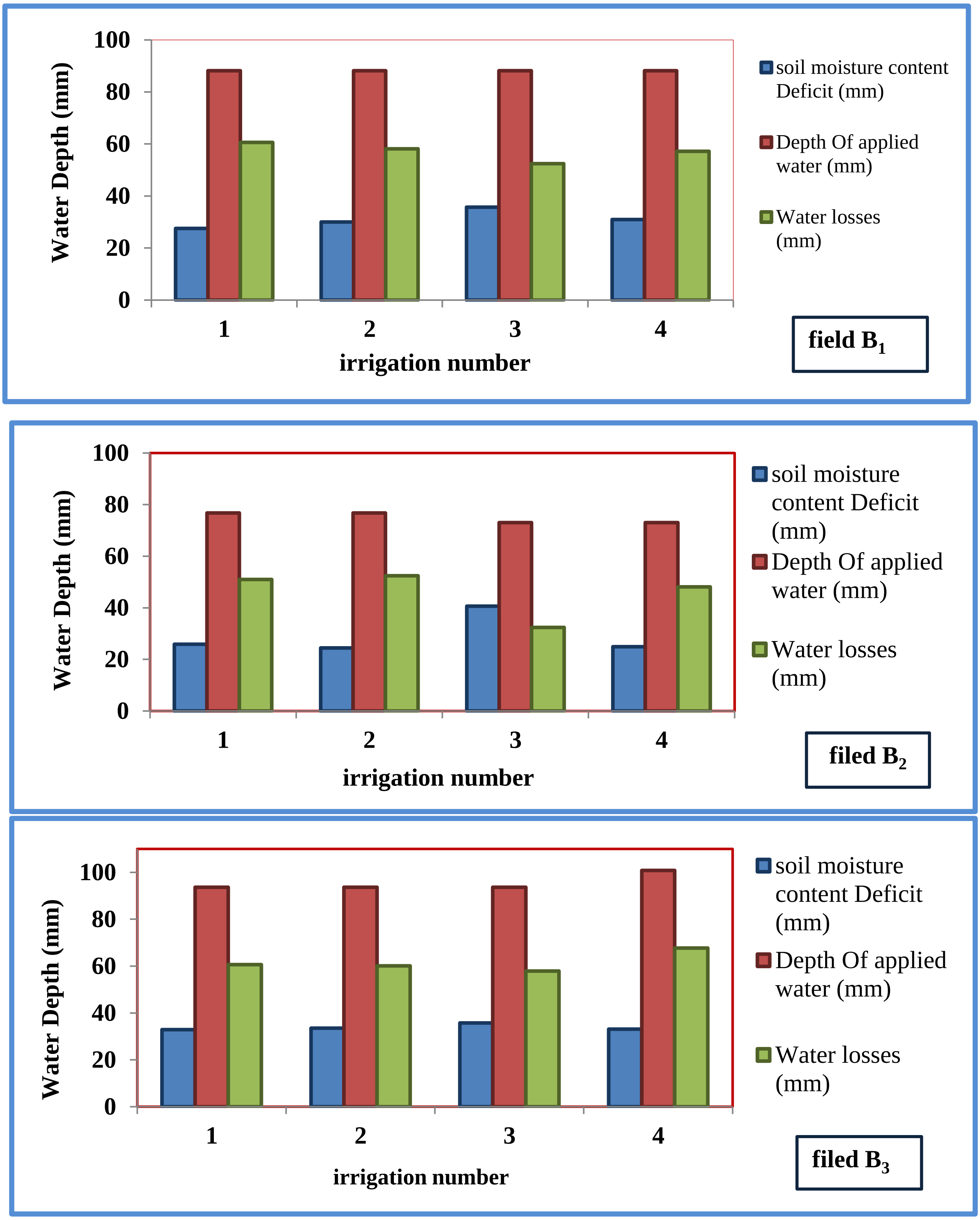


Figure 4. Depth of applied water, existing water content, and water losses in each watering number of project Elaj during the planting season.

6. Storage and Water Distribution Efficiencies

In general, the storage and distribution efficiencies were high according to the irrigation method used in the study area, which is the method of surface irrigation where the entire field is flooded with water. The basis for the success of the irrigation system is the necessity of the homogeneous distribution of moisture in the root zone so that the growing plants get a high degree of uniformity. This method has advantages, which are the homogeneity of moisture distribution in the root area until large quantities of water are wasted and go in the form of surface runoff and deep percolation, where the storage efficiency values for the Elaj project ranged between (80.1 to 94)% according to the type of soil for the selected fields within the study area. The distribution efficiency values for the project ranged between (93.6 to 96)%. Storage and water distribution efficiencies in each watering in all farms are shown in **Fig. 5.**

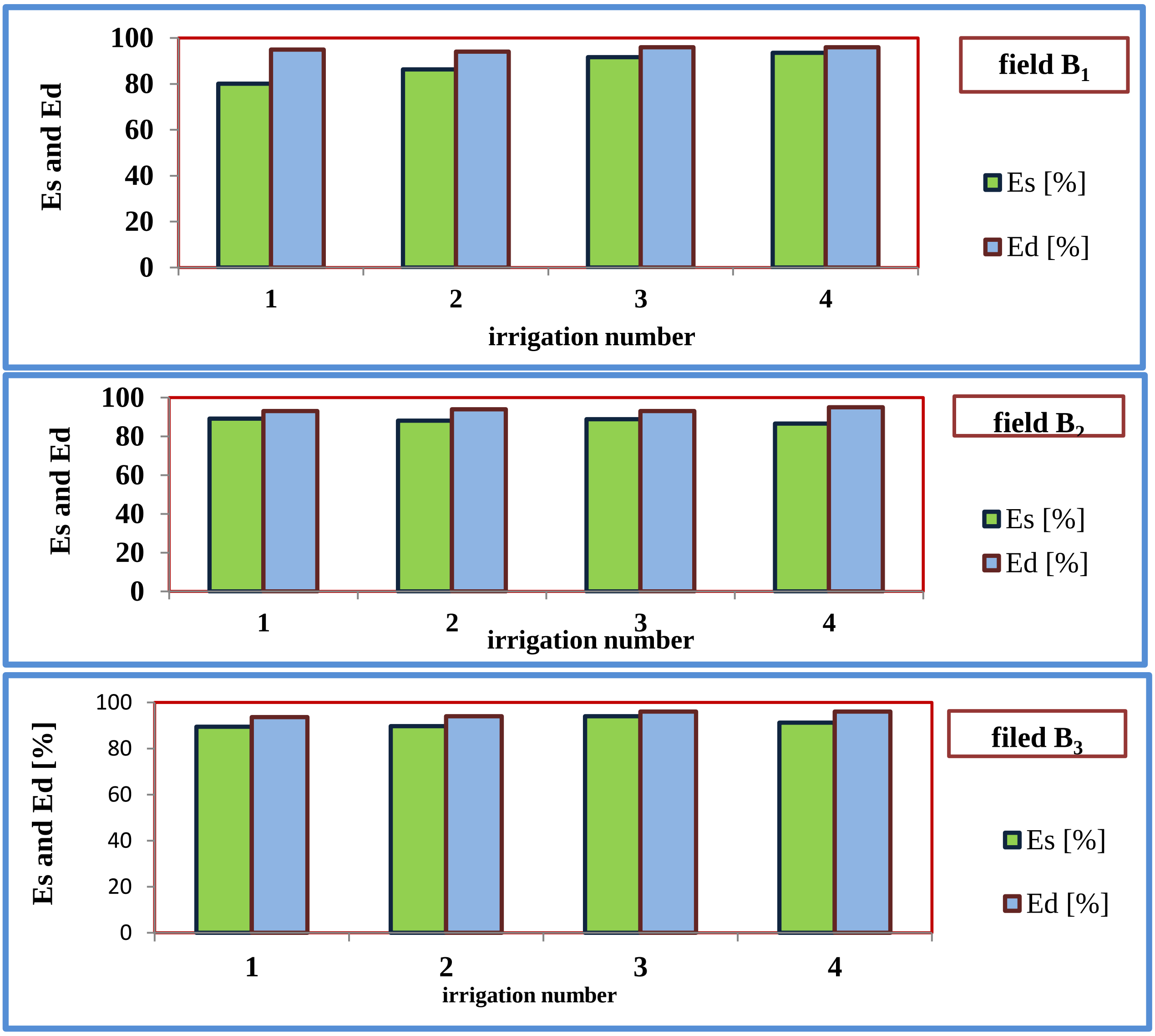


Figure 5. Storage and water distribution efficiencies in each watering in all farms within the Elaj project

7. CROP YIELD AND FIELD WATER USE EFFICIENCY

The crop yield in the Elaj canal ranges from 0.42 kg per m^2 in field B3 to 0.54 kg per m^2 in field B_1. From the results obtained, water use efficiency (kg/m^3) for fields B_1, B_2, and B_3 were: 1.13, 0.94, and 1.06, respectively. The value of FWUE was in small quantities. The crop yield is mainly depending on plant production. At the same time, the field water use efficiency depends on the amount of yield and the applied water depth.

8. ECONOMIC WATER PRODUCTIVITY (EWP)

Water productivity depends mainly on plant production and the amount of water consumed or water used during the growing season. This study implemented the economic water productivity (EWP) of winter wheat, which depends on the total yield value and water used. Where the Iraqi government determined the market value of winter wheat at the time of harvest at 300 dinars/kg, the EWP in (ID/m^3) for fields B_1, B_2, and B_3 were: 680, 815, and 897.4, respectively. The EWP in field B_3 was more than that in other fields where the value of the water productivity of the field (B_3) was more than the rest of the fields because it is less water-consuming and more productive for the winter wheat crop, and therefore the most revenue-generating field.

9. WATER APPLICATION EFFICIENCY

The results shown in **Table 2** for the efficiency of adding water to the selected fields within the study area show the deterioration of the irrigation reality and the unfair practices practiced by farmers during the irrigation process. The water application efficiency in all fields is ranged between (31% and 39%), which are unacceptable rates and reflect the amount of losses in the fields, as presented in **Table 2.**

Table 2. The application efficiency in the three fields within the Elaj project.

NO	Selected fields	Irrigation method	Net Area (Dounm)	Number of samples	irrigation number	Water application efficiency Ea %	Average Ea%	Overall average Ea%
1	B_1	Border	8	3	1st 2nd 3rd 4th	33 33 39 32	34.25	34
2	B_2		15	3	1st 2nd 3rd 4th	33 32 38 31	33.5	
3	B_3		8	3	1st 2nd 3rd 4th	32 33 39 33	34.25	

The efficiency in the field (B_3) was higher than in fields (B_1 and B_2) because of the lack of water continuously in the canals. Because of the low water level in Shatt Al Hilla resulting from maintenance work for more than one month, it was noticed that water application efficiency rose by 6% in all farms in the third watering in the period between (22/3/2021- 4/4/2021). According to the field measurements and the obtained results in the present study, the following conclusions may be listed as the application efficiency for the selected fields within the study area within the project is ranged between (33 to 39)% in B_1 (32 to 38)% in B_2 and (32 to 39)% in B_3. The current irrigation scheduling in the project needs modification. It should be converted to fifteen days of closing and five days of opening for the canals branching from Shatt Al-Hilla. Instead of seven days of closing and seven days of opening. The water losses in farms upstream of the Elag project are greater than those located at the tail. Although the two fields (B_2) and (B_3) have the same area, there is a variation in water use efficiency. The applied depth in the field (B_3) was 414 mm throughout the growing season, which is less than that used in the field (B_2) of 420mm during the same period. Due to the water scarcity at the tail of the evaluated project, the added amounts of water were less than the needed water for irrigation, so the application efficiency rises slightly in the field B3 compared to the fields located upstream of them.

10. THE OVERALL EFFICIENCY OF THE IRRIGATION SYSTEM (Effectiveness of the Scheme)

To evaluate any irrigation system, the conveyance efficiency, add efficiency, storage efficiency, and distribution efficiency must be calculated. Therefore, the efficiency was calculated for the project, as presented in **Table 5**.

Table 5 The overall efficiency in all fields within the project Elaj during the period (24/12/2020 to 16/5/2021)

Field	conveyance efficiency [%]	Application efficiency [%]	Average Application efficiency [%]	Distribution efficiency [%]	Average Distribution efficiency[%]	Effectiveness of the Scheme [%]
B_1	95	335.	35.97	95.2	94.63	32.3
B_2		35.4		93.8		
B_3		37.2		94.9		

The overall efficiency of the irrigation scheme was very low and less than 40% of the minimum rating of surface irrigation projects. Table (5) shows the reality of irrigation in Babil Governorate, with a value of 32.3 % in the project Elaj. As a result, existing irrigation systems must be improved and contemporary irrigation systems implemented. In light of the water scarcity in Iraq, raising farmers' awareness of the amount of water is a priority.

11. CONCLUSIONS

This research aims to evaluate the Elaj project within the Babil Governorate. Field measurements of the moisture content were conducted in the study before and after irrigation of the selected fields (B_1, B_2, and B_3) in the Elaj project for four sequential watering periods (24/12/2020 to 21/4/2021).
According to measurements of the fields selected within the study area, scheme efficiency [ηs%] for the project was calculated, which includes application efficiency [Ea %], storage efficiency [Es %], distribution efficiency [Ed %], water use efficiency [WUE] (kg/m3), water productivity efficiency [EWP] (ID/m^3), and conveyance efficiency [Ec %].
The main concluded points are:

1. The application efficiency for the selected fields within the study area ranged between (33 to 39)% in B_1, (32 to 38)% in B_2, and (32 to 39) % in B_3. The application efficiency in all fields increased by about 6% during the third watering period between (22/3/2021 to 4/4/2021) due to the drop in the water level of Shatt Al-Hilla during maintenance work that lasted more than a month.
2. The current irrigation scheduling in the project needs modification. It should be converted to fifteen days of closing and five days of opening for the canals branching from Shatt Al-Hilla. Instead of seven days of closing and seven days of opening. The actual irrigation time for the fields is approximately B_1, B_2, and B_3 must be 5, 7, and 5 hours instead of (14, 19, and 13) hours.
3. The water losses in farms upstream of the project are greater than those located at the tail. Although the two fields (B_2) and (B_3) have the same area, there is a variation in water use efficiency where the applied depth in the field (B_3) was 414mm throughout the growing season, which is less than that used in the field (B_2) of 420 mm during the same period.

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