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Scheduling the Laterals of Shattulhilla River by Utilizing the Genetic Algorithm as Water Sustainability Technique

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ABSTRACT

Open channels are very important to deliver water from main sources to laterals especially for developing countries. Production is subjective by the way that the water is scheduled, and this scheduling is subject to several irrigation constraints. In open channel projects, for instance, maximum discharge of the laterals and main channels, depending on the size of their dimensions and the water requirements for fields. The current paper shows how efficient water scheduling, regarding the delivering water from the main channel to laterals in consequent time slots, can be done by utilizing a genetic algorithm optimisation technique. This research is intended to be applied for scheduling the Shattulhilla River in Babylon City and has broad applications for open channel projects in Iraq. The obtained results clarify how the genetic algorithm optimisation modelling is a sophisticated tool which operators of irrigation projects could now utilize to timetable open channels of irrigation systems.

KEYWORDS: Open channel projects; Genetic Algorithm; Rationing; Water courses; Irrigation projects

1 INTRODUCTION

A considerable amount of water is utilized for the production of food in agricultural activities. According to [1], most of the water is applied in the agricultural sector. However, water requirements for the domestic and industrial sectors have put agriculture requirements under threat [2]. There are many methods to transfer water from sources such as reservoirs and canals to farms to cover the water requirements of crops. One of those ways is the "open channel systems". Transferring water to farms from the source is an important connection between providers of water and irrigators, and the gain depends on how well the water transfer is managed [3]. According to [4], a crucial development in water management will occur in the next decades due to using new techniques, like optimisation and modelling, which scientists are advancing. This modern management is highly needed in most developing countries, which have little resources to allocate to develop new techniques for irrigation management [5].

Moreover, several irrigation and drainage projects perform incompetently in several developing countries in relation to reliable water allocation systems that provide accurate amounts of water in time [6]. Therefore, many techniques have been advanced to overcome these issues since then, such as nonlinear and linear programming. However, applying genetic algorithms, GAs, and optimisation techniques would be an efficient method to solve the problem of delivering irrigation water.

2 DELIVERING OF IRRIGATION WATER

There is more than one way that is utilized to distribute water between irrigators for open channel irrigation projects; according to [3] and [7], rigid, rotational or on-demand distribution ways are used for delivering irrigation water. To control discharges at different spots, cross gates are used, for example, undershoot gates or overshoot weirs, to minimise head losses in flat areas [1].

[3] and [7] point out that, in the rigid method, irrigation water is delivered to irrigators continuously at a constant rate during the growing season. Rigidly, the distribution of water requires a constant supply at a fixed frequency with a changeable or steady discharge through different seasons. The method is suitable only if the discharge of the main channel is able to deliver water simultaneously to laterals.

According to [7], for the on-demand method of scheduling, all components of irrigation, like duration and flow rate, could be changed during the irrigation time to meet the availability of water and water requirements of crops. He points out that the on-demand method of scheduling is a successful technique for delivering water in an allocated time; however, it is not easy to manage scheduling without continuous supervising of soil moisture and gate control. Instead, a semi-demand way is used, which depends on the experience of farmers and the availability of water. It is difficult to run semi-demand irrigation delivery because all the irrigation systems should be considered. It seems that a rotational delivery system is a suitable choice since it tackles these problems.

Several countries around the globe use the rotational distribution way, and water is rotated among farmers in the chosen area and between outlets of the main channel. In this way, discharge changes through the irrigation time and the irrigation period could be minimised as the discharge of laterals is larger than the flow of continuous scheduling. [7] points out that applying rotational scheduling satisfies crop water requirements easily, specifically when the flow discharge of the main channel in the project is not sufficient to provide all laterals simultaneously. This scheduling can be applied in different methods, and one of them is the optimising technique.

3 OPTIMISATION TECHNIQUES

There have been a number of optimisation models that are applied to sufficiently schedule open channels of irrigation projects. [8] utilized a 0-1 program model to optimize flow in an open-channel project. To run this model, the best combination of chosen laterals must be first specified. Then, the hydrograph of flow has to be obtained in the operated laterals. For these single linear objective models, there are commercial programs that are suitable to obtain solutions to such problems, for example, LINGO and LINDO; the operators have to prioritise the order of operated outlets, however. [9] utilized a mixed-integer technique to schedule open-channel irrigation projects for irrigators. Their main purpose was to deliver water to irrigators as close as possible to the requested time and to allow multi-period planning. However, there are disadvantages to applying the mixed-integer technique; first, only inexact solutions can be gained, and second, specific characters are essential, like convexity and separability [10]. Therefore, there is a growth towards utilizing GAs optimisation techniques as they have become robust tools to solve problems that are with discrete variables [11].

3.1 Genetic algorithms

The GA is a heuristic method used to search for the solutions to the problem in an attempt to obtain the best solutions [3]; they were founded by John Holland, who used principles of organism development that Charles Darwin originated. GAs work in a similar way to living organisms and are influenced by the natural system of reproduction and selection, and GAs have been utilized since 1975 for obtaining solutions to a variety of problems. (Holland, 1975 cited in [12]).

According to [3], GAs are working in a similar procedure to chromosome developing of biological evolution. Firstly, a primary population is selected randomly or in a specified way. Populations are solutions that are coded by strings of digits; each one is called a gene, and every set of numbers symbolizes a decision variable called a chromosome. A set of chromosomes represents a solution. Real or integer numbers can be used in the adopted variable coding to illustrate a solution. The GAs are working on several processes that are selection, crossover, and mutation operations that work iteratively to obtain the value of the objective function. (See Fig. 1).

Selection: The selection operator in the GAs is applied to choose the fittest strings which the coming generation will use. Several approaches were utilised in GA to choose strings, and all are applied to decide the likelihood of selection as a function of fitness [13].

Crossover: The crossover operative is utilized to swap some of the information among two strings of population.

The goal of this is to preserve excellent genes to create strong chromosomes. Crossover is generally managed via the crossover possibility input, which ranges between 0.5 to 1.0 [14].

Mutation: The mutation operator is used to avoid GAs being limited by local solutions. This is done by introducing a random variation of the population to avoid similarity in the chromosomes. In fact, a very small change of variability could lead to slowing or even stopping searching for superior solutions [3].

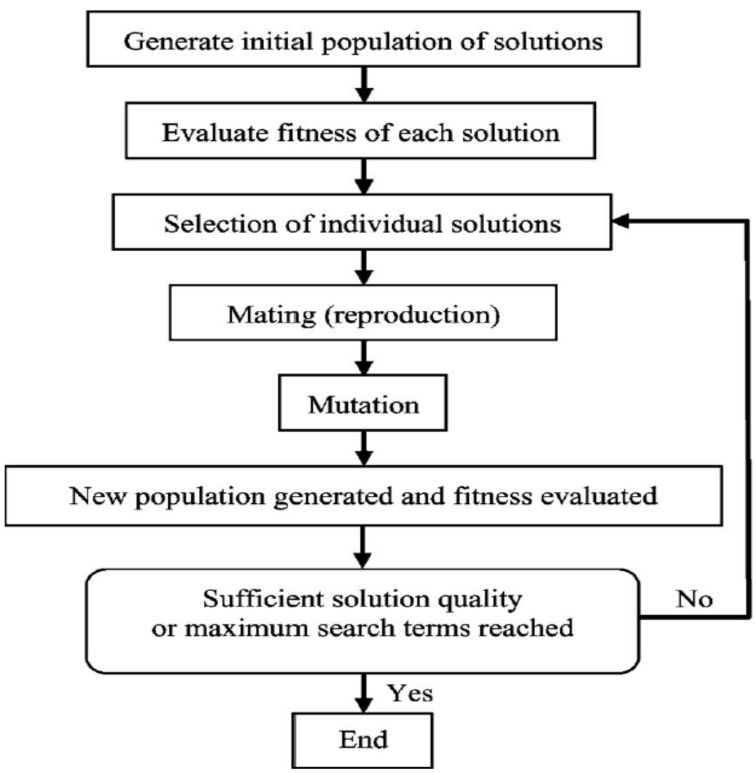

Figure 1 Generalised structure of Genetic Algorithm.

3.2 Characters of GAs

According to [15], it is nearly impossible to find the global optima; however, near-optimal solutions could be obtained quickly when using GAs for problem-solving. Other mentioned features by [3] are:

1- The GA starts searching from several points rather than starting from a single point, as is done in the classical algorithm.
2- Integer values can be used directly in the GAs; therefore, the objective functions do not need to be linear or differentiable. Moreover, it can obtain solutions for discrete variables.
3- GAs are beneficial for decision makers as they can obtain several near optima.
4- GAs were used to solve different issues in several sectors. They have been utilised successfully by [16] for scheduling exam timetables; [17] used to optimise pipe networks; [18] applied GA to establish resource allocation along with levelling of project management; [10] optimised off-farm scheduling; [6] used them for minimising the fluctuation rate of flow in the main canal with minimising seepage loss of all canals for the irrigation system and [3] and [19] utilized GAs to determine start times for lateral canals by using orders of users. They pre-specified a set of provision times for each lateral.

The uniform appearance will assist the reader in reading the paper of the proceedings. It is, therefore, suggested to authors to use the example of this file to construct their papers. This particular example uses an American letter format with 25 mm margins left, right, top and bottom.

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4 CASE STUDY

Shattulhilla River, Fig.2, is a very important one in Iraq; it branched upstream of the Alhindya barrage with long of 102 km. Then, it branched to two laterals, which are AdDaggaarah and AdDiwanyah, which 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 the highest release in the last two years, which is around 170 m3/s, 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 the Babylon district only.

Figure 2. Shattulhilla river

Genetic Algorithm

The genetic algorithm technology was founded by John Holland, who used principles of development of living organisms that were grown by Charles Darwin. The genetic algorithm guidance way has been utilized to research the solution of problems in trying to obtain the optimal solution**[21]**. A genetic algorithm has been used since 1975 to obtain solutions to an assortment of problems**[22]**. The genetic algorithm was doing the same as the procedure for chromosome evolution of biological development. The first operation uses the primary population randomly after that solution via a string of digits each one is named a gene. Also, each set of numbers are symbolized a decision variable named.

A chromosome. A group of chromosomes are solving. The genetic algorithm is doing some operations, which are selecting, crossover and mutation as shown in **Fig.3.**

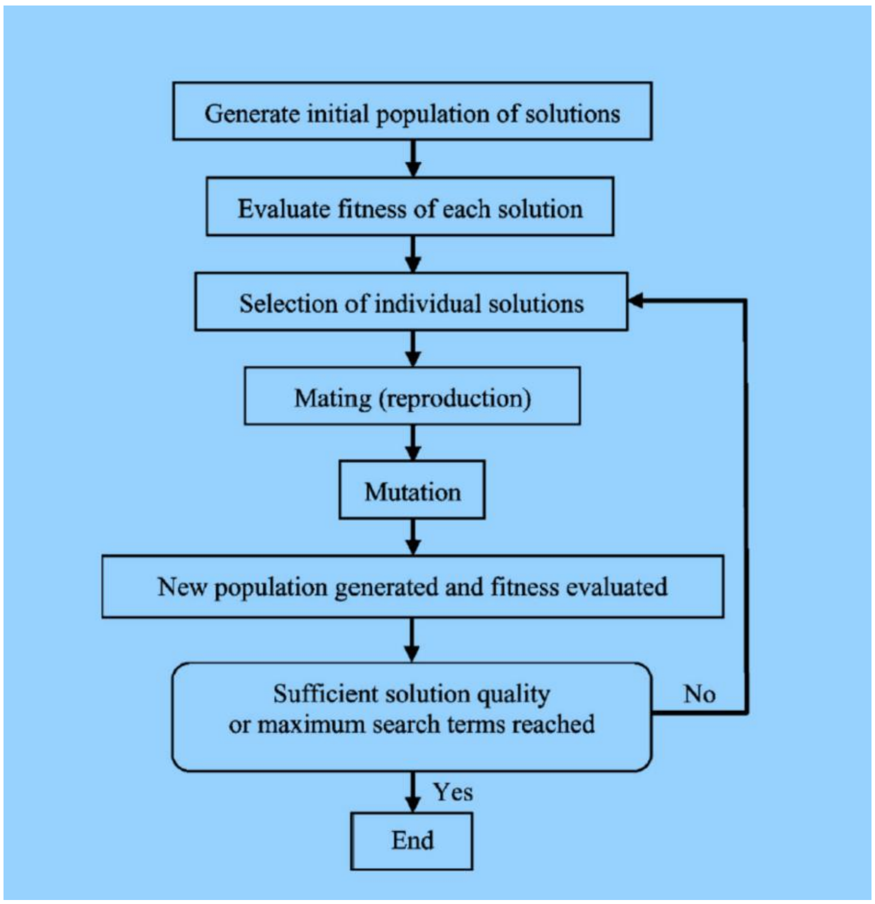

Figure 3. Generalizing Framework of a Genetic Algorithm [24]

The genetic algorithm was used to select the fittest strings that will be utilized via the coming generation. Some approaches were used in genetic algorithms to select strings and whole are utilized for deciding the probability of selecting as fitness function **[23].** Researchers mentioned that crossover operation is used to swap information between 2 strings of population. The operation aims to keep the best genes to do powerful chromosomes. The Mutation operator is utilized to prevent the genetic algorithm from being trapped via local results. Random changing is done of the population to avoid likeness in chromosomes. The variation was so small that changing led to deceleration or stopping researching excellent solutions **[24].** A genetic algorithm begins researching from several points instead of 1 point as it works in a traditional Algorithm. Integer values are utilized in GA directly, so objective functions do not need to be linear or nonlinear. Genetic algorithm is useful to decision-makers to obtain near-optimal solutions **[21].**

Fig.4 shows the creation of a string of numbers representing all the decisions that should be made. Each number is referred to as a "gene". Fig. 5 shows Perform crossover with a probability of PC, and Fig.8 shows Mutation occurs, replacing a randomly chosen bit with a randomly chosen value.

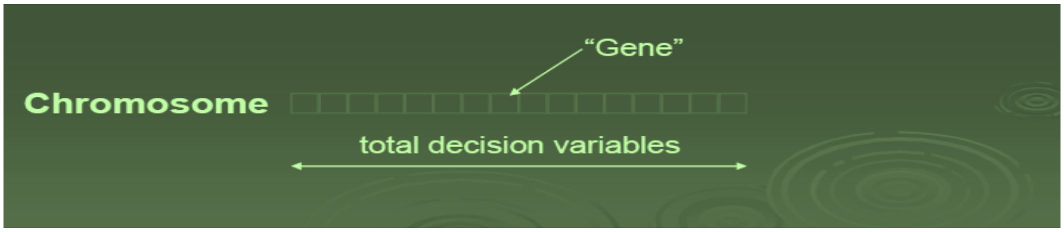

Figure 4. Create a string of numbers representing all the decisions that must be made. Each number is referred to as a "gene" [25].

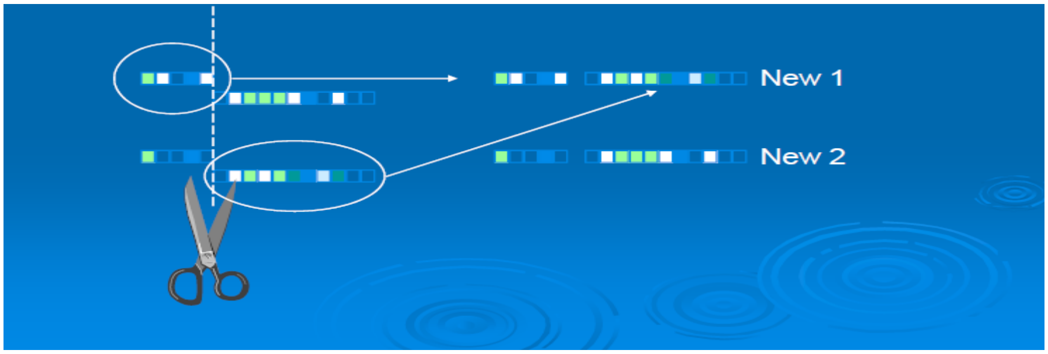

Figure 5. Perform crossover with a probability of PC [25]

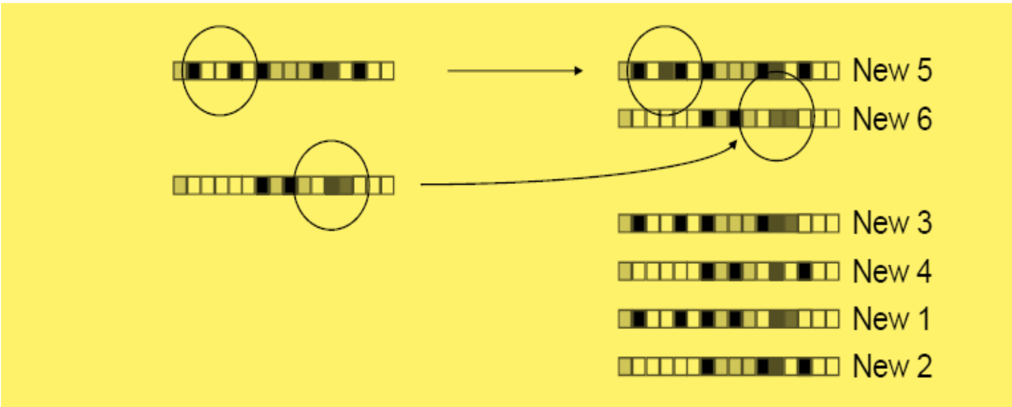

Figure 6. Mutation occurs, replacing a randomly chosen bit with a randomly chosen value [26]

The following points illustrate the current study process :

1- Binary coding was used in the model to operate canals with the highest possible capacity, as it is easier to satisfy water requirements.

2-Water for other needs is 20 m 3/s in Babylon.

3- Babylon obtains 45 % of total discharge.

The 4-Objective function is to minimize differences between (provided water for round 1 - provided water for round 2)2.

5- Squaring or absolute value is to avoid negative results in discharge deference under the root square equation.

6- Decision variables are capacities for all laterals (40 decision variables).

7- Total required water equal to the Summation of capacity for all lateral.

8- Required water for round 1 of ration (sum of chosen canals).

9- Available water for irrigation to each round equal to 0.45 multiplied by the total discharge- water for other needs.

10- Shortage equal to Total Required water-(available water*2round) (shortage is used up to 184 m3/s in this model because of the ability to run each round with full capacity for more than 184 m3/s.

11- The percentage rate of shortage equal to the available water / required water.

12- Then, the model was run for different discharges and different parameters with normal analysis, and satisfied results were found quickly and efficiently, as in Table 1.

Table 1. Model for rationing 40 laterals.

Total discharge	150	Share of babil = 0.45* total	Share for agriculture=0.45*total-other needs (20 m3/s				47.50	(m3/s)
Objective function	0.000000	Objective function is to minimise differences between 2 round				Share of babil =	67.50	(m3/s)
Total Required water= Sum of capacity for all laterals				125.96	(m3/s)			
Required water for round 1 of ration (sum of chosen cacals)=				62.98	(m3/s)			
Shortage= Total Required water-(available water*2round)				30.96	(m3/s)			
Rate of shortage % = available water / required water				0.25	(m3/s)			
	Available(provided) water for round 1 =			47.50	(m3/s)	Total=agriculture+othrer needs round 1		67.50
	Available (provided) water for round 2 =			47.50	(m3/s)	Total=agriculture+othrer needs round 2		67.50
Canal NO.	Canal name.	full canals capacity m^3/s	Round1 with full capacity		provided dischargem3/s round 1	provided discharge m3/s round 2	Ratio of used capacity round 1%	Ratio of used capacity round 2%
1	Sadda laterals	0.87	0.87		0.66	0.00	0.75	0.00
2	Mahaweel	10.75	0.00		0.00	8.11	0.00	0.75
3	khatonya	1.4	0.00		0.00	1.06	0.00	0.75
4	Fendya	0.9	0.90		0.68	0.00	0.75	0.00
5	Small latarals	2	2.00		1.51	0.00	0.75	0.00
6	Neel	3.5	3.50		2.64	0.00	0.75	0.00
7	Babil	15	0.00		0.00	11.31	0.00	0.75
8	Wardya	1.3	1.30		0.98	0.00	0.75	0.00
9	Small latarals	4	4.00		3.02	0.00	0.75	0.00
10	Tajya	0.65	0.00		0.00	0.49	0.00	0.75
11	Alameer	8.29	8.29		6.25	0.00	0.75	0.00
12	Dorra	3.66	0.00		0.00	2.76	0.00	0.75
13	Haminya	0.7	0.00		0.00	0.53	0.00	0.75
14	Small latarals	1	1.00		0.75	0.00	0.75	0.00
15	Pump 1	2.1	2.10		1.58	0.00	0.75	0.00
16	Elaj	6.8	6.80		5.13	0.00	0.75	0.00
17	Kamji	0.59	0.59		0.44	0.00	0.75	0.00
18	Emadya	1.12	1.12		0.84	0.00	0.75	0.00
19	Jarboya	9.94	0.00		0.00	7.50	0.00	0.75
20	Hashmya	0.98	0.00		0.00	0.74	0.00	0.75
21	pump 2	3.87	3.87		2.92	0.00	0.75	0.00
22	Small latarals	1	1.00		0.75	0.00	0.75	0.00
23	Bazol	0.72	0.72		0.54	0.00	0.75	0.00
24	Obeher	0.54	0.54		0.41	0.00	0.75	0.00
25	Haidare	7.42	7.42		5.60	0.00	0.75	0.00
26	Fayadya	0.05	0.05		0.04	0.00	0.75	0.00
35	Small latarals	3	3.00		2.26	0.00	0.75	0.00
36	Zabar	0.81	0.81		0.61	0.00	0.75	0.00
37	Um alwared	3.5	3.50		2.64	0.00	0.75	0.00
38	Shomely	6.2	6.20		4.68	0.00	0.75	0.00
39	Dalamya	7.1	0.00		0.00	5.35	0.00	0.75
40	Small latarals	3	0.00		0.00	2.26	0.00	0.75

5 RESULT AND DISCUSSION

From the results of the genetic algorithm, it was found that when applying the total discharge and its distribution in proportions that depend on the total discharge of the branch and 75% of its total discharge, with the addition of civil consumption, evaporation, and other specific consumptions, we obtained, with the algorithm equation, a regular exchange and specific discharges to ensure fair distribution and what is specified for each schedule or small channel depending on On the water meter, this modern method of distribution is better than the traditional methods that depend on the experience of the distributor. This genetic algorithm is applied to the Excel program with codes placed inside Excel. Using 40 to reduce the time of running may be used population from 40 to 200. Forty-five percent of the total discharge is Babylon governorate share from Shat Alhilla river.

The models of the Genetic Algorithm as described in Col.1 is canal no. and Col. Name canal also Col.3 run by GA to full discharge of canal, Col.4 run by GA to 75% discharge of canal and the result of Genetic Algorithm to one side (round1) right side; Col.5 run by GA to 75% discharge of canal and a result of Genetic Algorithm to one side (round2) left side, Col.6 and Col.7 percent of the water supply of any canal depending on total discharge from source 150m^3/s if total discharge reduction to 75m3/s the percent will become 22% as shown in the **table.1** the processing in exile program to apply and run code Genetic Algorithm. From the result of the Algorithm, we obtain on optimal distribution of canals as water resources management of shat Alhilla River.

6 CONCLUSION

Population increase has put allocated water for agriculture under threat due to the competition between domestic and industrial sectors. Hence, better management and actions in the water sector are significantly needed to meet the requirements of crops in precise and in-order time slots to reduce the entire irrigation time and decrease water loss. Recently, the rotational water method has become more preferred by managers of irrigation projects to constant water delivery due to water rotation minimizes losses and decreases the whole of irrigation time. In some irrigation projects, scheduling is achieved manually, which is a waste of time and greatly reliant on the experience and skills of the scheduler. Additionally, when linear programming is used, it requires the capability to indicate the number of channels that operate simultaneously so as to prevent top flow that could occur in the main channel. A mixed-integer technique could be applied for scheduling; nevertheless, only approximate results can be obtained; also reparability and convexity of equations are essential to solve the problem. In this study, the GA was utilized in order to schedule open-channel projects, as it has been used successfully in several sectors. The obtained results in this research point out that utilizing a genetic algorithm optimization technique to timetable the open channel of irrigation projects is an active method in regard to finding a reasonably regular flow while reducing the whole irrigation time. For better operation, it is suggested that further effort is required in the search to join together all parts of the Shattulhilla River in the other provinces for achieving better operation.

From GA obtain on best distribution to canals of Shatt Al-Hilla of two sides by 75% from total discharge. The method of technique is optimal from traditional distribution to obtain on fair share of canals.

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