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Cost of Dams in Al-Baha Province, Kingdom of Saudi Arabia

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Abstract: The purposes and the types of dams are reviewed in Al-Baha province, on the western south of KSA (Kingdom of Saudi Arabia). Data are collected and tabulated ascending according to the capacity of storing water. The cost (in Saudi Riyal) is plotted versus the capacity (in m^3) for the dams. Then a linear regression analysis is done employing Micro Software Excel. An equation is obtained to predict the cost of dams with storage capacities less than or equal 500,000 m^3, where the type of dam has no effect on the cost. Taking into consideration the inflation rates along the time, the 2013's costs are estimated and also another equation is obtained to predict the cost.

Key words: Dam, storing water, cost, Al-Baha.

1. Introduction

Rain fed agriculture constitutes 80% of global agriculture. As the global population swells, more food will be needed, but climate variability is likely to make farming more difficult. Providing farmers with a range of water stores could help them overcome dry spells that would cause their crops to fail [1].

Water storage is a term used to define locations where water is stored for later use. These range from natural water stores, such as groundwater aquifers, soil water and natural wetlands to small artificial ponds, tanks and reservoirs behind major dams [1].

A dam is a barrier that impounds water or underground streams. Dams generally serve the primary purpose of retaining water. A dam can also be used to collect water or for storage of water which can be distributed between locations [2].

Dams can be typically classified according to their size, purpose or structure [2].

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2. Water Resources and Uses in KSA (Kingdom of Saudi Arabia)

KSA, west of Asia, is classified among arid regions. It has neither rivers nor lakes. Rain ranges between 110 mm/year and 300 mm/year on the western south provinces. The flowing rain water is estimated between 2,000 millions m^3/year and 2,400 millions m^3/year, 60% of which occur on the western south provinces. A small part of this water feeds the ground water reservoirs, while the other part flows to the red sea, west of KSA.

Water resources in KSA in the year 1984 were 8,600 million m^3, and are summarized as shown in Fig. 1.

Also, water uses in KSA are summarized as shown in Fig. 2.

3. Dams in Al-Baha Province, KSA

Dams as a tool for storing water are widely constructed in different provinces of KSA mainly for irrigation purposes, recharging wells down stream the dams, potable water supply and protection against dangerous floods. The types of dams in KSA are

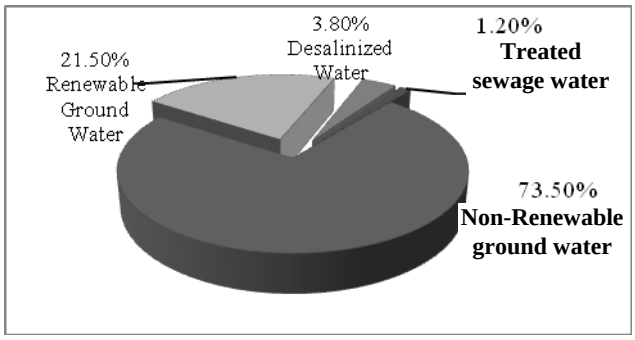

Fig. 1 Water resources in KSA.

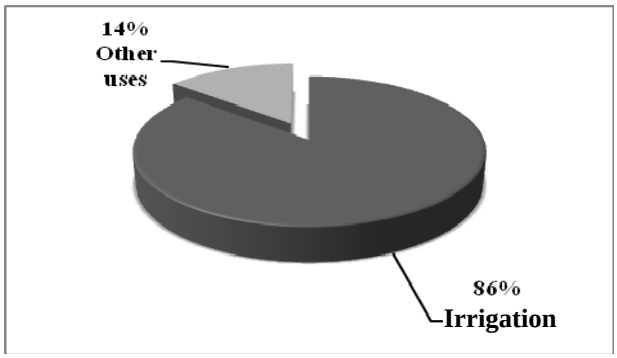

Fig. 2 Uses of water in KSA.

concrete, earth fill or rock fill and under ground dams [3].

Al-Baha province is located on the western south of KSA. It contains six governorates in addition to Al Baha city with a total population of about 430,000 capita and the smallest area among the provinces of KSA.

Data are collected for 17 dams that were constructed in Al Baha province during the period from 1981 to 1986 [3]. The data are tabulated ascending according to the capacity of storing water.

Thus the data concerning the 17 dams are shown in Table 1.

It is noted that the purposes of these dams are the same as all over KSA. The purposes of all dams are illustrated in Fig. 3.

Also, the types of these dams are the same as all over KSA. The types of all dams are illustrated in Fig. 4.

The cost (in Saudi Riyal) is plotted versus the capacity (in m^3) for the 17 dams as shown in Fig. 5.

4. Results and Discussion

First of all, it is noticed that the cost increases

Table 1 Data for 17 dams in Al-Baha Province [1].

No.	Name	Year of construction	Capacity (m^3)	Cost (Saudi Riyal)	Type	Purpose	Length (m)	Height (m)	2013's cost (Saudi Riyal)
1	Al-Habees	1983	10,000	3,100,000	Concrete	Control	40	14	4,500,001
2	Matwah	1983	24,000	2,900,000	Rock fill	Recharge	134	11	4,209,679
3	Dbdb	1983	30,000	3,000,000	Concrete	Control	38	12	4,354,840
4	Al-Ureisheen	1983	37,000	3,351,000	Rock fill	Recharge	117	14	4,864,356
5	Zaqat	1983	70,000	2,500,000	Rock fill	Recharge	160	10.5	3,629,033
6	Al-Qim	1983	80,000	3,800,000	Rock fill	Recharge	65	9	5,516,131
7	Zarwah	1983	98,000	3,850,000	Rock fill	Recharge	120	15	5,588,711
8	Al-Malah	1983	100,000	3,900,000	Concrete	Control	71	17	5,661,292
9	Al-Marba	1983	120,000	4,500,000	Rock fill	Recharge	133	16	6,532,260
10	Al-Kharrar	1983	150,000	5,700,000	Earth fill	Recharge	84	12	8,274,196
11	Al-Talqiyah	1981	200,000	6,300,000	Rock fill	Recharge	90	14	9,375,222
12	Subayhah	1983	300,000	6,300,000	Rock fill	Recharge	85	12.5	9,145,164
13	Al-Mazlumat	1983	400,000	7,650,000	Rock fill	Recharge	120	12	11,104,842
14	Al-Sadr	1981	500,000	12,000,000	Concrete	Irrigation	100	20	17,857,566
15	Marzooq	1986	750,000	8,000,000	Rock fill	Recharge	300	20	-
16	Madhas	1986	1,500,000	12,000,000	Concrete	Recharge	350	10	-
17	Beedah	1984	3,000,000	8,000,000	Rock fill	Recharge	150	24	-

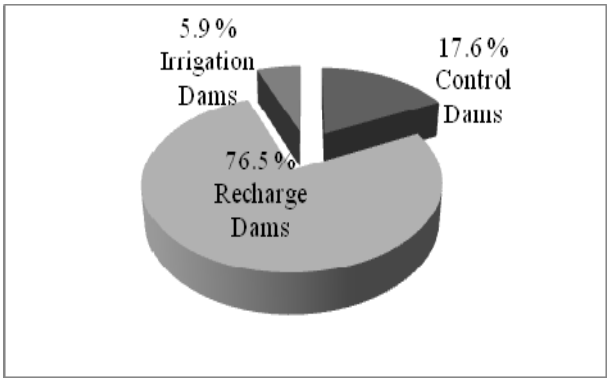

Fig. 3 Purposes of dams in Al Baha Province, KSA.

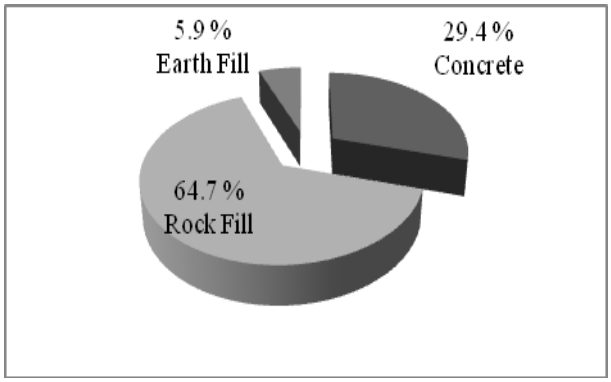

Fig. 4 Types of dams in Al Baha Province, KSA.

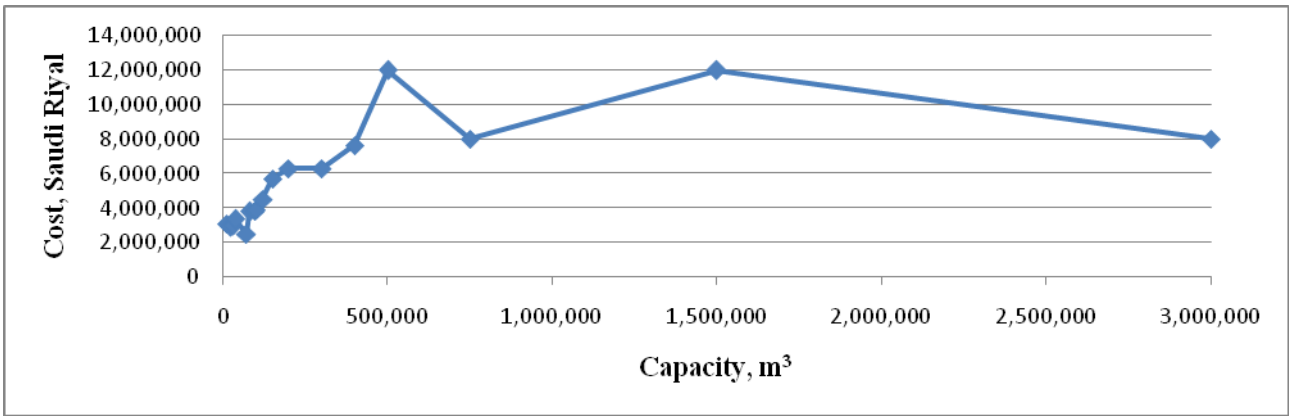

Fig. 5 Cost versus capacity for all 17 dams.

proportional to the storage capacity till the value 500,000 m^3. After this value, the cost varies differently with the storage capacity. The cost decreases much at the capacity of 750,000 m^3. Then, the cost increases at the capacity of 1,500,000 m^3, and it decreases again at the capacity of 3,000,000 m^3.

The 17 dams are divided into two groups of dams. The first group includes the dams with storage capacity less than or equal 500,000 m^3. This group contains 14 dams. The second group includes the dams with storage capacity range between 750,000 m^3 and 3,000,000 m^3. This group contains the other three dams.

For the first group of dams, the cost is plotted versus the storage capacity. Then a linear regression analysis is done employing Micro Software Excel. Also, an equation is obtained to predict the cost of any storage capacity within the range of this group.

Fig. 6 illustrates the variation of the cost against the storage capacity for the first group of dams. It includes the trend line obtained from the linear regression analysis.

The obtained equation is:

$$y = 16.36 \cdot x + 2{,}000{,}000 \quad (1)$$

where, y: the predicted cost (in Saudi Riyal);

x: the storage capacity (in m^3).

This equation can be used to predict the cost for a dam according to its storage capacity.

For the second group of dams, the cost has no clear trend versus the storage capacity as mentioned previously. That may be due to the effect of the type of the dams after the storage capacity of 500,000 m^3.

There is no much data for storage capacities between 500,000 m^3 and 3,000,000 m^3.

It can be noticed that the analyzed dams were constructed during the period from 1981 to 1986. The present values for these costs in the current year, 2013, are definitely different. That is to say that if these

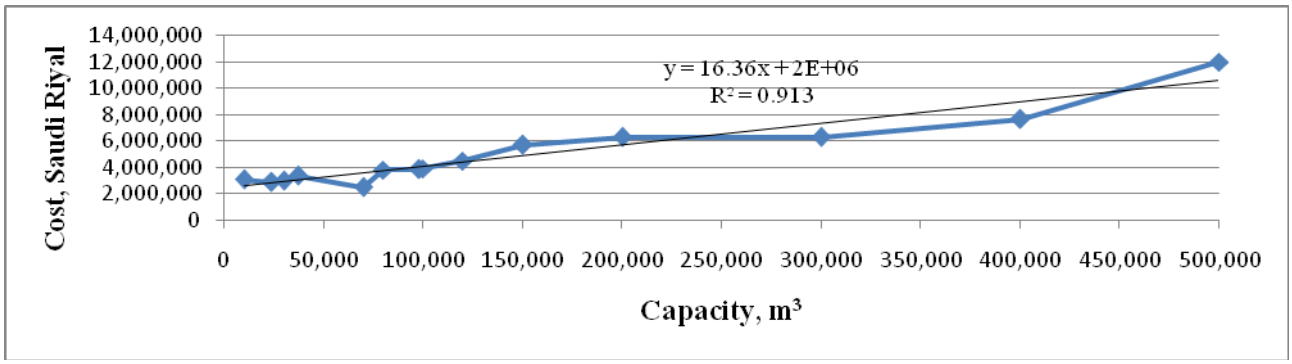

Fig. 6 Cost versus capacity for the first group of dams.

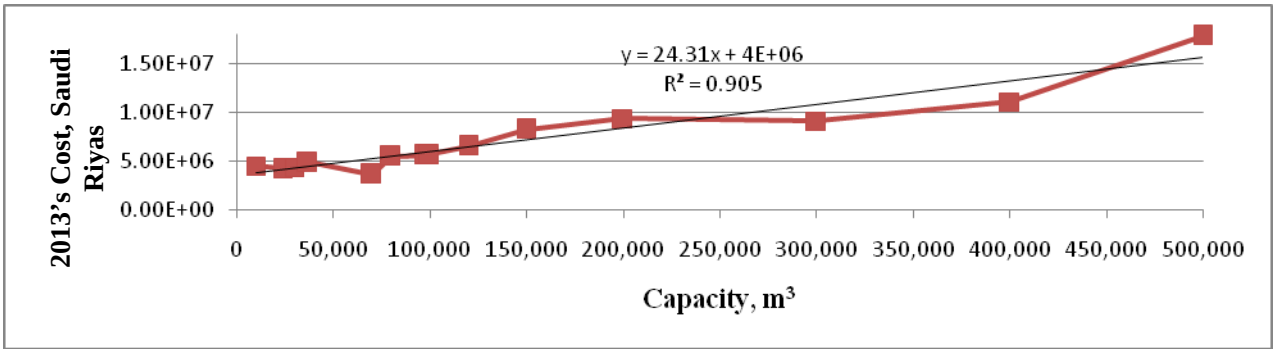

Fig. 7 2013's cost versus capacity for the first group of dams.

dams are to be constructed this year, then their costs are different. That is correct due to the inflation rates that lead to decreasing the value of money along the years.

Introducing the inflation rates [4], 2013's costs are calculated using the simple equation:

$$2013\text{'s } Cost = Cost\ (1+i)^n \quad (2)$$

where, *Cost*: the cost in the year of constructing the dam;

i: the inflation rate;

n: number of years from construction till the year 2013.

The data of 2013's costs for these dams are shown in last column of Table 1.

Fig. 7 illustrates the variation of the 2013's cost against the storage capacity for the first group of dams.

It includes also the trend line obtained from the linear regression analysis.

The obtained equation is :

$$y = 24.31 \cdot x + 4{,}000{,}000 \quad (3)$$

where: *y*: the predicted cost (in Saudi Riyal);

x: the storage capacity (in m^3).

This equation can be also used to predict the cost for a dam according to its storage capacity.

5. Conclusions and Recommendations

For the dams with storage capacities less than or equal 500,000 m^3, the type of the dam has no effect on the cost. The cost can be predicted employing the obtained equations.

For the dams with storage capacities more than 500,000 m^3, the type of the dam affects the cost.

It is recommended to study more cases for dams of different storage capacities more than 500,000 m^3, especially the range between 500,000 m^3 and 3,000,000 m^3.

It is recommended also to apply this study to more cases for other different dams in KSA.

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