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# Analysis of Comparative Advantage and Engineering Status of Freshwater Reservoirs across the Provinces in Iran

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**Abstract**

In the past decades, Iran faced severe rain deficiency and/or uneven distribution of location and time of rainfall. This has initiated dilemma for over consumption of underground water. In this research, economic and engineering analysis for comparative advantage of construction of a human-made pond-like reservoir based on the local price of freshwater and local climate in 31 provinces across the country was conducted. Among various criteria, the price of freshwater and evaporation were the most critical ones. However, other parameters such as temperature, reservoir geometry, annual precipitation and seepage were discussed. Accordingly, construction of a reservoir at Khorasan-South (Khorasan-Jonoobi) province was the most economical compared to other provinces. Markazi and Yazd provinces were the next most economical ones across the country. It was noted that temperature is an essential parameter affecting local evaporation and the impact of temperature is more prominent than the relative moisture. For example, Hormozgan and Bushehr provinces sustain high evaporation while relative moisture is high (and therefore low evaporation is expected). Further, analysis revealed that morphological and engineering characteristics of reservoir such as the reservoir volume, depth of water and the reservoir surface exposed to the air and to the sun light may somewhat be controlled in order to reduce evaporation.

***Key words:*** *Reservoir, Price of freshwater, Evaporation, Relative moisture*

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## Extended Abstract:

### 1. Introduction

The problem of fresh water scarcity has deeply plagued today's societies. People are looking for solutions to manage this challenge. Therefore, various proposals have been made so far, each of which in turn has a special value and is considered valuable because they target the extraction of an specific type of fresh water resource. The water issue in Iran has become so acute that even small scientific, technical or operational steps to improve the current situation can create significant local and national added value. This includes preventing flood waste, using various methods such as human-made pond-like reservoirs with a small investment, while they can locally generate significant added value. Of course, this issue also deals with its specific challenges such as the identification and analysis of various influencing climate parameters (such as rainfall, temperature and evaporation) and engineering geology of the region (including morphology and topography, reservoir geometry, type of reservoir bed).
International experiences of this kind include pools in parts of North Africa (East Sudan) known as Roman Pools, as well as longitudinal embankments in Tunisia and trapezoidal crescent-shaped ridges in Egypt. (Chakoshi and Tabatabai Yazdi, 2012). Another example of water harvesting is the storage ponds (dams created in the fields that are dug in the form of holes) in the farms of Kalgoorlie, Australia, as well as other examples of dams in the east of kojonup which is used to store rainwater (Stanton, 2005). Also Jothiprakash et al. (2009) explained India's experiences in rainwater extraction, where the parameters influencing the design of reservoirs were considered as topography, rainfall, storage volume, as well as the consumption of the extracted water. Moreover, due to the importance of rainwater harvesting, even in rainy countries such as Japan and France, modern facilities have been established for this purpose (Niemczynowicz, 1999).
In this study, essential parameters affecting economic value water harvesting in pits or water storage holes were analysed the relative advantages in different provinces of Iran were compared.

### 2. Materials and methods

In this study, engineering analysis for the implementation of a water storage reservoir in each of the 31 provinces of Iran has been accomplished according to climatic conditions and the price of fresh water. This analysis has been performed for a hypothetical rectangular reservoir with a volume of one million cubic meters with a length of 500, width of 200 and depth of 10 meters (surface area of 10 hectares). It was also assumed that the project is constructed in a location with an adequate natural depression that requires only a slight geometric correction. The annual amount of surface evaporation in a reservoir was calculated from Equation (1):

$$V_E = K \, . \, E_P \, . \, A \, (10^5) \qquad (1)$$

In the above relation, $V_E$ is the annual evaporation volume in million cubic meters, $E_P$ is the annual evaporation height from the basin in millimeters, A is the reservoir surface in hectares, and K (= 0.66) is the basin evaporation coefficient (Barideh et al., 2009).

The price of stored fresh water was calculated after deducting the amount of evaporation, based on water tariffs delivered from dams and other sources in each province (Iran Water Resources Management Company, 2018). Also, IRR (Invest Return Rate) was defined and calculated equivalent to the effective value of a full reservoir divided by the cost of reservoir construction.

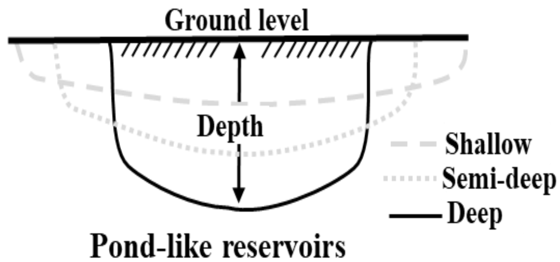


**Fig 1.** Various geometries for pond-like reservoir

## 3. Discusion

Accordingly, Khorasan-South (Khorasan-Jonoobi) province with a return on investment of 0.42 was the most economical province for the construction of such structures, that indicates if a reservoir only once stores 42% of its capacity, it will cover the construction cost. Next most profitable provices are Markazi and Yazd. The reason for this comparative advantage is the high rates of fresh water in these provinces (high rates are naturally due to water shortages and the value of agricultural products in the region).
Further analysis revealed that if the ratio of the surface-to-volume is increased (a shallow reservoir, as in Figure 1), water evaporation will increase to an extent that the project becomes uneconomical. However, the threshold of the economic surface-to-volume ratio varies in different provinces depending on the local annual evaporation height ($E_P$). This was considered as the second most influencing paramer in this analysis. Therefore, in general, it can be said that in provinces with substantially less annual evaporation (such as Golestan province), there is less sensitivity to the “surface-to-volume-ratio”.

## 4. Conclusion

The price of fresh water in the region was found to be the most important parameter for valuation of a pond-like human-made reservoir. It can make the construction of a reservoir cost-effective or uneconomical. Also, reservoir volume, annual rainfall, temperature and average annual evaporation are among the important and effective parameters. Engineering analysis of return on investment in 31 provinces of Iran revealed that Khorasan- South province is the most profitable region for water harvesting, followed by Markazi and Yazd provinces. Meanwhile, in these regions, fresh water price is the highest compared to other provinces. In is interesting that, from the point of view of geographical location, these provinces are located in the central and very dry zone of Iran, which somehow confirms the results of this study.

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