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Sustainable Management of Iraqi Valleys to Mitigate Climate Change Challenges. (Wadi Horan- Case Study)

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Abstract:
The western desert in Iraq was classified as an arid area, with very little precipitation ranges from 50 to 120 mm. Additionally, this area is characterized by a high evaporation rate ranging from 1700 to 1900 mm/year. The Iraqi Western Desert is characterized by the abundance of valleys that form a large streams for water movement during rainstorms. With an area of 16,550 Km2, Wadi Houran is considered the largest valleys not only in Anbar Governorate, but overall Iraqi area. The annual water flow in this valley is about 200,000,000 m^3/year. This research aims to Study the validity of sustainable development of Wadi Horan by constructing a small-dams-series to harvest rainwater in reservoirs and to recharge groundwater to improve its quality and quantity. Sustainable development aims can be defined as an environmental balance of natural resources such as groundwater. This system creates eco-friendly oases and parks that contributes to enhancing the local security in this border area. This research concludes the possibility of cultivating many millions of drought-resistant trees within a sustainable nature reserve park extending over an area of about 4000 km^2 irrigated with rainwater harvesting and groundwater pumped by renewable energy.

1- Introduction:
Water scarcity is the largest danger that facing the nation according to climatic change effects in arid zones. Researchers proposed many strategies management methods and techniques to maintain water resources to mitigate these challenges, rainwater harvesting is one of the important techniques to store water in large valleys [1], [2]. Rainwater harvesting by construction of a small dam in a large valley is considered as the most important technique to mitigate the climate change effects on intensity, frequency, and even type of precipitation, or a change in its spatial distribution, which may be causing a severe flood, soil erosion, and drought. Therefore, using rainwater harvesting techniques in establishing and rehabilitating the natural reserves is a necessary step. With an area of 16,550 Km2, Wadi Houran is considered the largest valley in Iraq, with average annual precipitation of 115 mm and great quantities of runoff in rainy season. Many previous studies, indicated that Wadi Houran was a continuous flow river before the second ice age. Small dams reservoirs are filled with water in rainy seasons and store water for several years, including dry seasons. Many oseases and natural reserves were established in Wadi Horan from 1973 to 1980, at Al-Massad reserve near to the Rutbah city. The reserve succeeded and more than three thousands of deer lived. In addition,

the oases were planted with date-palm and olive before ISIS destroyed these strategic projects. [3], [4].

This Study Aims To:

1- Study the validity of sustainable development of Wadi Horan by constructing a small-dams-series to harvest rainwater in reservoirs and to recharge groundwater to improve its quality and quantity. Additionally, planting trees and forests surrounding these reservoirs to reduce the levels of CO2 in the atmosphere and create good environment habitations for the plants and animals and minimize the evaporation losses from these reservoirs. Moreover, due to the presence of sufficient sunny hours and high wind speed there is a good opportunity to use renewable energy.

2- Planning to improve the security in western desert by increasing the population density within the considered study area. Improving the ecosystem and providing the valley with oases leads to establishing a desert tourist which is followed by security improvement.

2- Study Area:

Overall the western desert, Wadi Horan is the largest valley extend for about 460 km from the Euphrates River near Haditha city to the Iraqi-Saudi borders as shown in Figure 1. Horan valley is located between the longitude lines of 39˚00" 00' to 43˚00"00' East and the latitude 32˚00"00' to 43˚30'00" North. The valley elevation difference between its upstream near to Iraqi-Saudi borders, and downstream near to Haditha city is about 610 m. The Western desert in Iraq is classified as an arid region. Figure (1) is an image that explains the location of Wadi Horan. For the purpose of rainwater harvesting a set of four small dams were constructed in Wadi Horan stream during the period 1973 to 2003 with different storage capacities according the dam location, these dams are listed in Table 1 and shown in Figure 2. Furthermore, a series of thirteen small-dams of optimal Hight were proposed to be with capacity of 303 million m^3 of water to increase the valley reservoirs water surface area from 15 to 90 km^2. If these 13 dams are constructed the recharging amount to this valley aquifer will be increase from only 4.7 million m^3 to about 29 million m^3 every year [5]. Many researchers were studying this important natural phenomenon to store rainwater. Based on The Optimal Height and Location Model (OHALM)) will be used to design a small-dams-series with optimal heights to minimize the evaporation losses [6].

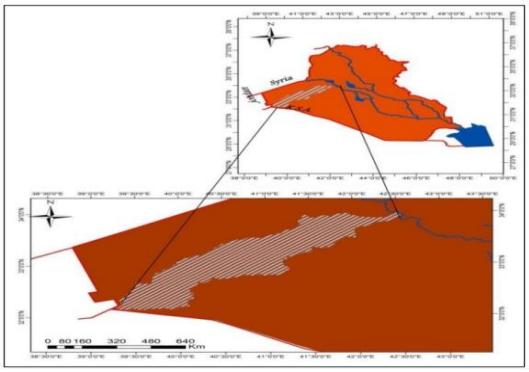


Figure 1: Wadi Horan, western-desert, Iraq

Table 1: The existing small dams in Wadi Horan.

No.	Dam Name	Date of construction	Height of the dam (m)	Reservoir capacity Million m^3
1	Rutba Dam	1981	19	32
2	Al-Ubailah Dam	1973	11.5	4
3	$Horan_2$ Dam	2007	15	5
4	$Horan_3$ Dam	2003	15	5.3

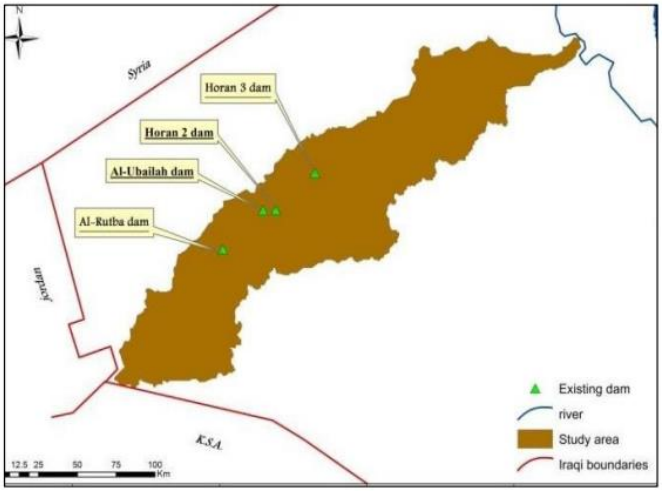


Figure 2: Small dams in Wadi Horan.

3- Hydrological Conditions: The average annually rainfall is about 110 mm and the annually evaporation losses are estimated to be 1600-1900 mm, (Table (2), Figure (3). The highest evaporation values will occur in the summer season while the highest rainfall values in winter.

Table2:The important Climatic factors of Wadi Horan, From Rutbah station (1971-2010)

Parameter	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Rainfall (mm)	22.7	21.2	24.6	23.9	7.2	0.01	0.0	0.0	0.01	6.7	13.0	24.0
Evaporation (mm)	55.6	81.6	122	202	296	378	420.7	402	354	234	116	61.3
Max. Temperature(C°)	13.2	15.3	19.4	25.9	31.6	35.7	38.3	38.1	35.8	29	21	14.6
Min. Temperature(C°)	1.9	3.1	6.5	11.8	16.6	20.2	22.8	22.4	19.2	14	7.6	3.6
Wind speed (m/s)	3.0	3.7	4.0	3.9	3.6	3.9	4.1	3.5	2.7	2.6	2.5	2.7

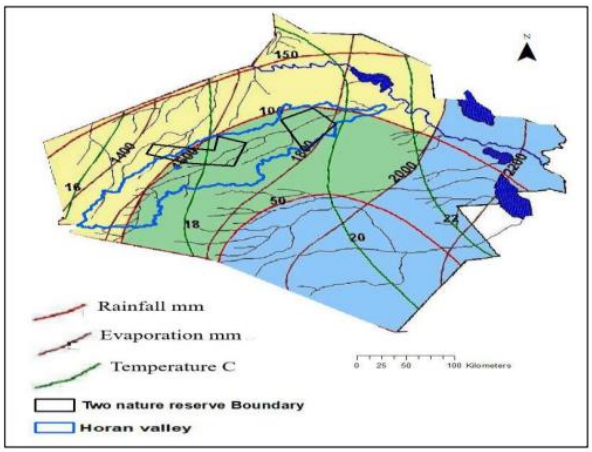
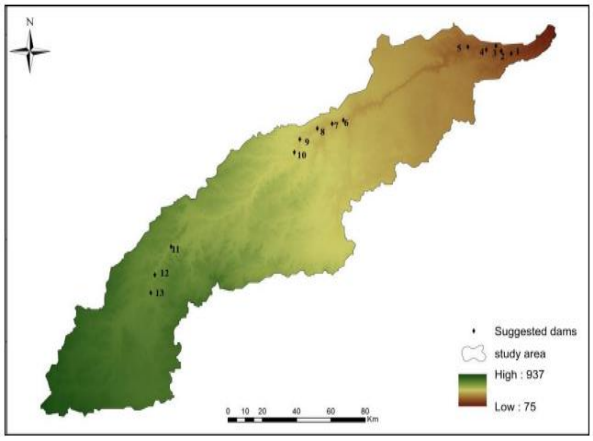


Figure 3: Rainfall, Evaporation and temperature in the study area.

During very wet years, about one billion m^3 of rainwater may be discharged from this valley to the Euphrates River, the average discharge value is about 400 million m^3 per year. [7],[8]. The catchment area of Wadi Horan is about 15300 km2, this area will be extended with the valley large tributaries like, Hussainiyat, Mihzam, Saqqar, and Amij to about 16550 km^2. each infiltrated mm of rainwater that reached the aquifer, will recharge the aquifers by 16.55 million m^3 for every rainfall event. Many studies were evaluated the best locations of the small dams, Figure (4) illustrates the recent study [6], while the best locations for rainwater harvesting sites are shown in Figure (5) [9].



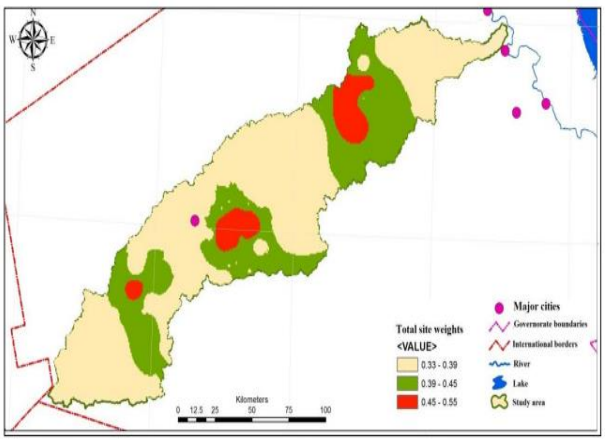


Figure 4: The Proposed Small. Dams in Wadi Horan

Figure 5: The Best Locations of Water Harvesting Areas

4- Hydrogeological Conditions: In the western desert, the direction of groundwater discharge to the drainage area (right bank of the Euphrates River) is mostly to the east and northeast, there are different local directions for the flowing in this region depending on the geological setting of the region and its topographical and structural characteristic [10]. Many depressions exist in the western desert, which receives rainwater that floods from the large valleys. Most of the aquifers are recharged from the large valleys rainfall and its runoff [11]. The groundwater quality and quantity depending on the aquifers geological formation, the wells depths ranging

between 20 m to 550 m. Figures (6) and (7) explain the direction of flow groundwater and the groundwater depth.

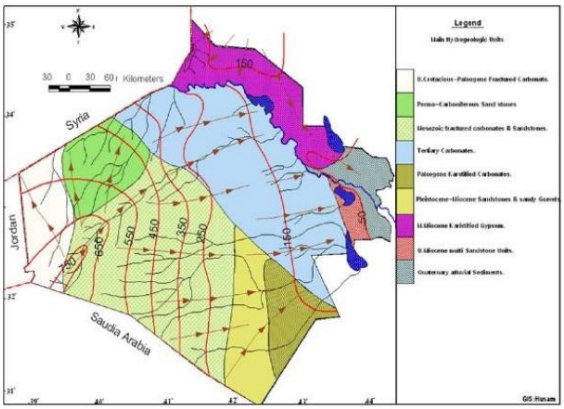


Figure 6: The Hydrological System Distribution Over Anbar Governorate(Hussein, 2010)

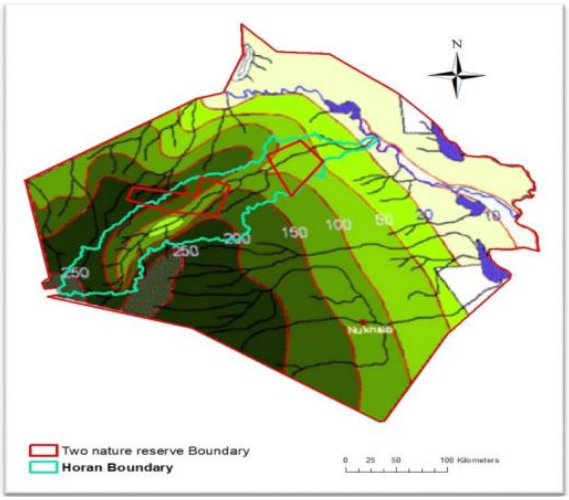


Figure 7: Groundwater Depths (Hussein, 2010)

5- Surface Runoff And The Ground-Water Recharging:

5.1- Rainfall-Runoff Relationships. There is only one weather station in Wadi Horan, located in Rutba city, and there is only one hydrometric station in this valley and its surrounding areas, so very little hydrological data about this valley. There are no ~~any~~ rainfall intensity or runoff data was recorded. The flood that occurred on 12/2/2019, as shown in Figure 8. As the flow velocity below the bridge can be estimated as about 3 m/sec, and the cross-section area of the flow below the bridge is about 610 m^2, so the discharge in this flood event is about 1800 m^3/sec. The volume of water that is discharged at one hour is about 6.48 million m^3. According to this proposed discharge estimation, all reservoirs in this valley are filled at about 7 hours of this discharge if they are empty before this flood event [12]. In many years, Wadi Horan discharge duration is about 10 days in the heavy storms in many years. The peak flood value will occur early then it will decrease gradually during one or two days after the flooding begins. All small dams in Wadi Horan are filled in wet years, and still store large quantities of water among a period of three to four dry years [13]. Because of the lack of hydrological data in this valley, it

is not easy to forecast the rainfall-runoff relation, very difficult to predict the rainwater harvesting quantities.

In many cases, the land use, and land cover will be used to predict runoff by using hydrological models. Using GIS and remote sensing, Watershed Modeling System (WMS) can used to determine the runoff. Multiple steps are required to produce the necessary layers in WMS Tools. The largest rainwater harvesting volumes in the Iraqi western desert in collected from Wadi Horan [14].

Figure 8: Flooding in Study Area (2/12/2019) (Bmmagazine, 2019).

5.2: Groundwater Recharging: every year, in the reservoirs bed of the small dams the precipitate sediment loads especially the fine particles such as clay will decrease the soil infiltration, and decreasing the groundwater recharging. The hydraulic conductivity of the soil at the reservoir bed will be decreased to the minimum value of about 1*10-8 m/sec [15]. Therefore, the amount of water that infiltrates the aquifers is about 31.54 cm every year. According to this approach, about 4.7 million m^3 will be recharged to the valley aquifers every year from the existing 4 dams, the annual recharging volume will be extending to about 29 million m^3. if the proposed 13 small dams-series constructed. The direct infiltration from rainwater and surface runoff above the valley area (16,500 km^2) is other recharging resource that feeding the aquifers.

6- Conclusion and Recommendations:

Although it is very few quantities of rainfall and large quantities of evaporation losses, there are suitable opportunities to rainwater harvesting by constructing a small-dams-series that harvests large quantities of high-quality water and recharging the ground water to improve its quantity and quality. Climate change challenges must be mitigated by a strategic study to decrease its severe effects. Constructing oases and national parks in large valleys like Wadi Horan is very important to improve the ecosystem and minimize the climate change effects.

Many weathers station network must be established in the Wadi Horan area to provide weather data base that leads to more precise studies of its hydrological features. The annual rainfall rates will ensure the sustainability of these facilities without affecting groundwater elevation. The researchers are planning to update this study simulating the climate changes in the western desert and expanding this proposal in other large valleys in the western desert to optimize the natural resources management in these critical climate conditions.

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