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Upper Euphrates Basin Developing Center

Guideline of Iraqi Valleys Development (1- Wadi Horan)

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Preface

The western desert in Iraq is classified among the arid and semi-arid areas. This classification is an outcome of low rainfalls that ranges between 50-110 mm across the entire area. While, the high summer temperatures fallouts in high annual evaporation rates of 1800 mm in those areas. The western desert is also characterized by the abundance of valleys in which large amounts of flowed water moves during the rainy season. Horan valley is well-thought-out as the largest one of these valleys, with an area of more than 15000 Km^2 and an annual water flow of more than 200,000,000 m^3. The previous researches indicate that the valley was a river before second ice age, thus, it was nominated as a model of valleys in the western desert. The present study aims to design a guidebook for developing those valleys, to ensure the sustainability of their resources and acquire their maximum benefit. This objective will contribute in sustainable environmental balance through the expansion and establishment of oases, natural preserves and national parks to preserve biological diversity without violating the natural resources of groundwater and natural plants of the valleys. Moreover, the study included a comprehensive survey of the valley's nature and the small dams that built to confine rainwater on its route. In addition, some plans were based on the recent studies to establish a series of small dams with optimal heights to ensure storing the largest amount of rainwater with the least surface evaporation losses from their reservoirs. The sustainable development aims to achieve an optimal investment of the resources to guarantee their preservation within an environmental balance which required for human health and biosafety. Hence, the development projects start from investing untapped land in agricultural projects that equalize the carbon emitted from factories, such as the establishment of nature preserves and national parks, which ensure the medium and long term balanced ecological system. This system creates environmentally friendly tourism that contributes to enhancing the country’s national security. The study branded the possibility of planting several million drought-resistant trees within a nature reserve park with a total area of 4000 Km^2. The annual rates of rainfall ensure the sustainability of these facilities without exhausting groundwater in the area. Thus, the researchers are looking forward to continue updating this study to simulate the climate changes, thereby, expanding the present indications on other valleys of the western desert to ensure optimal management of water and natural resources.

Highlights

1. The availability of water and energy is one of the most important elements to enhance the investment opportunities and environmental development. Based on previous studies on Wadi Horan that indicated the abundance of water and the possibility of using renewable energy (solar and wind) will provide a successful investment.

2. The importance of creating two natural reserves (National park and Nature reserve) will fill the security gap left in Wadi Horan after war on ISIS. Security will provide permanence to the reserves and the area around via advanced monitoring and warnings technology.
3. Wadi Horan area is 16550 km^2 and the average depth of precipitation over the Wadi Horan is about 100 mm, therefore, the volume of annual water precipitation is about 1.5 billion m^3.
4. The average annual runoff according to published studies is about 400 million m^3.
5. Despite the large area of Wadi Horan, there is only one weather station and there is no station to measure the discharge, so there is intense need to install new stations for more accurate hydrological calculations.
6. The average groundwater recharge to aquifers of Horan regions is about 180 million m3 per year.
7. Smart forestation plan for the perimeter area to the center of the two reserves will act as a fence to protect the reserves. A plan includes one million trees to be planted along the contour lines to harvest rainwater and the trees will be irrigated using drip irrigation and water deficit technologies.
8. Preserving the ecological and animal diversity (rare plants and endangered animals) inside the central area of the nature reserve is considered a very important issue. It is also considered the major goal of establishing natural reserves. Therefore, establishing a remote monitoring system using modern technology is an important step.
9. Tourism and urban development planning are recommended in the second phase 2025 -2030 after accomplishing the master plan for the two reserves.
10. The presence of a large number of wild plants and cohabiting animals along with the successful establishments of the Deer reserve and dozens of desert oases will encourage the agricultural and animal investment in the Iraqi western desert.
11. Preparing the Development Studies on Rutba city is required to be a model for the Smart City because it is the only city in Wadi Horan. It has a great potential to become first Smart Eco-City in Iraq.
12. Observing small dams are to be sure that they are filled with water in wet years and store water for several years, including dry years.

1. Introduction

Nowadays, the ecotourism has gained extensive interest among the tourism sectors, which has become a modern type of tourism that is interested by the developed countries. The establishment and rehabilitation of nature reserves and national parks in these countries began to emerge as an important tourism factor. Iraq is characterized by the diversity of vegetation cover resulting from the topographical and climatic variation, in addition to the variation in the rates and distribution of rainfall. Furthermore, the diversity of the soil and the difference in its geological composition, in addition there are clear differences in its natural topography, which varies between desert and mountainous areas with a height around 900 meters above sea level. Due to the technical developments used in spatial studies, especially geographic information systems (GIS), it has become very important to use these modern technologies to establish and rehabilitate various tourist sites, including natural reserves and national parks, as the availability of integrated information system such as GIS in the management and development of natural reserves is considered an essential part in achieving sustainable tourism development. Towards more sustainable tourism, more attention should be paid to ecotourism and natural reserves, and the management of the available resources by exploiting them in an optimal way. Establishing and exploiting the natural reserves and national parks require optimal planning that achieve the expected benefits by focusing on using the modern technologies in their establishment and management.

Water scarcity is a global problem caused by the climatic change so rainwater harvesting is very important to mitigate this problem. Effective planning and management of water resources are necessary to provide fresh water and improve the quality of life especially in arid and semi-arid areas such as Iraqi western desert since rainfall is extremely limited. "Water harvesting" is considered one of the most important approaches to face the climate change associated with a shortage of precipitation, or a change in its spatial and temporal distribution, which causes floods and torrential torrents, soil deterioration, drought and high temperatures. Accordingly, for the purpose of water saving, using water harvesting techniques in establishing and rehabilitating nature reserves is an important step.

Wadi Horan is the largest valley in Iraqi western desert, about 16,550 Km^2 with average annually rainfall depths of about 115 mm and great quantities of runoff. Small dams are filled with water in wet years and store water for several years, including dry years. Natural reserve and wide desert oases were established in this valley at period 1973-1980, Al-Massad reserve near Rutbah city reserve succeeded and more than tree thousands of deer

lived. Also the oases were planted with palm and olives groves. But ISIS war destroyed these great projects.

2. Aims of the Study:

This study focuses on developing the study area by achieving the following goals:

2.1 Environment and Ecology Improvements:

a. Improving the environment of Wadi Horan by using rainwater harvesting techniques, constructing small-dams-series will lead to increase the recharge of groundwater, and improve its quality. About 90 km^2 of water surface area of reservoirs originated through 4 dams and 13 proposed small dams. Bird and fish with trees surrounding reservoirs will create a very healthful environment.
b. Surrounding the reserve and the national park by trees and planting forests around reservoirs and shallow wells using renewable energy pumps will create good environment habitations for the plants and animals that live in the desert conditions.
c. Establishing renewable energy stations due to the presence of sufficient sunny hours in general, and high wind speed in areas at mountains of 700 m above sea level around Rutbah city makes it possible to construct a solar energy sheets workhouse near the mine of high quality Cristal near Rutbah.

2.2 Security Aspects:

a. Creating job opportunities in agricultural and pastoral sectors, without violating the valley environment.
b. Planning to increase the population density per unit area within the region's ecosystem.
c. Engaging the valley by oases and surrounded and/or open reserves.

2.3 Desert Tourism

a. Establishing tourist resorts in the national park and near the valley's oases.
b. Construct semi-open zoos within the park.
c. Constructing stadiums such as golf courses, horse and camel riding in the national park.

3. Study Area

3.1 General Description

Wadi Horan is extending for 458 km from the Iraqi-Saudi borders to Euphrates river south of Haditha city as shown in Figure 1. The geographical location of the valley is between the longitude 39˚00" 00' to 43˚00"00' East and the latitude 32˚00"00' to 43˚30'00" North. The valley catchment area is around 16,550 Km^2 and the difference in elevation between upstream and downstream is around 600 m. Wadi Horan region is classified as an arid region characterized with hot summer and cold winter.

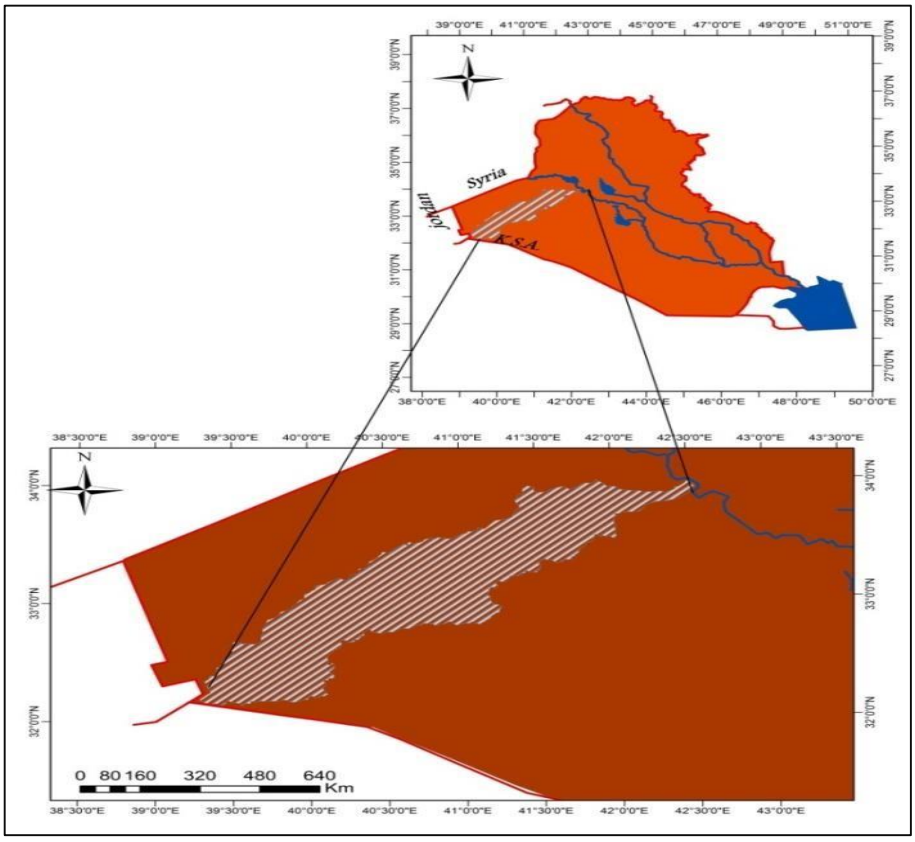

Figure 1: The location of Wadi Horan in Iraq

The western desert contains valleys that receive large quantities of torrents water, namely Horan, Al-Ghadaf, Tabl .... etc. Also, the valleys have several small dams constructed during the 1970s and 1980s with different heights and storage capacities**.** Where there are twelve small dams constructed in western desert and four small dams in Wadi Horan that listed in Table 1. Furthermore, 13 optimal height dams have been proposed to store about 303 million m^3 of water and increase water surface area of reservoirs in this valley from 15 to 90 km^2

which leads to increase the water volume that probably will recharge the groundwater from 4.7 million m^3 to 28 million m^3 per year (Naif and Abdulhameed 2020). It also discharges huge amounts of water as surface runoff during rainy seasons and it has only four small dams as shown in Table 1 and Figure 2. Therefore, many studies were published to cover this important natural phenomena aiming to save as much rainwater as possible. Optimal Height and Location Model (OHALM)) are constructed to design small dam series with optimal heights and locations for Wadi Horan using GIS (Naif and Abdulhameed 2020).

Table 1: Small dams in Wadi Horan.

No.	Dam Name	Accomplished date	Dam Height (m)	Storage capacity (million m^3)
1	Rutbah (Horan 1)	1981	19	32
2	Al-Ubailah	1973	11.5	4
3	Horan 2	2007	15	5
4	Horan 3	2003	15	5.3

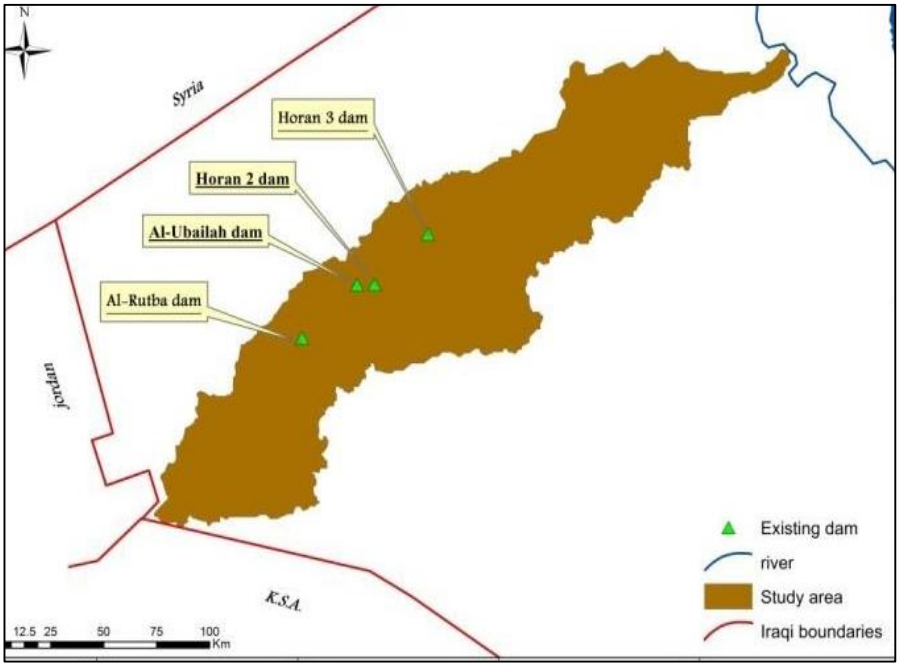

Figure 2: Small Dams in the Study Area

3.2 Geological Description and Groundwater Aquifers.

Wadi Horan is the largest valley not only in the Iraqi Western Desert but in the whole Iraqi Territory. The length of the valley inside Iraq is about 450 Km, and the drainage basin area inside Iraq is 16550 Km^2. The valley includes different forms along its stream; like shallow and wide, deep and wide, and canyon. The valley starts from the Iraqi – Saudi Arabian international borders and even inside Saudi Arabia and runs generally north-eastwards; with slight changes in its main stream trend, exhibiting many right angle meanders. The oldest exposed rocks along the course and banks of Wadi Horan belong to the Upper Triassic Zor Horan Formation, whereas the youngest exposed rocks belong to the Middle Miocene Nfayil Formation. Different Quaternary sediments occur in the valleys course and banks. The main structural elements along the stream of Wadi Horan are a set of NW – SE trending faults, beside extensive jointing of the rocks, especially in the left bank northwest of Rutbah town.

Different geomorphological units and forms are developed along the stream of the valley and on its banks. From economical point of view, enormous amounts of sand and gravel are developed as valley fill sediments. Limestone for cement industry and many other metallurgical industries with huge geological reserves is available in different formations, like Ratga and Euphrates. Pure silica for glass and crystal industry is available in Rutbah Formation. Bauxite and sedimentary iron are available in Hussainiyat Formation. Clays for different industrial uses are available in different formations; like Ubaid, Hussainiyat, Muhaiwir, Hartha, Tayarat and Akashat formations. The different forms of Wadi Horan along its stream with different exposed rocks and developed different slopes along its banks have developed different mass wasting phenomena in different parts. Among the most common forms are: Toppling, rock fall, slumping, creep and very rare sliding.

Figure 3: Horan Geological Map

Geomorphology of Wadi Horan

1- Fluvial units includes:

Terraces, **Flood Plain** (Holocene), **Alluvial Fans** (Holocene), **Valley Fill** (Holocene).

2. Glacis (Holocene):

3. Solution and Evaporation Units include:

Sinkholes Karst Forms, Calcrete.

4- Aeolian Unit includes:

sand sheets, Nabkhas

Weathering and Erosion

The weathering and erosion resistant of the exposed rocks in different geological formations along the course of wadi Horan has caused development of different landscapes in the valley. Therefore, the valley is divided into four main forms:

Gulley Erosion, Sheet Erosion and Rill Erosion

Geomorphological Forms

The common geomorphological forms that are developed along the course of wadi Horan are the following:

Mesa and Butte, Hamada and Sarir, Residual Soil,

Mass Movements

The most common movements are:

Toppling, Rock Fall, Creep,

Drainage Patterns

The most common types are:
Dendritic Drainage, Annular Drainage, Parallel Drainage,

Tectonics and Structural Geology

The whole course of wadi Horan is located in the Rutba Subzone within the Inner Platform of the Arabian Plate. The subzone is generally characterized by simple tectonic scheme and almost no structural geological features, apart from faults of different types [20]. Some of those faults reach the course of the valley and had caused displacements of some geological formations. The displacement ranges within magnitude of few tens of meters; majority of them are strike slip faults, few of the existing faults had shifted the course of the valley. From reviewing the geological maps and the existing faults , it is clear that the majority of the large and acute meanders of wadi Horan are not related to tectonic activity.

Stratigraphy

The exposed rocks along the stream of wadi Horan range in age from Upper Triassic to Middle Miocene with many large unconformities. This wide range of age includes 20 geological formations with wide variety of rocks within the formations and locally within the same formation. Consequently, this diversity in the lithology has formed different forms of the valley along its course and banks. The exposed geological formations are;

-Zor Horan Formation (Upper Triassic)

-Ubaid Formation (Lower Jurassic)

-Hussainiyat Formation (Lower Jurassic)

-Amij Formation (Upper Jurassic)

-Muhaiwir Formation (Upper Jurassic)

-Najmah Formation (Upper Jurassic)

-Nahr Umr Formation (Lower Cretaceous)

-Mauddud Formation (Lower Cretaceous)

-Rutbah Formation (Upper Cretaceous)

-**M'sad Formation** (Upper Cretaceous)

Hartha Formation (Upper Cretaceous)-

-Tayarat Formation (Upper Cretaceous)

-Digma Formation (Upper Cretaceous)

-Akashat Formation (Paleocene)

-Ratga Formation (Eocene)

-Sheikh Alas Formation (Lower Oligocene)

-Shurau Formation (Lower Oligocene)

-Ghar Formation (Lower Miocene)

-Euphrates Formation (Lower Miocene)

Nfayil Formation (Middle Miocene)-

-Quaternary Sediments

Economic Potential.

Different industrial rocks and minerals are available along the stream of wadi Horan and its banks, majority of them are non-metallic. The main industrial rocks and minerals are:

- **Ironstone**

-Bauxite&Flint

-Kaolinitic Claystone

-Montmorillonite and Palygorskite Claystones

-Porcelanite

-Limestone

-Dolomite

-Quartz-sand

-Heavy Minerals Sandstones

- Gravels and Sands

- Geodes

Hydrogeology of Wadi Horan

Wadi Horan is an excellent source for feeding the ground water during rainy seasons. This is attributed to its length and width besides its main branches and tributaries. The thickness of the recent sediments in the course of the valley ranges between 2 – 5 m and locally thicker with slight gradient along its course; ranges from (1.72 – 2.34) %. This contributes in decreasing the surface run off and increase infiltration and recharging the aquifers along the course of the valley. Moreover, many earth-fill dams are constructed along the course of the valley and its main branches.

The Mulussi, Ubaid, Muhaiwir, Rutbah, M'sad, Hartha, Tayarat Akashat, Ratga, Euphrates, formations and Quaternary sediments are good aquifers to yield fresh water. The groundwater level varies from about 300 m below ground surface, in the southern parts to

artesian or near ground surface, in recharge zones along the Euphrates River. Salinity of the water increases with depth and also towards discharge zones. It ranges from fresh in the western parts to very high salinity in discharge areas. Water type also varies from bicarbonate or mixed to mainly chloride or sulphatic in the discharge zones.

3.3 Soil and Morphology Data Sources.

The present study is based on different types of data that were collected from different sources to identify the reserve and park location and the valley properties, besides the optimal height and location of small dams (Naif and Abdulhameed 2020). The Global Digital Elevation Model (GDEM) was taken from the National Aeronautics and Space Administration (NASA) website (earthdata.nasa.gov) in 13-6-2019 as shown in Figure 4. The hydrological soil group map of Wadi Horan was obtained from previous studies, while the soil map based on physical tests were conducted on samples of soil obtained from the study site in the soil laboratory- University of Anbar, as shown in Figure 5.

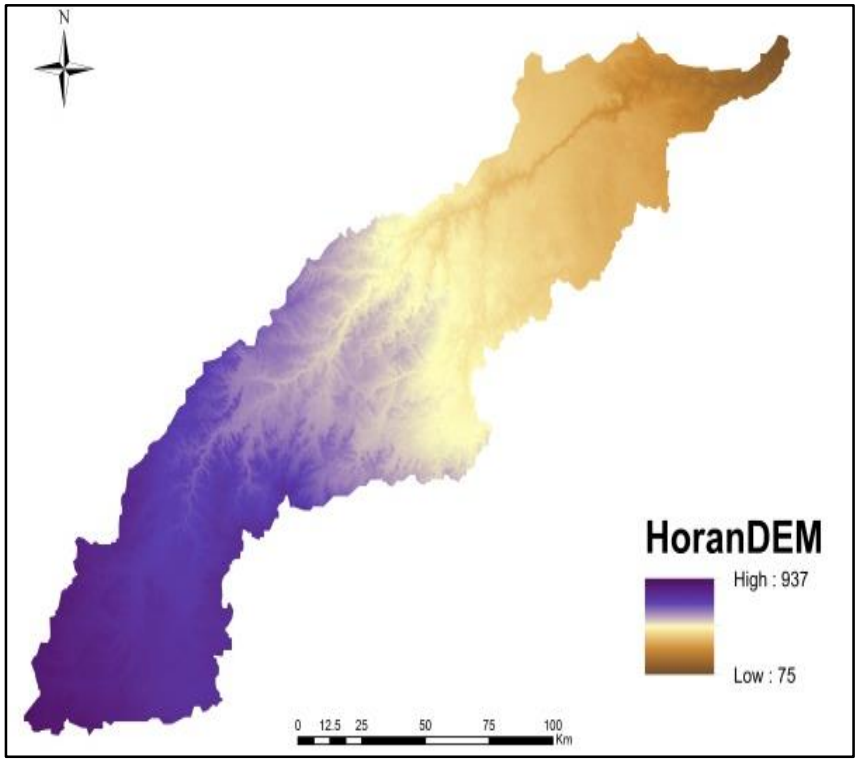

Figure 4: Global Digital Elevation Model for the Study Area

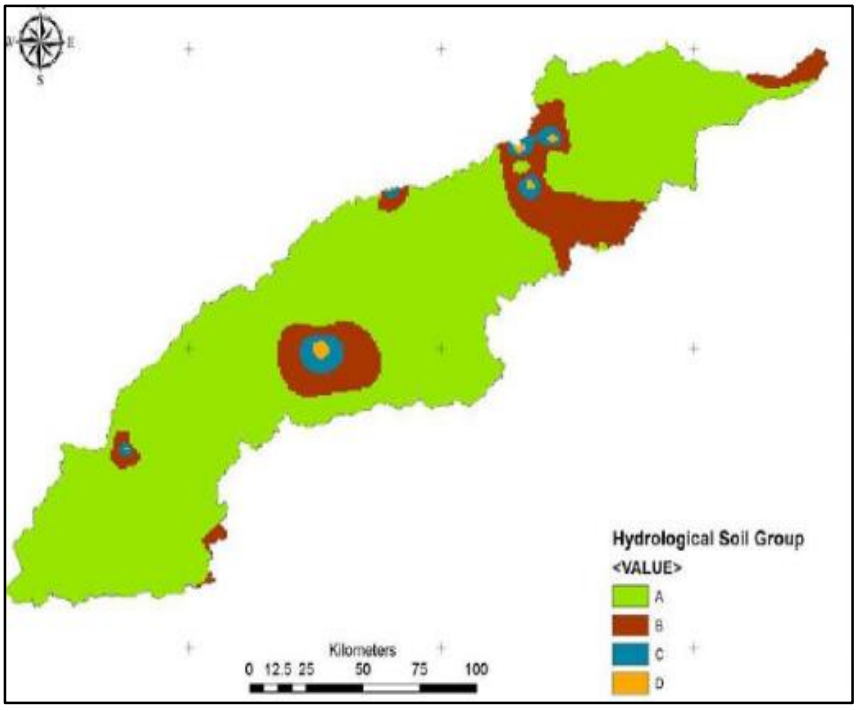

Figure 5: Hydrological Soil Group map. (Sayl *et al.*, 2017)

3.4 Hydrological Characteristics

The average annual rainfall is 115 mm; Wadi Horan is characterized by considerable temperature ranges between (0 - 48) C˚. The annual evaporation value for the study area ranges between (1600-1900) mm as shown in Table 2 and Figure 6. The highest evaporation value occurs during the months of June, July and August.

Table 2: Climatic factors from Rutbah Station, period (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

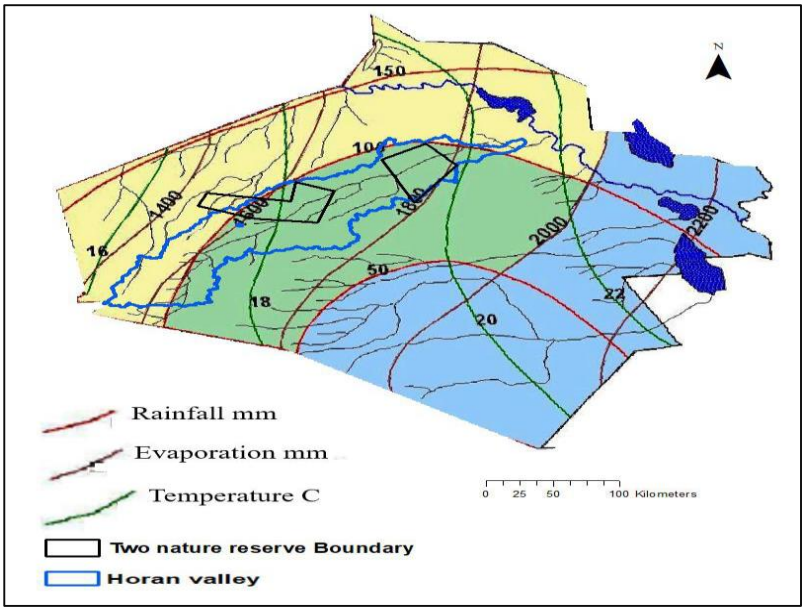

Figure 6: Distribution of Rainfall, Evaporation and Temperature.

About billion m^3 of rainwater may be discharged in rainy season to Euphrates river in some years with average yearly value about 400 million m^3. (Kamel, 2012), (AlJawad and Al-Ansari 2017). The catchment area of Wadi Horan with its large tributaries like, Hussainiyat, Mihzam, Saqqar, Amij is about 16550 km^2. Infiltrating of one mm of rainwater means feeding aquifers by 16.55 million m^3. The best proposed locations of small dams are shown in Figure 7, while the best locations of rainwater harvesting are shown in Figure 8.

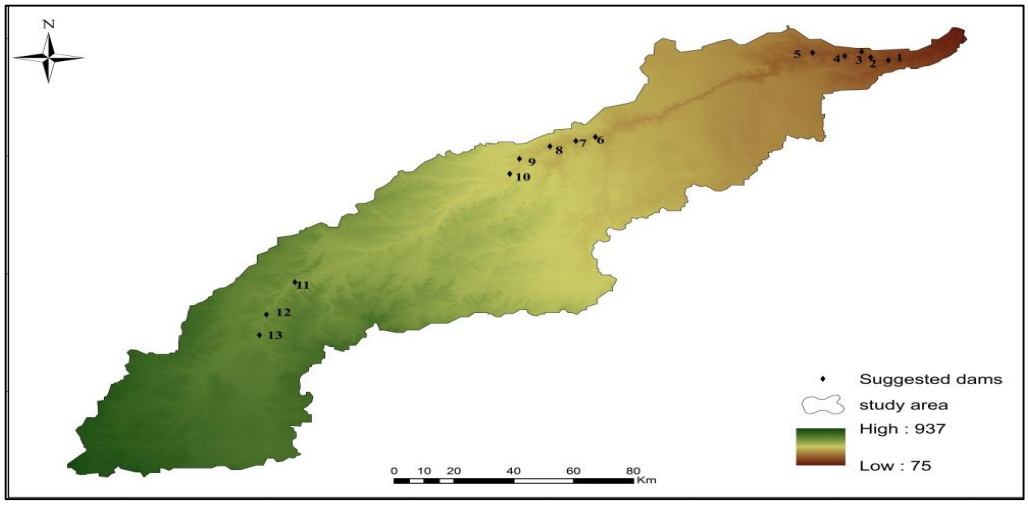

Figure 7: Proposed 13 Small Dams Series, Source: (Naif And Abdulhameed, 2020)

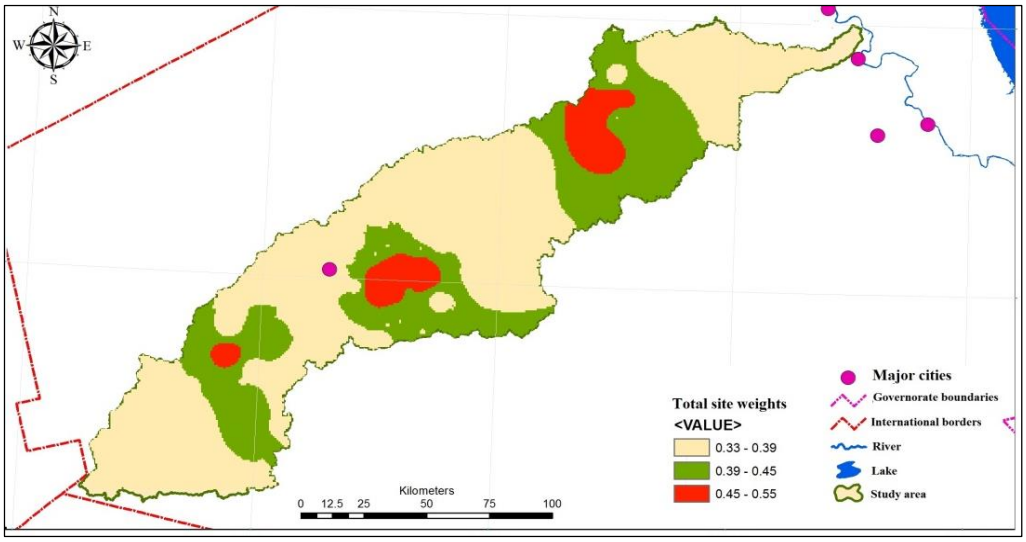

Figure 8: Categories of Water Harvesting Areas in Wadi Horan.

3.5 Hydrogeological Characteristics:

The direction of groundwater discharge in the Iraqi western desert is mostly to the east and northeast, to the drainage area represented on the western (right) bank of the Euphrates river, but there are different local directions for flowing through the region depending on the geological setting of the region and their topographical and structural characteristic (Saleh et al., 2020). Several depressions exist in the Iraqi western desert, which receive water from large valleys. The Ga'ara aquifer is one of the main aquifers in the region due to the large width of the valley and high water content. Most of the aquifers are recharged from rainfall and runoff of the intermittent valleys. (Al-Jiburi and Al-Basrawi, 2007). The groundwater level varies according to the geological formation of the area, whereas it is extracted by well drilling and this method is widespread in Anbar governorate. The wells, depths ranging between 10 m to 700 m, are located in high areas source their water through the marine sediment or the remaining of ancient saline ponds. The Figures 9 and 10 illustrate the groundwater flow direction and geographical distribution of the groundwater depth.

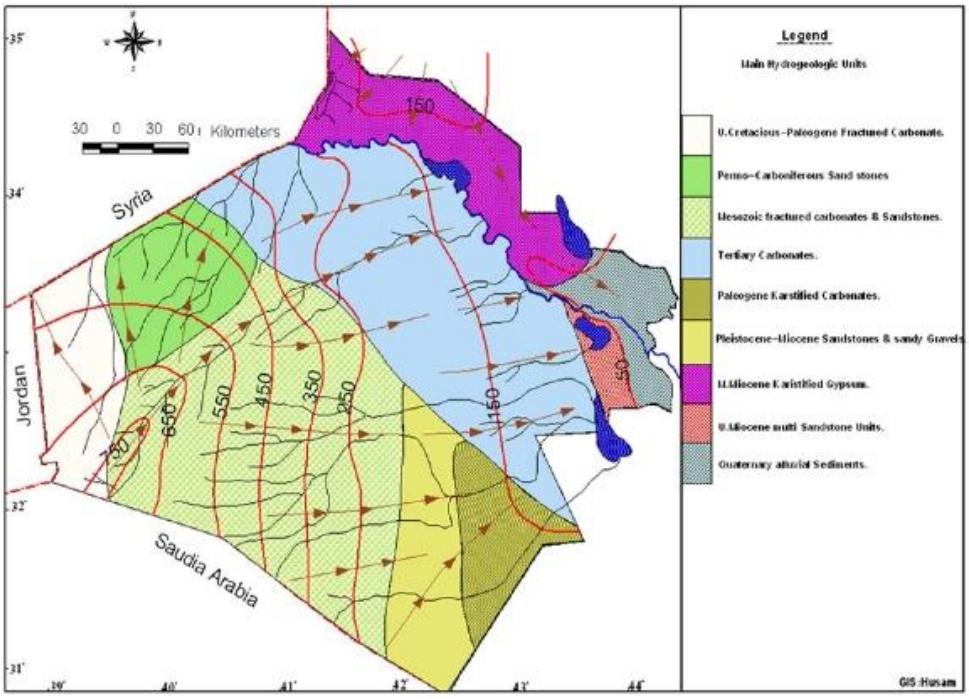

Figure 9: The Hydrological System Distribution Over Anbar Governorate (Hussein, 2010)

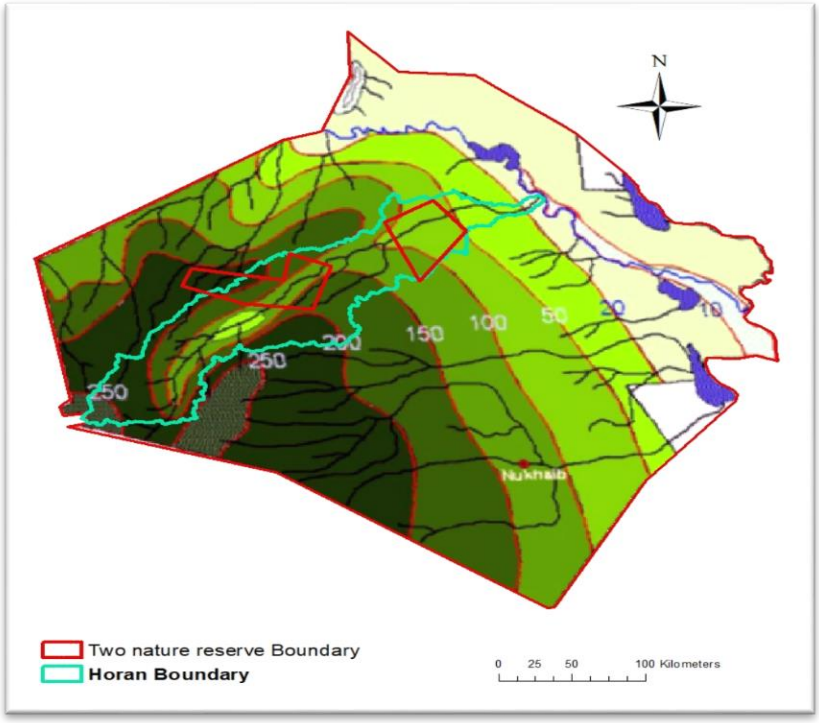

Figure 10: Groundwater Depths (Hussein, 2010)

3.6 Biological Characteristics:

3.6.1 Plants

There are many oases in Wadi Horan. Albayati and ALalwany, (2011) studied the vegetation species in Wadi Horan and compared their findings with what was reported by Guest (1966), who found disappearance of some species due to variations in the physical environment within the oases, therefore; it is very important to construct natural reverse to protect the valley's environment. Most plants in this valley are Haloxylon salicornicum, Helianthemum aegypticum, Artemisia scoparia, Centaurea sinaica, Salsola barysoma, Ducrosia anethifolia, Gundelia tourneforti, Avena barbata, Hordium spontanium, Avena wiestii and Iagonychium farctum. Trees like Date palms, Olive, Opuntia spp, and Eucalyptus spp are shown in Appendix 2A, while Appendix 2B shows the trees of high drought tolerance.

3.6.2 Animals

In 1970, a deer sanctuary was established in Wadi Horan. The gazelles have historical significance in Iraq through their drawings that were found in the monuments of Babylon, especially the dama - dama species, which thereafter extinct consequently the government which was forced to import the gazelles from Bulgaria and breeding them to be adapted to the Iraqi local conditions. Due to its importance to the Arabs, it was mentioned in Arabic literature and poetry, and gained distinction in the poems of many poets. In addition to the dama - dama species, there is the Iraqi reem, which is a wild deer characterized by the beauty of shape and agility, and its color is bright red. Furthermore, many other types were found in Iraq and some Arab countries, including the Arabian Oryx, red Ibex, Antelope, deer and mountain deer. Iraqi Ministry of Agriculture requested from the International Union for Conservation of Nature and some countries concerned with wildlife have been contacted to supply these reserves with new and rare species and develop Al-Masad nature reserve near Rutba city. Other animals live in the western desert like Camel, Deer (Gazella subgutturosa), Rabbit, wolf, Wild Rabbit, Gray Wolf, Goat, Sheep, Brown Fish, Jackal, birds like Pterocles, Deer Falcon, Al-Shaheen, and Houbara as shown in Appendix 3.

4. Surface Runoff and Groundwater Recharging

4.1-Rainfall-Runoff Relationships.

Little hydrological information is available about wadi horan area, because it contains only one weather station in Rutba city and no hydrometric stations in the valley and the surrounded areas. Flooding occurred in certain dates, and no rainfall intensity or any surface runoff was recorded. This occurred in 25/11/2018 and 2/12/2019, as shown in Figure 11. The cross suction area of the flow below the bridge is 610 m^2. The flow velocity below the bridge is about 3 m/sec, which means that the discharge is about 1800 m^3/sec. So the volume of discharge per one hour is 6.48 million m^3. That means all reservoirs in this valley are completely filled (if they are empty before this storm) at only 7 hours of this discharge (Abdulhameed *et al* 2020). The duration of Wadi Horan discharge in heavy storms are not less than 10 days. The peak flood value will occur early then decreases gradually during one or two days of the flooding time. Small dams were filled by rainfall harvested water in wet years, and still store many millions cubic meters during dry years, which is clearly shown in figures a-f (Appendix 4). It is very difficult to predict the rainfall-runoff relation in western desert of Iraq because of the lack of hydrological data. Table 3 and Table 4 show the annual rainfall data and the volume of runoff in Wadi Horan (H1, H2, Horan bridge) during 1971 - 2019 period.

Figure 11: Flooding in Study Area (2/12/2019) (Bmmagazine, 2019)

Land cover, land use and soil properties lead to predict runoff by using hydrological models. So the Watershed Modeling System (WMS) will be used to estimate the runoff using remote sensing data. Multiple steps are required to produce the necessary layers in WMS Tools (Sulaiman *et al.*, 2019). Wadi Horan has the largest value of surface runoff and water harvesting volumes among other valleys in western desert as shown in Table 5. The analysis of wet years and dry years was explained in Appendix 4.

Table 3: Annual Rainfall Data

Year	Rainfall mm	State	Year	Rainfall mm	State
1971	139.7	Wet Year	1996	93.8	Dry Year
1972	219.1	Wet Year	1997	98.8	Dry Year
1973	66.3	Dry Year	1998	268.4	Wet Year
1974	167	Wet Year	1999	31.3	Dry Year
1975	125.8	Wet Year	2000	55.8	Dry Year
1976	138.4	Wet Year	2001	103.3	Dry Year
1977	96.9	Dry Year	2002	103.5	Dry Year
1978	80.9	Dry Year	2003	109.9	Dry Year
1979	52.5	Dry Year	2004	95.6	Dry Year
1980	138.3	Wet Year	2005	124.5	Wet Year
1981	97.2	Dry Year	2006	107.5	Dry Year
1982	143	Wet Year	2007	72.2	Dry Year
1983	128.7	Wet Year	2008	72.9	Dry Year
1984	42.6	Dry Year	2009	23.3	Dry Year
1985	119.9	Wet Year	2010	109	Dry Year
1986	107.5	Dry Year	2011	87.9	Dry Year
1987	63.4	Dry Year	2012	73	Dry Year
1988	216.3	Wet Year	2013	134.2	Wet Year
1989	163.6	Wet Year	2014	83.3	Dry Year
1990	90.9	Dry Year	2015	8.2	Dry Year
1991	70.9	Dry Year	2016	11	Dry Year
1992	130.8	Wet Year	2017	6	Dry Year
1993	130	Wet Year	2018	101.8	Dry Year
1994	64.1	Dry Year	2019	134.9	Wet Year
1995	339.5	Wet Year			

Table 4: Results of Surface Runoff volume for the Study Area (Naif, 2020)

		H2	H1	Bridge
Date	**Rainfall mm**	**volume of runoff Mm^3**	**volume of runoff m^3**	**volume of runoff Mm^3**
1971	139.7	87.87	43.788	36.226
1974	167	0.152	0.2169	0.0714
1989	163.6	0.152	0.2169	0.0714
1990	90.9	4.905	2.963	2.0129
1992	130.8	……..	0.321	……..
1993	130	4.221	2.818	1.861
1994	64.1	41.941	21.729	18.119
2006	107.5	0.2005	0.255	0.092
2008	72.9	0.0356	0.107	0.0195
2010	109	5.3876	3.2199	2.208
2011	87.9	7.235	4.193	2.954
2013	134.2	58.205	30.76	23.494
2014	83.3	0.457	0.439	0.20004
2018	101.8	44.8403	22.953	18.032
2019	134.9	2.297	1.604	1.251

Table 5: The Physical Characteristics and Harvesting Volumes of Western Desert Valleys. (Sulaiman *et al*, 2019)

Valleys	**Area (km^2)**	**Length (km)**	**Slope (%)**	**Yearly harvesting (m^3/ km^2)**
Horan	13,340	490	0.162	15,355.36
Al-Abeith	6515	340	0.169	4582.31
Al-Ghadaf	5900	165	0.236	7098.64
Ameg	5399	170	0.223	6405.22
Al-Awaj	1246	60	0.28	4782.34

4.2 Groundwater Recharging

When the sediment loads disposed in the reservoirs behind small dams, the fine particles will decrease the hydraulic conductivity of the soil in the reservoir bed. The conductivity will decrease and it will approach to the minimum value about $1*10^{-8}$ m/sec (Mortezaei and Karimpour, 2017). Consequently, about 31.54 cm of water will be infiltrated to ground water every year. Multiplying this depth by reservoir bed area which is equal to the volume of water that recharges the aquifers every year from small dam's reservoirs. It is about 4.7 million m3/year from the existing 4 dams, and it extends to 28 million m^3/year if the proposed small dams series are constructed. Other recharging volumes are due to infiltration of rainwater and surface runoff among 16550 km^2 (the global valley's area). It is very important to establish weather station network in this strategic valley in order to collect more representative data that enable to study its hydrological features.

Valerie Kotchoni *et al* (2019) found that the recharge occurs seasonally and linearly in response to rainfall exceeding an apparent threshold of between 140 and 250 mm $year^{-1}$ at annually rainfall depth of 1200 mm $year^{-1}$. Therefore, the recharge depth is 11.7% to 20.8% of rainfall depth. Since this study was conducted in humid zone and Wadi Horan is in semi-arid zone, so the lower ratio is more significant and the ratio of 10% assumed to be acceptable in this study. From the valley Isohyets map (Figure 6), the average rainfall depth is 91 mm year−1. Therefore, about 9 mm is recharged annually to the groundwater aquifers. The valley area is 16550 km^2, the recharging volume of rainwater is 180 million m^3 year−1.

About 31.5 cm of water was infiltrated from the reservoirs behind small dams to the groundwater aquifers yearly (Abdulhameed *et.al*. 2020). About 2% of rainwater depth was recharged to these aquifers directly from rainfall and surface runoff, the infiltration rate in bare soil is greater than the reservoir bed, but the time of the rainfall and its surface runoff is very limited where about 80% of rainwater is consumed by the plants and about 15% is discharged to reservoirs, so the recharging volume per year can be assumed as 5% of rainfall depth. The average rainfall depth in Wadi Horan is about 100 mm/year, although 5cm infiltrates to aquifers in this valley every year, but according to very little information, current study supposes that only 1 cm infiltrates every year to the groundwater. Therefore,

it is very important to construct an observation wells and monitoring the water table and/or phreatic lines of confined and unconfined aquifers. Table 6 explains the recharging volume per year. So about 180 million m^3 are stored every year in Wadi Horan aquifers.

Table 6: Recharging quantities to the valley aquifers. (By researchers)

Recharging resource	Annually Recharging depth, cm	Recharging Surface Area, km^2	Annually Recharging Volume, Million m^3
Existing Reservoirs	31.5	15	4.725
Proposed Reservoirs	31.5	75	23.625
Bare Soil of the Valley	0.91	16550	150.6

5. Natural Reserve and National Park:

It is very important to construct a natural reserve in this valley in order to maintain the ecosystem and save the animals and birds. One successful natural reserve was constructed near Rutbah city in 1974, but this reserve was destroyed after the ISIS war. In addition, a national park is very important to hebetate small green villages in this valley, established a desert tourism, and maintain the security in this region.

5.1: Planting System.

Regarding the planting system, crops and trees with limited water requirements should be selected to maintain the groundwater sustainability, for example, cactus pear value of the mean crop coefficient approximately 0.40. Furthermore, date Palm, olive and sidr can be planted under deficit irrigation strategies.

Deficit irrigation technique must be applied in this semi-arid valley, the level of irrigation supply under deficit irrigation may be achieving 60–100% of full evapotranspiration. Several cases on the successful use of Regulated Deficit Irrigation (RDI) in fruit trees and vines are showing that RDI will increase the water productivity. The main objective of RDI strategies is to increase its adoption in water-limited areas. (Consoli *et al* 2013).

5.2 Water requirements:

In order to maintain groundwater sustainability, the deficit irrigation and especial crops must be planted. If plant coefficient is 0.4 as a cactus pear, and the average evaporation depth is 1700 mm year^{-1}, then the average of water requirements is about 680 mm year^{-1}.

The Irrigated Area (IA) can be estimated as a ratio of annually rainfall depth to the water requirements as in the equation 1:

$IA = \frac{Rf}{ETc} * 100\%$ ……. (1)

If planting cactus pear,

IA= $\frac{90}{680}$*100% = 13.23%

That means the rainwater can maintain the requirements of only 13% of the area if it is compared with the area planted near a river or sufficient renewable water resource. Cactus pear trees were spaced 5 × 6 m apart (333 trees ha−1), then a number of trees in the valley TN_v is:

$TN_v = TN_i * IA$ ……. (2)

$$TN_v = 333 * 13.23\% = 44\ trees\ ha^{-1}$$

For olive, and Palm, the average crop coefficient is about 1, but by using deficit irrigation with 60% of water requirements, then the average irrigation water depth Id is:

$Id = 1700 * 60\% = 1020\ mm\ yeer^{-1}$

From equation 1, the Irrigated Area (IA) for Palm and Olive are:

IA= 90/1020*100% = 8.82 %

Olive planted at a high density of about 494 to 856 trees per hectare, while Date Palm is planted as 125 trees per hectare.

Assuming two rows of date palms and one row of olive in order to save the olive from the summer sunshine, two- thirds of the area planted by date palm of 125 trees per hectare, i.e. only 83 date palms have to be planted per hectare. One- third is planted by olive, if the

lower limit of planting density (494 trees per hectare) is selected, then only 165 are planted per hectare.

Using equation 2 to estimate the number of each type of trees per hectare.

$TN_{v\ for\ olive} = 165 * 8.82\% = 14 \frac{trees}{hectar}$.

$$TN_{v\ for\ palm} = 83 * 8.82\% = 7 \frac{trees}{hectar}$$

As we planting a row of 50m length and a spacing of 200m between adjacent rows, it is better to plant only 11 olives per hectare as a mid-row between two rows of date palms as shown in figure 11. The distance between two adjacent date palm is 16.67m and between mid-olive row is 5m date palm as shown in figure (10) will plant as external boundary of the reserve at both sides of Wadi Horan. The rainwater depth average is greater than 100 mm/year. Surface runoff coefficient in this valley is about 15%, so 15 mm of rainwater is flow over ground surface, so one hectare will supply 150 m^3 of rainwater, that mean each km length of external boundary will be contain 668 date palm trees and 334 olive trees. Appendix 5 explains the water harvesting theory with solved example.

5.3 Planting Program and Techniques:

The surrounding trees will be planted in five stages, one stage every year. After observing the available wells, digging a well for every 5 km of the reserve boundary. Only one km at the reserve surround is planted near each well in the first year while the other four kilometers will be cultivated over four years, at a rate of one kilometer per year. The surrounding trees row length is equal to the boundary length of the reserve while the total row width is one km. This km width is divided into five rows of 2.5 m to 6 m width. Figure 12 explains the external row of date palm and olive of 6 m width, while the cactus peer row is of 2.5 m width. The spacing between each two adjacent rows is 200 m as shown in Figure 13.

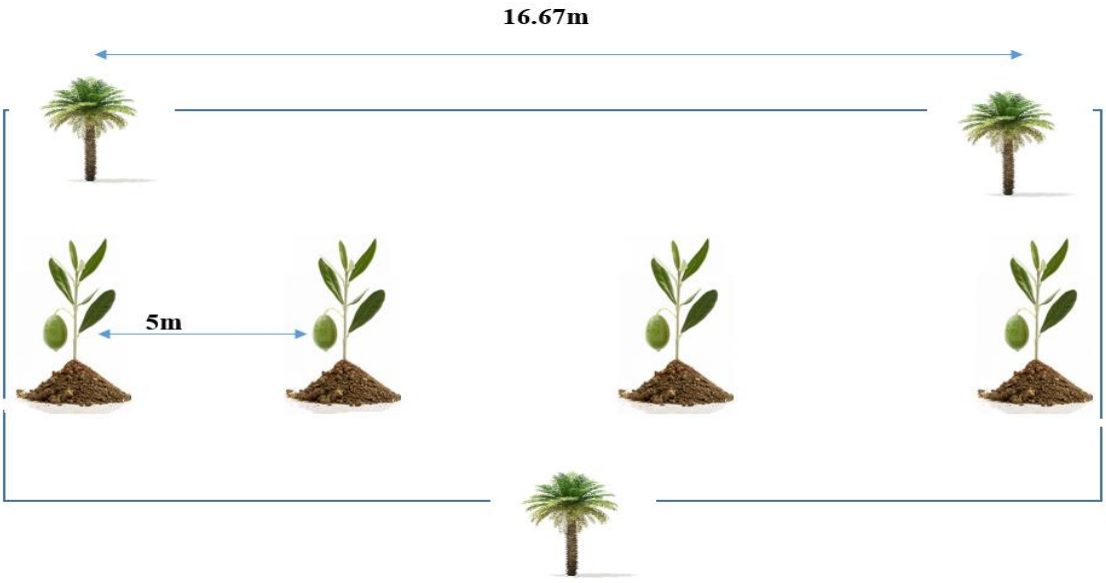

Figure 12: Surround planting layout of date Palm and olive.

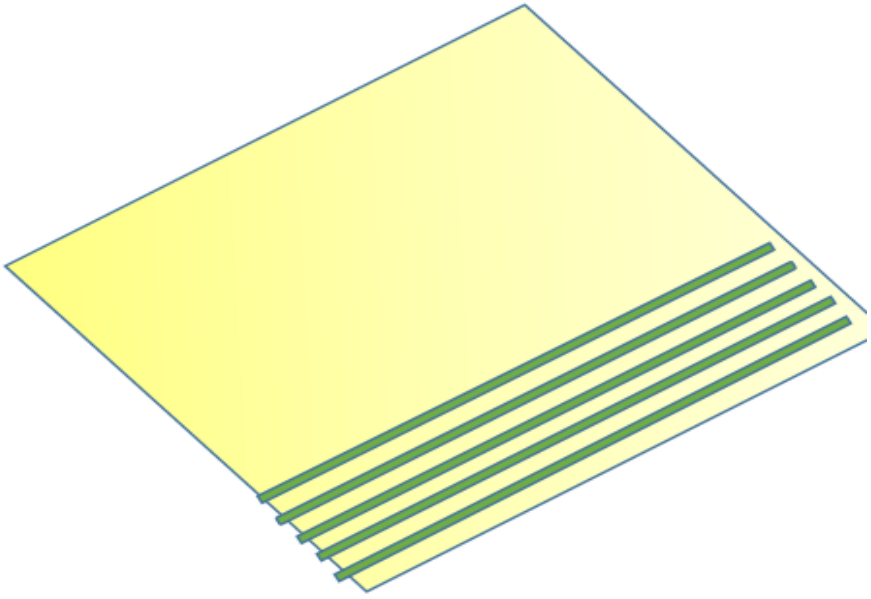

Figure 13: Five trees rows at one surrounded side of the reserve, 200m between each neighboring rows.

5.4 Time and method of planting trees:

Each tree will be planted in a pit 70 cm deep and 80-100 cm in diameter of alluvial or clayey soil 50 cm deep. Then this soil will cover with 20 cm of gravel to store more quantity of rainwater and reduce evaporation losses from soil surface by up to 90% of evaporation losses. Trickle irrigation will use under deficit irrigation technique in summer months. Trickle emitters and moisture content sensors will be installed carefully within the root zone under the gravel layer in order to minimize evaporation losses. Solar-energy submersible pumps will use to discharge water to the trees when the soil moisture sensors indicate that the water content decreases below the permissible limit within the deficit irrigation technology. The planting time will start at the beginning of rainfall season on October, and irrigate each tree at the same planting day, then depends on the rainwater harvesting until reaching the summer season and the sensor operates the solar energy submerged pumps in the wells. The surrounding trees are plants from five stages at ten years, one stage every two years in order to minimize the irrigation process.

5.5 Trees Numbers in the Nature reserve and National Park surrounds

5.5.1 Natural reserve surrounds:

The natural reserve which surrounds length is about 262.4 km, as shown in Figure 14.

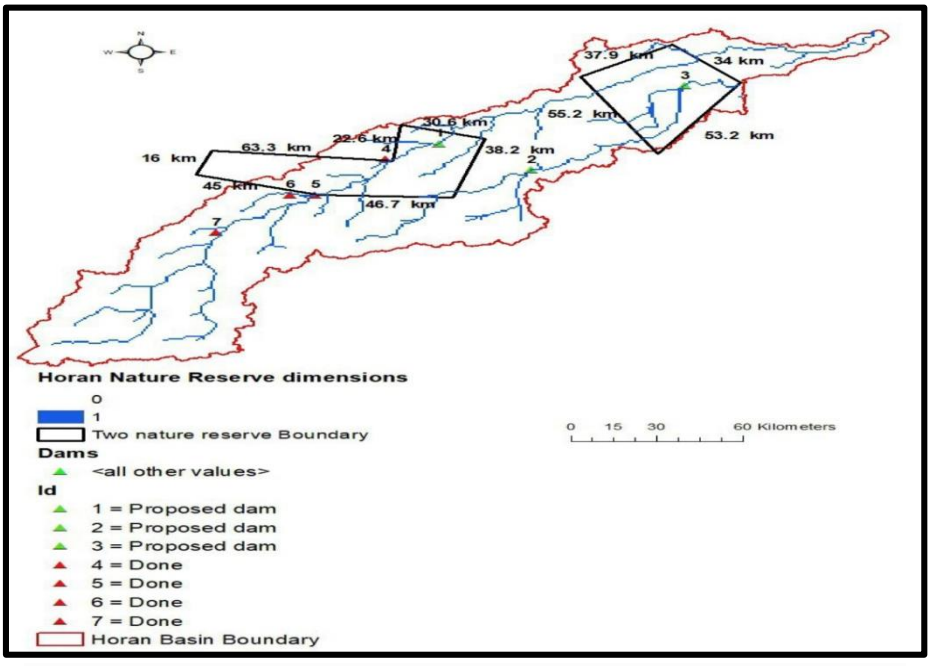

Figure 14: Wadi Horan Natural reserve and national park locations.

Regarding Date Palms and Olives surround, each km will be planted by 70 Palms and 140 Olive trees. In each row there are 18,378 Palms and 36,735 Olives. As each hectare is occupied by 83 Palms or 165 Olives, then these members of trees mean that Palms and Olives are planted about 444 hectares. If olive tree yield is at its lower limit, 25 km per tree, so 918 tons of olives per year is harvested. Date Palm yield is not less than 100 kg per tree, so 1800 tons per year will be harvested from each surrounding rows. To decrease the planting costs by minimizing the number of pumping wells that dug around the reserve, we suggest that planting one km and leaving 4 next kilometers in the first ten years of planting. The irrigation process is evaluating every year. Only one well has to be dug in every 5 kilometers length of the surrounding and planting trees that need not to irrigated (Drought Tolerance) except at first two or three years and then this depends on rain fall harvesting only. Planting the external two rows by Date Palm and Olive then planting tree internal rows by trees of very low water requirements like Sidr. Contour furrows to harvest rainwater are to surround all trees rows. The two external rows will irrigate in summer of the first two years only by pumping water from wells or small dam's reservoirs by using solar energy pumps. Trees that are very tolerant of drought and salinity must plant the center of the reserve because of the difficulties to irrigate this zone. There are two small dams which are constructed at the reserve upstream. These reservoirs are used to irrigate the reserve surrounding, while the third small dam at the mid zone can be used to irrigate trees and the animals living at the reserve center, as shown in Figure 15.

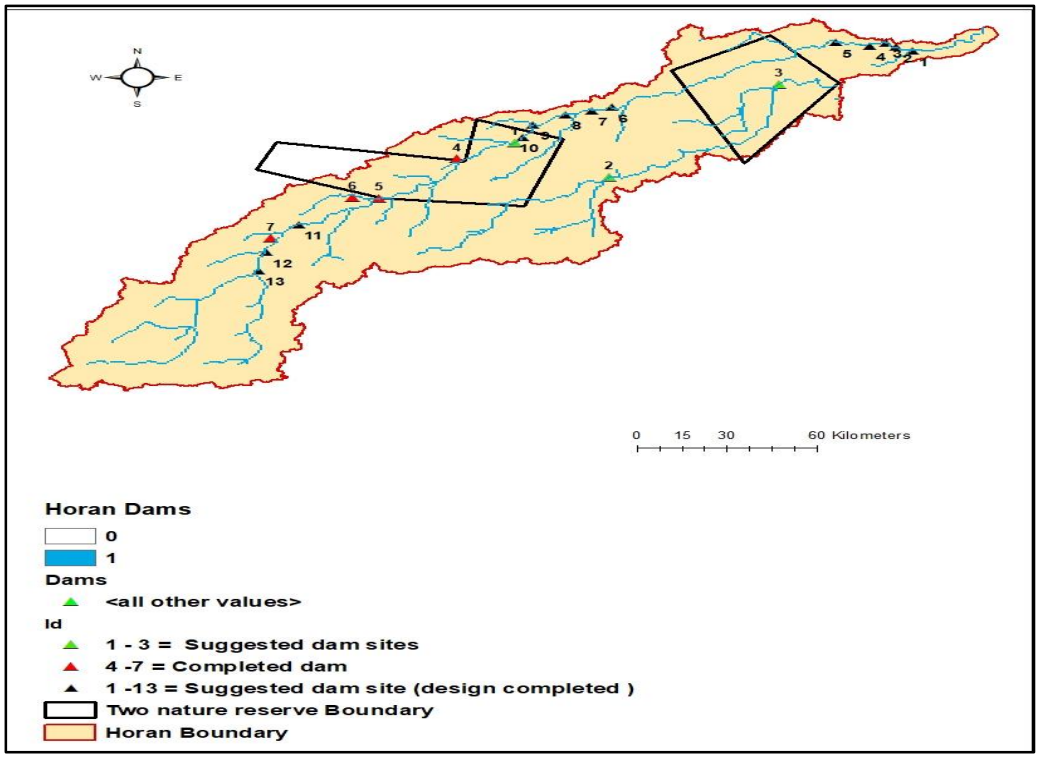

Figure 15: Dams at Wadi Horan.

5.5.2 National Park Surrounding

As shown in Figure 14, the length of the park surrounding is 180.2 km. This distance is about 69% of the reserve surrounding, so about 12,637 Palms and 25,260 Olives will be planted per row. If three rows are planted here, 3791 tons of palm dates and 1892 tons of olive are to be harvested every year. Other two surrounding rows were planted by cactus pear trees. The center of the reserve will contain some small dams and flow measuring structures; everyone is saving rainwater behind it. These water quantities are used to irrigate plants and animals in the zoo.

5.5.3 Central Reserve

Reserve Center is a protected area with a specific design for the preservation of renewable environmental resources in the main natural reserve and the application of good systems for their exploitation, and it is supervised by a certain office. The afforestation of reserve center will be by selecting drought-tolerant trees as mentioned in Table 7. Using the drought-tolerant trees will facilitate the central reserve management through reducing the labor and cost of irrigation and fertilization (using fertigation) of the trees especially during the first stage of the Reserve construction.

Table 7: Trees of high tolerance to drought.

No.	Scientific name	Common name
1	Pinus sliveatris	Scots pine
2	Acacia spp	Acacias
3	Tamarix desrti Boiss	Athel pine
4	Ziziphus spina Christi wild	Christ's thorn jujube
5	Capressus sempervirens var. horizontalis	Italian cypress
6	Cupressus Sempervirens var. Pyramidalis	Mediterranean cypress

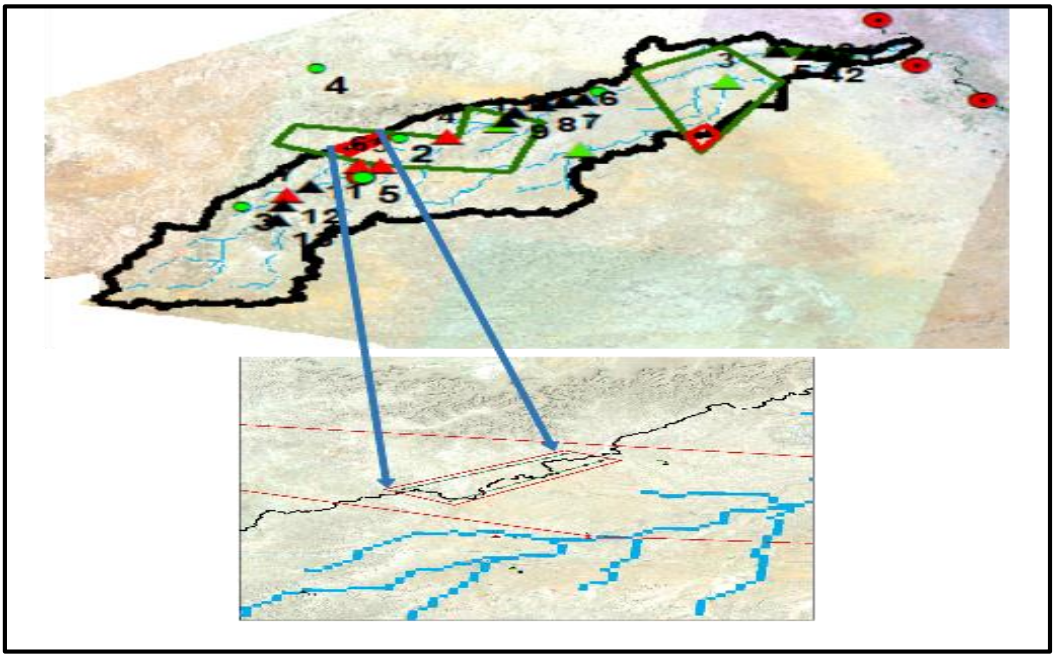

Figure 16: Central Area in the Nature Reserve – Wadi Horan.

The central area was located, as shown in Figure 16 in the north of the Nature Reserve, with an area of 214 km^2.

Water harvesting techniques and digging wells will be used in central area to develop the agricultural field, increase vegetation cover, grazing, livestock development, forest development in addition to contributing in food security in this region. For utilizing groundwater in the development of the central area, 20 wells will be drilled to extract the water as shown in Figure 17. The first well is at a distance of 1 km from the eastern border of the reserve. The distance between two successive wells is 2 km. The wells will be operated by remote control via control towers used renewable energy.

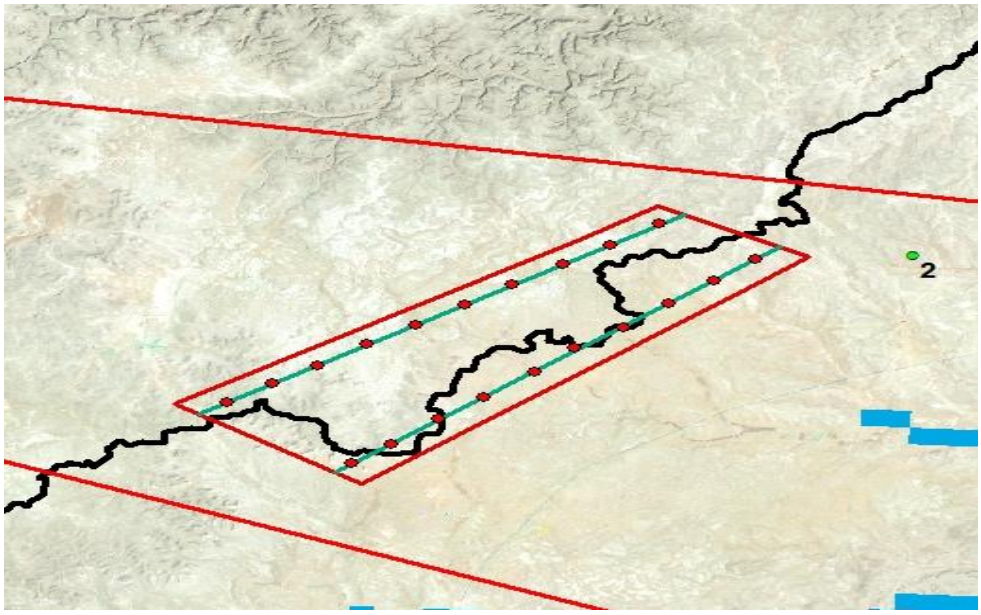

Figure 17: The Locations of Wells in Central Area in The Nature Reserve

The cross sections of the central reserve as shown in the Appendix 6 show the possibility of constructing a number of small dams at heights ranging from 2-4 m that can provide large quantities of water for long periods to reduce the groundwater pumping. The management of pumping wells will be controlled by monitoring towers to ensure the availability of drinking water for animals at a distance ranging between 2-3 km. Regarding the irrigation of plantings and crops, all the trees that will be planted in this area with drought-tolerant and are surrounded by the water harvesting systems that are illustrated in the Appendix 2B. Due to the shortage of rainfall in the areas of the natural reserve and the national park, in addition to the large depth of ground water, the process of drilling wells is

an urgent necessity to provide a permanent source of water for various purposes. The wells costs are shown in Table 8

Table 8: Costs of Wells in Nature reserve

Well depth (m)	Number of wells	Drilling cost/m $	Total drilling Costs $	Price unit of Submerse pump $	Total Pumping Cost $	Cost of Solar cells with accessories $	Total cost $
150	20	25	75000	500	10000	46000	131000

5.5.4 Central Park

Central Reserve can be used for environmental conservation purposes. These parks are considered as nature reserve, semi nature reserve, or developed lands that a sovereign state declares it owns. Figure 18 shows the national park and center park.

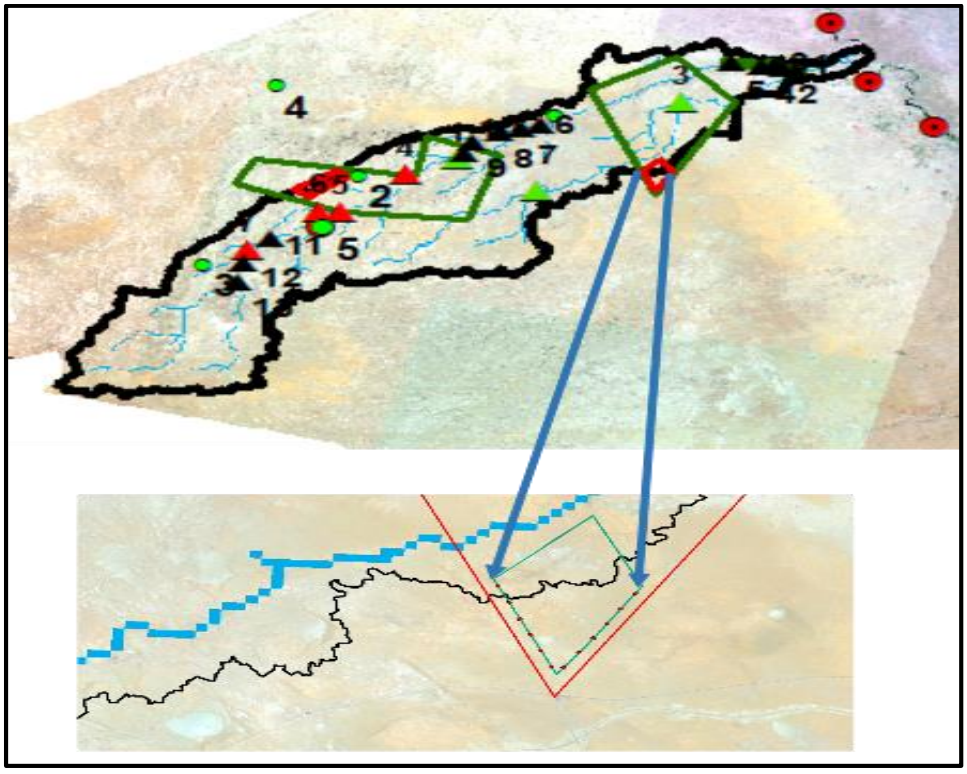

Figure 18: Central Park in the National Park – Wadi Horan.

For the purpose of utilizing groundwater in the development of the central park, 12 wells will be drilled to extract the water as shown in Figure 19. The first well is at a distance of 1 km from the eastern border of the reserve, the distance between two adjacent wells is 2 km. The outer boundaries will consist of several rows of trees close to each other. While, fences will be built around important facilities only. Regarding the facilities, the central park will contain recreational spaces including parks, barbeque places, toilets, cricket nets, and a playground with swings, cable car and slide.

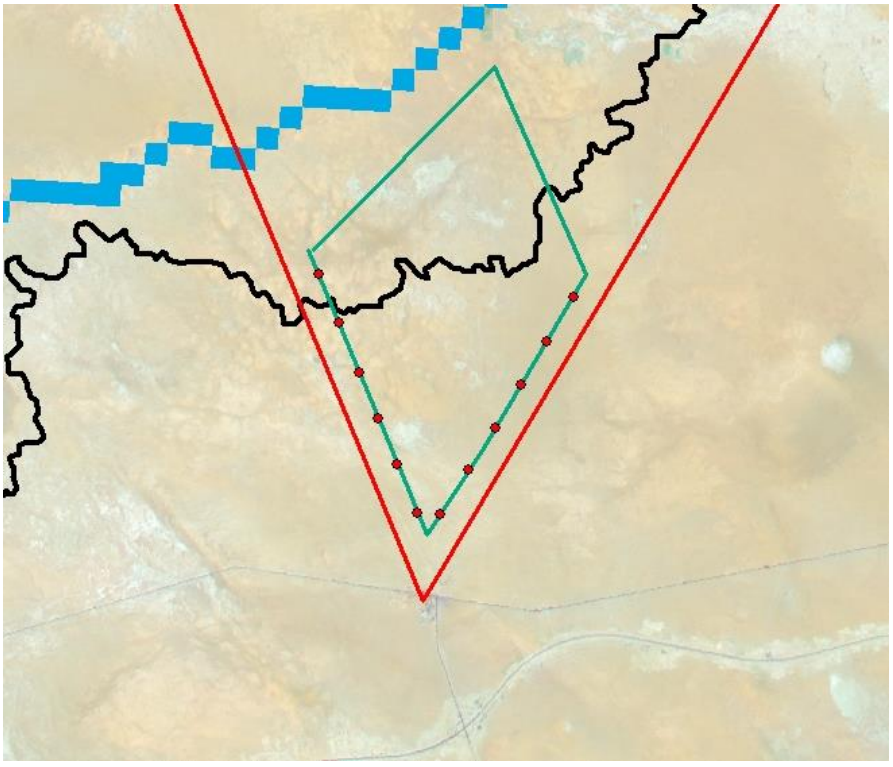

Figure 19: Central Park in The National Park.

Table 9: Costs of Wells in National park

Well depth (m)	Number of wells	Drilling cost/m $	Total drilling Costs $	Price unit of Submerse pump $	Total Pumping Cost $	Cost of Solar cells with accessories $	Total cost $
200	12	25	60000	500	6000	27600	93600

5.5.5 Oases in The Park

In the oases several types of drought-tolerant trees will be planted, such as high-oil olives, date palms, pistachios, and windbreaks of all kinds, in addition to the presence of nurseries for the production of all types of seedlings. There are four oases in Wadi Horan, one of them within the park and about 35 km from the central park as shown in Figure 20.

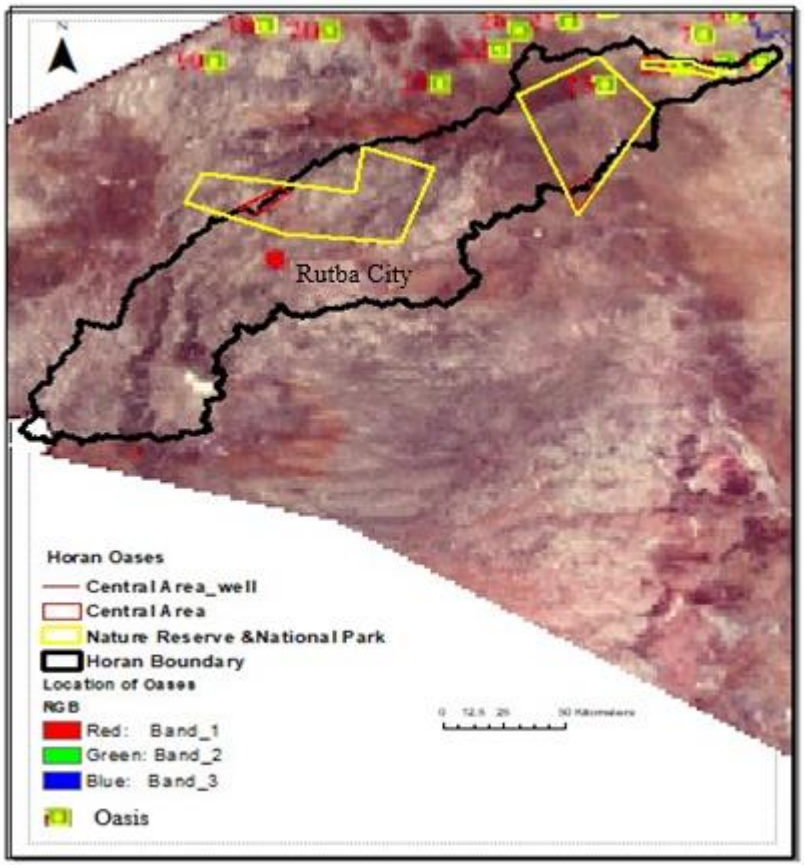

Figure 20: Horan Oases

6 Required devices, stations and structures:

6.1 Flow measurement:

It is very important to construct flow-meter stations to estimate the valley discharge in rainy seasons. The broad crested weir is a hydraulic structure widely used for flow measurement and depth control in the field and laboratory. The geometry described as a flat-crested structure with a length (L) of crest large enough compared to the flow thickness over the crest of the weir. It is broad when the flow lines are parallel to the crest and the pressure distribution is hydrostatic as shown in Figure 21.

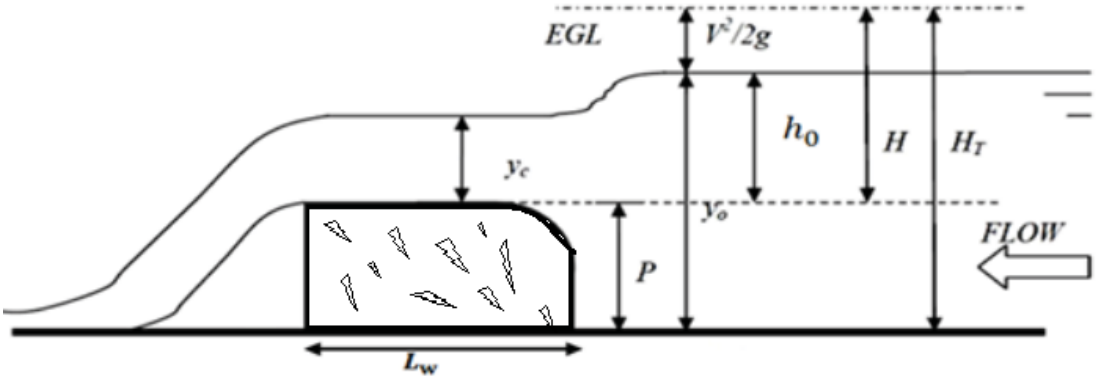

Figure 21: General shape of broad crested weir

The discharge equation of the weir represents a function of the head over weir crest and the geometrical weir (Eq. (1))

$$Q = CLH^{\frac{3}{2}} \dots\dots\dots\dots (1)$$

Where; Q is the discharge, C is the dimensionless coefficient of discharge, H is the head over the U/S weir crest to the free surface, and L are the width of the weir. More detailed about the scientific basis for the design of the discharge meter in Appendix 7.

6.1.1 Location of Flow Measurement Weir:

The proposed location for flow measurement weir is illustrated in Figure.22 that can give indicator for runoff or flow discharge from Horan catchment area to Euphrates River. Figure 23 shows the geometry of weir site, while Figure 24 explains the details of proposed design.

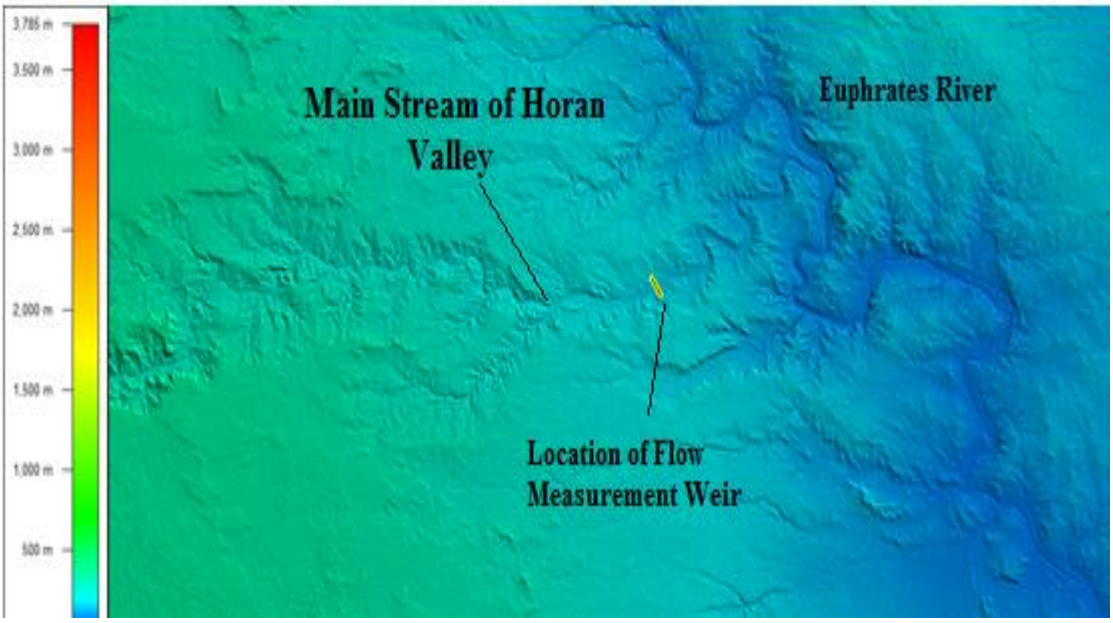

Figure 22: Location of flow measurement weir

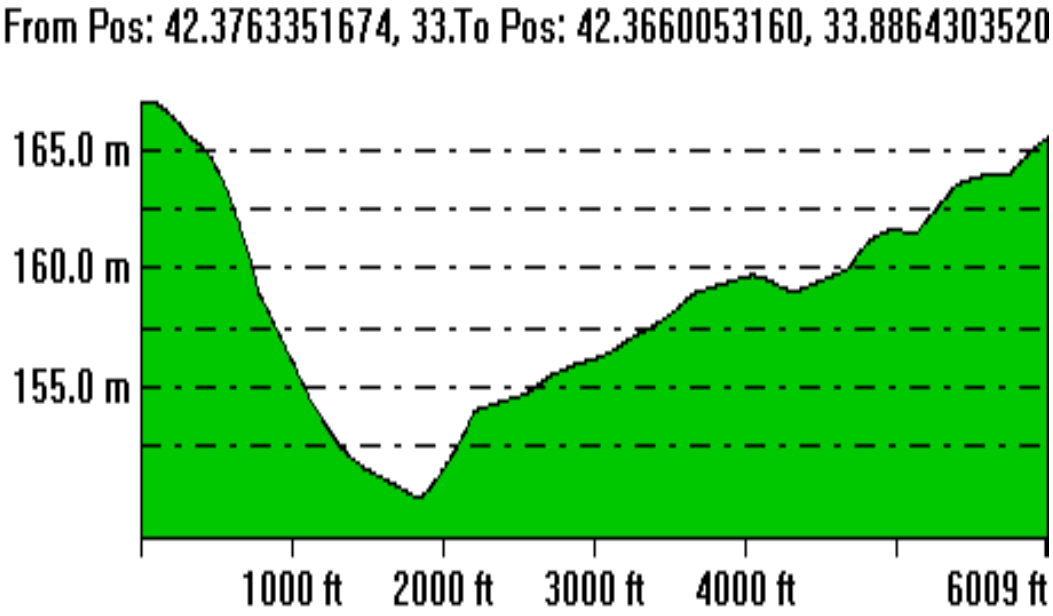

Figure 23: Cross section of Wadi Horan at the site of weir

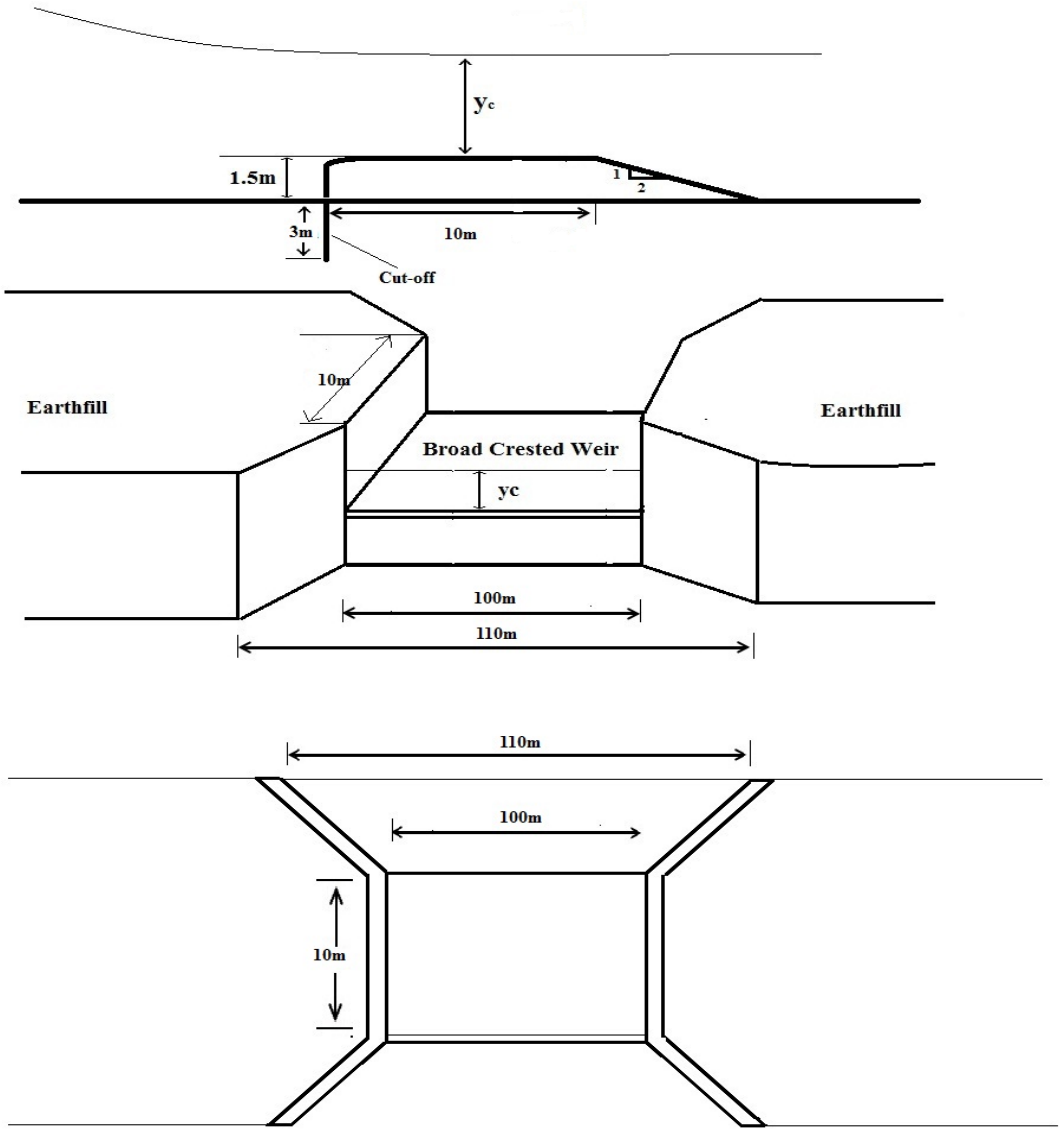

Figure 24: Details of proposed design of measurement weir

6.1.2 Calculation of Flow Section:

Depending on theory of specific energy which was mentioned before as well as the hydrologic study for Wadi Horan, the maximum discharge in the main stream is about 250 m^3/s. The length of proposed length of the weir is about 100 m:

$$Q = CLH^{\frac{3}{2}} \quad \ldots\ldots\ldots\ldots 250 = 2.1 * 100 * H^{1.5} \;==\; H = 1.12m$$

$$y_c = \sqrt[3]{\frac{q^2}{g}} = \sqrt[3]{\frac{2.5^2}{9.81}} = 0.86m$$

$$V = \frac{Q}{A} = \frac{250}{100*1.12} = \frac{2.2m}{s}$$

$$y_c = \frac{2}{3}\left(H + \frac{V^2}{2g}\right) = \frac{2}{3}\left(1.12 + \frac{2.2^2}{20}\right) = 0.89m \approx 0.86m \equiv o.k$$

As the height of this weir is 1.5m, it can store a rainwater upstream for many months after the rainy season because the annually evaporation depth is about 1.6-1.9 m. These quantities of water are very useful to habitat animals, birds and to irrigate plants in the natural reserve and national park, so many flow meters have to be constructed. Table 10 illustrates the details of materials quantity that used for construction of weir.

Table 10: The materials quantity that were used for construction of the weir.

	Item	**Unit**	**Quantity**	**Price $**
1	Foundation Earth Work	m^3	16000	250,000
2	Concrete of Foundation	m^3	825	140,000
3	Concrete of Main Dam	m^3	1500	250,000
4	Concrete for Retaining Wall	m^3	90	15,000
5	Earth-fill Work	m^3	68000	1,130,000
6	Concrete of D/s Protection	m^3	990	165,000
7	Concrete of cut-off Work	m^3	165	30,000
Total ($) million and nine hundred eighty thousand $				1,980,000

6.2 GIS laboratory:

Geographic information systems (GIS) have become now a very important scientific tool for various scientific and applied disciplines that are used by specialists and researchers. Due to the growth of ecotourism, which has become an important side in modern tourism that has attracted the interest of many developed countries. Therefore, establishing or rehabilitating natural reserves is very important factor in tourist attractions.

GIS is an important tool in establishing, rehabilitating and managing natural reserves. Many studies mentioned that there are many environment benefits when using the GIS techniques in preparing structural plans for natural reserves like the two nature reserves in Wadi Horan such as reducing the waste of area and identifying the areas that have environmental sensitivity. Because of the development of the techniques of geo-matic engineering, especially GIS techniques, it emerged as the urgent need for a GIS laboratory to use it for establishing or rehabilitate tourist areas, especially natural reserves has become a basic requirement in achieving sustainable tourism development. In current study, GIS techniques have emerged as an important tool to determine the best sites to establish two nature reserves in Wadi Horan in the western region of Iraq, which is characterized by large topographical ranges more than 500 meters, and a climatic parameter that changing spatially and temporally. Furthermore, for mapping the stream network, main cites and roads and railway are given.

6.2.1 Requirements for GIS laboratory

Table 11: Hardware devices

No	Device	Quantity	Cost $	Total price $
1	Complete computer Desktop Dell core i7 with all secondary parts including UPS, Monitor 21 in	25	2500	
2	Computer Laptop core i7	5	2,000	
3	Server, with installation and networking	1	15,000	
4	Plotter A0 (HP Design Jet T1700 A0+ Plotter) + Scanner A_0	1	6000	
5	Laser printer hp	2	100	
6	Navigation GPS	3	500	
7	Data show	1	500	
8	Smart board	1	1100	
9	Internal Network	1	850	
10	Data Storage 50 Tera	1	10000	
11	Color printer 3*1 Canon 643 – multifunction A4	2	165	
12	Color printer 3*1 Canon A3	1	850	

13	Computer table with seat	25	150	
14	Office table 120 cm with seat	3	350	
15	Office Cabinets 190 cm	2	150	
16	Filing cabinet	2	150	
17	Fully Internet system (Nano bridge + Rawter)	1	180	
18	LCD monitor 52 inch	1	400	
19	External CD drive	2	40	
	Total Cost		40985	

Table 12: Software program

No	Device	Quantity	Cost $	Total price $
1	Educational Remote Sensing and GIS Software License, includes: 1- ERDAS Imagine, with Extensions 2- Geomedia , with Extensions 3- ERDAS Photogrammetry, with Extensions 4- ERDAS Apollo	1 Package for 5 User	20,000	
	1 Package for 15 User		45,000	
	Training (3 – 5 Trainees) includes: 1- ERDAS Imagine Basic 2- ERDAS Imagine Advance 3- ERDAS Imagine Extensions 4- Geomedia Basic 5- Geomedia Advance 6- Geomedia Extensions 7- Photogrammetry 8- Apollo	1 week 1 week 1 week 1 week 1 week 1 week 1 week 1 week	1,000 1,500 3,000 1,000 1,500 3,000 2,000 3,000	
	Total		81000	

Table 13: Devices for GIS Laboratory

No.	Item	Qty	Unit Price $	Total Price $
1	Spectro Radiometer for environmental applications	1	30,000	30,000
2	Thermal Camera for Monitoring	1	5,000	5,000
1	WingtraOne Package Ready to fly (no payload):	1	**30,000**	**30,000**
2	RX1 Camera Kit (42 MP) fully integrated	1	**10,000**	**10,000**
3	PPK high precision GPS receiver module includes:	1	**10,000**	**10,000**
4	RedEdge-MX Payload Kit	1	**10,000**	**10,000**
5	Micasense Altum thermal+ multispectral payload kit	1	**21,000**	**21,000**
6	Pix4Dmapper-PL-bundle	**1**	**8,000**	**8,000**
7	Pix4D Fields -YS	**1**	**5,000**	**5,000**
8	Accessories includes: ● Set of Flight Batteries ● Middle Stand ● Pair of Side Stands ● Pair of Propeller	 **1** **1** **1** **1**	 **1,000** **700** **200** **200**	**2,100**
9	HARD CASE	**1**	**2,250**	**2,250**
10	Training for 4 trainees 5 working days in UAE ● Flight planning ● Safety features ● Flying ● WingtraOne handling ● Image geotagging ● Post-processing ● Camera settings ● Support setup	1 Week	**25,000**	**25,000**
				158,350

Table 14: Total Cost for GIS Laboratory

No	Device	Total price $
1	Hardware (Table 11)	40985
2	Software (Table 12)	81000
3	Devices (Table 13)	158,350
	Total	**280335**

6.3 Wells drilling in Study Area

The diameter length of the nature reserve is about 444 km in the first stage; the suggested interval distance between the wells is 4 km. Therefore, the total number of wells would be 110 wells. The number of wells will rise as needed in the next stages. Show Table 15.

Table 15: Number and total cost of drilling the required wells.

No.	Well depth (m)	Number of wells $	Drilling cost/m $	Total drilling Costs $	Price unit of Submerse pump $	Total Pumping Cost $	Solar cells with accessories $	Total cost $
1	150	30	25	112500	500	15000	69000	196500
2	200	40	25	200000	500	20000	92000	312000
3	180	40	25	180000	500	20000	92000	292000
								800500

6.4 **Weather and Environment Monitoring of Wadi Horan.**

Despite the large area of this valley, there is only one weather station located in Rutbah city far 5 Km from the valley. From scientific view, one weather station to monitor this large area is insufficient. Therefore, it requires installing at least five weather stations model **Davis Vantage Pro2**, located at H1, H2, H3, near earth dam and near Euphrates River as shown in Figure 25. In addition to two mobile weather station, model **Magellan MX501.**

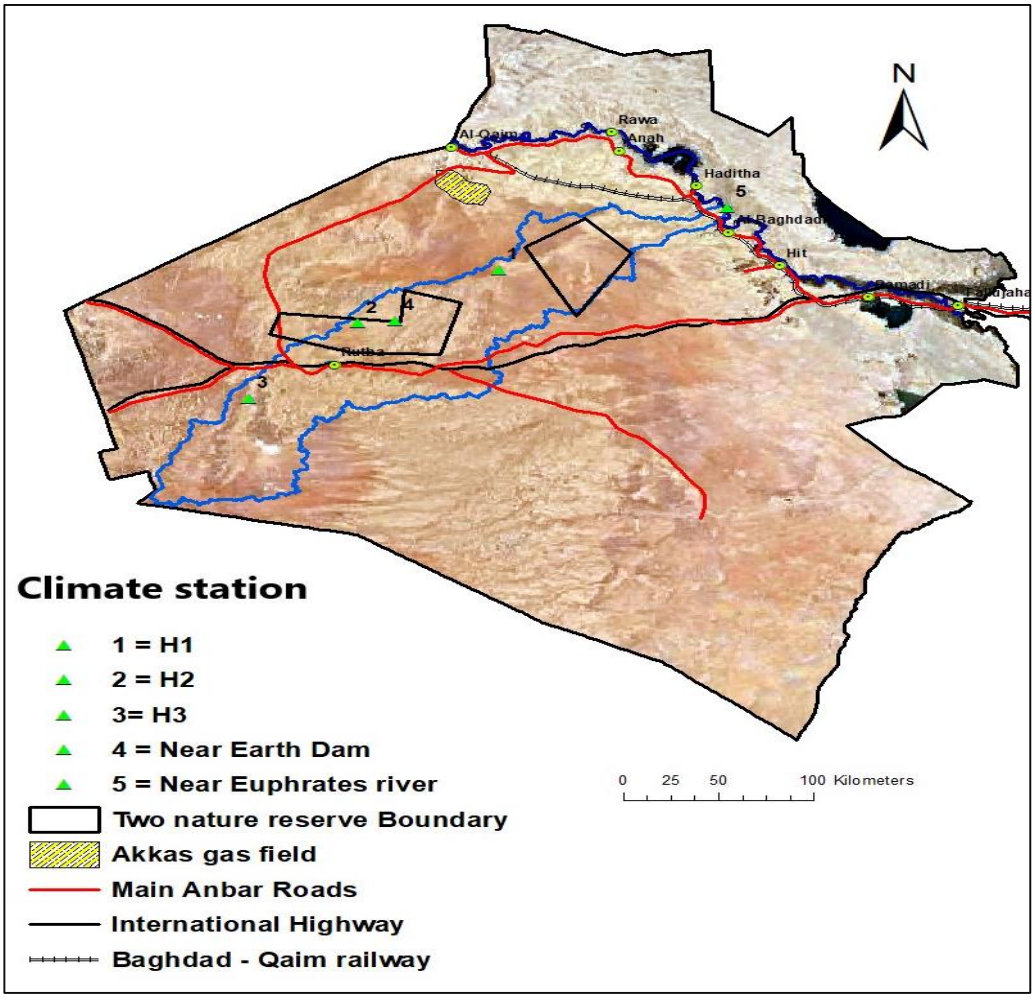

Figure 25: Climate Stations Proposed Locations in Wadi Horan.

Weather instruments provide the ability to analyze and evaluate the data collected. This data does not only provide the details of weather over time, but it also helps to predict future weather patterns Locally, the climate of Iraq is a hot semi- arid. Therefore, climatic changes have serious implications for the state of Iraq for years to come. Hence, installing two MX501 mobile weather station and five fixed weather stations (Davis Vantage Pro2) can help in monitoring large area to determine the effects of Atmospheric factors on the nature life. The price unit and specifications of each unit will be shown in Table 16 and Table 17.

Table 16: Specifications and Price of Davis Vantage Pro Weather Station.

No	Device	Quantity	Cost $	Total price $
1	**Weather Station USA product type:** e range(outside) (- 40 to 65C),Wind speed range :2 to 150 mph; 2 to 130 knots;1 to 67 m/s;3 to 241 km/hr., Wind direction range :0 to 360, Solar radiation range :0 to 1800W/m2 , Rain fall rage : 0 to 99.99 in ,Time range : 24 hours (12 or 24 hour format) ,Dimensions: display console:9.5 in Wx6 in H x 1.5 in D; Sensor assembly: 8.25 in Wx7.25 in H x 7.75 in D, UV radiation range : 0 to 16, Wind chill range : (-79 to 54C).	5	6.889	**34.445**

Table 17. Specifications and price unit of Magellan MX501 Mobile Weather Station

No.	Device	Quantity	Cost $	Total price $
1	Magellan MX501 Weather Station	2	6,399.00	12,798.00
2	**Weather Master Software for Windows operating system** Graphical weather monitoring software for Windows operating system; displays, Reports, and records current weather conditions. Readings data is logged in an SQL database for future analysis and inclusion with other Windows- based programs. Additional calculates parameters are such as Heat Index, Wind Chill, Wet Bulb, and Dew Point. Internet capable, alarm notification, and multistation Communication features. Includes Cameo/Aloha Interface and Northorientation Offset. Includes three computer licenses	2	493.00	986
3	**USB to Serial Adapter, DB-9 male** To provide a serial port for communication between the weather station and software	2	142.00	284
4	Documents Fee	2	100	200
				14268

In addition to climate change, toxic pollutants in the air, or deposited on soils or surface of water, can affect wildlife in a number of ways. Like humans, animals can experience health problems if they are exposed to sufficient concentrations of air toxics over time. Studies show that air toxics are contribute to birth defects, reproductive failure, and disease in animals. Persistent toxic air pollutants are particular concern in aquatic ecosystems. These pollutants accumulate in sediments and may bio-magnify in tissues of animals at the top of the food chain to concentrations many times higher than in the water or air. In addition, exposure to ambient air pollutants can cause damage to crops and trees in a variety of ways. Many scientists believe that global warming could have significant impacts on human health, agriculture, water resources, forests, wildlife, and coastal areas. Therefore, nowadays determination of air quality becames an urgent necessity. Portable pump suction multi gas analyzer, model S360 can measure many toxic gases in the environment. Therefore, it is one of the very important devices for the pollution laboratory, as shown in Table 18.

Table 18: Specifications and price of Portable pump suction multi- gas analysis

No.	Device	Quantity	Cost $	Total price $
1	Portable type pump suction multi gas analyzer **Model S360**. **Measurements:** CH4 : 0-100% LEL O2 : 0-30% VOL O3 : 0-10 PPM CO : 0-1000 PPM CO2 : 0-5000 PPM H2 : 0-1000 PPM H2S : 0-100 PPM NO : 0-250 PPM NO2 : 0-20 PPM	1	1060	1060
	Freight			**250**
	Total			**1310**

6.5 Renewable Energy:

Renewable energy, often referred to as clean energy, comes from natural sources or processes that are constantly replenished. For example, sunlight or wind keeps shining and blowing, even if their availability depends on time and weather. As a large area Wadi Horan has a good opportunity to establish renewable energy such as solar energy, wind energy and biomass energy in areas with levels greater than 600 meter above sea level among this valley. The energy loads for pumping ground water from the wells and the energy required for all park and reserve infrastructures are calculated and taken into consideration. No any other source of electricity is required.

7 General Discussion:

7.1 Water Harvesting.

Wadi Horan will discharge huge amount of rainwater runoff, about billion m^3 in some observed years. (Kamel and Mohammed 2010). According to the unique Rutbah weather station data, the average yearly runoff in Wadi Horan could have reached around $400x10^6$ m3 (AlJawad and Al-Ansari 2017), Table 19 illustrated 13 small dams in which reservoir volumes are 303.2 million m3. If these dams will construct, the total harvested volume of all 17 dams will be50 million m^3, which is less than the average surface runoff that is recommended by (AlJawad and Al-Ansari 2017). (Naif and Abdulhameed, 2020). Many weather stations and flow meters must be constructed in this valley in order to observe rainfall and surface runoff date.

Table 19: Proposed Dams in Wadi Horan Naif and Abdulhameed 2020)

No.	Location	Height	Storage volume Mm^3	Surface Area m^2	Ranking
1	**Upstream**	14	13.2	2,502,431.6	9
2		13.5	11.4	2,740,177	12
3		13	15.3	3,528,017	10
4		12.5	25.8	7,351,076	11
5		13.5	24.3	4,471,927	3
6	**Midstream**	13.5	13	2,548,380	8
7		12.5	28.5	2,620,139	1
8		13.5	25.5	10,499,504	13
9		13.5	37.9	7,534,638	6
10		13.5	24	2,962,105	2
11	**Downstream**	13.5	32.8	5,536,197	4
12		13.5	18.2	2,755,617	5
13		14	33.3	12,571,899	7

7.2 Trees Planting:

About one million trees will be planted depending upon rainwater harvesting and ground water safe yield in order not to cause the water table decline, to maintain the groundwater sustainability. Many types of high tolerant trees can be planted under deficit irrigation and rainwater harvesting technique.

7.3 The best location of a natural reserve for wild animals.

Target area of 4000 km^2 is selected in the midstream of the valley, Figure 26 explains this area which shown as black polygon. There are many constraints affecting the best location to construct the natural reserve. These are the water harvesting capacity, the

ground water depth, groundwater quality and the renewable energy opportunities. Both wind and solar energy are possible to establish in Wadi Horan. Figure 27 shows the elevation of the target area above sea level.

The current study recommended selecting the location that verify these active constraints and recommended evaluating these constraints by field observations and investigations. It is necessary to conduct field investigation to study the soil and geological studies in order to select the best-proposed small dam's locations, which affect the central natural reserve, and central national park locations.

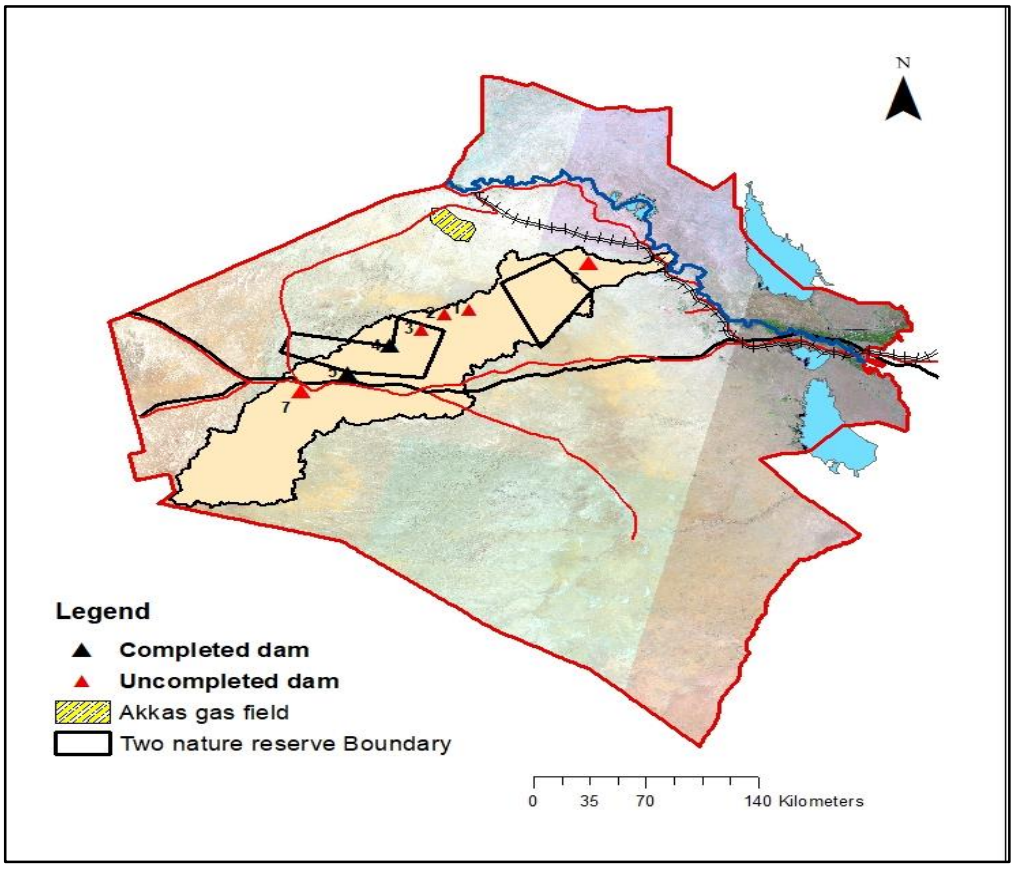

Figure 26: The Target Area in Wadi Horan

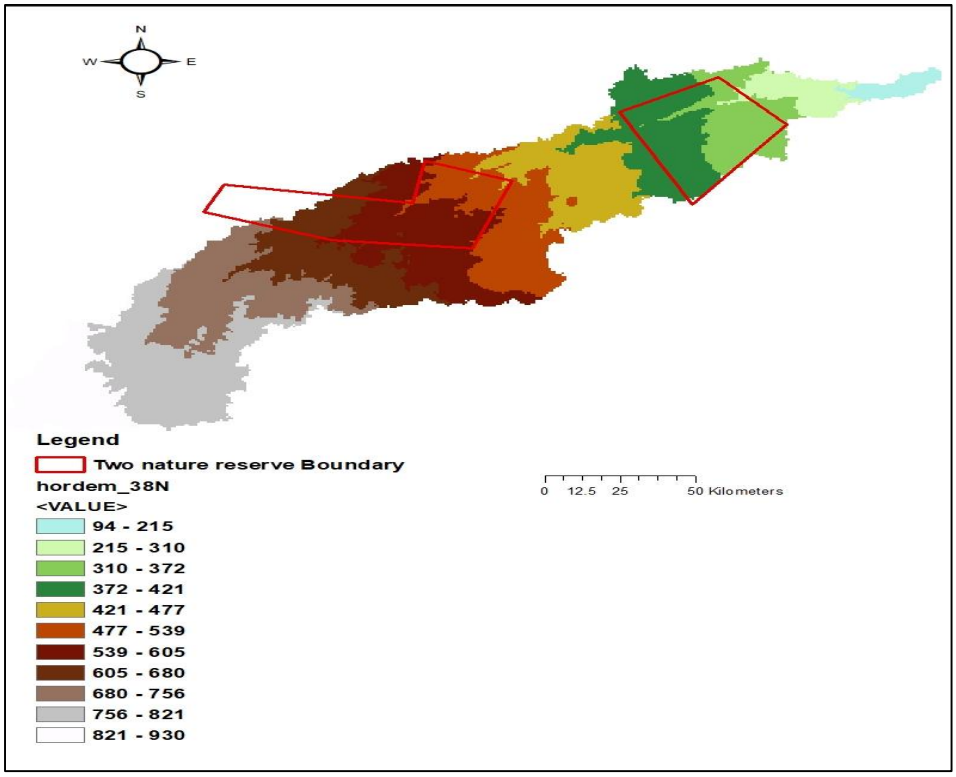

Figure 27: Elevations of Target Area.

8 Project stages.

8.1 First stage (2021- 2025):

a- Constructing weather station network, 5 stations at H1, H2, H3, dams and bridge location.

b- Constructing renewable energy stations in selected areas within or near to natural reserve and national park.

c- Surrounding the natural reserve and the national park by first stage of tolerant trees and design and construction pumping wells and observation wells to irrigate the trees and to observe the groundwater quantities and flow direction.

d- Constructing three small dams at the best sites according to the ranking criteria, and supplying these dams by flow meter stations.

e- Constructing one flow meter.

f- Planting a windbreaker trees around the small dam reservoirs and at the best rainwater harvesting locations.

g- Planting many grass plants by using airplanes during rainfall season to establish an open reserve for camels.

8.2 Second stage (2026- 2030):

a. Evaluating of the first stage projects.
b. Redesign the tree surround planting and irrigation strategies.
c. Expanding the reserve and completing the tree surrounds.
d. Constructing other 3 best location small dams and supply it by weather stations and flow meter stations.

8.3 Third stage (2031- 2050):

a- Evaluating of both first and second stages.
b- Completion the proposed small dams' series of 13 dams by constructing the last seven among the valley and surrounding all reservoirs by forests.
c- Expanding the reserve that constructed early.
d- Monitoring water quantity and quality in aquifers and study the system sustainability.

9 Economic Feasibility Study

The Upper Euphrates Basin Developing Center - University of Anbar, plans to establish a network of weather stations and study rainfall, runoff, flows, types of aquifers and well networks, average annual recharge, and safe return. Note that some of the studies prepared by the Center have positive aspects that help in developing Wadi Horan Basin in the required manner, including:

1. Wadi Horan contains many types of trees, natural herbs, and wild animals, which requires the establishment of a nature reserve to manage and develop the ecosystem of this large area.

2. The establishment of the reserve and national parks contributes to achieving a better security reality while creating job opportunities and sustainable development for this large and important area.

3. More than one million trees can be cultivated based on rainwater harvesting and safe good pumping that maintains the sustainability of groundwater.

4. About 400 million cubic meters of rainwater can be harvested in this valley, so it is very important to build at least 13 proposed small dams. High-quality water can be uses to irrigate millions of several types of trees, reducing dust, erosion, and carbon dioxide and improving the environment and ecosystem.

5. The feeding is about 180 million cubic meters of rainwater to the aquifers in this valley. So the cultivation is for a million very safe trees especially if these tolerant trees are irrigated by water harvesting and irrigation incomplete.

6. A series of small dams consisting of 13 dams with an ideal height and location will increase the free water area in the valley from 15 to 90 km^2. which will improve the climatic conditions and environment of the valley. Re-fed groundwater by 31.54 cm/year means feeding the aquifers of the valley by 28 million m3 / year despite the direct feeding of rainwater at about 152 million m^3/year. These large recharge amounts will maintain the quantity and quality of water resources in the oasis and reserve areas.

7. Renewable energy such as solar, wind and biomass energy is very suitable and can be generated in areas more than 600 meters above sea level in Wadi Horan.

In the economic evaluation of such projects, the method of conducting a comparative study of project costs and benefits derived from all purposes is recognized worldwide.

The economic analysis of the valley projects was carried out by calculating the net present value (NPV) and the benefit-cost ratio) B/C (using different discount rates by the discounted cash flow method based on the costs and benefits of the project, then the Internal Rate of Return (IRR) which represents the discount rate at which the present value of each of the cost-benefit streams that are equal to each other is calculated.

The IRR allows the economic benefits of a project to be evaluated by comparing the annual rate of return with the opportunity cost of capital (OCC) in the country.

In Iraq, the (OCC) is about 10%, which is the lending ratio of the Central Bank of Iraq. The economic life that represents the period covered by the economic evaluation of the project is 50 years, 5 years for construction, and 4 to 5 years after completion, so the 50 years will be adopted in the economic feasibility study. Below is a preliminary introduction to the feasibility study, including the project cost and basic standard criteria, as well as the conclusions and recommendations. The details of the feasibility study are in Appendix 8.

9.1 Project Costs:

Project costs of reserve and national park costs consist of the capital cost for the construction of the project, including the establishment of 13 small dams including soil filling works of dam body, and water outlet, and the power plant briefly depends on the special needs of dams and nearby facilities, including only handed fish, service bridge, roads, and other structures, in addition to the annual costs of operation, maintenance, management and construction of hydrometer dams and GIS laboratories and weather stations.

Other costs have been included for the establishment of nature reserves that surround of length estimated 262.4 kilometers and the park surround is (180.2 km) with all operational accessories for this park which is an international park (Central Park. It includes a zoo, cable cars, recreation areas, a tourist hotel, villas for weddings, gardens, a water city with its accessories, in addition to Bedouin sheds made of Arab tents according to designs that mimic the nature of Wadi Horan, tracks for horse and camel racing, and rugged fields for four-wheel-drive vehicles.

The costs include construction of 115 artesian wells up to depths of 200 meters with submersible pumps powered by solar energy to irrigate one million diverse trees of palms, olives, prickly pears, and other trees such as Buckthorns and other fruitful and non-fruitful trees that are environmentally friendly as windbreaks, as well as the costs of agricultural lands with reservoir water and abundant production of Ground vegetables and fruits as well as covered.

Note: The total costs of the project will be calculated in US dollars according to the pricing of the Central Bank of Iraq.

9.2 Basic Standards:

The cost of Horan Dam development project was estimated after numerous discussions with the experts of the Upper Euphrates Basin Development Center - the University of Anbar, experts at the College of Engineering and the College of Agriculture, and other experts from outside the university. In addition, the fixed prices are subjected to increase and decrease depending mainly on the market movement and the economic balance of the country. The following considerations are taken into account when estimating the cost:

A-The unit construction prices were calculated taking into consideration the recent construction projects in Iraq and the experience in the construction works of the contractors, in addition to the regional conditions of Wadi Horan site.

B-The cost of construction was estimated in foreign currency to ensure stability in the Iraqi market for work. Foreign currency includes costs of materials to be produced in Iraq and

labor costs. In addition to the internal transportation of imported materials and machines, warehouse costs, electromechanical equipment, power conversion facilities, communications facilities, and cable cars.

C-An emergency sum of 7% has been added to the cost of all construction works, including civil, water, electrical and mechanical equipment.

D-Salaries and wages of engineers and other personnel, costs of utilities and maintenance of field offices for Wadi Horan Development Project, and engineering costs including detailed design work and construction supervision which are included in the administrative expenses.

E-The interest was calculated during construction based on the annual requirements of the fund. All tables of calculations are listed in Appendix 8.

9.3 Final Feasibility Conclusions and Recommendation

9.3.1 Feasibility Conclusions:

From the economic evaluation of the Wadi Horan Development Project, we note the following conclusions:

After subjecting the data concerning Wadi Horan Development Project to analysis and under commercial profitability criteria to know whether or not the project was accepted, the results and each standard were as follows:

First: The percentage of the cost of benefit and the internal rate of capital recovery:

The cumulative cash flow of the project will become positive in the tenth year of the economic life of the project which means that the project will pay its investment costs eleven years after the start of the project or after 6 years of operation or 11 years from the start of the work.

Second: Standard interval recovery Pay Back Period (PBP):

Net annual cash flows were collected and the recovery period was as follows:

The project begins with profit and recovery of investment and operational costs after the thirteenth year of the start of the project and after the eighth year of operation of the project, i.e. the remaining years are years of profit-taking, the recovery period falls at the period (21-25) years. In other words, the remaining years are the years of profit taking the project is acceptable and economically feasible according to this standard.

Third: Average internal rate of return Average Rate of Return (ARR): We note that the internal rate of return is higher than (3.08-3.00) at the period (19-30) years and then lower before and after this period.

Fourth: Net Present Value (NPV):

The results showed that the current net worth standard for periods of the project life (20-50) years. All of them have a positive value after the 20th year (greater than zero), the internal rate of return of the project will be greater than (10%). This indicates that the project is economically viable according to this criterion as well.

Fifth: Guide of profitability or the current value of return/ costs (Benefit-Cost Ratio) (B/C):

Distance Extract Values Guide The results showed that the standard Guide profitability or the value current for return/ costs Benefit-Cost Ratio (B/C) For periods in the life of the project (25 - 50), all of them are valuable Positive after the twenty-fifth year (greater than 1), which indicates the positive economic feasibility of the project benefit to cost ratio (B / C) Ranging from (1.042 - 1.717) at a discount rate of 10% for the period (25 -50) years and a rate ratio of (1. 379 5) which represents the opportunity cost of alternative capital to the public sector in Iraq, which signify the realization of revenues which Excel the costs and thus this Standard signify the feasibility of the project, therefore, it is believed that Wadi Horan Development Project is economically worthy of implementation, and the project is economically feasible."

Sixth: Guide of profitability or the current value of return/ costs Benefit-Cost Ratio (B/C):

After obtaining net current values at multiple discount rates, positive and negative results were given and it was found that the discount factor that gives the current value equal to zero falls between 10% and (15%, according to the table (22). The internal rate of return = 11.1%, at which the current value is equal to zero. Since the internal rate of return is equal to (11.1%) Greater than the interest rate or discount rate of funds invested in the market (10%), so the project is successful and a decision is made to accept and implement it. This criterion, therefore, demonstrates the feasibility of the project, so it is believed that the Wadi Horan Development Project deserves to be implemented economically, and the project is economically viable."

9.3.2 Recommendations of Economic Feasibility Study:

Distance Application Standards of commercial profitability of the project it turns out that the Wadi Horan Development Project in Anbar Governorate is acceptable and economically viable under standards of commercial profitability so it is recommended by decision adoption regarding projects in Iraq.

10 Conclusions: The conclusions of the study are summarized as follows:

1. Wadi Horan contains many types of trees, natural herbs and wild animals, which requires the establishment of natural reserve to manage and develop the ecosystem for this large area.
2. The establishment of the reserve and national park contributes to achieving a better secure reality while creating job opportunities and sustainable development for this large and important area.
3. More than one million trees can be planted depending on rainwater, harvesting and safe well pumping that maintain groundwater sustainability.
4. About 400 million m^3 of rainwater can be harvested in this valley, so it is very important to construct not less than 13 proposed small dams. High quality of water can be used to irrigate some millions of several types of trees, which reduce dust, erosion, CO2 and improve the environment and ecology system.
5. More than 160 million m^3 of rainwater were percolated to groundwater aquifers in Wadi Horan, so planting one million trees is very safe especially if these trees are tolerant and irrigated by water harvesting and trickle deficit irrigation.
6. Small dam's Series of 13 small dams of optimal height and location will increase the free water area in the valley from 15 to 90 km^2, which will lead to improve the climate conditions and ecology of the valley. Recharging ground water by 31.54 cm/year means feeding the valley aquifers by 28 million m^3/year in spite of direct rainwater feeding by about 139 million m^3/year. These large recharging quantities will sustain the water resource quantity and quality in the oases and reserves regions.
7. Integrated Renewable Energy Farms (IREF) can be established, renewable energy such as solar, wind and biomass energy are very suitable and can be installed in areas with levels greater than 600 meter above sea level in Wadi Horan as Rutbah city.
8. Small dams that are filled with rainwater harvesting in wet years may be still full with water for several years, including dry years. This phenomenon can be seen in figures a-f in Appendix 8.

Recommendations:

a- Geological and soil investigations for the suggested dam's sites are recommended to determine the geologic feasibility of the site and to find out the extent and precision of detailed subsurface investigations required to get the desired information regarding the design and construction.

b- Drawing Three-Dimension maps of Wadi Horan especially for natural reserve and national park areas.

c- Studying the hydraulically and hydrological flow in Wadi Horan to examine a preliminary quality and evaluation of the groundwater for possible future development in different uses. Also the investigation of the hydro geologic flow will provide vital information and give essential guide for the selection of the most favorable groundwater areas in the future programs.

d- Studying the aquifers properties including determining the quantity, quality and direction of water flow, in addition to the annual variations in water table depth.

e- Preparing fences cultivation program, in successive stages of time, to define the natural reserve boundaries and to keep management units of the reserve. In addition to green fences, wildlife friendly fence design suggested to prevent the animals from roaming outside the natural reserve.

f- Studying the establishment of a desert tourism city linked with national park, which will be built using environmentally friendly material and energy produced by using water harvesting and recycling water techniques.

g- Studying possibility to convert the city of Rutbah city which entirely dependent on renewable energy due to it has the best sites for generating wind energy. besides, the large number of sun hours in the area.

h- studying the construction of a solar cell factory near the quarries of glass sand with a purity of about 99% located close to Rutbah city to reduce the cost of solar energy.

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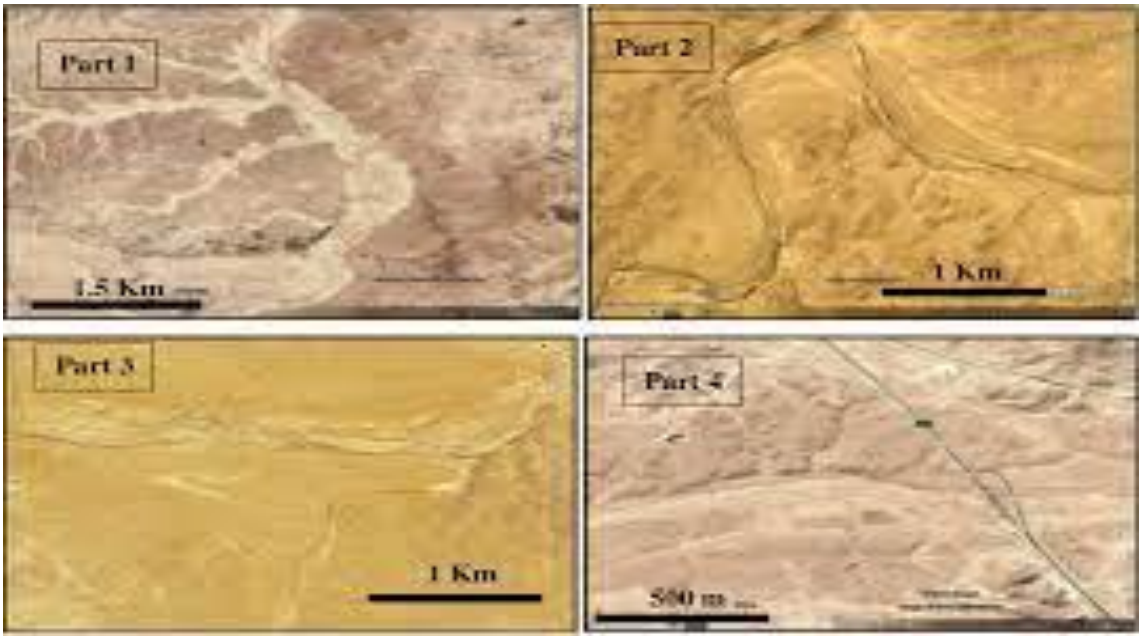
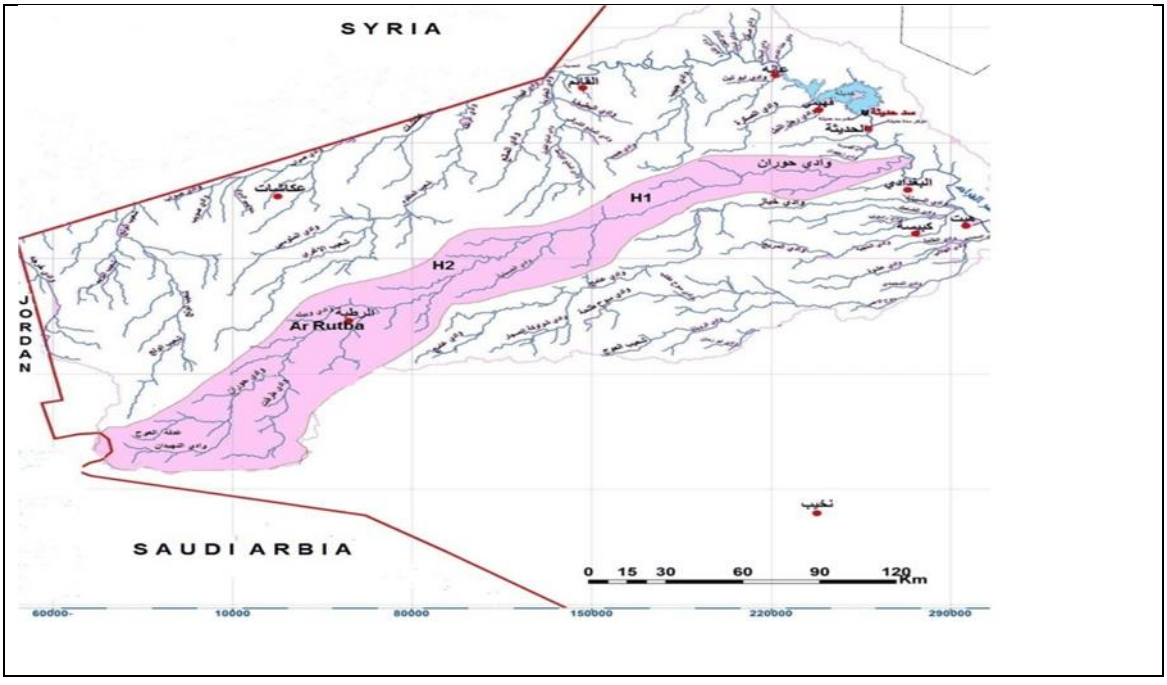
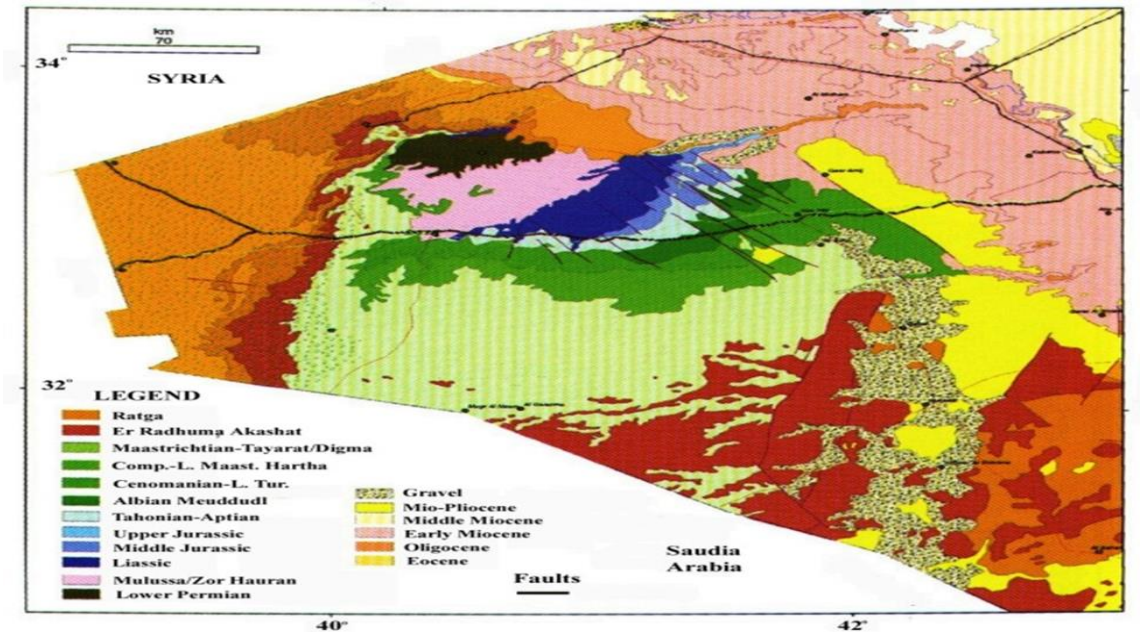
Appendix 1.

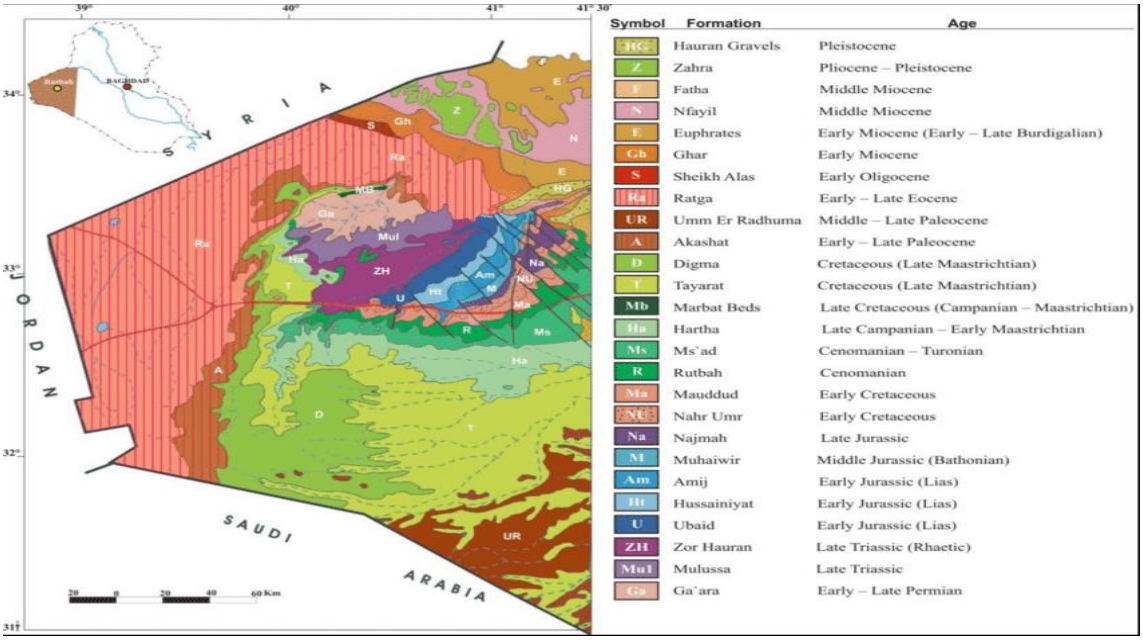
Geology of Wadi Horan

The whole stream of Wadi Horan is located in the western desert subzone within the inner platform of the Arabian plate. The subzone is generally characterized by simple tectonic scheme and almost no structural geological features apart from faults of different types. Some of those faults reached the stream of the valley and had caused displacements of some geological formations. The displacement ranges within magnitude of few tens of meters; majority of them are strike slip faults. Few of the existed faults shifted the course of the valley. From reviewing the geological maps and the existing faults, it is clear that the majority of the large and acute meanders of Wadi Horan are not related to tectonic activities. The exposed rocks along the course of this valley range in age from Upper Triassic to Middle Miocene with many large unconformities. The range of age of this valley includes 20 geological formations with wide variety of rocks within the formations and locally within the same formation. The course of Wadi Horan is tectonically controlled; in its uppermost reach its trend is almost S – N; following Nabitah Fault system. Farther on, it changes its trend towards the northeast following the main transversal fault and lineament system. Along its course, tens of normal and abnormal large meanderings occur. Those which are abnormal are controlled tectonically as revealed from the existing lineaments of NW – SE trend.

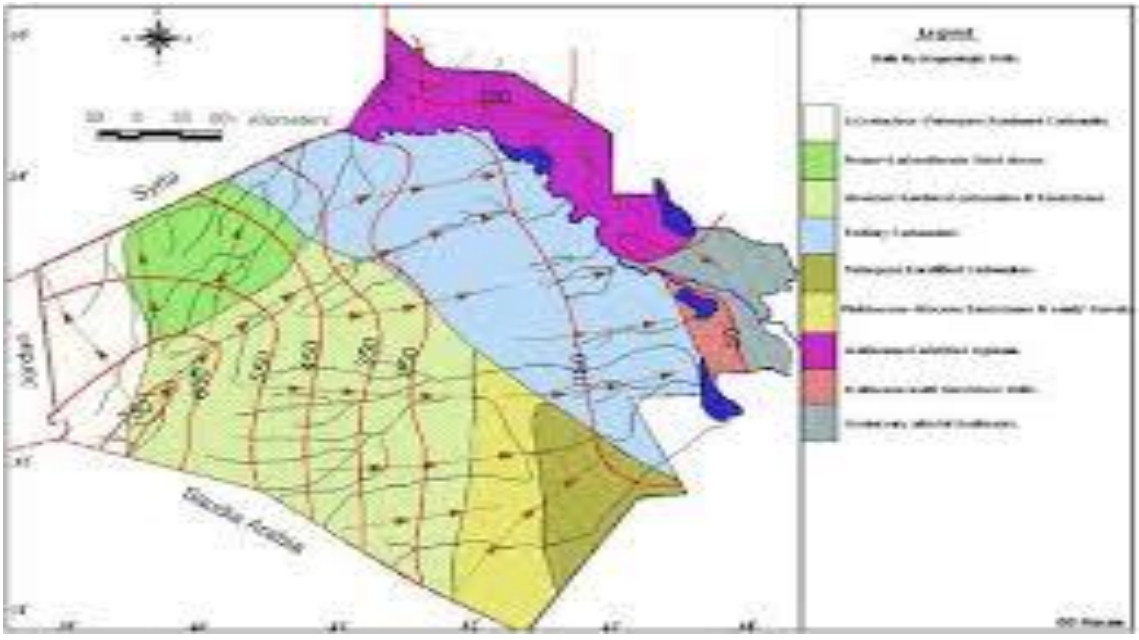

Part 1
1.5 Km
Part 2
1 Km
Part 3
1 Km
Part 4
500 m

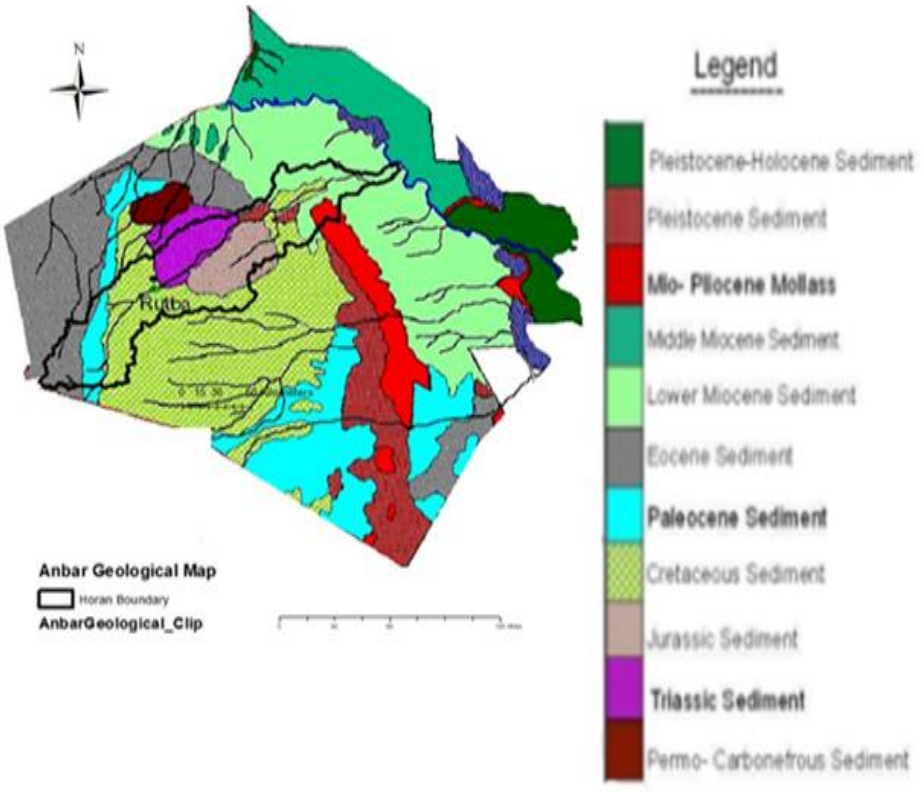

SYRIA
JORDAN
SAUDI ARBIA
H1
H2
وادي حوران
Ar Rutba
0 15 30 60 90 120 Km





Symbol	Formation	Age
HG	Hauran Gravels	Pleistocene
Z	Zahra	Pliocene – Pleistocene
F	Fatha	Middle Miocene
N	Nfayil	Middle Miocene
E	Euphrates	Early Miocene (Early – Late Burdigalian)
Gh	Ghar	Early Miocene
S	Sheikh Alas	Early Oligocene
Ra	Ratga	Early – Late Eocene
UR	Umm Er Radhuma	Middle – Late Paleocene
A	Akashat	Early – Late Paleocene
D	Digma	Cretaceous (Late Maastrichtian)
T	Tayarat	Cretaceous (Late Maastrichtian)
Mb	Marbat Beds	Late Cretaceous (Campanian – Maastrichtian)
Ha	Hartha	Late Campanian – Early Maastrichtian
Ms	Ms`ad	Cenomanian – Turonian
R	Rutbah	Cenomanian
Ma	Mauddud	Early Cretaceous
NU	Nahr Umr	Early Cretaceous
Na	Najmah	Late Jurassic
M	Muhaiwir	Middle Jurassic (Bathonian)
Am	Amij	Early Jurassic (Lias)
Ht	Hussainiyat	Early Jurassic (Lias)
U	Ubaid	Early Jurassic (Lias)
ZH	Zor Hauran	Late Triassic (Rhaetic)
Mul	Mulussa	Late Triassic
Ga	Ga`ara	Early – Late Permian




N
Legend
Pleistocene-Holocene Sediment
Pleistocene Sediment
Mio- Pliocene Mollass
Middle Miocene Sediment
Lower Miocene Sediment
Eocene Sediment
Paleocene Sediment
Cretaceous Sediment
Jurassic Sediment
Triassic Sediment
Permo- Carbonefrous Sediment
Rutba
Anbar Geological Map
Horan Boundary
AnbarGeological_Clip

Appendix 2A:

Common wild plants and their economic importance and western desert of Iraq.

Scientific name	Family	Importance
Prunus Arabica	Rosaceae	M
Alhagi camelorum	Papilionaceae	M
Astragalus annularis	Papilionaceae	Pa
Astragalus bombycinus	Papilionaceae	Pa
Astragalus hamosus	Papilionaceae	Pa
Astragalus hauarensis	Papilionaceae	Pa
Hippocrepis unisiliquosa	Papilionaceae	Pa
Lotus corniculatus	Papilionaceae	M
Lotus halophilus	Papilionaceae	M
Lotus lanuginosus	Papilionaceae	M
Medicago intertexta	Papilionaceae	Pa
Sophora gibbosa	Papilionaceae	M
Trifolium purpureum	Papilionaceae	Pa
Trifolium resupinatum	Papilionaceae	Pa
Trigonella filipes	Papilionaceae	M
Vicia villosa	Papilionaceae	M
Citrullus colocynthis	Cucurbitaceae	Po
Althaea ludwigii	Malvaceae	M
Malva aegyptica	Malvaceae	Pa
Malva nicaeensis	Malvaceae	Pa
Tribulus macropterus	Zygophyllaceae	Po
Adonis dentate	Ranunculaceae	M
Hypecoum geslinii	Papaveraceae	M
Papaver glaucum	Papaveraceae	Po
Papaver hybridum	Papaveraceae	Po

Papaver rhoeas	Papaveraceae	Po
Roemeria hybrid	Papaveraceae	Po
Fumaria bracteosa	Fumariaceae	M
Alyssum szovitsianum	Cruciferae	Pa
Anastatica heirochuntica	Cruciferae	M
Erucaria hispanica	Cruciferae	M
Farsetia burtonae	Cruciferae	M
Glastaria glastifolia	Cruciferae	M
Lepidium aucheri	Cruciferae	Pa
Lepidium latifolium	Cruciferae	Pa
Lepidium perfoliatum	Cruciferae	M
Neotorularia torulosa	Cruciferae	M
Sinapis alba	Cruciferae	M
Sterigmostemum sulphareum	Cruciferae	Pa
Caylusea hexagyna	Resedaceae	M
Oligomeris linifolia	Resedaceae	M
Reseda alba	Resedaceae	M
Loeflingia hispanica	Caryophyllaceae	M
Minuartia picta	Caryophyllaceae	M
Paronychia argentea	Caryophyllaceae	M
Polycarpaea repens	Caryophyllaceae	M
Sclerocephalus arabicus	Caryophyllaceae	M
Silene rubella	Caryophyllaceae	M
Spergula fallax	Caryophyllaceae	M
Glinus lotoides	Aizoaceae	Pa
Papaver hybridum	Papaveraceae	Po
Papaver rhoeas	Papaveraceae	Po
Roemeria hybrid	Papaveraceae	Po

Fumaria bracteosa	Fumariaceae	M
Alyssum szovitsianum	Cruciferae	Pa
Anastatica heirochuntica	Cruciferae	M
Erucaria hispanica	Cruciferae	M
Farsetia burtonae	Cruciferae	M
Glastaria glastifolia	Cruciferae	M
Lepidium aucheri	Cruciferae	Pa
Lepidium latifolium	Cruciferae	Pa
Lepidium perfoliatum	Cruciferae	M
Neotorularia torulosa	Cruciferae	M
Sinapis alba	Cruciferae	M
Sterigmostemum sulphareum	Cruciferae	Pa
Caylusea hexagyna	Resedaceae	M
Oligomeris linifolia	Resedaceae	M

Calligonum tetrapterum	Polygonaceae	Pa
Polygonum patulum	Polygonaceae	M
Rheum palaestinum	Polygonaceae	M
Anabasis setifera	Chenopodiaceae	Po
Arthrocnemum glaucum	Chenopodiaceae	M
Atriplex dimorphostegia	Chenopodiaceae	Pa
Atriplex halimus	Chenopodiaceae	Pa
Atriplex tatarica	Chenopodiaceae	Pa
Bassia eriophora	Chenopodiaceae	M

Bassia muricata	Chenopodiaceae	M
Cornulaca aucheri	Chenopodiaceae	M
Cornulaca leucocantha	Chenopodiaceae	M
Halocnemum strobilaceum	Chenopodiaceae	M
Hammada tamariscifolia	Chenopodiaceae	Pa
Salsola crassa	Chenopodiaceae	Pa
Salsola cyclophylla	Chenopodiaceae	Pa
Salsola incanescens	Chenopodiaceae	Pa
Salsola inermis	Chenopodiaceae	Pa
Salsola jordanicola	Chenopodiaceae	Pa
Salsola kali	Chenopodiaceae	Pa
Salsola longifolia	Chenopodiaceae	Pa
Salsola vermiculata	Chenopodiaceae	Pa
Seidlitzia rosmarinus	Chenopodiaceae	M
Traganum nudatum	Chenopodiaceae	M
Gentiana olivieri	Gentianaceae	M

Samolus valerandi	Primulaceae	M
Limonium axillare	Plumbaginaceae	M
Limonium carnosum	Plumbaginaceae	M
Limonium cylindrifolium	Plumbaginaceae	M
Limonium thouini	Plumbaginaceae	M
Anisoscidium lanatum	Umbelliferae	M

Ducrosia anethifolia	Umbelliferae	M
Turgenia latifolia	Umbelliferae	M
Cephalaria syriaca	Umbelliferae	M
Scabiosa olivieri	Dispsacaceae	M
Scabiosa palaestina	Dispsacaceae	M
Aaronosohnia factorovskyi	Compositae	M
Achillea conferta	Compositae	M
Achillea frgrantissima	Compositae	M
Achillea membranacea	Compositae	M
Anthemis deserti	Compositae	M
Anthemis pseudocotula	Compositae	M
Anthemis rascheyana	Compositae	M
Anvillea garcini	Compositae	Pa
Artemisia herba-alba	Compositae	M
Asteriscus pygmaeus	Compositae	M
Atractylis cancellata	Compositae	Pa
Atractylis carduus	Compositae	M
Carthamus oxyacantha	Compositae	M
Centaurea ammocyanus	Compositae	M

Centaurea bruguierana	Compositae	M
Centaurea pseudosinaica	Compositae	M
Chrysanthemum coronarium	Compositae	M
Echinopus polyceras	Compositae	M
Filago germanica	Compositae	Pa
Filago pyramidata	Compositae	Pa
Gymnarrhena micrantha	Compositae	M
Lactuca orientalis	Compositae	M
Launea angustifolia	Compositae	M
Launea mucronata	Compositae	M
Launaea nudicaulis	Compositae	M
Leontodon Laciniatus	Compositae	M
Matricaria aurea	Compositae	M
Matricaria chamomilla	Compositae	M
Picris damascene	Compositae	M
Reichardia tingitana	Compositae	M
Scorzonera papposa	Compositae	Pa
Scorzonera rawi	Compositae	Pa
Scorzonera tortuosissima	Compositae	Pa
Senecio desfontainel	Compositae	M
Senecio vulgaris	Compositae	M
Sonchus asper	Compositae	Po
Hyoscyamus pusillus	Solanaceae	Po
Solanum incanum	Solanaceae	Po
Convolvulus buschiricus	Convolvulaceae	M
Convolvulus euphraticus	Convolvulaceae	M
Convolvulus oxyphyllus	Convolvulaceae	M
Convolvulus pilosellaefolius	Convolvulaceae	M
Erodium deserti	Geraniaceae	M

Geranium tuberosum	Geraniaceae	Pa
Arnebia hispidissima	Boraginaceae	M
Arnebia lanceosepla	Boraginaceae	M
Arnebia linearfolia	Boraginaceae	M
Arnebia macrocalyx	Boraginaceae	M
Arnebia tetrastigma	Boraginaceae	M
Echium rauwolfii	Boraginaceae	M
Gastrocotyle hispida	Boraginaceae	M
Heliotropium europaeum	Boraginaceae	Po
Heliotropium lasiocarpum	Boraginaceae	Po
Heliotropium supinum	Boraginaceae	Po
Moltkiopsis ciliate	Boraginaceae	M
Salvia aegyptiaca	Labiatae	M
Salvia lanigera	Labiatae	M
Salvia spinosa	Labiatae	M
Teucrium oliverianum	Labiatae	M
Teucrium polium	Labiatae	M
Thymus bovei	Labiatae	M
Allium hamrinense	Liliaceae	M
Allium paniculatum	Liliaceae	M
Allium phanerantherum	Liliaceae	M
Allium sindjarense	Liliaceae	M
Bellevalia mosheovii	Liliaceae	M
Muscari longipes	Liliaceae	M
Gynandriris sisyrinchium	Iridaceae	Pa
Aegilops crassa	Gramineae	Pa

Aeluropus littoralis	Gramineae	Pa
Aristida adscensionis	Gramineae	Pa
Bromus diandrus	Gramineae	Pa
Bromus madritensis	Gramineae	Pa
Bromus rubens	Gramineae	Pa
Chloris virgate	Gramineae	Pa
Crypsis alopecuroides	Gramineae	Pa
Cutandia memphitica	Gramineae	Pa
Dinebra retroflexa	Gramineae	Pa
Echinaria capitata	Gramineae	Pa
Eragrostis cilianensis	Gramineae	Pa
Lophochloa pumila	Gramineae	Pa

M: Medicinal plant Pa: pasture plant Po: Poisonous plant

Appendix 2B:

Trees of high tolerance to drought.

No.	Scientific name	Common name
1	Pinus sliveatris	Scots pine
2	Acacia spp	Acacias
3	Tamarix desrti Boiss	Athel pine
4	Ziziphus spina Christi wild	Christ's thorn jujube
5	Capressus sempervirens var. horizontalis	Italian cypress
6	Cupressus Sempervirens var. Pyramidalis	Mediterranean cypress

Appendix 3:

Wild Animals of Iraqi Western desert

Wadi Horan provides a haven for wild animals, hares, desert fox, gray wolf and reem gazelles, we can get steep cliffs a rare haven from endangered birds and nest in the valley during the winter. The most common animals in this valley are:

Camel

Camels (Camelus dromedarius) are important livestock species in the arid and semi-arid areas. Camels are well adapted to arid environments and there are able to produce milk under adverse conditions. Change in climate where rainfall patterns have become erratic and droughts more frequent led to an increase in the camels' importance in some areas as a strategy to adapt to the changing environmental conditions. Camels play an important role in the food security of communities in the arid and semi-arid lands, including provision of milk and meat a means of transport, and sources of income from sale of live camels and camel products.

The average lifespan of a camel is between thirty to forty years, and the length of a full-grown camel is about one meter and 85 cm at the shoulders, and two meters and 15 cm at the hump, where the length of the hump is about 76 cm regarding the speed of a camel it is

about 65 kilometers per hour, and it can endure running at a speed of 40 kilometers per hour.

Sheep and goats

Sheep are distinguished by their types of different sizes, shapes, and colors, and can be classified according to their main goal, which is the production for milk, meat, and wool, or the type of their outer cover, their strings, or the colors of their faces in addition to their production or physical characteristics, and the following types of sheep.

In general, sheep are considered seasonal for reproduction, and during the spawning season, estrus cycles are repeated every 17-18 days on average, and the period of estrus lasts 24-36 hours on average, and this period during which the sheep are vaccinated, and the period of estrus may range from 3 to 72 hours.

These breeds have a high ability to adapt, and over the centuries, it has adapted to live with nomads, and to live with rural non-nomads as well. It can walk long distances to graze, and it has the ability to withstand the extreme temperatures, and arid seasons (through the consumption of stored fat in the tail), and their ability to reproduce and care for their lambs, their ewes provide milk even in the most difficult feeding conditions. The Naimiya sheep are actually an improved type of Awassi.

Goats

Domestic goats (Capra aegagrus hircus), are a species of goat domesticated from wild goats in Southeast Asia and Eastern Europe. Goats are part of the bovine family, and it is close to sheep, and both are in the genus of Olifiers. There are over 300 distinct breeds of

goats. [1] Goats are among the oldest domesticated species, and are used for their milk, meat, hair, and skin in most parts of the world. In 2011, there were more than 924 million goats live around the world, according to the United Nations Food and Agriculture Organization.

Goats feed on grass and young shrubs, and it is important to transfer the herd of goats to a new pasture every once in a while. So that they graze the lands evenly, so that parasites do not accumulate and spoil the land, and the goats always need hay even with pastures to graze on. This is because they cannot eat all the fresh grass. [Also, fresh water must be provided, which is important for goats, especially in the breeding season, and the male goats are called "goats" and the female "goats" and their young are known as Capricorn.

A flock of sheep is not without a number of goats, as they navigate the grazing path in front of the rest of the herd. The gestation period for female goat’s ranges from 4 to 5 months, and the birth times are usually between midnight until early morning. Among the signs of approaching childbirth is lethargy 3 to 4 days before childbirth and during childbirth the female does not make any sound and most often does not need help or human intervention

Goat milk is characterized by high fatness and makes the best cream cheese and yogurt from it. A flock of sheep is not without a number of goats, as they probe the grazing path in front of the rest of the herd.

Fish

Fish farming is the raising of fish of all kinds, whether saltwater or freshwater fish, which are used as human food under controlled conditions and under human control, and in certain areas, whether breeding ponds or cages, with the intention of developing production and establishing farmer's ownership of products. The field of fish farming is considered one of the activities of the food-producing sectors in the world during the last two decades, and therefore fish farming is considered one of the most important solutions to confront the problem of food shortage that threatens the world, especially developing countries with limited resources, as it provides a protein source with high nutritional value and relatively cheap compared to protein sources Other.

The "Euphrates River" and its lake formed behind its dam in the Tabqa area are known as an artificial lake and store about 14.5 billion cubic meters of water home to many types of delicious fish, and it is known that fish is known for its nutritional value as it contains protein.

Each type of "phratty fish" has its own characteristics and taste. However, in the end, the Furati fish all have in common that they have a wonderful taste. There are fish of large sizes such as "cressin" fish, turkey, "carp", "running", and many others. Types of fish and how to eat it varies, either grilled on charcoal or in the oven or fried in oil.

There are other types that are distinguished by their small size, and this is only suitable for one method of cooking, which is frying with oil. At the forefront of these types comes the "mullet" fish, which is characterized by its small size and great taste, and it is almost not without a restaurant of "Al-Raqqa" restaurants that serve fish meals from This type.

Brown Fish

The Euphrates is considered the mother's habitat for brown fish. Perhaps the "brown" fish is one of the most important of these straight Fratian fish, and it is in terms of the external shape of flat fish, as it is distinguished by its brownish color.

Its name was taken from this color, but there is a "brown" fish whose color tends to be golden yellow, which lives in the course of the "Balikh" river. I believe that the reason for this is due to the difference in the nature of the water between the "Euphrates" and "Balikh", where the water of the latter is characterized by something of salinity, and this type is very similar to the golden "carp", which is a family of relatively small fish, if compared to other river species, where the highest weight that can achieve is 2 kg, and this weight is very rare. The range of its weight, is customary among fishermen between 500 grams and 1000 gram.

Carp fish

Living environment: The grass carp was recorded from the Al-Shuyoukh market lagoon in April 2005 and in other areas of Iraq as free-living fish. It was also introduced to Khuzestan, Iran in the 1970s for the purpose of controlling aquatic plants in irrigation canals. Grass carp can form reproductive groups in the large rivers of southern Iraq and Iran where the environment is favorable and has a continuous, uninterrupted stream of water to help the eggs hatch.

Wild Rabit

Wild rabbits feed on the weeds available in the surrounding environment, including the short weeds that grow in the spring season, and wild rabbits do not drink water when it is not available and compensate for drinking water by eating desert plants such as acid of all kinds in which quantities of water are available that make up for it for drinking water.

Wild rabbits are found in most parts of the world and in the countries of the Arab world. They are found in the Gulf countries in short supply due to overfishing. They are also found in Syria, Iraq, Libya, Egypt, Morocco, Algeria, Jordan and most Arab countries.

The wild rabbit is slightly larger in size than the domestic rabbit, and it is the fastest enemy of it, and is distinguished from it by the length of the ears, and it has shorter hands than the legs. It has strong and very sharp claws that it uses to jump and the soil.

The color of the wild rabbit is a dark brown wavy with gray, a color that is in harmony with its environment, and the weight of the wild rabbit ranges between one to three kilograms.

Jackal

(Jackal) is an animal belonging to the family of canines, which also includes wolves, foxes, and dogs. It lives in pairs, or in a herd of mostly six individuals, which are animals that feed on both meat and plants, as their diet consists of ground birds, reptiles, antelopes, fruits, insects, berries, and grass, as they feed on the remains of other animal prey, and even the carcasses of decaying animals, and in seasons when food is scarce, they can feed on human waste.

Jackals give birth to 2-4 pups in a single lap after a gestation period of 57-70 days, and both parents take care of the young. Baby jackals are able to open their eyes ten days after being born, and they are fed on mother's milk and regurgitated food that the mother vomits after chewing. The lifespan of jackals ranges from 8-9 years in the wild, and they may reach 16 years in closed spaces for their upbringing.

The gray wolf

Gray wolf Canis lupus, also known as a forest wolf or just a wolf in Arabic, is a carnivore of the Canidae family that shares a common ancestor with the domesticated dog. The sizes and weights of wolves vary greatly across their habitat, and the height of wolves is usually 0.6-0.8 meters at the shoulder, and their weight ranges from about 23 to 59 kg, which makes them the largest of the wild dogs. The Arabian wolves (the Arab race) are the smallest subspecies in size, as the adult females weigh 10 kg. The length of wolves from the nose to the tail, which forms about a quarter of the body length, is about 1.3-2 m. Wolves have a great endurance, they have external characteristics that help them to move its narrow chests, back, and strong legs all contribute to the skill and effectiveness of its mobility, as it is able to cover many miles by fading at a speed of 10 km per hour, and it is also known for its ability to run with a capacity of about 65 km per hour during its pursuit of prey, In the event of a jump, wolves are known to cover 5 meters per jump.

There are three main species endemic to the Arab world, and they are:

- The Arabian wolf, which is currently in southern Iraq, some Gulf regions, Oman, Yemen, Asir, southern Jordan, and Sinai.
- The Egyptian wolf, which is found in North Africa, especially in northern Egypt and northeastern Libya.
- The Indian wolf is found in southern Syria, Lebanon north of Jordan, and Pakstine, parts of northern and western Iraq.

Reem deer

The thyroid gazelle, which is also known as the black-tailed deer, the reem as the Arabs call it, the Persian gazelle is one of the deer species that are found in a wide area of Central and Western Asia, including part of Iran, southwestern Pakistan and the Gobi Desert, in addition to the Arabian Peninsula and southwestern Asia.

These animals are called thyroid gazelles because the neck and throat of males swell during the mating season, but this swelling is not considered a true thyroid swelling due to an enlarged thyroid gland. It should be noted that reem is also the name given to another type of deer that inhabits North Africa. The most prominent dangers that these animals are exposed to throughout their entire habitat are illegal hunting and loss of housing,

Houbara

The bustard bird is a symbol of the deserts of the Arabian Peninsula and is the first and heritage prey of falconers

The bustard is small to medium in size, it measures 55-65 cm in length, and extends 135-170 cm across the brown and white wings, with a black stripe down the sides of its neck, in flight the wings appear long with large areas of black and brown on the flight feathers. Females are 66 cm tall, but smaller and gray, males are 73 cm tall, body weight 1.15-2.4 kg in males and 1-1.7 kg. In the breeding season, males and females only meet the choice of a breeding mate.

Pterocles

This bird is a migratory bird that lives in the same group with its platoon, and it is a bird that cannot live in the **place** without water, and it spreads all over the world, including North Africa and the Middle East, and has an amazing speed of attention that distinguishes it from any other bird.

• After a month, the bird hatches its eggs, the female protects her young, and the male goes to bring the food for them

• The female lies on her eggs in the rough nest.

• The bird is characterized by the similarity of its legs to snow boots. It is suitable for walking, with an ax-shaped beak and black claws.

The falcon

Al- Shaheen is considered one of the strongest and bravest falcons and is famous for its speed and its superior ability to maneuver by air and it is smaller in size than the heat and its multitude of colors, including the Red Shaheen, the Bahri Shaheen and the Mountain Shaheen. Peregrine falcon is widespread on the planet, and the peregrine falcon can be found almost everywhere. This makes it one of the most common birds of prey in the world.

Al- Shaheen is considered sexually mature for mating from the first three years of life, but it is advisable to give birth after two to three years of age. Usually the male and the female meet each year when mating for life and return to the same place of nesting annually.

Female Shaheen usually lays eggs from February to March in the northern hemisphere, and from July to August in the southern hemisphere, although Australia and the Macrops strain were born in late November in Equatorial Guinea. The incubation of eggs takes place from 29 to 33 days, mostly by the female, with the male cooperating to incubate the eggs during the day only.

Saker (Falcon)

The Saker Falcon (from now on referred to as Saker) is classified as Endangered according to the IUCN Red-list of Threatened Species, due to a rapid population decline globally of 47% between 1993 and 2012 (Birdlife International, 2012; IUCN, 2013). According to Kova´cs et al. (2014), the Saker population trend varies between countries, for instance the population is increasing or stable in Austria, the Czech Republic, Hungary, Slovakia, and Ukraine, whilst it is decreasing in Bulgaria, China, Iraq, Kazakhstan, Russia, Serbia and Uzbekistan. As a result of unsustainable trapping in these areas, the Saker is typically used by falconers in Arab countries, and traditionally has been trapped for falconry during the autumn. Arabs are the first people who knew the Saker Falcon, where they used it for hunting purposes. Its name (Saker Falcon) came from his Arabic name. Its types are very numerous and it is difficult to enumerate and count, and the approved measure of distinction is the general color of the falcon through its back and chest feathers, in addition to the presence or absence of spots or points, as well as the color of the head, the front of the neck and the chest, do not depend on length and weight.

Appendix 4:

Wet year and Dry year in Study Area

Table below explains the wet years which mean any year in which the rainfall depth is greater than the average rainfall depth, while the dry year is of depth less than the average. Small dams are filled with water in wet years and store water for several years, including dry years, (as shown below in figures a-f).,

Table a: Annual Rainfall Data 1971-2019

Year	Rainfall mm	State	Year	Rainfall mm	State
1971	139.7	Wet Year	1996	93.8	Dry Year
1972	219.1	Wet Year	1997	98.8	Dry Year
1973	66.3	Dry Year	1998	268.4	Wet Year
1974	167	Wet Year	1999	31.3	Dry Year
1975	125.8	Wet Year	2000	55.8	Dry Year
1976	138.4	Wet Year	2001	103.3	Dry Year
1977	96.9	Dry Year	2002	103.5	Dry Year
1978	80.9	Dry Year	2003	109.9	Dry Year
1979	52.5	Dry Year	2004	95.6	Dry Year
1980	138.3	Wet Year	2005	124.5	Wet Year
1981	97.2	Dry Year	2006	107.5	Dry Year
1982	143	Wet Year	2007	72.2	Dry Year
1983	128.7	Wet Year	2008	72.9	Dry Year
1984	42.6	Dry Year	2009	23.3	Dry Year
1985	119.9	Wet Year	2010	109	Dry Year
1986	107.5	Dry Year	2011	87.9	Dry Year
1987	63.4	Dry Year	2012	73	Dry Year
1988	216.3	Wet Year	2013	134.2	Wet Year
1989	163.6	Wet Year	2014	83.3	Dry Year
1990	90.9	Dry Year	2015	8.2	Dry Year
1991	70.9	Dry Year	2016	11	Dry Year
1992	130.8	Wet Year	2017	6	Dry Year
1993	130	Wet Year	2018	101.8	Dry Year
1994	64.1	Dry Year	2019	134.9	Wet Year
1995	339.5	Wet Year			

Wet years

Figure (a): Wet year 1989 in Wadi Horan, rainfall depth 163.6 mm

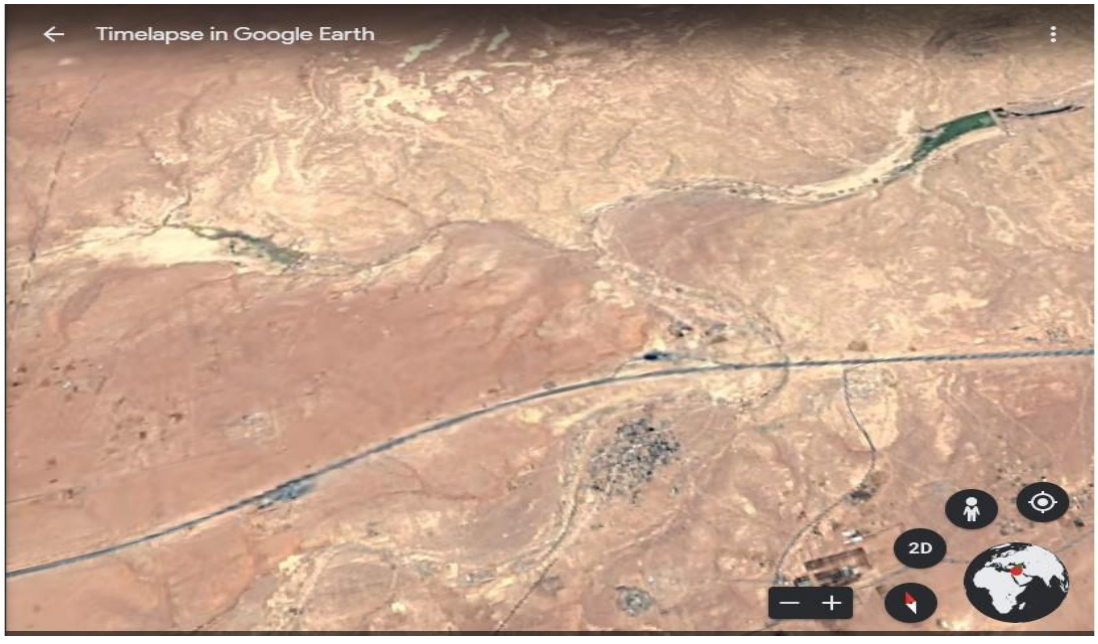


Figure (b): Wet year 2013 in Wadi Horan, rainfall depth 134.2 mm

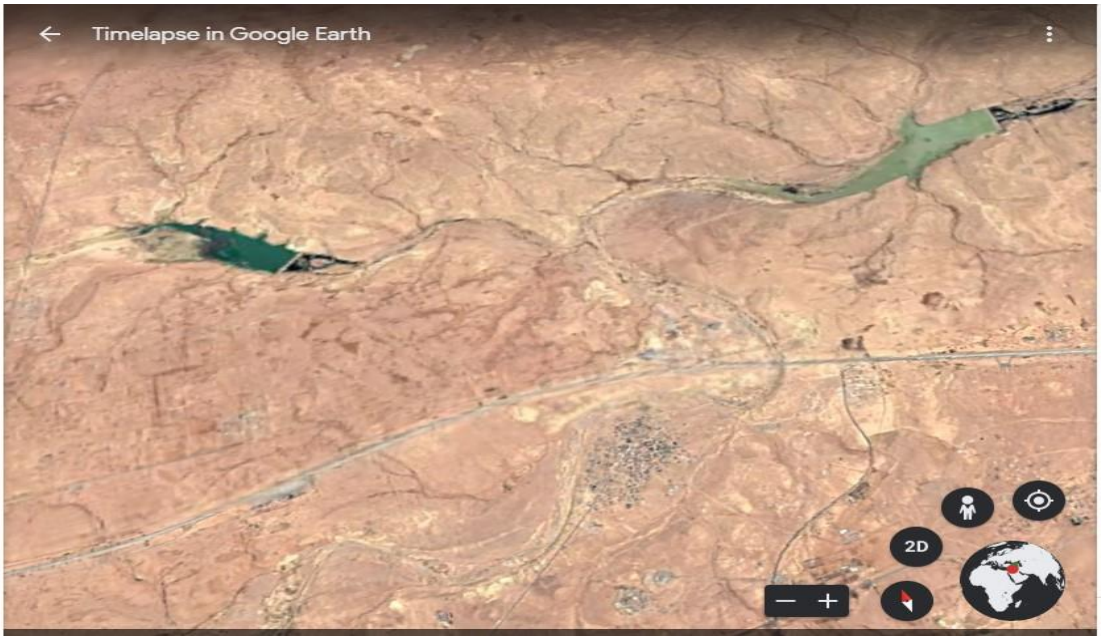


Figure (c): Wet year 2019 in Wadi Horan, rainfall depth 134.9 mm

Dry years

Figure (d): Dry year 2008 in Wadi Horan, Rainfall depth 72.9 mm

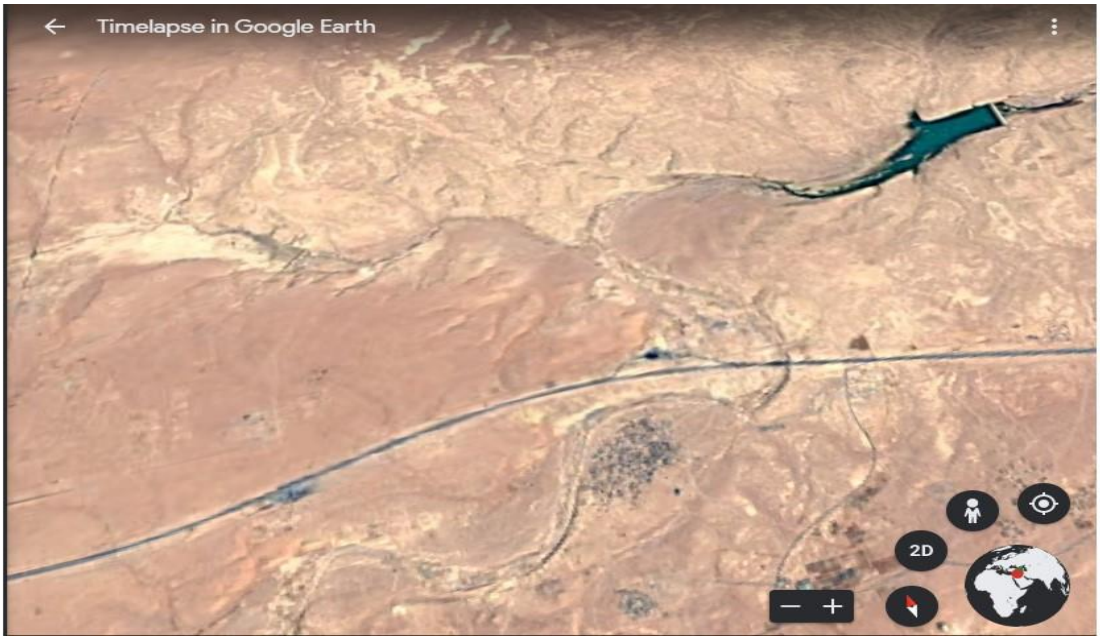


Figure (e): Dry year 2011 in Wadi Horan, Rainfall depth 87.9 mm

Figure (f): Dry year 2014 in Wadi Horan, rainfall depth 83.3 mm

Appendix 5:

Water Harvesting Methods

The scientific principle of water harvesting contains the determination of catchment area of wide-area collets the runoff produced from rainfall to convert water to cultivated area which is a small area toward the slope of the land, i.e. the water harvesting means the collection of water from a wide area to concentrate it in a small area which needs the water supply especially in arid desert regions that have a small volume of rainfall quantities insufficient for forestation or naturally grown trees. In the case of investment in the desert, it is very important to consider the above-mentioned principle to increase the water needed for the single tree which is sufficient for growth.

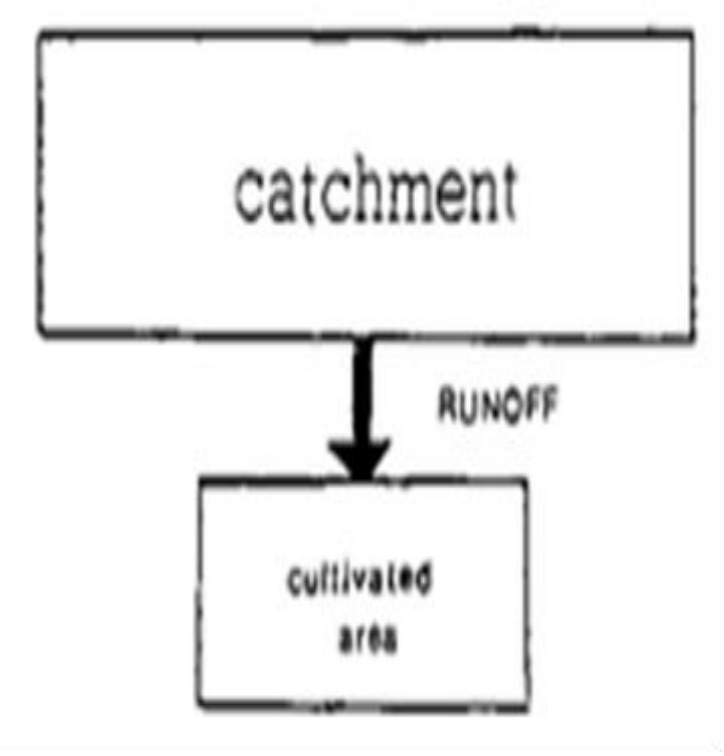


Figure 1 The principle of water harvesting

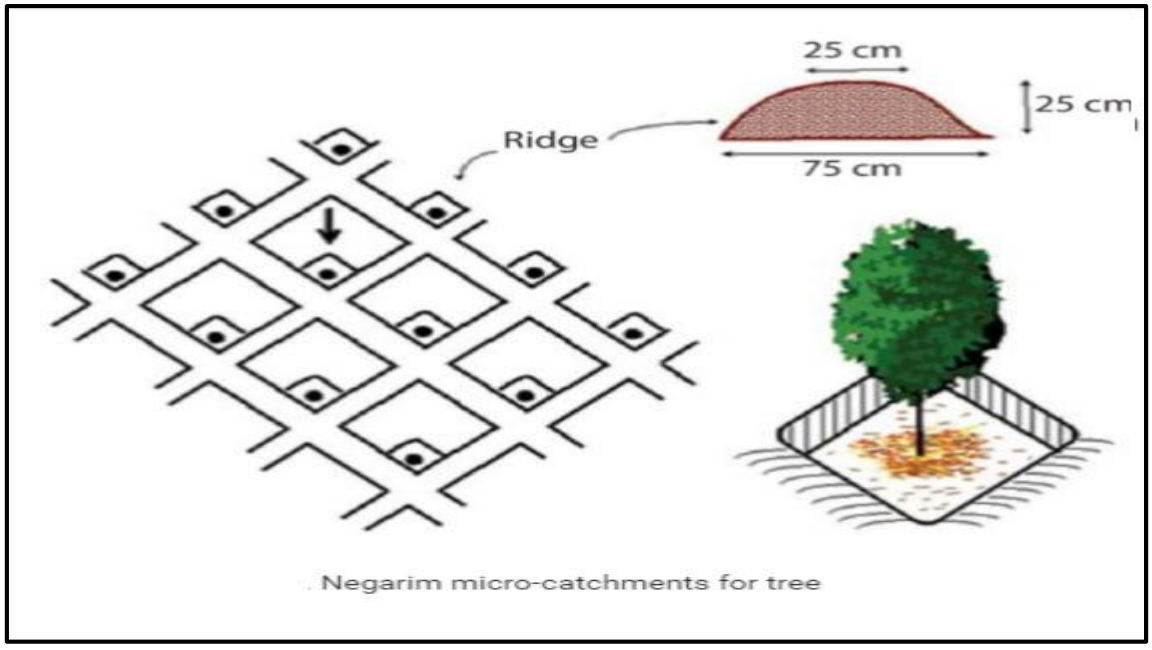


Figure 2 The Negarim micro- catchments for tree

The theoretical base:

$$\text{System unit area} = \text{CA area} \times \frac{consumptiv\ use - rainfall\ volume}{rainfall\ volume \times runoff\ coefficient \times activity\ coefficient}$$

This equation is based on the following assumptions:

The volume of water in the catchment area (SA) = the CA water requirements ……. 1

$$\text{CAT} = \text{CAT area (system unit)}\ rainfall\ volume \times runoff\ coefficient \times activity\ coefficient \quad \ldots\ldots\ldots\ 2$$

$$\text{CA water requirements} = \text{CA area} \times plant\ requirements\ (evapotranspiration) - rainfallvolume \quad \ldots\ldots\ldots\ldots\ 3$$

By replacing 2 and 3 in 1 equation it produces the following:

$CAT\ area \times runoff\ coefficient \times activity\ coefficient$ = the CA water requirements $plant\ requirements\ (ET) - rainfallvolume$ …….. 4

Rearranging 4 equation produce the following equation:

$$\frac{CAT\ area}{CA\ area} = \frac{plant\ requirement - rainfall\ volume}{rainfallvolume \times runoff\ coefficient \times activity\ coefficient} \quad \ldots\ldots\ 5$$

Example:

Assume that the Negarim water harvesting system will be used to cultivate an olive tree in a desert region. What are the dimensions and area of the system unit?

Solution:

Assume that the olive tree occupies a circle of 1 meter diameter. Then the area of the cultivated area will be calculated as the following:

CA area = $(1)^2 \times 3.14 = 3.4\ m^2$

Assume that the rainfall depth is 91 mm/year

Assume that the olive tree needs 1200 mm/year

The runoff coefficient is 0.3 (the ratio of rainfall as runoff).

The activity coefficient is 0.5 (the excess of runoff water)

Then

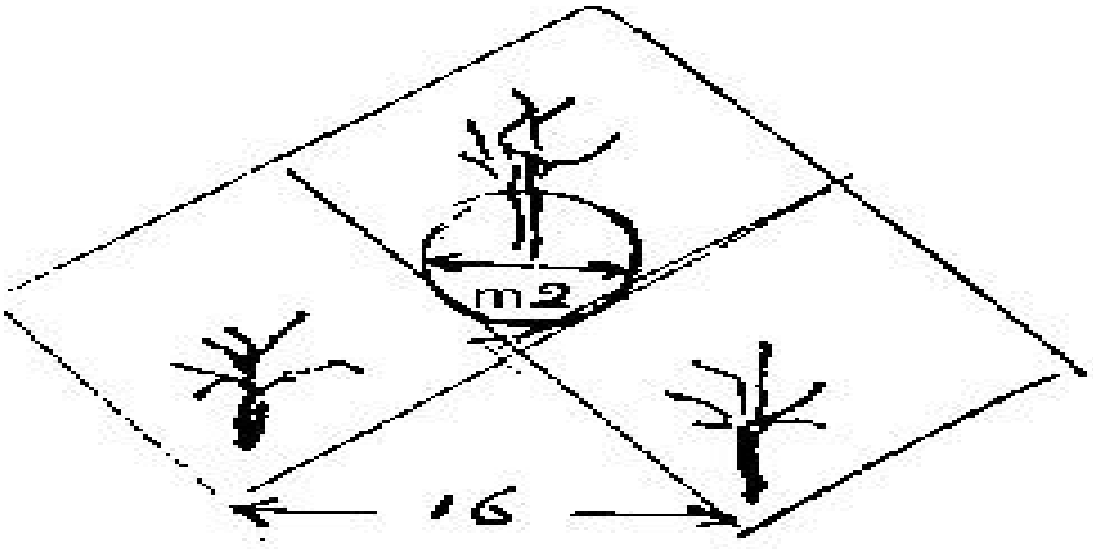
The area of the Negarim system according to equation (5) is:

$$\frac{catchment\ unit\ area}{the\ area\ of\ cultivated\ region} = \frac{plant\ requirement - raifall\ volume}{rainfall\ volume \times runoff\ coefficient \times activity\ coefficient}$$

$$\frac{catchment\ unit\ area}{3.14} = \frac{1200-91}{91 \times 0.3 \times o.5}$$

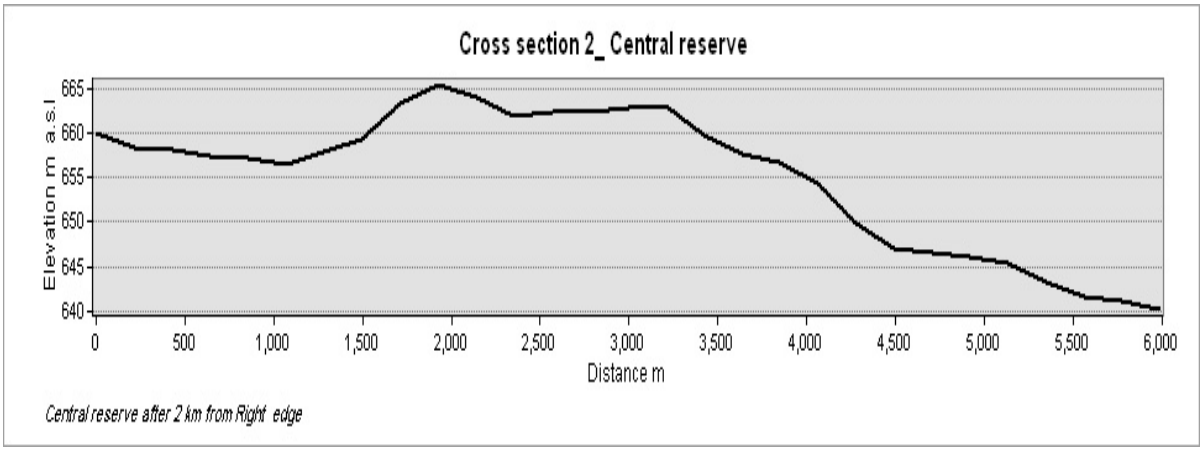
Then: the area of system area (Negarim shape) = 255 m^2

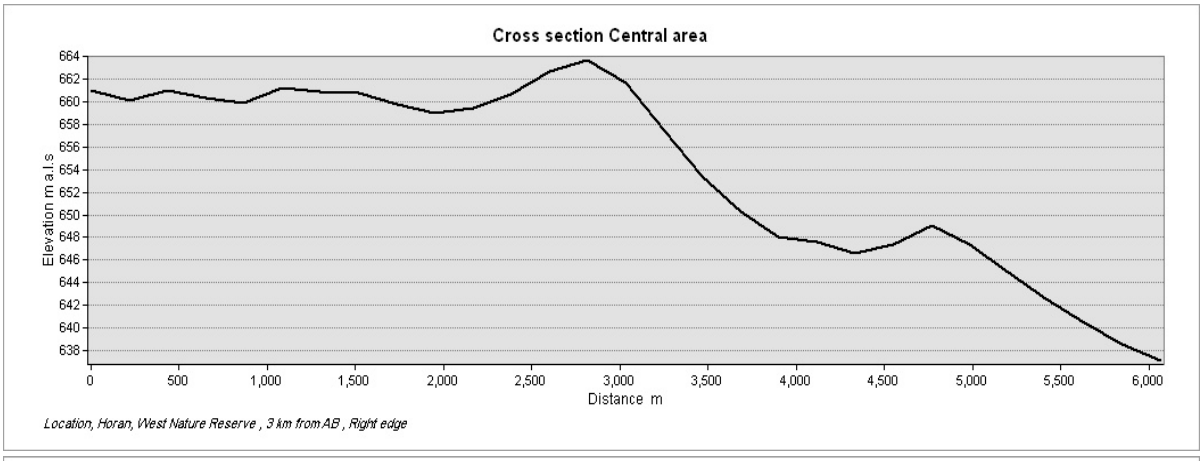
That is, the area of the Negarim shape system is approximately 250m^2.

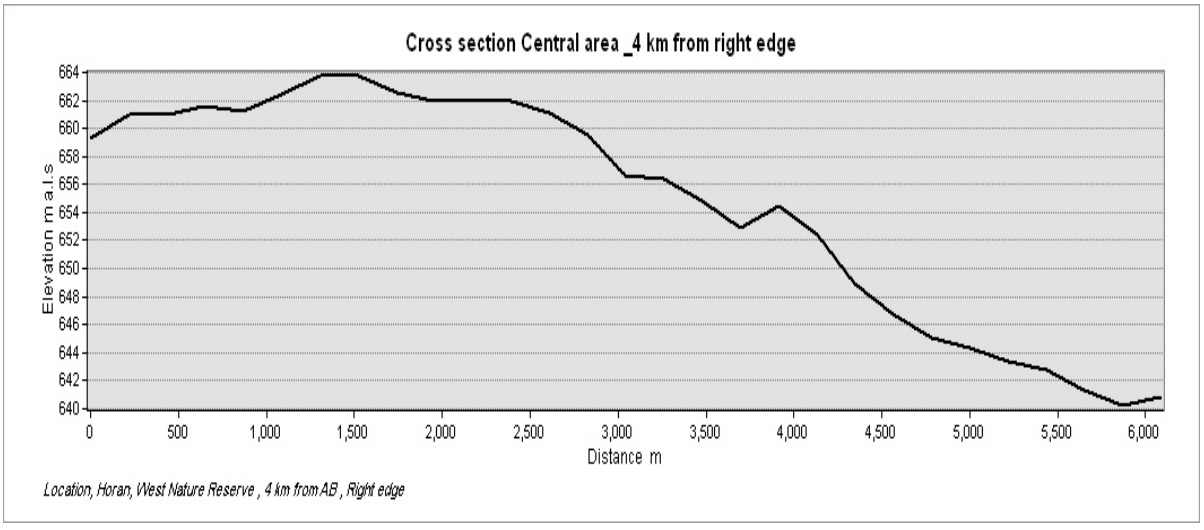

m2
16
m

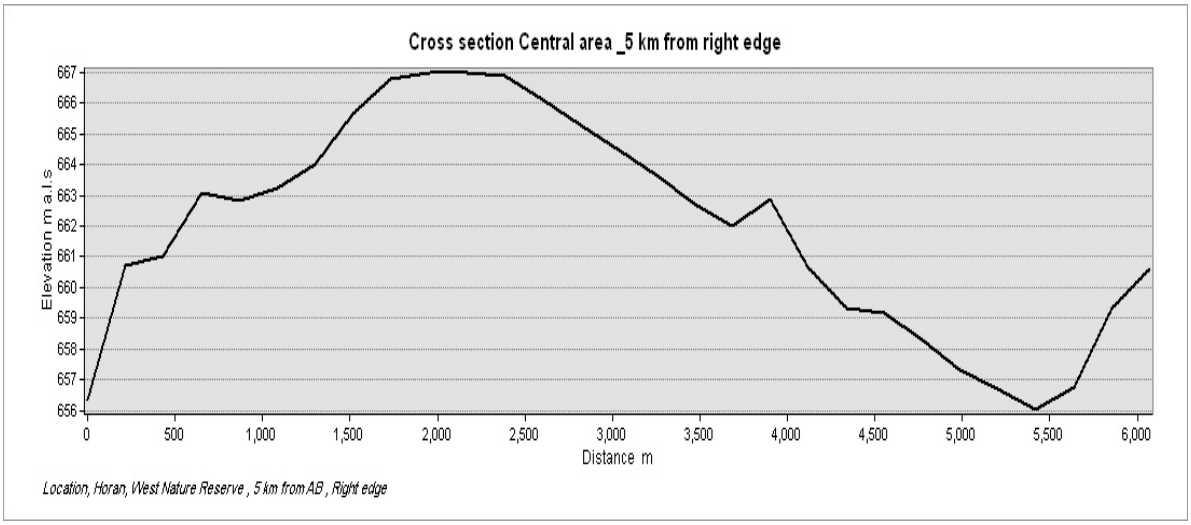
Appendix 6A:

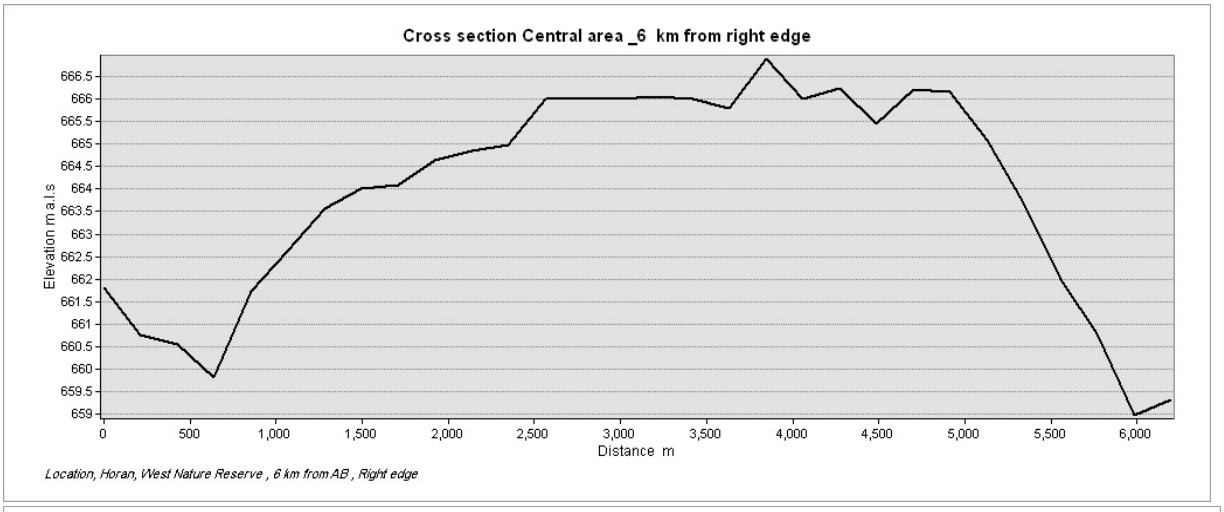
Longitudinal and transverse Cross sections in Nature reserve and International Park

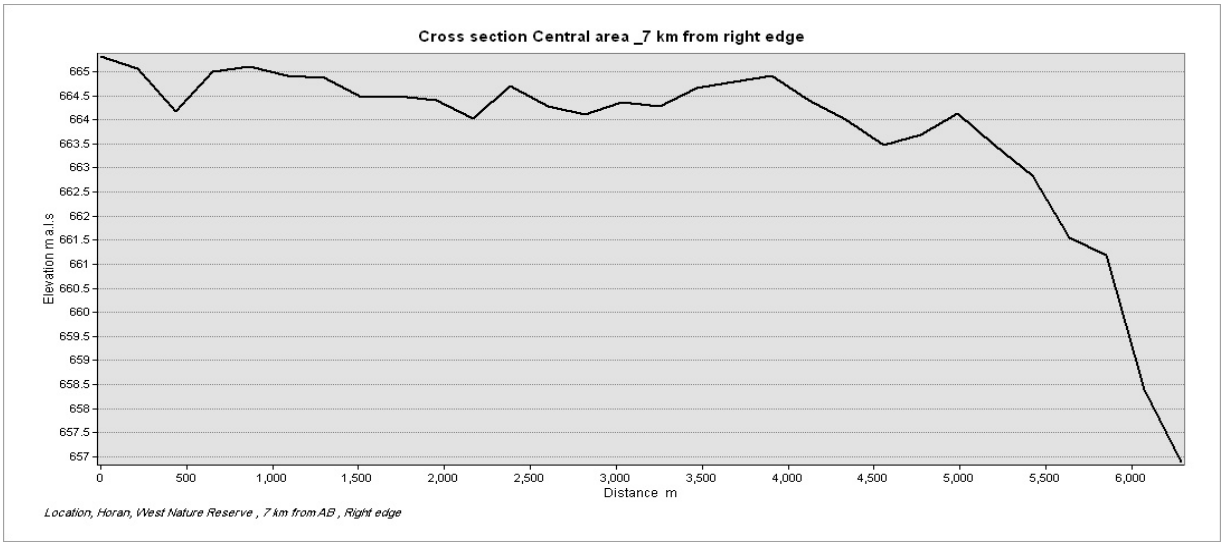




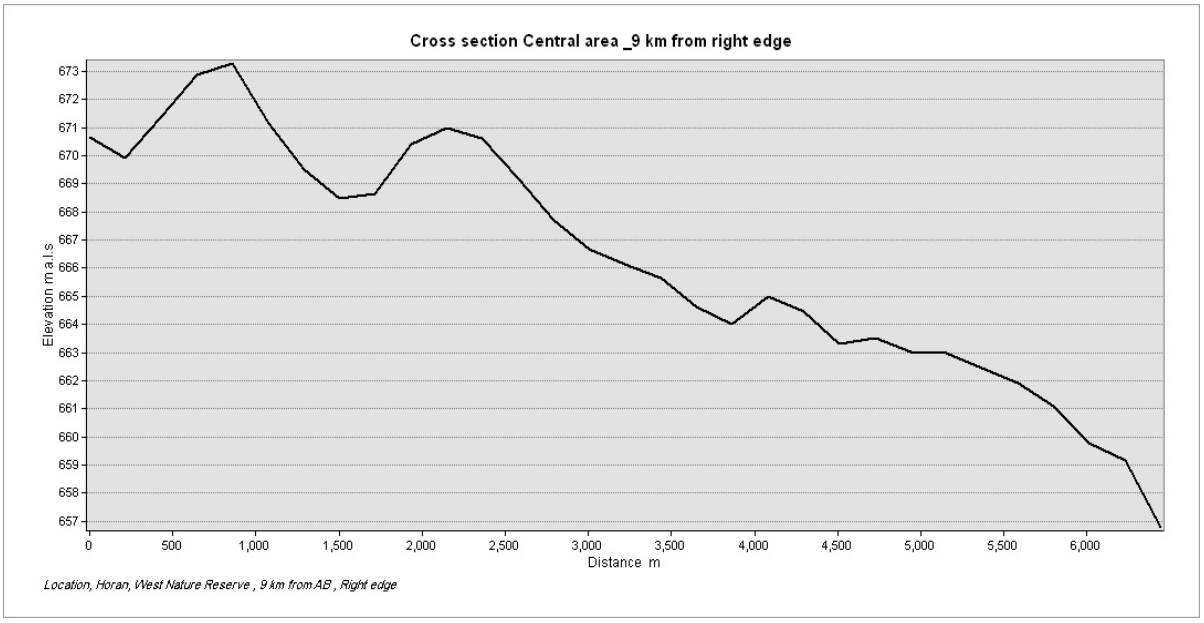


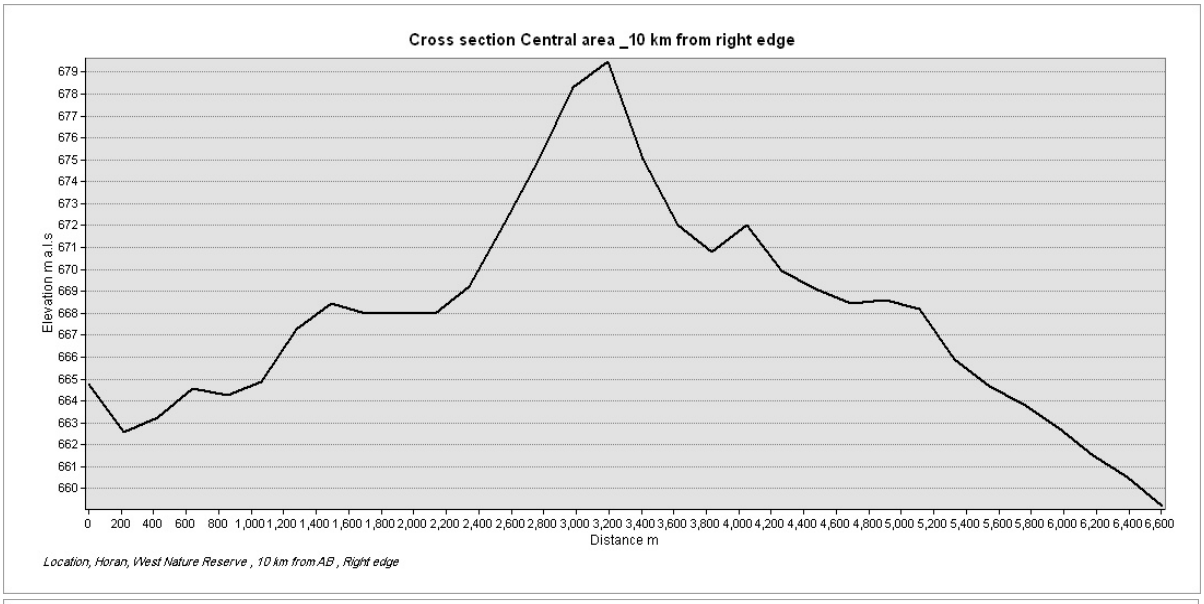

Cross section Central area _5 km from right edge
Elevation m a.l.s
667
666
665
664
663
662
661
660
659
658
657
656
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
5,500
6,000
Distance m
Location, Horan, West Nature Reserve , 5 km from AB , Right edge

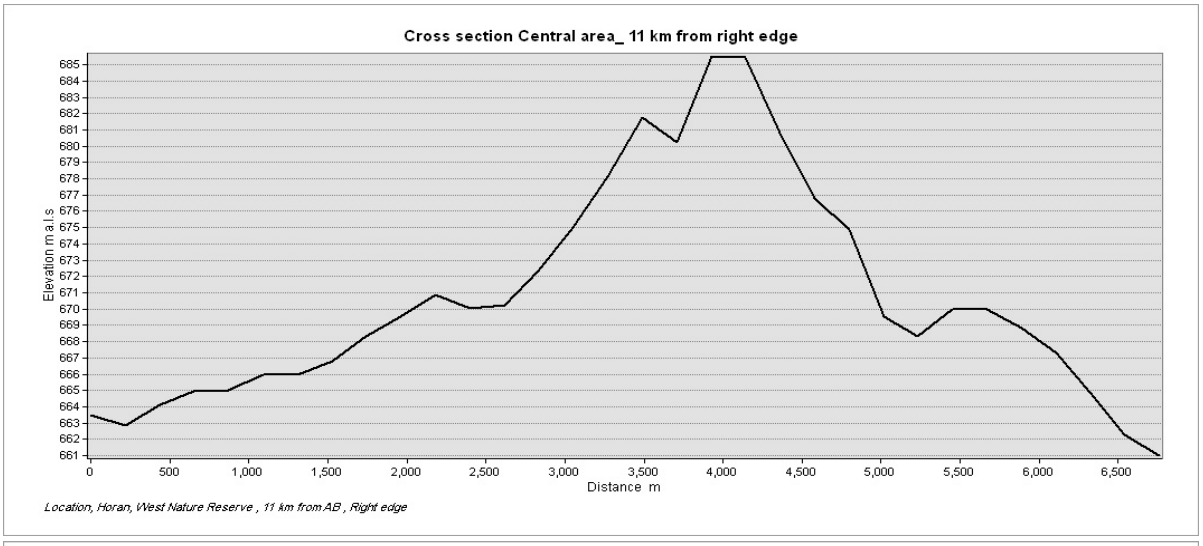

Cross section Central area _6 km from right edge
Elevation m a.l.s
666.5
666
665.5
665
664.5
664
663.5
663
662.5
662
661.5
661
660.5
660
659.5
659
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
5,500
6,000
Distance m
Location, Horan, West Nature Reserve , 6 km from AB , Right edge

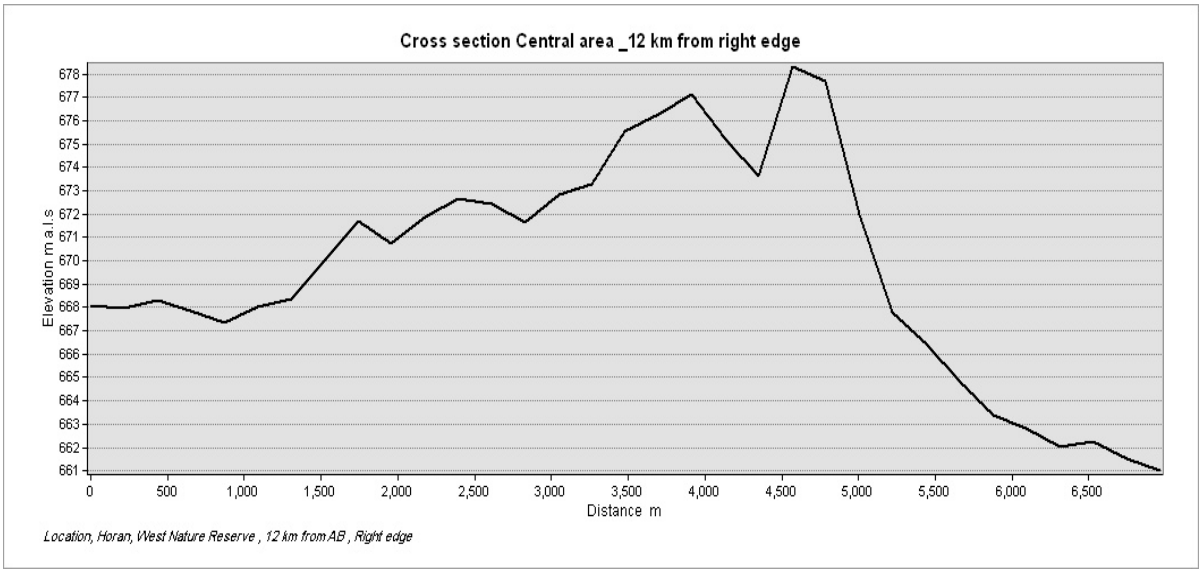

Cross section Central area _7 km from right edge
Elevation m a.l.s
665
664.5
664
663.5
663
662.5
662
661.5
661
660.5
660
659.5
659
658.5
658
657.5
657
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
5,500
6,000
Distance m
Location, Horan, West Nature Reserve , 7 km from AB , Right edge

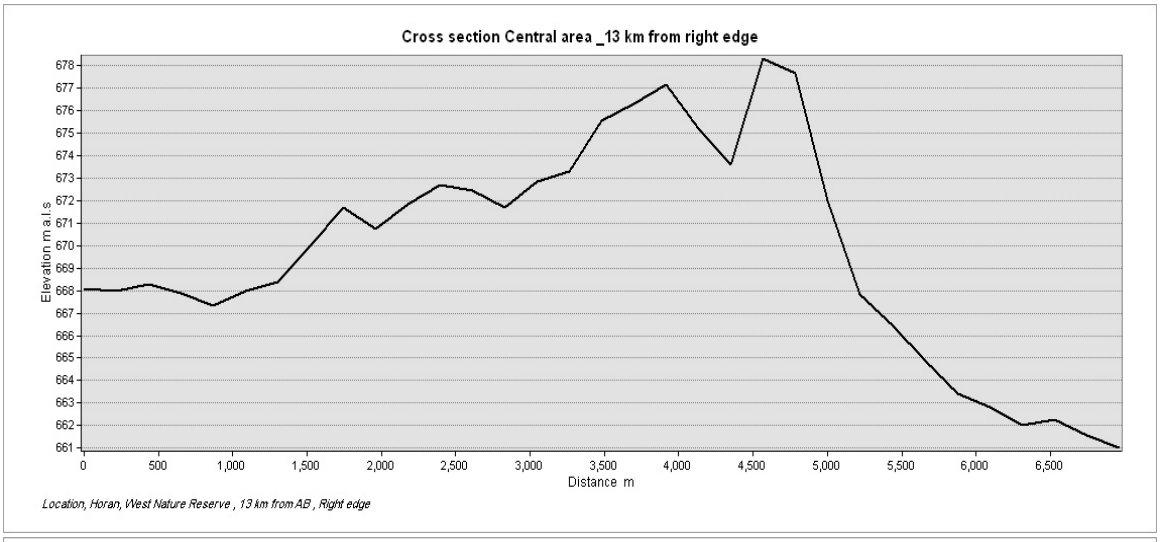

Cross section Central area _8 km from right edge
Elevation m.a.l.s
668
667.5
667
666.5
666
665.5
665
664.5
664
663.5
663
662.5
662
661.5
661
660.5
660
659.5
659
658.5
658
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
5,500
6,000
Distance m
Location, Horan, West Nature Reserve , 8 km from AB , Right edge

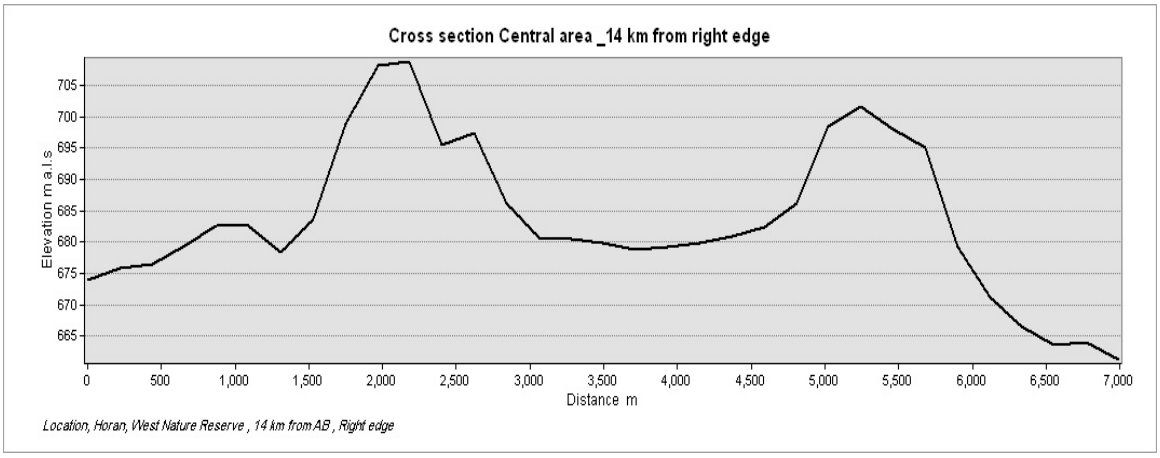

Cross section Central area _9 km from right edge
Elevation m.a.l.s
673
672
671
670
669
668
667
666
665
664
663
662
661
660
659
658
657
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
5,500
6,000
Distance m
Location, Horan, West Nature Reserve , 9 km from AB , Right edge

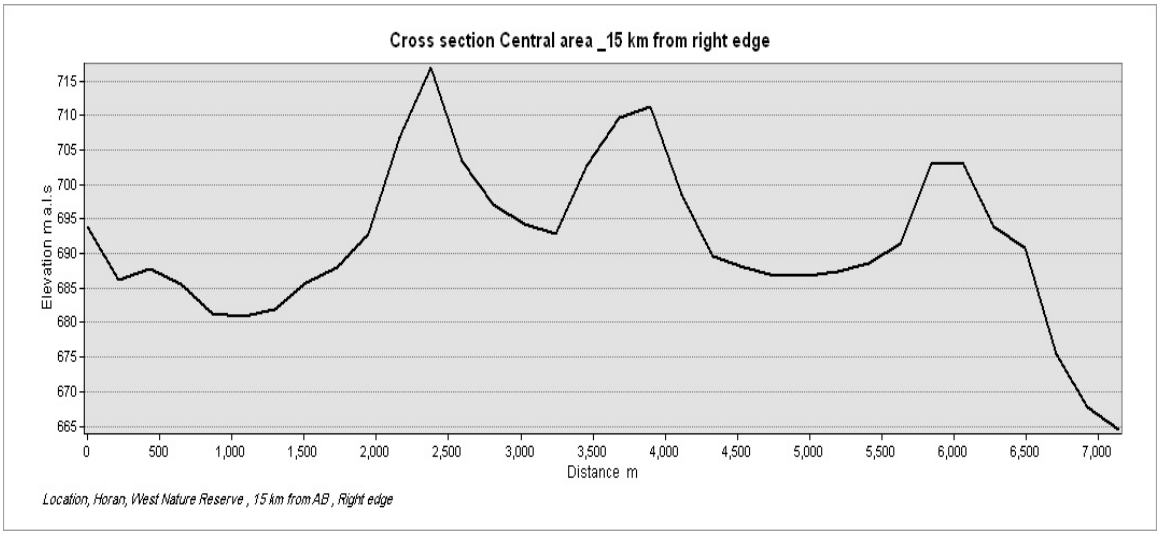

Cross section Central area _10 km from right edge
Elevation m.a.l.s
Distance m
Location, Horan, West Nature Reserve , 10 km from AB , Right edge

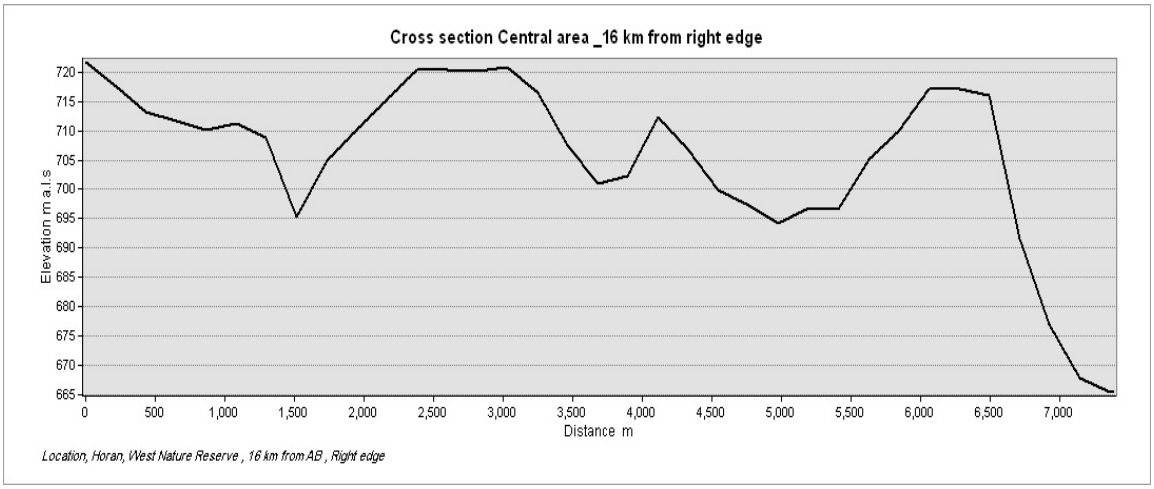

Cross section Central area_ 11 km from right edge
Elevation m.a.l.s
Distance m
Location, Horan, West Nature Reserve , 11 km from AB , Right edge

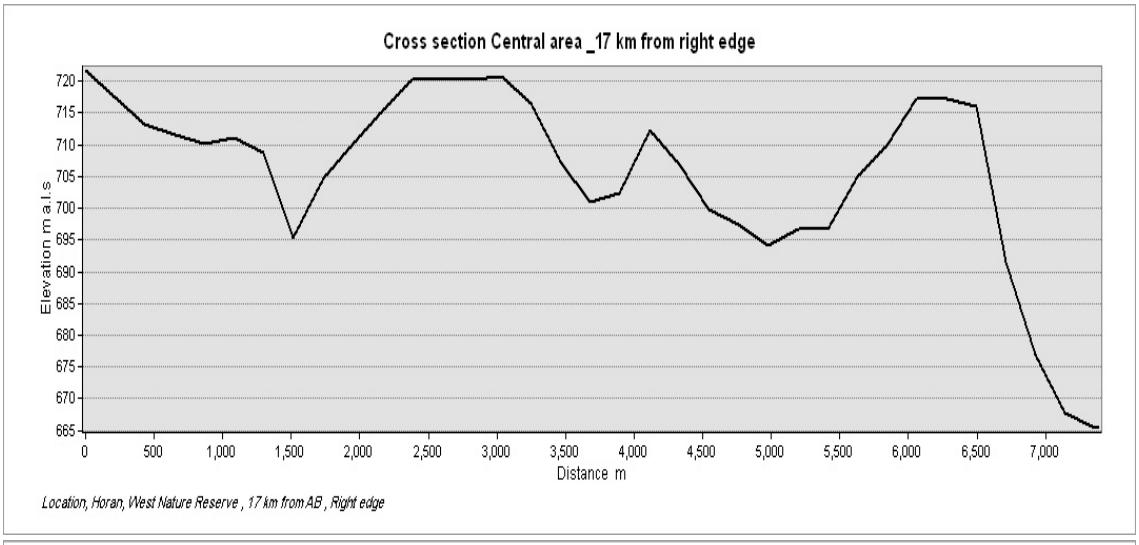

Cross section Central area _12 km from right edge
Elevation m.a.l.s
Distance m
Location, Horan, West Nature Reserve , 12 km from AB , Right edge

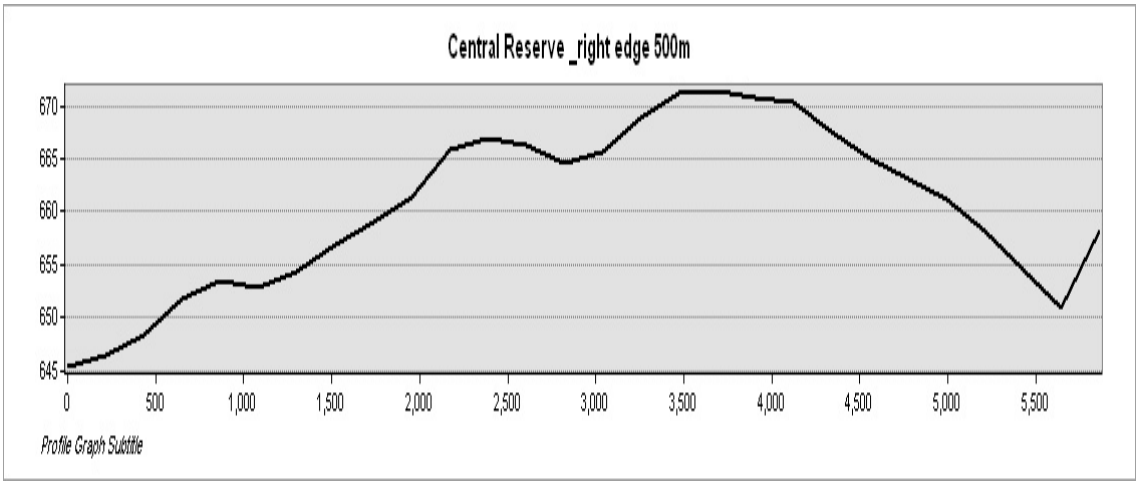

Cross section Central area _13 km from right edge
Elevation m.a.l.s
678
677
676
675
674
673
672
671
670
669
668
667
666
665
664
663
662
661
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
5,500
6,000
6,500
Distance m
Location, Horan, West Nature Reserve , 13 km from AB , Right edge

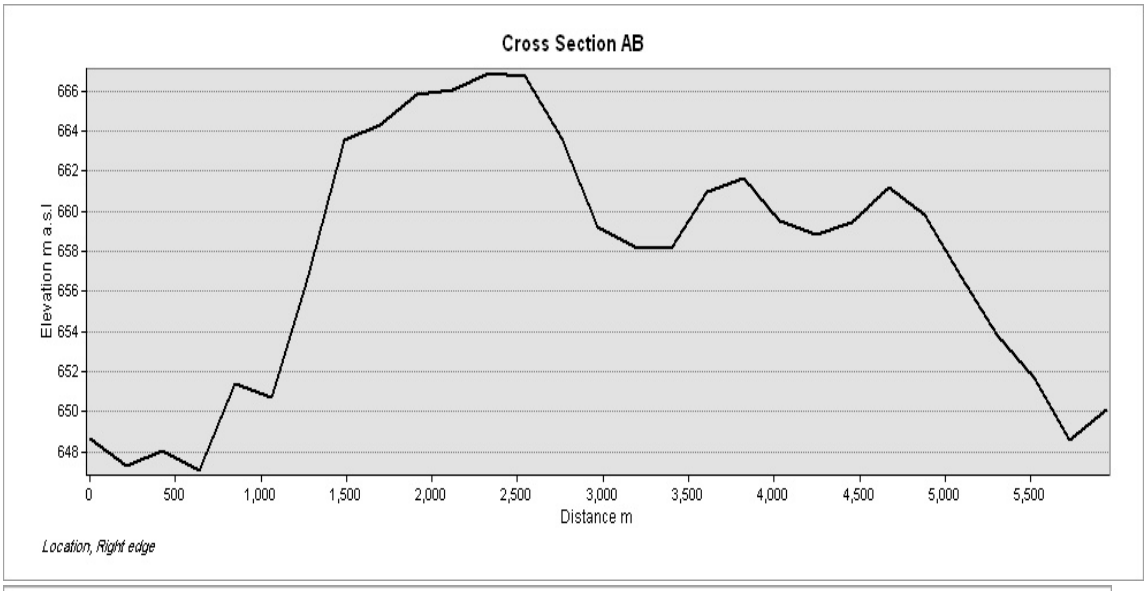

Cross section Central area _14 km from right edge
Elevation m.a.l.s
705
700
695
690
685
680
675
670
665
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
5,500
6,000
6,500
7,000
Distance m
Location, Horan, West Nature Reserve , 14 km from AB , Right edge

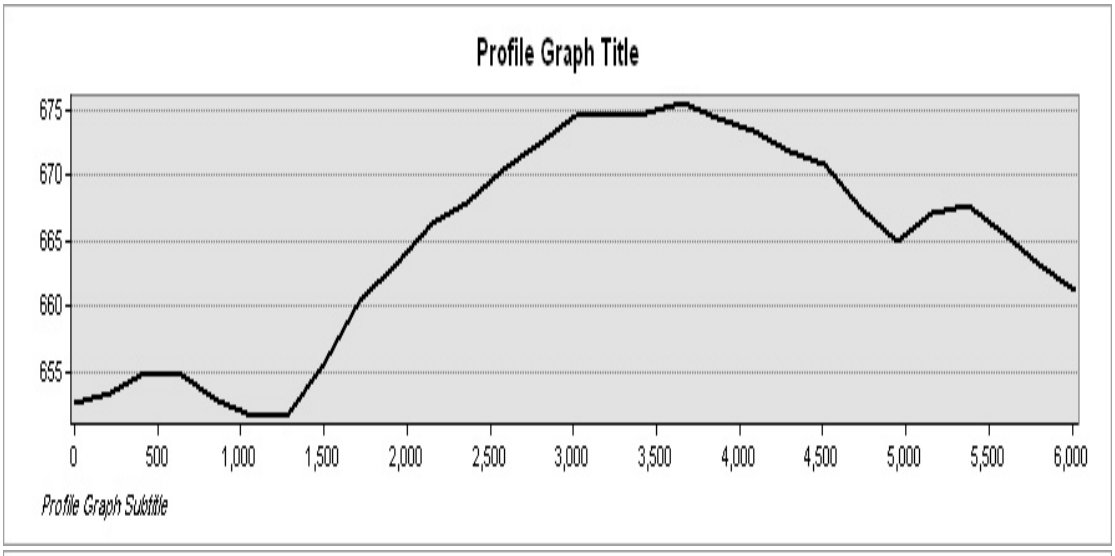

Cross section Central area _15 km from right edge
Elevation m.a.l.s
715
710
705
700
695
690
685
680
675
670
665
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
5,500
6,000
6,500
7,000
Distance m
Location, Horan, West Nature Reserve , 15 km from AB , Right edge

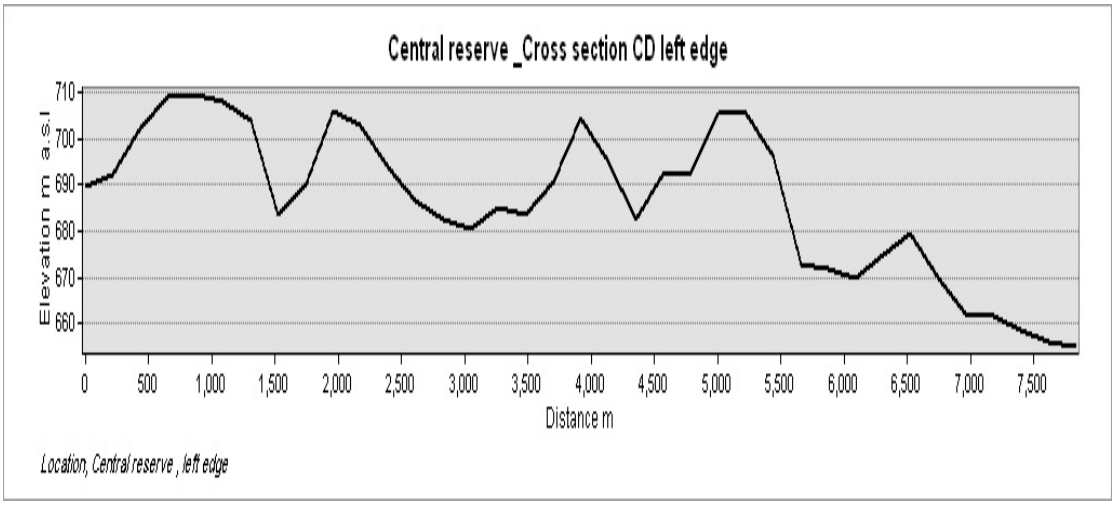

Cross section Central area _16 km from right edge
Elevation m.a.l.s
720
715
710
705
700
695
690
685
680
675
670
665
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
5,500
6,000
6,500
7,000
Distance m
Location, Horan, West Nature Reserve , 16 km from AB , Right edge

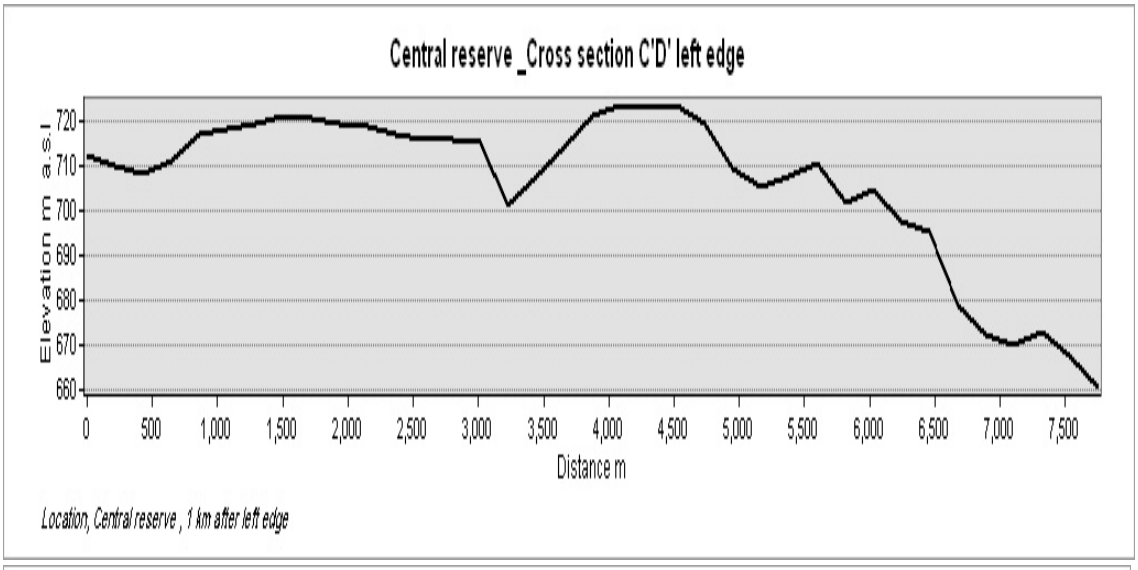

Cross section Central area _17 km from right edge
Elevation m.a.l.s
720
715
710
705
700
695
690
685
680
675
670
665
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
5,500
6,000
6,500
7,000
Distance m
Location, Horan, West Nature Reserve , 17 km from AB , Right edge


Central Reserve _right edge 500m
670
665
660
655
650
645
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
5,500
Profile Graph Subtitle

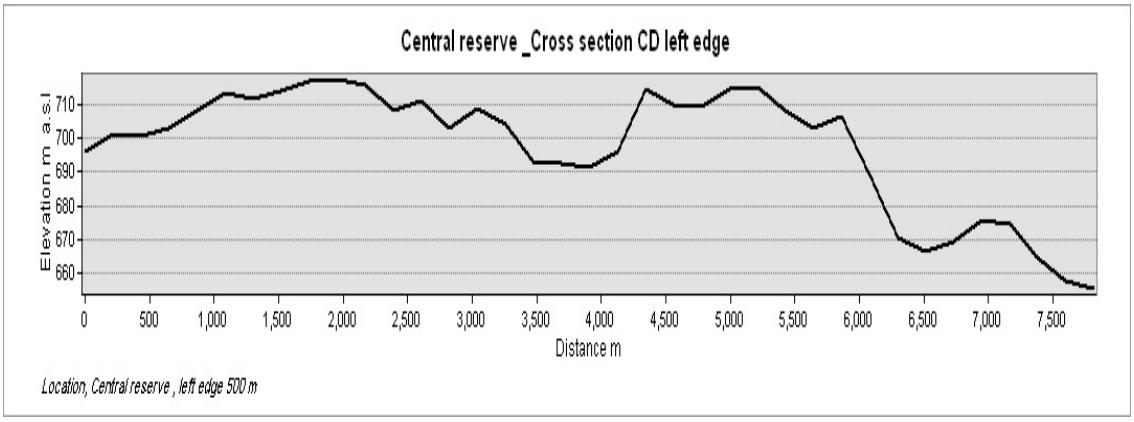

Cross Section AB
Elevation m a.s.l
666
664
662
660
658
656
654
652
650
648
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
5,500
Distance m
Location, Right edge


Profile Graph Title
675
670
665
660
655
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
5,500
6,000
Profile Graph Subtitle

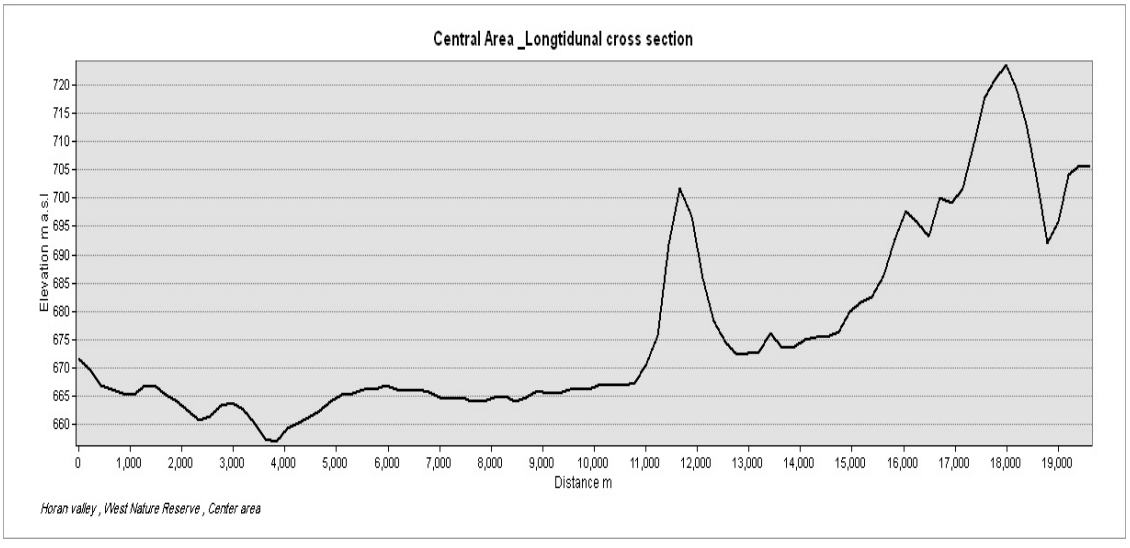

Central reserve _Cross section CD left edge
Elevation m a.s.l
710
700
690
680
670
660
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
5,500
6,000
6,500
7,000
7,500
Distance m
Location, Central reserve , left edge



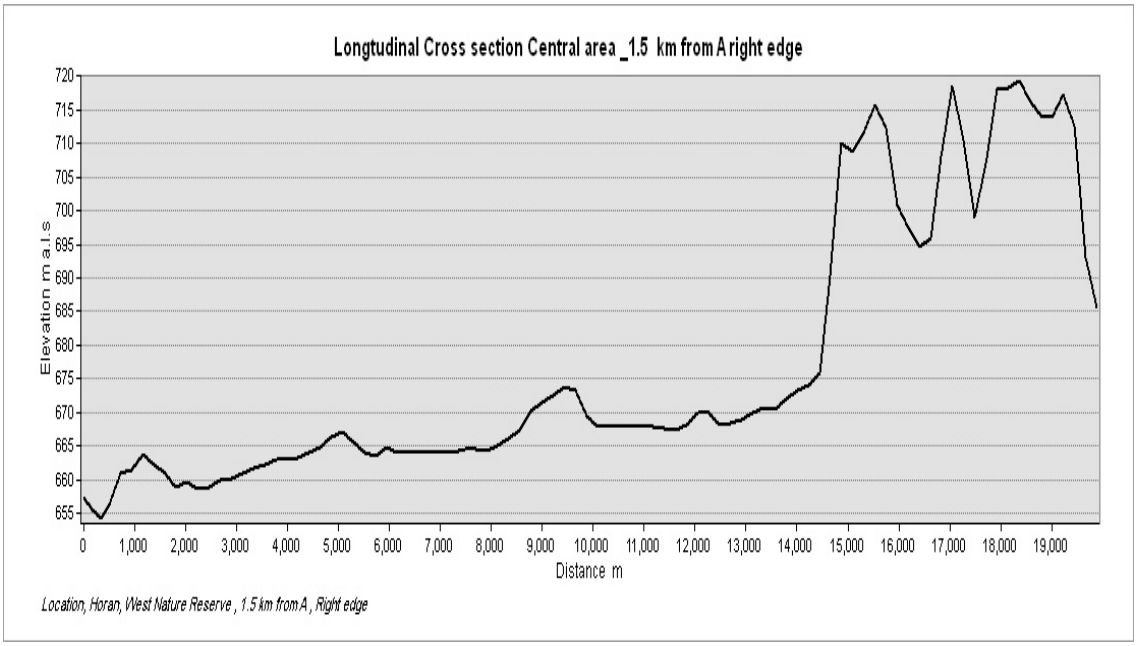
Location, Central reserve , 1 km after left edge

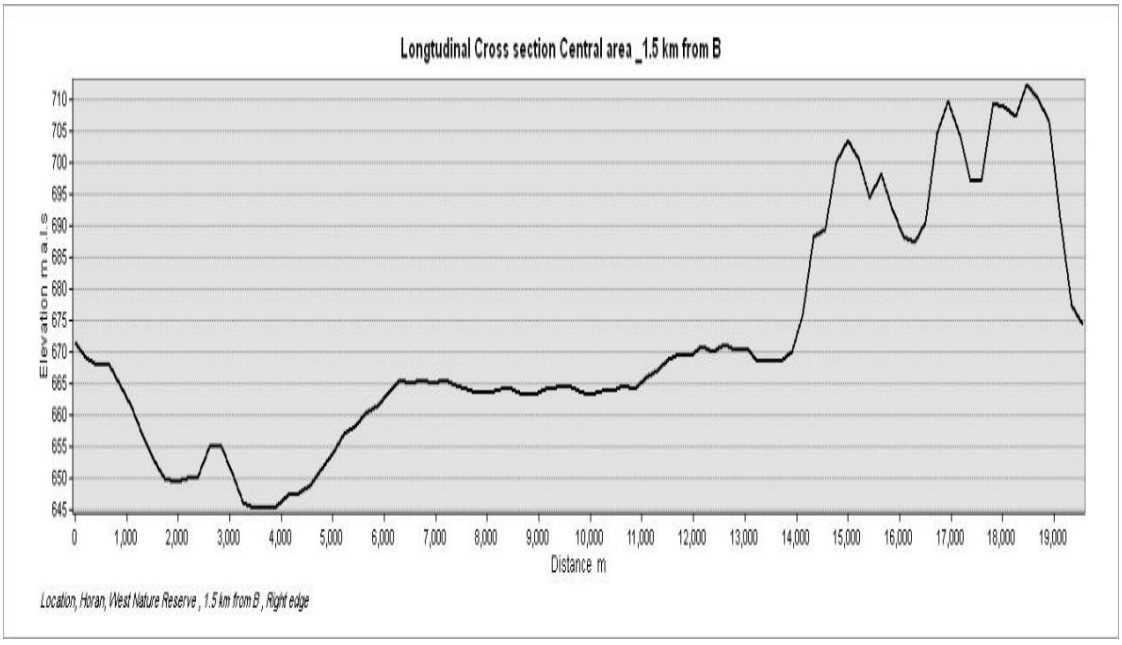


Location, Central reserve , left edge 500 m

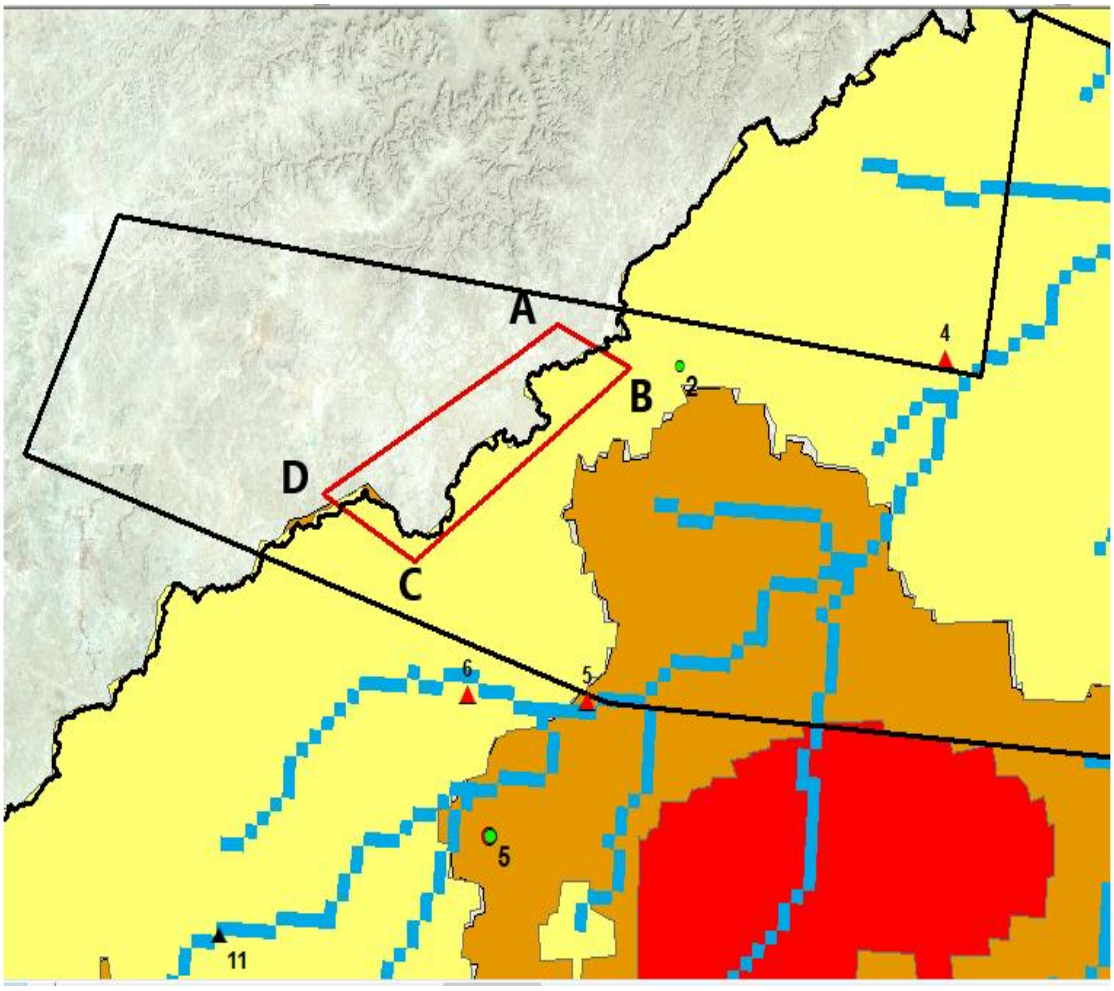


Horan valley , West Nature Reserve , Center area


Longtudinal Cross section Central area _1.5 km from A right edge
Elevation m.a.s
720
715
710
705
700
695
690
685
680
675
670
665
660
655
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
15,000
16,000
17,000
18,000
19,000
Distance m
Location, Horan, West Nature Reserve , 1.5 km from A , Right edge


Longtudinal Cross section Central area _1.5 km from B
Elevation m.a.s
710
705
700
695
690
685
680
675
670
665
660
655
650
645
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
15,000
16,000
17,000
18,000
19,000
Distance m
Location, Horan, West Nature Reserve , 1.5 km from B , Right edge

Appendix 6B: Coordinate of Central Reserve



Point	N	E
A	3695275	69107.7
B	3692346	72606.7
C	3680492	56938.18
D	3684672	50365

Appendix 7:

The scientific basis for the design of the discharge meter

Theory of Measurement:

The total energy of a channel flow is given by,

$$H = z + y + \frac{V^2}{2g} \dots\dots\dots\dots (1)$$

If the datum coincides with the channel bed at the cross-section, the resulting expression is known as specific energy or (E) which is the energy at a cross-section of an open channel flow with respect to the channel bed. It is very useful in defining critical water depth and in the analysis of open channel flow. It may be noted that while the total energy in a real fluid flow always decreases in the downstream direction, the specific energy is constant for a uniform flow and can either decrease or increase in a varied flow, since the elevation of the bed of the channel relative to the elevation of the energy line, determines the specific energy. Specific energy at a cross-section is,

$$H = y + \frac{V^2}{2g} = y + \frac{Q^2}{2gA^2} \dots\dots\dots\dots (2)$$

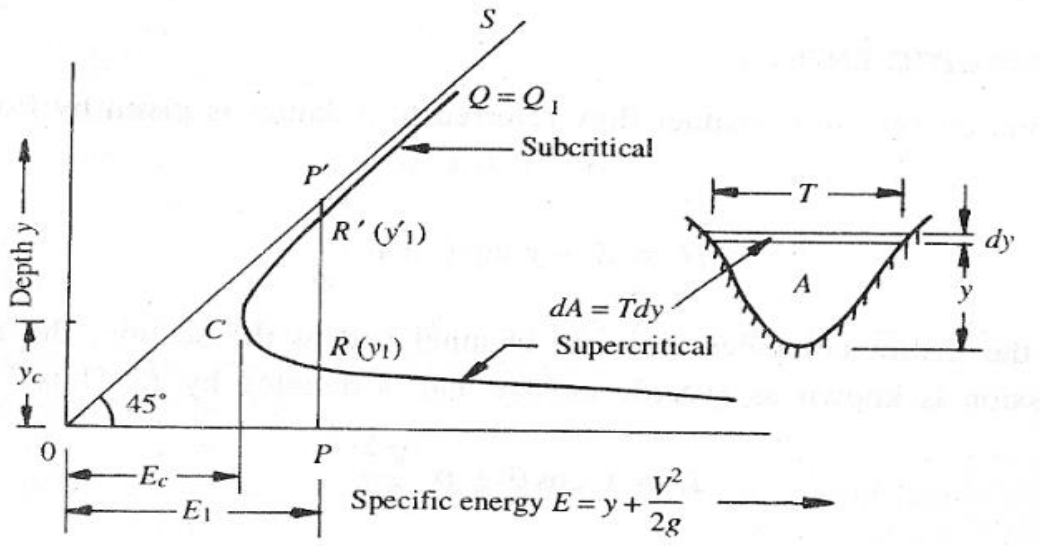


Figure (1): Specific energy diagram

For known geometry, E = f (y, Q). Keeping Q = constant = Q1, the variation of E with y is represented by a cubic parabola as shown in Figure 1. There are two positive roots for the

equation E indicating that any particular discharge Q1 can be passed in a given channel at two depths and still maintains the same specific energy E1. The depths of flow can be either PR = y1 or PR` = y`1. These two possible depths having the same specific energy are known as *alternate depths*. As shown in Figure 1, a line (OS) drawn such that E = y (i.e. at 45^0 to the abscissa) is the asymptote of the upper limb of the specific energy curve. It may be noticed that the intercept P`R` and P`R represents the velocity head. Of the two alternate depths, one (PR = y1) is smaller and has a large velocity head while the other (PR`= y`1) has a larger depth and consequently a smaller velocity head. For a given Q, as the specific energy is increased the difference between the two alternate depths increases. On the other hand, if E is decreased, the difference (y`1 – y1) will decrease and a certain value E = Ec, the two depths will merge with each other (point C in Figure 1). No value for y can be obtained when E < Ec, denoting that the flow under the given conditions is not possible in this region. The condition of minimum specific energy is the *critical flow condition* and the corresponding depth *yc* is *critical depth*.

Rectangular Cross-Section

For a rectangular channel, A = By, and T = B,

$$E = y + \frac{Q^2}{2gB^2y^2}$$

q=(Q/B)= Discharge per unit width

$$E = y + \frac{q^2}{2gy^2}$$

$$\frac{dE}{dy} = 1 - \frac{q^2}{gy^3} = 0$$

$$\frac{q^2}{g} = y_c^3$$

$$y_c = \sqrt[3]{\frac{q^2}{g}}$$

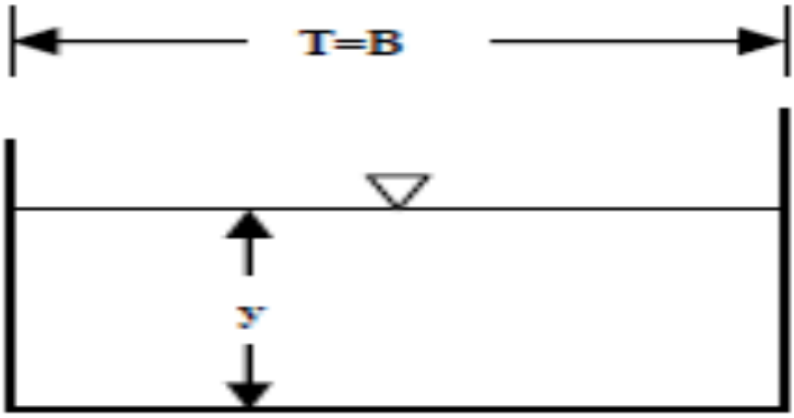


Figure 2: Channel Cross-Section.

Appendix 8- Economic feasibility of the project

1-Technical and Economic Study

1.1 Economic Evaluation Method:

Horan Valley extends 458 km from the Iraqi-Saudi border to the Euphrates River south of Haditha. The geographical location of the valley lies between longitude 39-00'00' to 43˚00'00' east and latitude 32-00' '00' to 43'30'00' N. The area of the valley is about 15,321 square kilometers and the difference in elevation between upstream and downstream is about 600 meters. Horan Valley is classified as an arid region characterized by hot summers and cold winters.

The Upper Euphrates Basin Development Center - University of Anbar, plans to establish a network of weather stations and study rainfall, runoff, flows, types of aquifers and well networks, average annual recharge, and safe return. Note that some of the studies prepared by the Center have positive aspects that help in developing Horan Valley Basin in the required manner, including the following:

1. Horan Valley contains many types of trees, natural herbs, and wild animals, which require the establishment of a nature reserve to manage and develop the ecosystem of this large area.

2. The establishment of the reserve and national parks contributes in achieving a better security reality while creating job opportunities and sustainable development for this large and important area.

3. More than one million trees can be cultivated based on rainwater harvesting and safe good pumping that maintains the sustainability of groundwater.

4 About 400 million cubic meters of rainwater can be harvested in this valley, so it is very important to build at least 13 proposed small dams. High-quality water can be used to irrigate millions of several types of trees, reducing dust, erosion, and carbon dioxide and improving the environment and ecosystem.

5. The feeding of more than 160 million cubic meters of rainwater to the aquifers in the valley of Horan, so the cultivation of a million very safe trees especially if these tolerant trees are irrigated by water harvesting and irrigation incomplete.

6. A series of small dams consisting of 13 dams with an ideal height and location that will increase the free water area in the valley from 15 to 90 km^2, which will improve the climatic conditions and environment of the valley. Re-fed groundwater by 31.54 cm/year means

feeding the aquifers of the valley by 28 million m3 / year despite the direct feeding of rainwater at about 139 million m ^{3} / year. These large recharge amounts will maintain the quantity and quality of water resources in the oasis and reserve areas.

7. Renewable energy such as solar and wind energy is very suitable and can be generated in areas more than 600 meters above sea level in Horan valley.

In the economic evaluation of such projects, the method of conducting a comparative study of project costs and benefits derived from all purposes is recognized worldwide. The economic analysis of Horan Valley project was carried out by calculating the net present value (NPV) and the benefit-cost ratio) B/C (using different discount rates by the discounted cash flow method based on the costs and benefits of the project, then the internal rate of return (IRR) which represents the discount rate at which the present value of each of the cost-benefit streams that are equal to each other is calculated. The IRR allows the economic benefits of a project to be evaluated by comparing the annual rate of return with the opportunity cost of capital (OCC) in the country. In Iraq, the (OCC) is about 10%, which is the lending ratio of the Central Bank of Iraq. The economic life that represents the period covered by the economic evaluation of the project is 50 years, 5 years for construction, and 4 and 5 years after completion, so the 50 years was adopted in the economic feasibility study.

1-2 Project Costs:

Project costs of Horan Valley project consist of the capital cost for the construction of the project, including the establishment of 13 soil dams (4 dams of them were executed) including soil filling works of dam body, and water outlet, and the power plant briefly depends on the special needs of dams and nearby facilities, including only handed fish, service bridge, roads, and other structures, in addition to the annual costs of operation, maintenance, management and construction of hydrometer dams and GIS laboratories and weather stations.

Other costs have been included for the establishment of nature reserves perimeter total estimated 262.4 kilometers and the park perimeter is estimated at 180.2 km with all operational accessories for this park which is an international park (Central ParkIt includes a zoo, cable cars, recreation areas, a tourist hotel, villas for weddings, gardens, a water city with its accessories, in addition to Bedouin sheds made of Arab tents according to designs that mimic the nature of Horan valley, tracks for horse and camel racing, and rugged fields for four-wheel-drive vehicles.

The costs include the construction of 115 artesian wells up to depths of 200 meters with submersible pumps powered by solar energy to irrigate a million diverse trees of palms, olives, prickly pears, and other trees such as Buckthorns and other fruitful and non-fruitful trees that are environmentally friendly as windbreaks, as well as the costs of agricultural lands with reservoir water and abundant production of Ground vegetables and fruits as well as covered.

Note: The total costs of the project will be calculated in foreign currency (US dollars) and according to the pricing of the Central Bank of Iraq.

1-3 Basic Standards:

The cost of Horan Dam development project was estimated after numerous discussions with the experts of the Upper Euphrates Basin Development Center - the University of Anbar, professors at the College of Engineering and the College of Agriculture, and other experts from outside the university. Also, the fixed prices are subject to increase and decrease depending mainly on the market movement and the economic balance of the country. The following considerations were taken into account when estimating the cost:

A-The unit construction prices were calculated taking into consideration the recent construction projects in Iraq and the experience in the construction works of the contractors, in addition to the regional conditions of the Horan valley site.

B-The cost of construction was estimated in foreign currency to ensure stability in the Iraqi market for work. Foreign currency includes costs of materials to be produced in Iraq and labor costs. In addition to the internal transportation of imported materials and machines, warehouse costs, electromechanical equipment, power conversion facilities, communications facilities, and cable cars.

C-An emergency sum of 7% has been added to the cost of all construction works, including civil, water, electrical and mechanical equipment.

D-Salaries and wages of engineers and other personnel, costs of utilities and maintenance of field offices for the Horan Valley Development Project, and engineering costs including

detailed design work and construction supervision are included in the administrative expenses.

E-The interest was calculated during construction based on the annual requirements of the fund.

1-4 Construction Costs:

The estimated total cost of the project development is 2392638730.0 US dollars. Construction costs by type of work are shown in Table (1).

Table (1) Costs of establishing Wadi Horan Development Project (US dollars)

No.	Item	Total Cost (US $)
1	Small Dams (9 No.) and Weirs	61,2 00 , 000
2	Recreation structure near water flats , GIS lab+ Meteorological Building and fences	53 , 000, 000
3	Nature reserves	35, 00,000
4	Central Park, Animals, Recreation, Hotel, villas,	105 ,0 00,000
5	Well system	1,594,366
6	Trees+ Ground Vegetables with earthworks , Agriculture tress	35,000,000
	Total for Civil Works	**29 0,794,366**
7	Hydro mechanical Works , Electrical Equipment	25,000,000
8	Chairlifts (Tele reek), GIS devices Lab, Meteorological devices, cars 4X4 (20 No.)	48, 349, 820
	Total for Hydromechanical Works & Electrical Equipment & Mechanical	**73, 349.820**
	Total Construction Costs	**364 , 144 , 1861**
9	Engineering + Administration Costs (1%)	3, 64 1,441,860

10	Consulting Services (3%)	10, 92 4,325. 580
11	Contingencies for Items (1-8) (7%)	25 , 49 0.093.020
12	Investment Cost	40 4, 20 0, 046. 46
	Interest during Construction (i= 10%, n= 5)	105, 092, 012. 08
	Plant Cost	**509, 292, 058. 54**

1-5 Annual Costs:

The annual costs of Horan Valley Development Project include depreciation, operation, and maintenance costs, in addition to administrative expenses. The cost of establishing Horan Valley Development Project is (509,292,058.54 (US dollars. The equivalent annual cost of this project over the service life of the project is shown in Table (2). Here the applicable interest rates are 10% for the foreign currency. The service life for civil works is 45 years and for waterworks and electrical and mechanical equipment is 30 years. The total annual cost of the Horan Valley Development Project is (32,670,218,748) US dollars, as shown in Table 2.

Table (2) The annual costs of the Wadi Horan Development Project (US dollars)

No.	Item	Annual cost
1	Amortization; Civil works (i =10%, n = 50 yr) 0.1008 Hydro mechanical works. electrical equipment and power lines (i =10%, n = 35 yr) 0.1 033	19,312,072.097,577,036.406
2	Operation and maintenance Civil works (i =10, n =5 0 yr) Hydro mechanical works electrical equipment and facilities (i =10, n = 35 yr)	965, 603.604.757, 703. 640
3	Administration expense Civil works (i =10, n =5 0 yr) Hydro mechanical	3,224,327.812,833,475,196
	Total	**32,670,218,748**

1-6 Secondary Costs:

Besides the costs of establishing Horan valley development project and the annual costs including operation, maintenance, and administration, the establishment of Horan valley development will also lead to other costs as compensation to the citizens in the areas to be invested.

The areas that will be invested include some residential communities that own residential complexes with agricultural lands and quarries of raw materials for construction, including coarse and fine aggregates, glass sand, and iron dust that is used in the cement industry.

The estimated cost of the areas and villages that are related with the development of Horan valley will be decided after reviewing the schemes and images, and making discussions with officials in the Upper Euphrates Research Center and a group of experts and after the analysis of the net amount of compensation after deducting the payments of cash (35,000,000) American dollars.

The cost of agricultural land which belongs to others is mostly agricultural land planted with wheat and barley. The area that will be invested is of an estimated (4000 "(hectares. The cost of the land value of the annual returns that would be lost as a result of the investment of these lands is (1,600,000 (US dollars annually" by approving the annual net profit (40) dollars/hectare and the total amount) 80One million US dollars within the life span of the development of the Horan Valley Basin.

1-7 Annual Disbursement Schedule for Project Costs:

The annual disbursement schedule has been developed based on the project cost estimate and the proposed construction schedule for Horan Valley Development Project.

The project construction period is estimated five years. The cost distribution for each event has been assumed as follows:

10% of the total cost in the first year.

25% of the total cost for the second year

25% of the total cost for the third year

25% of the total cost for the fourth year

10% of the total cost in the fifth year

5% of the total cost in the sixth year

It is assumed that compensation for the scattered housing complexes that will be acquired in the first year of the project's life will be disbursed, while compensation for agricultural areas, quarries of raw materials, glass sand, and iron dust that is used in the cement industry will be disbursed in Table 3. While table (4) shows, the project cost flow over the economic life of the project.

Table 3 Annual Exchange of project's severance during the implementation period (USD)

No.	**Item/ Year**	**1**	**2**	**3**	**4**	**5**	**6**
1	Inundated areas (without agricultural lands)	35,000,000	-	-	-	-	-
2	Small Dams (9 No.) and Weirs	8,647,280.563	21,618,201.407	21,618,201.407	21,618,201.407	8,647,280.563	4,323,640.281
3	Recreation structure near water flats, GIS lab+ Meteorological Building and fences	7,488,658.004	18,721,645.010	18,721,645.010	18,721,645.010	7,488,658.004	3,744,329, 002
4	Nature reserves	4,945,340.191	12,363,350. 477	12,363,350. 477	12,363,350. 477	4,945,340.191	2,472,670.095
5	Central Park, Animals, Recreation, Hotel, villas,	14,836,020.573	37,090,051.432	37,090,051.432	37,090,051.432	14,836,020.573	7,418,010.286
6	Well system	164,378.032	410,945.080	410,945.080	410,945.080	164,378.032	82,189.016
7	Trees+ Ground Vegetables with earthworks, Agriculture tress	4,945,340.191	12,363,350. 477	12,363,350. 477	12,363,350. 477	4,945,340.191	2,472,670.095

	Total for Civil Works	***41,027,017.554***	***102,567,543.885***	***102,567,543.885***	***102,567,543.885***	***41,027,017.554***	***20,513,508.777***
8	Hydro mechanical Works, Electrical Equipment	3,375,000	8,437,500	8,437,500	8,437,500	3,375,000	1,687,500
9	Chairlifts (Tele reek), GIS devices Lab, Meteorological devices, cars 4X4 (20 No.)	6,527,225.700	16,318,064.250	16,318,064.250	16,318,064.250	6,527,225.700	3,263,612.850
	Total for Hydro mechanical Works & Electrical Equipment & Mechanical	***9,902,225.700***	***24,755,564.250***	***24,755,564.250***	***24,755,564.250***	***9,902,225.700***	***4,951,112.850***
10	***Total Cost/ Year***	***85,929,243.254***	***127,323,108.135***	***127,323,108.135***	***127,323,108.135***	***50,929,243.254***	***25,464,621.627***
11	***Total Cost (US $)***	***509,292,058.540***					
12	Cost of the agricultural lands that will be an investment in the project	80000000					
13	***Wadi Horan Development Cost (ID)***	***589,292,058.540***					

Table No. (4) The flow of the cost of the project on the length of the old economic project (US dollars)

Year	Capital Cost			Annual Cost	Total Cost
	Secondary	Civil Work	Hydro-mech. & Electr. & Mechanical		
1	35,000,000 1,600,000	41,027,017.554	9,902,225.700	-	85,929,247.254
2	1,600,000	102,567,543.885	24,755,564.250	-	128,923,108.135
3	1,600,000	102,567,543.885	24,755,564.250	-	128,923,108.135
4	1,600,000	102,567,543.885	24,755,564.250	-	128,923,108.135
5	1,600,000	41,027,017.554	9,902,225.700	-	50,929,247.254
6	1,600,000	20,513,508.777	4,951,112.850	32,670,218.748	59,734,840.375
7	1,600,000			32,670,218.748	34,270,218.748
8	1,600,000			32,670,218.748	34,270,218.748
9	1,600,000			32,670,218.748	34,270,218.748
10	1,600,000			32,670,218.748	34,270,218.748
11	1,600,000			32,670,218.748	34,270,218.748
12	1,600,000			32,670,218.748	34,270,218.748
13	1,600,000			32,670,218.748	34,270,218.748
14	1,600,000			32,670,218.748	34,270,218.748
15	1,600,000			32,670,218.748	34,270,218.748
16	1,600,000			32,670,218.748	34,270,218.748
17	1,600,000			32,670,218.748	34,270,218.748
18	1,600,000			32,670,218.748	34,270,218.748
19	1,600,000			32,670,218.748	34,270,218.748
20	1,600,000			32,670,218.748	34,270,218.748
21	1,600,000			32,670,218.748	34,270,218.748
22	1,600,000			32,670,218.748	34,270,218.748

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26	1,600,000			32,670,218.748	34,270,218.748
27	1,600,000			32,670,218.748	34,270,218.748
28	1,600,000			32,670,218.748	34,270,218.748
29	1,600,000			32,670,218.748	34,270,218.748
30	1,600,000			32,670,218.748	34,270,218.748
31	1,600,000		9,902,225.700	32,670,218.748	44,172,444,448
32	1,600,000		24,755,564.250	32,670,218.748	59,025,782.998
33	1,600,000		24,755,564.250	32,670,218.748	59,025,782.998
34	1,600,000		24,755,564.250	32,670,218.748	59,025,782.998
35	1,600,000		9,902,225.700	32,670,218.748	44,172,444,448
36	1,600,000		4,951,112.850	32,670,218.748	39,221,331.598
37	1,600,000			32,670,218.748	34,270,218.748
38	1,600,000			32,670,218.748	34,270,218.748
39	1,600,000			32,670,218.748	34,270,218.748
40	1,600,000			32,670,218.748	34,270,218.748
41	1,600,000			32,670,218.748	34,270,218.748
42	1,600,000			32,670,218.748	34,270,218.748
43	1,600,000			32,670,218.748	34,270,218.748
44	1,600,000			32,670,218.748	34,270,218.748
45	1,600,000			32,670,218.748	34,270,218.748
46	1,600,000			32,670,218.748	34,270,218.748
47	1,600,000			32,670,218.748	34,270,218.748
48	1,600,000			32,670,218.748	34,270,218.748
49	1,600,000			32,670,218.748	34,270,218.748
50	1,600,000			32,670,218.748	34,270,218.748

2- Revenues Earned by the Project:

The concept of the benefit of the project is represented by the number of returns and positive cash flows that will be achieved by the implementation of Horan Valley Development Project. The main proposals for the development of Horan valley are to store the available running water in Horan valley. It can be used for water storage power generation Co., Ltd. to operate the dam facilities and buildings attached to special restaurants, cafes, camping places, lakes, and cities Games. In addition to that Flow regulation for irrigation, and flood protection and raise the water table with the reserves and the Arab Bedouin, international garden, fields of horse racing, camels, and cars with four-wheel drive revenue.

2-1 Generating Revenues of Energy and Renewable Energy:

Hydroelectric energy is the electrical energy that is used to generate potential water energy. Thus, it is one of the forms of clean energy that is environmentally friendly and used on a wide global scale. The generation method depends on converting the potential energy of water into kinetic energy first, and the amount of energy produced depends on the amount of water passing per second and the water level in the tank. Accordingly, and to calculate the benefits, the average selling price of electricity supplied to homes for OECD countries is (16 cents/kilowatt-hour), and taking into account Iraq's quest to achieve one of its most important goals in improving the level of electric power production after 2016 by raising the currently approved price to the level of more balanced as mentioned in previous feasibility studies.

The estimated selling price (MWh) according to the above tariff is ($160). Therefore, the selling price for each (MWh/day) will be about (3840.00 dollars). Therefore, the selling price for each (Megawatt / Year) will be about (1401, 600 dollars). If the station operation of the dams at full capacity amounting to (20 MW) will be the annual revenue (28, 032, 000 dollars). In the case of operation of stations data by 8 0% of its operational capacity will be the annual revenue (22, 425, 6 00 dollars). In the case of adding 50% of the kinetic and solar energy that will be produced at the site of Horan valley, the annual revenue will be from energy (33,638,400dollars).

2.2 Revenue of Irrigation and Agriculture:

Irrigation revenue was calculated by obtaining the average annual net profit, which will be gained from the area irrigated with stored water upon completion of the small dams on Horan valley and its tributaries. About one billion cubic meters of rainwater are discharged in the rainy season to the Euphrates River in some years, with an annual average of about 400 million cubic meters. (Kamel, 2012), (Al-Jawad and Al-Ansari 2017). Constructing dams in Horan Valley will organize discharging of the valleys in the direction of the back and front of dams, leading to the provision of water for irrigation of agricultural land, which was suffering from impotence. The additional quantities of water provided by the dam (400) million m 3 per year or (12. 67) m^3 / sec almost ". Assuming that 1 cubic meter/second of water is needed to irrigate (1000) hectares, and with the available quantities of water, it is possible to irrigate the area (12,670) hectares of (50680) acres. To determine the revenue generated by irrigation in these areas, it has been taking an average net annual interest of $ (120) US dollars per acre based on modern feasibility studies for irrigation projects in Iraq, which were completed in 2001, taking into account changes in local market prices, according to this figures, the annual net benefit by irrigation would be (6,081,600) US dollars / that year. While the revenue from the cultivation of palms, olives, and some fruits, such as Christ's-thorn which resist desertification, is estimated at one million fruitful trees, and the production is estimated at 3,791 dates and 1,892 olives. Therefore, the annual revenue for tree cultivation is as follows:

3791 * 450 = 1,705,950 US dollars annually

1862 * 600 = 1,117,200 US dinars annually

In addition to other revenues from pistachio trees and prickly pear fruits, which are estimated at (1,500,000) US dollars, and therefore the return on agriculture only for trees, without crops (4,323,150) US dollars. The net annual benefit through irrigation and agriculture (10,404,750) US dollars.

2-3 Revenues from Flood Control:

Horan Valley Reservoir will provide a certain degree of protection to the inhabitants of the downstream basin. It is considered the benefit of flood control which is the cost of the dam and d variant which has the same function as flood control for Horan valley its control capacity is up to 4 00 million cubic meters.

It estimated the cost of establishing These dam's d (6897 * 13 = 89 655) US dollars

Annual costs are calculated as follows: -

1- Amortization (10% interest, service life 50 years) =0.101*89655000= 90550000 dollars US

$A/P = i(1 + i)^{n} / (1+i)^{n} -1= 0.1\ (1.1)^{50} / (1.1)^{50} – 1 = 0.101$

2- Maintenance and operation (0.5% of the construction cost) = 0.005 * = 89655 000448275US dollars
3- Administration (0.33% of the construction cost) 0.0033*89655000=295860 US dollars.

The total annual cost resulting =9,799,135 US dollars is taken as an annual productive benefit.

2-3 Animal Development Revenues:

The livestock sector is one of the important economic sectors in Iraq, with its capabilities and resources, and its importance is not limited to the economic aspect but extends beyond it to the social aspects. Livestock development is where many Iraqis work, which helps social stability. To determine the resulting revenue for animal development, including the docks fish basin, the valley takes an average interest net annual livestock of (265 0) to $ US for each animal field on the basis that each hectare of agricultural area (4 acres) is available by one field, according to this

Figures, the annual net benefit through livestock will be (6,625.000) US dollars/year, which is the net benefit from livestock.

2-4 Tourism Revenue:

There are many tourism revenues are taking advantage of the dam lakes and make it a major source of the region's economy through the creation of tourist and recreational resorts and low cost, markets, hotels and marinas boats and yachts, and thus will be a return on a financial positive and it has taken an average interest annual net tourism of nature reserves and national park The tracks Rally cars and fields of horse racing, and returns of restaurants, cafes, as well as the return of the hotel, chalets, and what mentioned above the financial return of (23205.409) US dollars per kilometer adult square (1 9 32.739) km 2 of these reserves and for annual net benefit by Tourism will be (4 4, 85 0, 000) US dollars/year.

2-5 Groundwater Recharge:

The area of water catchment in valley Horan and its tributaries such as Hussainiyat, Muhazam, Saffar, and Amej are about 16550 km^2. The leakage of 1 mm of rainwater means that the aquifers are recharged by 16.55 million cubic meters. (Figure 2) shows the best small dams sites, while the best sites show rainwater harvesting in (Figure 3) has been taking an average interest annual net of (500) US dollars per acres and therefore the total revenues of this paragraph amounted to (8, 325, 0 00) US dollars annually.

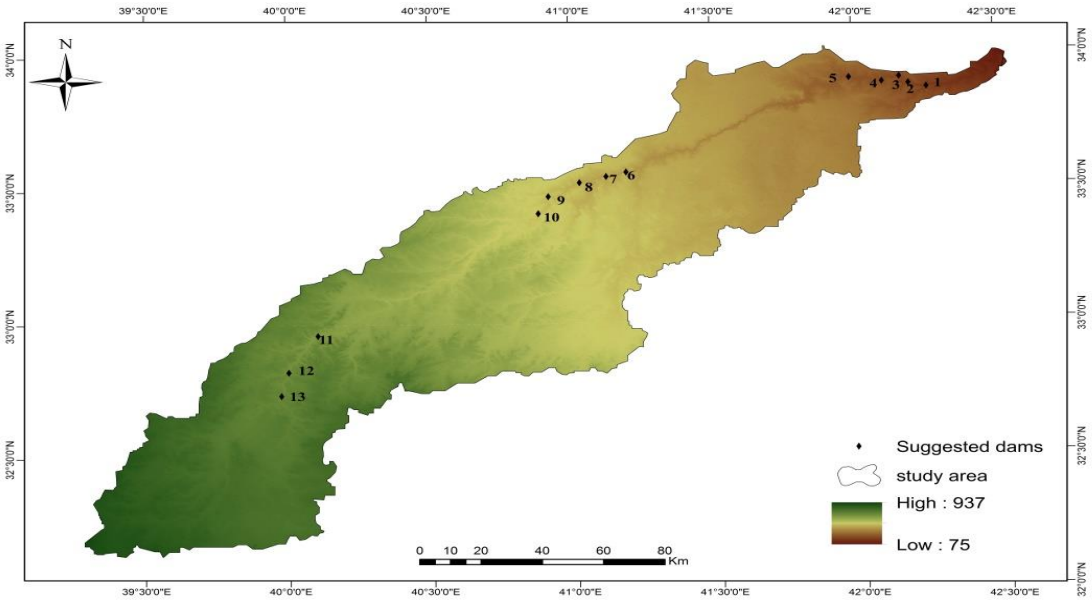

Figure (2): Shows the Best Locations for Small Dams

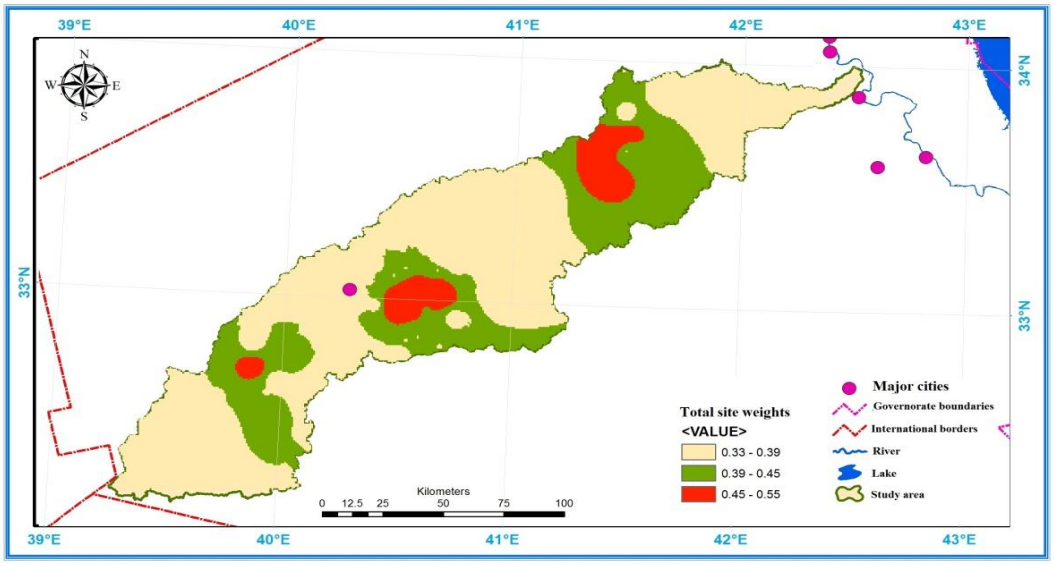

Figure (3): Best Rainwater Harvesting Sites

2-6 The income of the Rivers Not Eroding:

Water bodies in valleys are an important way to save the soil from erosion during the decline of torrential rains when the rains are heavy, and this contributes to reducing the amount of dredged soil. Thus, the number of deposits transferred to be very huge, the presence of the dams or water ponds prevents soil drifts and achieving annual revenues of (5000000) US dollars as a revenue for the project of Wadi Horan development as opposed to the costs spent on the rivers of these to raise deposits in the case of Failure to implement this small dam.

2-7 Climate Mitigation Revenue and Good Environmental Benefits:

The presence of wide water bodies helps reduce heat throughout the area around the body of the dam and the reservoir, by opening the way for fresh air flow, as well as more trees and green spaces, which would help maintain temperatures at an acceptable level, in addition to other environmental benefits and thus will provide annual returns of (1000000) US dollars.

2-8 Semi-Permanent Storage in Water Bodies Located in Wadi Horan:

It estimated the size of semi-permanent inventories in the lakes of dams by about (400 million m^3). It is known that the total concentration of dissolved salts in the water stored in the lake Habaniyah is over 500 ppm while to be in the water basins of Horan valley less much of this focus. The presence of Horan valley development will provide a financial return to maintain the same water quality at this site is estimated at 12 dollar / m^3 and on this basis can the value of this yield calculation, which will maintain good water in its lake and accompanied by improved development and service level annually " as follows:

400,000,000 m^3 ×0.0 3D or t / m 3 = 12, 000,000 dollars US.

2-9 Operating Income of Hands Working:

The existence of this project means the adoption of an economic policy that generates job opportunities and stimulates the private sector through the adoption of a unified planning system for the workforce. The need to employ manpower to implement, operate, and maintaining the project is not limited to the five years of implementation only but extends over the lifespan of the project. Average volume of employment that will

engage in a workers' implementation of the dam and run around (500) workers, this means providing the opportunity to run 500 unemployed were before establishment and operation of the dam, a burden on the social solidarity program estimated annual cost of about 500 workers × 150, 000 dinars / Unemployed monthly x 12 months = 900,000,000 dinars annually, which is equivalent to (600,000) US dollars. This figure represents the annual return derived from the employment of the labor force in the dam. Table No. (5) Shows the interest flows from the development of Horan valley according to the economic life of the project.

3. Economic Evaluation:

The economic evaluation of the Horan Valley Development Project was carried out using the cash flow method. This assessment includes the calculation of the net present value (NPV) and the cost-benefit ratio (B / C), in addition to calculating the internal revenue rate (IRR). Table (6) shows the cash flow of the Horan Valley Development Project

3.1 Economic Criteria:

3-1-1 Ratio of Cost-Benefit and Internal Rate of Return of Capital:

Table (7) shows the ratio of cost-benefit and the internal rate of capital recovery. It is noticed that the cumulative cash flow of the project will become positive in the eleventh year of the economic life of the project or after 6 years after the operation. This means that the remaining subsequent years are the years of profit-taking.

Table (5): Revenue Streams of the Wadi Horan Development Project (US Dollars)

year	Energy Production	Irrigation	Flood control	Livestock development	Tourism
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	-	-	-	-	-
5	-	-	-	-	-
6-50	33,638,400	10,404,750	9,799,135	6,625,000	44,850,000

year	Groundwater nutrition	Non-river erosion	Moderate climate	Water quality & availability	Manpower employment	Total Benefit
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	-	-	-	-	-	-
4	-	-	-	-	-	-
5	-	-	-	-	-	-
6-55	8,325,000	5,000,000	1,000,000	12,000,000	600,000	132,242,285

Table (6): shows the cash flow of the Wadi Horan Development Project (US dollars)

Year	Total future benefits	Total cost (US $)	Incremental Benefits (Cash Flow)	Accumulative Cash flow
1	0	85,929,247.25	-85,929,247.25	-85,929,247.25
2	0	128,923,108.14	-128,923,108.14	-214,852,355.39
3	0	128,923,108.14	-128,923,108.14	-343,775,463.52
4	0	128,923,108.14	-128,923,108.14	-472,698,571.66
5	0	50,929,247.25	-50,929,247.25	-523,627,818.91
6	132,242,285	59,734,840.38	72,507,444.63	-451,120,374.29
7	132,242,285	34,270,218.75	97,972,066.25	-353,148,308.04
8	132,242,285	34,270,218.75	97,972,066.25	-255,176,241.78
9	132,242,285	34,270,218.75	97,972,066.25	-157,204,175.53
10	132,242,285	34,270,218.75	97,972,066.25	-59,232,109.28
11	132,242,285	34,270,218.75	97,972,066.25	38,739,956.97
12	132,242,285	34,270,218.75	97,972,066.25	136,712,023.22
13	132,242,285	34,270,218.75	97,972,066.25	234,684,089.48
14	132,242,285	34,270,218.75	97,972,066.25	332,656,155.73
15	132,242,285	34,270,218.75	97,972,066.25	430,628,221.98
16	132,242,285	34,270,218.75	97,972,066.25	528,600,288.23
17	132,242,285	34,270,218.75	97,972,066.25	626,572,354.48
18	132,242,285	34,270,218.75	97,972,066.25	724,544,420.74
19	132,242,285	34,270,218.75	97,972,066.25	822,516,486.99
20	132,242,285	34,270,218.75	97,972,066.25	920,488,553.24
21	132,242,285	34,270,218.75	97,972,066.25	1,018,460,619.49

22	132,242,285	34,270,218.75	97,972,066.25	1,116,432,685.74
23	132,242,285	34,270,218.75	97,972,066.25	1,214,404,752.00
24	132,242,285	34,270,218.75	97,972,066.25	1,312,376,818.25
25	132,242,285	34,270,218.75	97,972,066.25	1,410,348,884.50
26	132,242,285	34,270,218.75	97,972,066.25	1,508,320,950.75
27	132,242,285	34,270,218.75	97,972,066.25	1,606,293,017.00
28	132,242,285	34,270,218.75	97,972,066.25	1,704,265,083.26
29	132,242,285	34,270,218.75	97,972,066.25	1,802,237,149.51
30	132,242,285	34,270,218.75	97,972,066.25	1,900,209,215.76
31	132,242,285	44,172,444.45	88,069,840.55	1,988,279,056.31
32	132,242,285	59,025,783.00	73,216,502.00	2,061,495,558.31
33	132,242,285	59,025,783.00	73,216,502.00	2,134,712,060.32
34	132,242,285	59,025,783.00	73,216,502.00	2,207,928,562.32
35	132,242,285	44,172,444.45	88,069,840.55	2,295,998,402.87
36	132,242,285	39,221,331.60	93,020,953.40	2,389,019,356.27
37	132,242,285	34,270,218.75	97,972,066.25	2,486,991,422.52
38	132,242,285	34,270,218.75	97,972,066.25	2,584,963,488.78
39	132,242,285.00	34,270,218.75	97,972,066.25	2,682,935,555.03
40	132,242,285	34,270,218.75	97,972,066.25	2,780,907,621.28
41	132,242,285	34,270,218.75	97,972,066.25	2,878,879,687.53
42	132,242,285	34,270,218.75	97,972,066.25	2,976,851,753.78
43	132,242,285	34,270,218.75	97,972,066.25	3,074,823,820.04
44	132,242,285	34,270,218.75	97,972,066.25	3,172,795,886.29
45	132,242,285	34,270,218.75	97,972,066.25	3,270,767,952.54

46	132,242,285	34,270,218.75	97,972,066.25	3,368,740,018.79
47	132,242,285	34,270,218.75	97,972,066.25	3,466,712,085.04
48	132,242,285	34,270,218.75	97,972,066.25	3,564,684,151.30
49	132,242,285	34,270,218.75	97,972,066.25	3,662,656,217.55
50	132,242,285	34,270,218.75	97,972,066.25	3,760,628,283.80

Table (7): Benefit-Cost Ratio and Internal Rate of Capital Recovery (US Dollars)

Year	**Total cost**	**Accumulative Total cost**	**Total Future Benefits**	**Incremental Benefits**	**Accumulative Cash Flow**	**Benefit-cost ratio**
	(US $)	(US $)		(Cash Flow)	(US $)	
1	85,929,247.25	85,929,247.25	0	-85,929,247.25	-85,929,247.25	-1
2	128,923,108.14	214,852,355.39	0	-128,923,108.14	-214,852,355.39	-1
3	128,923,108.14	343,775,463.52	0	-128,923,108.14	-343,775,463.52	-1
4	128,923,108.14	472,698,571.66	0	-128,923,108.14	-472,698,571.66	-1
5	50,929,247.25	523,627,818.91	0	-50,929,247.25	-523,627,818.91	-1
6	59,734,840.38	583,362,659.29	132,242,285.00	72,507,444.63	-451,120,374.29	-0.773
7	34,270,218.75	617,632,878.04	132,242,285.00	97,972,066.25	-353,148,308.04	-0.572
8	34,270,218.75	651,903,096.78	132,242,285.00	97,972,066.25	-255,176,241.78	-0.391
9	34,270,218.75	686,173,315.53	132,242,285.00	97,972,066.25	-157,204,175.53	-0.229
10	34,270,218.75	720,443,534.28	132,242,285.00	97,972,066.25	-59,232,109.28	-0.082
11	34,270,218.75	754,713,753.03	132,242,285.00	97,972,066.25	38,739,956.97	-1
12	34,270,218.75	788,983,971.78	132,242,285.00	97,972,066.25	136,712,023.22	-1

13	34,270,218.75	823,254,190.52	132,242,285.00	97,972,066.25	234,684,089.48	0.051
14	34,270,218.75	857,524,409.27	132,242,285.00	97,972,066.25	332,656,155.73	0.173
15	34,270,218.75	891,794,628.02	132,242,285.00	97,972,066.25	430,628,221.98	0.285
16	34,270,218.75	926,064,846.77	132,242,285.00	97,972,066.25	528,600,288.23	0.388
17	34,270,218.75	960,335,065.52	132,242,285.00	97,972,066.25	626,572,354.48	0.483
18	34,270,218.75	994,605,284.26	132,242,285.00	97,972,066.25	724,544,420.74	0.571
19	34,270,218.75	1,028,875,503.01	132,242,285.00	97,972,066.25	822,516,486.99	0.652
20	34,270,218.75	1,063,145,721.76	132,242,285.00	97,972,066.25	920,488,553.24	0.728
21	34,270,218.75	1,097,415,940.51	132,242,285.00	97,972,066.25	1,018,460,619.49	0.799
22	34,270,218.75	1,131,686,159.26	132,242,285.00	97,972,066.25	1,116,432,685.74	0.866
23	34,270,218.75	1,165,956,378.00	132,242,285.00	97,972,066.25	1,214,404,752.00	0.928
24	34,270,218.75	1,200,226,596.75	132,242,285.00	97,972,066.25	1,312,376,818.25	0.987
25	34,270,218.75	1,234,496,815.50	132,242,285.00	97,972,066.25	1,410,348,884.50	1.042
26	34,270,218.75	1,268,767,034.25	132,242,285.00	97,972,066.25	1,508,320,950.75	1.093
27	34,270,218.75	1,303,037,253.00	132,242,285.00	97,972,066.25	1,606,293,017.00	1.142
28	34,270,218.75	1,337,307,471.74	132,242,285.00	97,972,066.25	1,704,265,083.26	1.189
29	34,270,218.75	1,371,577,690.49	132,242,285.00	97,972,066.25	1,802,237,149.51	1.233
30	34,270,218.75	1,405,847,909.24	132,242,285.00	97,972,066.25	1,900,209,215.76	1.274
31	44,172,444.45	1,450,020,353.69	132,242,285.00	88,069,840.55	1,988,279,056.31	1.314
32	59,025,783.00	1,509,046,136.69	132,242,285.00	73,216,502.00	2,061,495,558.31	1.352
33	59,025,783.00	1,568,071,919.68	132,242,285.00	73,216,502.00	2,134,712,060.32	1.371
34	59,025,783.00	1,627,097,702.68	132,242,285.00	73,216,502.00	2,207,928,562.32	1.366
35	44,172,444.45	1,671,270,147.13	132,242,285.00	88,069,840.55	2,295,998,402.87	1.374
36	39,221,331.60	1,710,491,478.73	132,242,285.00	93,020,953.40	2,389,019,356.27	1.397
37	34,270,218.75	1,744,761,697.48	132,242,285.00	97,972,066.25	2,486,991,422.52	1.425

38	34,270,218.75	1,779,031,916.22	132,242,285.00	97,972,066.25	2,584,963,488.78	1.453
39	34,270,218.75	1,813,302,134.97	132,242,285.00	97,972,066.25	2,682,935,555.03	1.48
40	34,270,218.75	1,847,572,353.72	132,242,285.00	97,972,066.25	2,780,907,621.28	1.505
41	34,270,218.75	1,881,842,572.47	132,242,285.00	97,972,066.25	2,878,879,687.53	1.53
42	34,270,218.75	1,916,112,791.22	132,242,285.00	97,972,066.25	2,976,851,753.78	1.554
43	34,270,218.75	1,950,383,009.96	132,242,285.00	97,972,066.25	3,074,823,820.04	1.577
44	34,270,218.75	1,984,653,228.71	132,242,285.00	97,972,066.25	3,172,795,886.29	1.599
45	34,270,218.75	2,018,923,447.46	132,242,285.00	97,972,066.25	3,270,767,952.54	1.62
46	34,270,218.75	2,053,193,666.21	132,242,285.00	97,972,066.25	3,368,740,018.79	1.641
47	34,270,218.75	2,087,463,884.96	132,242,285.00	97,972,066.25	3,466,712,085.04	1.661
48	34,270,218.75	2,121,734,103.70	132,242,285.00	97,972,066.25	3,564,684,151.30	1.68
49	34,270,218.75	2,156,004,322.45	132,242,285.00	97,972,066.25	3,662,656,217.55	1.699
50	34,270,218.75	2,190,274,541.20	132,242,285.00	97,972,066.25	3,760,628,283.80	1.717

3-1-2: Pay Back Period (PBP):

It is the number of years in which the revenue of the value of the original investment is achieved, with the aim of selecting a project that will return its investment costs in a short period of time, Therefore, the capital payback period of the project is the period that elapses until the net cash flows are equal to the investment costs of the project That is, the number of years that elapse until the project can cover its investment costs, table (17) shows the details of calculating the criteria for recovery and profitability

- Project investment cost = 589,292,058.540 (US dollars)
- Operating costs = (32,670,218.748 US dollars)
- The achieved annual project revenues = (132,242,285 US dollars)

From table (8), it is noticed that the project begins with profit and the recovery of investment and operational costs after the thirteenth year from the beginning of the project

and after the eighth year of the project's operation, meaning that the remaining subsequent years are the years of profit-taking.

• Note that the average payback period ranges (30. 985 - 30.982) at the period (21 - 25) years and then it decreased after this period. The highest value for the rate of the recovery period of (152.45 3) at the thirteenth year of the beginning of the implementation of the project's eighteenth year from running the project.

• Standard interval recovery Pay Back Period (PBP) = (investment costs / annual net flow rate)

• The payback period for the paid-up capital as a cash flow located at the period (21 - 25 years) where all the capital recovered will be entirely recovered.

Table (8): Details of A Standard Interval Payback and Profitability (USD)

Year	Total cost (US $)	Total future benefits	Incremental Benefits (Cash Flow)	Discount rate 10 %	Present growth(US $)	Accumulative present growth(us)	Payback period /years
1	85,929,247.25	0	-85,929,247.25	-	-85,929,247.25	-85,929,247.25	
2	128,923,108.14	0	-128,923,108.14	-	-128,923,108.14	-214,852,355.39	
3	128,923,108.14	0	-128,923,108.14	-	-128,923,108.14	-343,775,463.52	
4	128,923,108.14	0	-128,923,108.14	-	-128,923,108.14	-472,698,571.66	
5	50,929,247.25	0	-50,929,247.25	-	-50,929,247.25	-523,627,818.91	
6	59,734,840.38	132,242,285.00	72,507,444.63	0.9091	65,915,858.75	-457,711,960.16	-1.293
7	34,270,218.75	132,242,285.00	97,972,066.25	0.8264	80,968,649.80	-376,743,310.37	-3.231

8	34,270,218.75	132,242,285.00	97,972,066.25	0.7513	73,607,863.45	-303,135,446.92	-6.264
9	34,270,218.75	132,242,285.00	97,972,066.25	0.683	66,916,239.50	-236,219,207.42	-11.38
10	34,270,218.75	132,242,285.00	97,972,066.25	0.6209	60,832,945.00	-175,386,262.42	-21.22
11	34,270,218.75	132,242,285.00	97,972,066.25	0.5645	55,302,677.27	-120,083,585.15	-46.044
12	34,270,218.75	132,242,285.00	97,972,066.25	0.5132	50,275,161.16	-69,808,423.99	-202.514
13	34,270,218.75	132,242,285.00	97,972,066.25	0.4665	45,704,691.96	-24,103,732.03	152.453
14	34,270,218.75	132,242,285.00	97,972,066.25	0.4241	41,549,719.97	17,445,987.94	68.387
15	34,270,218.75	132,242,285.00	97,972,066.25	0.3855	37,772,472.70	55,218,460.63	49.131
16	34,270,218.75	132,242,285.00	97,972,066.25	0.3505	34,338,611.54	89,557,072.17	40.902
17	34,270,218.75	132,242,285.00	97,972,066.25	0.3186	31,216,919.58	120,773,991.76	36.543
18	34,270,218.75	132,242,285.00	97,972,066.25	0.2897	28,379,017.80	149,153,009.56	33.993
19	34,270,218.75	132,242,285.00	97,972,066.25	0.2633	25,799,107.09	174,952,116.65	32.44
20	34,270,218.75	132,242,285.00	97,972,066.25	0.2394	23,453,733.72	198,405,850.37	31.498
21	34,270,218.75	132,242,285.00	97,972,066.25	0.2176	21,321,576.11	219,727,426.48	30.958
22	34,270,218.75	132,242,285.00	97,972,066.25	0.1978	19,383,251.01	239,110,677.49	30.7
23	34,270,218.75	132,242,285.00	97,972,066.25	0.1799	17,621,137.28	256,731,814.77	30.649
24	34,270,218.75	132,242,285.00	97,972,066.25	0.1635	16,019,215.71	272,751,030.48	30.754
25	34,270,218.75	132,242,285.00	97,972,066.25	0.1486	14,562,923.37	287,313,953.86	30.982

26	34,270,218.75	132,242,285.00	97,972,066.25	0.1351	13,239,021.25	300,552,975.10	31.308
27	34,270,218.75	132,242,285.00	97,972,066.25	0.1228	12,035,473.86	312,588,448.97	31.715
28	34,270,218.75	132,242,285.00	97,972,066.25	0.1117	10,941,339.87	323,529,788.84	32.19
29	34,270,218.75	132,242,285.00	97,972,066.25	0.1015	9,946,672.61	333,476,461.45	32.722
30	34,270,218.75	132,242,285.00	97,972,066.25	0.0923	9,042,429.65	342,518,891.10	33.303
31	44,172,444.45	132,242,285.00	88,069,840.55	0.0839	7,389,539.86	349,908,430.96	33.928
32	59,025,783.00	132,242,285.00	73,216,502.00	0.0763	5,584,785.24	355,493,216.19	34.59
33	59,025,783.00	132,242,285.00	73,216,502.00	0.0693	5,077,077.49	360,570,293.68	35.287
34	59,025,783.00	132,242,285.00	73,216,502.00	0.063	4,615,524.99	365,185,818.67	36.013
35	44,172,444.45	132,242,285.00	88,069,840.55	0.0573	5,047,155.15	370,232,973.82	36.767
36	39,221,331.60	132,242,285.00	93,020,953.40	0.0521	4,846,269.33	375,079,243.15	37.59
37	34,270,218.75	132,242,285.00	97,972,066.25	0.0474	4,640,196.18	379,719,439.34	38.495
38	34,270,218.75	132,242,285.00	97,972,066.25	0.0431	4,218,360.17	383,937,799.50	39.414
39	34,270,218.75	132,242,285.00	97,972,066.25	0.0391	3,834,872.88	387,772,672.38	40.346
40	34,270,218.75	132,242,285.00	97,972,066.25	0.0356	3,486,248.07	391,258,920.45	41.241
41	34,270,218.75	132,242,285.00	97,972,066.25	0.0323	3,169,316.43	394,428,236.88	42.135
42	34,270,218.75	132,242,285.00	97,972,066.25	0.0294	2,881,196.75	397,309,433.63	43.029
43	34,270,218.75	132,242,285.00	97,972,066.25	0.0267	2,619,269.78	399,928,703.41	43.937

44	34,270,218.75	132,242,285.00	97,972,066.25	0.0243	2,381,154.34	402,309,857.75	44.858
45	34,270,218.75	132,242,285.00	97,972,066.25	0.0221	2,164,685.77	404,474,543.51	45.792
46	34,270,218.75	132,242,285.00	97,972,066.25	0.0201	1,967,896.15	406,442,439.66	46.736
47	34,270,218.75	132,242,285.00	97,972,066.25	0.0183	1,788,996.50	408,231,436.16	47.69
48	34,270,218.75	132,242,285.00	97,972,066.25	0.0166	1,626,360.45	409,857,796.62	48.655
49	34,270,218.75	132,242,285.00	97,972,066.25	0.0151	1,478,509.50	411,336,306.12	49.628
50	34,270,218.75	132,242,285.00	97,972,066.25	0.0137	1,344,099.55	412,680,405.67	50.61

3-1 -3. Average Internal Rate of Return (ARR):

It is also called return Accountant or standard Yield investment and it Represents standard simply to measure profitability investment, In order to judge the feasibility and profitability of any investment project according to this standard, the revenue from it must be compared with the revenue on the opportunity, whether it is the average market interest rates or the weighted average cost., Where done Comparison between Average revenue inner and rate Cost get On money if it was This the average Larger From Cost money accept The project and otherwise He reject The project shows Table (9) a summary of the details of the calculation of the standard Average Rate The internal rate of revenue and table (10) shows the detailed calculations of the internal rate of revenue.

• Net rate profit Accountant=Total cumulative for net the flow cash for every Years Project / Duration

• Average return inner= (net rate profit Accounting / Cost investment) x 100%

• The cost Investment = 589,292,058.540 US dollars)

Table (9) shows the details of the internal rate of return, and Table (10) shows the detailed calculations of the internal rate of return

Table (9) shows the details of the internal rate of return

Year	Average Rate Of Return
19	3.08258
20	3.17484
21	3.23020
22	3.25733
23	3.26280
24	3.25164
25	3.22772
26	3.19408
27	3.15308
28	3.10659
29	3.05607
30	3.00271

From Table (10) we note that the project begins with profit and recovery of investment and operational costs at the thirteenth year from the beginning of the project implementation and after the eighth year of the project's operation, meaning that the remaining subsequent years are the years of profit-taking.

Note that the internal rate of return is higher by about what is (3 .08 - 3. 00) at the period (19 - 30 years) and then at least before and after this period. The highest value for the internal rate of return of (3.2628 %) at the twenty-third year **from the beginning of the implementation of the project**, the eighteenth year of operation of the project.

Table (10): Details of A Standard Average Internal Rate of Return (US$)

Year	Total cost (US $)	Total future benefits	Incremental Benefits (Cash Flow)	Discount rate 10 %	Present growth(US $)	Accumulative present growth(us)	ARR %
1	85,929,247.25	0	-85,929,247.25	-	-85,929,247.25	-85,929,247.25	
2	128,923,108.14	0	-128,923,108.14	-	-128,923,108.14	-214,852,355.39	
3	128,923,108.14	0	-128,923,108.14	-	-128,923,108.14	-343,775,463.52	
4	128,923,108.14	0	-128,923,108.14	-	-128,923,108.14	-472,698,571.66	
5	50,929,247.25	0	-50,929,247.25	-	-50,929,247.25	-523,627,818.91	
6	59,734,840.38	132,242,285.00	72,507,444.63	0.9091	65,915,858.75	-457,711,960.16	-1.293
7	34,270,218.75	132,242,285.00	97,972,066.25	0.8264	80,968,649.80	-376,743,310.37	-3.231
8	34,270,218.75	132,242,285.00	97,972,066.25	0.7513	73,607,863.45	-303,135,446.92	-6.264
9	34,270,218.75	132,242,285.00	97,972,066.25	0.683	66,916,239.50	-236,219,207.42	-11.38
10	34,270,218.75	132,242,285.00	97,972,066.25	0.6209	60,832,945.00	-175,386,262.42	-21.22
11	34,270,218.75	132,242,285.00	97,972,066.25	0.5645	55,302,677.27	-120,083,585.15	-46.044

12	34,270,218.75	132,242,285.00	97,972,066.25	0.5132	50,275,161.16	-69,808,423.99	-202.514
13	34,270,218.75	132,242,285.00	97,972,066.25	0.4665	45,704,691.96	-24,103,732.03	152.453
14	34,270,218.75	132,242,285.00	97,972,066.25	0.4241	41,549,719.97	17,445,987.94	68.387
15	34,270,218.75	132,242,285.00	97,972,066.25	0.3855	37,772,472.70	55,218,460.63	49.131
16	34,270,218.75	132,242,285.00	97,972,066.25	0.3505	34,338,611.54	89,557,072.17	40.902
17	34,270,218.75	132,242,285.00	97,972,066.25	0.3186	31,216,919.58	120,773,991.76	36.543
18	34,270,218.75	132,242,285.00	97,972,066.25	0.2897	28,379,017.80	149,153,009.56	33.993
19	34,270,218.75	132,242,285.00	97,972,066.25	0.2633	25,799,107.09	174,952,116.65	32.44
20	34,270,218.75	132,242,285.00	97,972,066.25	0.2394	23,453,733.72	198,405,850.37	31.498
21	34,270,218.75	132,242,285.00	97,972,066.25	0.2176	21,321,576.11	219,727,426.48	30.958
22	34,270,218.75	132,242,285.00	97,972,066.25	0.1978	19,383,251.01	239,110,677.49	30.7
23	34,270,218.75	132,242,285.00	97,972,066.25	0.1799	17,621,137.28	256,731,814.77	30.649
24	34,270,218.75	132,242,285.00	97,972,066.25	0.1635	16,019,215.71	272,751,030.48	30.754
25	34,270,218.75	132,242,285.00	97,972,066.25	0.1486	14,562,923.37	287,313,953.86	30.982
26	34,270,218.75	132,242,285.00	97,972,066.25	0.1351	13,239,021.25	300,552,975.10	31.308
27	34,270,218.75	132,242,285.00	97,972,066.25	0.1228	12,035,473.86	312,588,448.97	31.715

28	34,270,218.75	132,242,285.00	97,972,066.25	0.1117	10,941,339.87	323,529,788.84	32.19
29	34,270,218.75	132,242,285.00	97,972,066.25	0.1015	9,946,672.61	333,476,461.45	32.722
30	34,270,218.75	132,242,285.00	97,972,066.25	0.0923	9,042,429.65	342,518,891.10	33.303
31	44,172,444.45	132,242,285.00	88,069,840.55	0.0839	7,389,539.86	349,908,430.96	33.928
32	59,025,783.00	132,242,285.00	73,216,502.00	0.0763	5,584,785.24	355,493,216.19	34.59
33	59,025,783.00	132,242,285.00	73,216,502.00	0.0693	5,077,077.49	360,570,293.68	35.287
34	59,025,783.00	132,242,285.00	73,216,502.00	0.063	4,615,524.99	365,185,818.67	36.013
35	44,172,444.45	132,242,285.00	88,069,840.55	0.0573	5,047,155.15	370,232,973.82	36.767
36	39,221,331.60	132,242,285.00	93,020,953.40	0.0521	4,846,269.33	375,079,243.15	37.59
37	34,270,218.75	132,242,285.00	97,972,066.25	0.0474	4,640,196.18	379,719,439.34	38.495
38	34,270,218.75	132,242,285.00	97,972,066.25	0.0431	4,218,360.17	383,937,799.50	39.414
39	34,270,218.75	132,242,285.00	97,972,066.25	0.0391	3,834,872.88	387,772,672.38	40.346
40	34,270,218.75	132,242,285.00	97,972,066.25	0.0356	3,486,248.07	391,258,920.45	41.241
41	34,270,218.75	132,242,285.00	97,972,066.25	0.0323	3,169,316.43	394,428,236.88	42.135
42	34,270,218.75	132,242,285.00	97,972,066.25	0.0294	2,881,196.75	397,309,433.63	43.029
43	34,270,218.75	132,242,285.00	97,972,066.25	0.0267	2,619,269.78	399,928,703.41	43.937
44	34,270,218.75	132,242,285.00	97,972,066.25	0.0243	2,381,154.34	402,309,857.75	44.858

45	34,270,218.75	132,242,285.00	97,972,066.25	0.0221	2,164,685.77	404,474,543.51	45.792
46	34,270,218.75	132,242,285.00	97,972,066.25	0.0201	1,967,896.15	406,442,439.66	46.736
47	34,270,218.75	132,242,285.00	97,972,066.25	0.0183	1,788,996.50	408,231,436.16	47.69
48	34,270,218.75	132,242,285.00	97,972,066.25	0.0166	1,626,360.45	409,857,796.62	48.655
49	34,270,218.75	132,242,285.00	97,972,066.25	0.0151	1,478,509.50	411,336,306.12	49.628
50	34,270,218.75	132,242,285.00	97,972,066.25	0.0137	1,344,099.55	412,680,405.67	50.61

3 -1- 4. Standard Clear the Value Present Net Present of Value (NPV):

Known that the difference between the current total value of benefits and the total value current and that using price Discount Represent Cost the opportunity alternative to head the money at Society, and table (11) shows the criteria currently value.

• Is being the project acceptable if It was Clear the value current at price Discount a certain Larger from zero

• The value current for the net the flow cumulative = (sum value current discounted per the years + Values Project Recovery - cost construction at End the project)

• Values recovery: We assume the recovery value = 35 % of the total value of the project

= 0.35 * 589,292,058.540 US dollars) 206,252,220.489 = US dollars.

Table (11) shows the current value for periods in the life of the project (19- 50) years and all of them are positive after the nineteenth year from the beginning of the implementation of the project, which indicates the positive economic feasibility of the project

Table (11): Criteria of Present Current Value

YEAR	Net Present of Value	YEAR	Net Present of Value
19	-7,846,370.117	**35**	163,980,753.331
20	13,475,205.993	**36**	168,827,022.664
21	32,858,457.003	**37**	173,467,218.847
22	50,479,594.284	**38**	177,685,579.013
23	66,498,809.994	**39**	181,520,451.891
24	81,061,733.366	**40**	185,006,699.962
25	94,300,754.614	**41**	188,176,016.390
26	106,336,228.476	**42**	191,057,213.143
27	117,277,568.350	**43**	193,676,482.918
28	127,224,240.963	**44**	196,057,637.259
29	136,266,670.611	**45**	198,222,323.024
30	143,656,210.469	**46**	200,190,219.174
31	149,240,995.705	**47**	201,979,215.674
32	154,318,073.192	**48**	203,605,576.128
33	158,933,598.180	**49**	205,084,085.632
34	161,858,457.003	**50**	206,428,185.181

3 -1- 5. Guide Profitability or The Value Current for Return/ Costs Benefit-Cost Ratio ((B/C):

It is also defined as Standard Guide profitability (Profitability Index) which is known as the standard which measures the capacity of the investment project to gain its profit. Nevertheless, this standard is considered a relative scale on the opposite of the current standard value for the project.

According to this method, the account of the current value for returns net expected rate to the investment costs to know the project acceptance or not, the results compared with the constant one as the following:

- If the values guide profitability greater than 1. The project will be accepted and here returns exceed costs.
- If the values guide profitability less than 1. The project will not be accepted because returns were not exceeding costs.
- If the values guide profitability equal to 1. The returns will cover costs.

Using the data in Table (10), this criterion is calculated as follows:

The current total net value = (sum of the current value of discounts for every year+ Values Project Recovery)

- The total cost of the project = 589,292,058.540 US dollars
- Values recovery: We assume the recovery value = 35% of the total value of the project = 0.35 * 589,292,058.540 = 206,252,220.489 US dollars.
- The current value for return / costs= the current total net value / cost of the project is bigger than 1.0.

As the value current for revenue / the costs is greater than 1. This is Indicates that this project has Feasibility and profitability

Table (12) shows standards Guide profitability or the value current for revenue / costs benefit-cost ratio (B/C) For periods in the life of the project (24- 50) years, all of which is greater than (1) after the twenty-fourth year from the beginning of the implementation of the project, which indicates the positive economic feasibility of the project.

Table (12): Shows Standard Guide Profitability Or The Current Value For Return/ Costs Benefit-Cost Ratio (B/C)

YEAR	Benefit-Cost Ratio	YEAR	Benefit-Cost Ratio
24	0.987	**38**	1.453
25	1.042	**39**	1.480
26	1.093	**40**	1.505
27	1.142	**41**	1.530
28	1.189	**42**	1.554
29	1.233	**43**	1.577
30	1.274	**44**	1.599
31	1.314	**45**	1.620
32	1.352	**46**	1.641
33	1.371	**47**	1.661
34	1.366	**48**	1.680
35	1.374	**49**	1.699
36	1.397	**50**	1.717
37	1.425		

2 **-1-6. The Average Inner Rate of Return (IRR):**

This standard considered most important standards evaluation projects, and the standard which relies on the world bank to create and reconstruction at analyzing projects as well depends on the most bodies project finance, is used the bank international expression rate return financial inner for the project at case study profitability the project commercial analysis financial as such uses expression rate internal return at a study profitability economic (Evaluation Economic) and the decision based on this standard is:

A- Accept the project if it was inner return rate for the project equal to or larger from head cost the money.

B- The project is refused if its IRR was less than yield the opportunity alternative to head the money at the society.

There is no specific method that can account for this average or price discount which makes value current revenue of the project equal completely for its costs which makes clear the current value equal to zero. Therefore, the followed method is the way of (experience and the error) and (interpolation). This average will calculate the net current value at a certain price of discount so if this value is positive, we calculate the current IRR value once other at a higher discount price and so on until the price of discount of which the current value is equal to zero located between the two other prices of discount.

Table (13): Details A Standard Average Internal Rate of Return (US$)

Year	Total cost (US $)	Total future-benefits	Incremental Benefits (Cash Flow)	Accumulative present growth 10%	Accumulative present growth 15%	Accumulative present growth 11.1%
1	85,929,247.25	0	-85,929,247.25	-416,969,085.31	-416,969,085.31	-416,969,085.31
2	128,923,108.14	0	-128,923,108.14	-545,892,193.44	-545,892,193.44	-545,892,193.44
3	128,923,108.14	0	-128,923,108.14	-674,815,301.58	-674,815,301.58	-674,815,301.58
4	128,923,108.14	0	-128,923,108.14	-803,738,409.71	-803,738,409.71	-803,738,409.71
5	50,929,247.25	0	-50,929,247.25	-854,667,656.96	-854,667,656.96	-854,667,656.96
6	59,734,840.38	132,242,285.00	72,507,444.63	-788,751,798.21	-791,617,705.12	-789,345,634.78
7	34,270,218.75	132,242,285.00	97,972,066.25	-707,783,148.42	-717,536,747.65	-709,829,307.98
8	34,270,218.75	132,242,285.00	97,972,066.25	-634,175,284.97	-653,118,523.76	-638,192,977.53
9	34,270,218.75	132,242,285.00	97,972,066.25	-567,259,045.47	-597,102,676.91	-573,655,742.89

10	34,270,218.75	132,242,285.00	97,972,066.25	-506,426,100.47	-548,393,244.86	-515,514,090.06
11	34,270,218.75	132,242,285.00	97,972,066.25	-451,123,423.20	-506,037,216.99	-463,134,222.64
12	34,270,218.75	132,242,285.00	97,972,066.25	-400,848,262.04	-469,205,888.40	-415,945,152.90
13	34,270,218.75	132,242,285.00	97,972,066.25	-355,143,570.08	-437,178,646.16	-373,432,477.45
14	34,270,218.75	132,242,285.00	97,972,066.25	-313,593,850.11	-409,328,870.29	-335,132,769.85
15	34,270,218.75	132,242,285.00	97,972,066.25	-275,821,377.42	-385,111,673.89	-300,628,528.76
16	34,270,218.75	132,242,285.00	97,972,066.25	-241,482,765.88	-364,053,242.23	-269,543,626.88
17	34,270,218.75	132,242,285.00	97,972,066.25	-210,265,846.30	-345,741,562.53	-241,539,210.77
18	34,270,218.75	132,242,285.00	97,972,066.25	-181,886,828.49	-329,818,362.79	-216,310,007.07
19	34,270,218.75	132,242,285.00	97,972,066.25	-156,087,721.40	-315,972,102.15	-193,580,994.73
20	34,270,218.75	132,242,285.00	97,972,066.25	-132,633,987.68	-303,931,875.50	-173,104,407.03
21	34,270,218.75	132,242,285.00	97,972,066.25	-111,312,411.57	-293,462,113.20	-154,657,030.73
22	34,270,218.75	132,242,285.00	97,972,066.25	-91,929,160.56	-284,357,972.07	-138,037,772.79
23	34,270,218.75	132,242,285.00	97,972,066.25	-74,308,023.28	-276,441,327.61	-123,065,468.35
24	34,270,218.75	132,242,285.00	97,972,066.25	-58,288,807.57	-269,557,288.94	-109,576,905.79
25	34,270,218.75	132,242,285.00	97,972,066.25	-43,725,884.20	-263,571,168.37	-97,425,047.63
26	34,270,218.75	132,242,285.00	97,972,066.25	-30,486,862.95	-258,365,846.13	-86,477,427.66
27	34,270,218.75	132,242,285.00	97,972,066.25	-18,451,389.09	-253,839,478.96	-76,614,706.97

28	34,270,218.75	132,242,285.00	97,972,066.25	-7,510,049.21	-249,903,507.51	-67,729,373.02
29	34,270,218.75	132,242,285.00	97,972,066.25	2,436,623.40	-246,480,923.65	-59,724,567.65
30	34,270,218.75	132,242,285.00	97,972,066.25	11,479,053.05	-243,504,763.76	-52,513,031.29
31	44,172,444.45	132,242,285.00	97,972,066.25	19,699,443.64	-240,916,798.64	-46,016,151.68
32	59,025,783.00	132,242,285.00	88,069,840.55	27,172,525.99	-238,666,394.19	-40,163,106.98
33	59,025,783.00	132,242,285.00	73,216,502.00	33,966,237.22	-236,709,520.76	-34,890,093.75
34	59,025,783.00	132,242,285.00	73,216,502.00	40,142,338.34	-235,007,891.68	-30,139,631.37
35	44,172,444.45	132,242,285.00	73,216,502.00	45,756,975.72	-233,528,214.23	-25,859,935.54
36	39,221,331.60	132,242,285.00	88,069,840.55	50,861,191.52	-232,241,538.18	-22,004,353.71
37	34,270,218.75	132,242,285.00	93,020,953.40	55,501,387.71	-231,122,689.44	-18,530,856.56
38	34,270,218.75	132,242,285.00	97,972,066.25	59,719,747.87	-230,149,777.50	-15,401,579.86
39	34,270,218.75	132,242,285.00	97,972,066.25	63,554,620.75	-229,303,767.11	-12,582,411.65
40	34,270,218.75	132,242,285.00	97,972,066.25	67,040,868.82	-228,568,105.90	-10,042,620.47
41	34,270,218.75	132,242,285.00	97,972,066.25	70,210,185.25	-227,928,400.51	-7,754,520.32
42	34,270,218.75	132,242,285.00	97,972,066.25	73,091,382.00	-227,372,134.94	-5,693,168.82
43	34,270,218.75	132,242,285.00	97,972,066.25	75,710,651.78	-226,888,425.76	-3,836,095.40
44	34,270,218.75	132,242,285.00	97,972,066.25	78,091,806.12	-226,467,809.08	-2,163,056.29
45	34,270,218.75	132,242,285.00	97,972,066.25	80,256,491.88	-226,102,055.44	-655,813.84
46	34,270,218.75	132,242,285.00	97,972,066.25	82,224,388.03	-225,784,008.80	702,062.24

47	34,270,218.75	132,242,285.00	97,972,066.25	84,013,384.53	-225,507,446.50	1,925,374.02
48	34,270,218.75	132,242,285.00	97,972,066.25	85,639,744.99	-225,266,957.55	3,027,456.71
49	34,270,218.75	132,242,285.00	97,972,066.25	87,118,254.49	-225,057,836.72	4,020,323.99
50	34,270,218.75	132,242,285.00	97,972,066.25	88,462,354.04	-224,875,992.52	4,914,799.02

• From the data and results of Table (13) above, the present value of the cumulative net flow was found at a discount factor (10 %). Most of its values are positive after the twenty-ninth year from the start of project implementation.

• Data and results table (13) found above the current value of the net cumulative flow at the discount factor (15%), where the T between the All values are negative.

• Data and results of table (13) the current value of the net cumulative flow was calculated at the discount factor (11. 1 %). All of its values are negative up to the year (46) to turn positive after that.

After the calculation of current net value at multiple discount rates, it gave consequences positive and negative show that coefficient Discount Which Gives the value current equal for zero Located between % 10) And the (% 15, according to Table (13) was an average return inner = % 11. 1

Which is the average which has the current value equal to zero

what that Rate return inner equal to (1.11 %) Larger from price Benefit or price Discount invested money at the market (10 %)And therefore then The project successful and take the resolution to accept it and implement it.

2-3 Final Conclusions:

3-2-1 Conclusions:

From the economic evaluation of the Wadi Horan Development Project, we note the following conclusions:

After subjecting the data on the Wadi Horan Development Project to analysis and testing under commercial profitability criteria to know whether or not the project was accepted, the results and each standard were as follows:

First: the percentage of the cost of benefit and the internal rate of capital recovery:

It is noticed that the cumulative cash flow of the project will become positive in the tenth year of the economic life of the project, which means that the project will pay its investment costs eleven years after the start of the project or after 6 years of operation or 11 years from the start of the work.

Second: standard interval recovery Pay Back Period (PBP):

Net annual cash flows were collected and the recovery period was as follows:

The project begins with profit and recovery of investment and operational costs after the thirteenth year of the start of the project and after the eighth year of operation of the project, i.e. the remaining years are years of profit-taking, the recovery period falls at the period (21-25) years.

In other words, the remaining years are the years of profit-taking, the project is acceptable and economically feasible according to this standard.

Third: average internal rate of return Average Rate of Return (ARR):

We note that the internal rate of return is higher than (3.08-3.00) at the period (19-30) years and then lower before and after this period.

Fourth: Net Present Value (NPV):

The results showed that the current net worth standard for periods of the project life (20-50) years. All of them have a positive value after the 20th year (greater than zero), the internal rate of return of the project will be greater than (10%) . This indicates that the project is economically viable according to this criterion as well.

Fifth: Guide of profitability or the current value of return/ costs (Benefit-Cost Ratio) (B/C):

distance extract Values Guide The results showed that the standard Guide profitability or the value current for return/ costs Benefit-Cost Ratio ((B/C)For periods in the life of the project (25 - 50), all of them are valuable Positive after the twenty-fifth year (greater than 1), which indicates the positive economic feasibility of the project

benefit to cost ratio (B / C) Ranging from (1.042 - 1.717) at a discount rate of 10% for the period (25 -50) years and a rate ratio of (1. 379 5) which represents the opportunity cost of alternative capital to the public sector in Iraq, which signify On Investigation Revenues Excellence costs and thus signify This Standard On Feasibility The project, therefore, it is believed that the Horan Valley Development Project is economically worthy of implementation, and the project is economically feasible."

Sixthly: Guide of profitability or the current value of return/ costs Benefit-Cost Ratio (B/C):

After obtaining the net present values at multiple discount rates that gave positive and negative results, it was found that the discount factor that gives the present value equal to zero is between 10% (15%), according to Table (22); the internal rate of return = 11.1%, which is the rate In which the present value is equal to zero, since the internal rate of return is equal to (11.1%) greater than the interest rate or the discount rate of the money invested in the market (10%), and therefore the project is successful and a decision is taken to accept and implement it. This criterion indicates the feasibility of the project, Therefore, it is believed that the Horan Valley Development Project is economically worthy of implementation, and the project is economically feasible."

3-2-2 Recommendations:

After applying the commercial profitability criteria to the project, it became clear that the Horan Valley Development Project in Anbar Governorate is acceptable and economically feasible according to the commercial profitability criteria, so we recommend the decision to adopt this type of project in Iraq