TRADITIONAL WATER HARVESTING SYSTEMS AND MANAGEMENT IN WADI HADHRAMOU YEMEN

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ABSTRACT

Wadi Hadhramout, a key area for agricultural production, is located in Southern East of Yemen . Yemeni civilization had prospered in an area where water is the most limiting factor. Traditional methods of water resources control, storage and delivery including soil erosion prevention, rainwater harvesting, and irrigation and drinking water-delivery structures, some of which have survived for many centuries. This indigenous knowledge has neither been well documented nor scientifically analyzed in order to utilize it for supporting the sustainable development of rain-fed runoff and spate irrigated farming.

In some areas the water management and water rights are known as the Habits (ALAADAT) which other areas sometimes use these habits to solve unprecedented problems in water management and water rights in these areas.

A long experience in water harvesting and management as well as the maintenance of the irrigation structures systems are nearly to be disappeared and no record is known for this experience. During the period 1970 - 1990 of the Communist Regime in the Southern Governorate, the agricultural land was taken from its owners and distributed to others, thus participated in the negligence of the traditions. After the Unity the lands were returned to its owner. Also after the unity water acompanying oil add other problems.

It is of most important to find out the water management experienced in the water harvesting agricultural areas and test the possibilities to get lesson from it to improve water harvesting.

1 - INTRODUCTION BACKGROUND

Wadi Hadhramout, a key area for agricultural production, is located in Southern East of Yemen, and physically isolated by mountains and desert. Yemeni civilization had prospered in an area where water is the most limiting factor. Water harvesting and

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conservation have been developed and practiced for many centuries. Due to its location and the large differences in elevation and features of its mountainous area the Republic of Yemen (ROY) intercepts varying amounts of rainfall. Since early history, farmers have realized that agriculture is only possible by replenishing the plant available soil-water from limited and difficult to control water resources. Often, crop production is not possible under solely rain-fed condition and therefore runoff water harvesting and conservation are crucial for successful cropping.

Traditional methods of water resources control, storage and delivery including soil erosion prevention, rainwater harvesting, and irrigation and drinking water-delivery structures, some of which have survived for many centuries. These structures, being long lasting, indicate that advanced procedures had been followed in their design and construction. With their traditional knowledge, the farmers of ancient Yemen must have understood and analyzed data relating to rainfall, runoff, soils and climatic conditions associated with land and water resources management. This indigenous knowledge has neither been well documented nor scientifically analyzed in order to utilize it for supporting the sustainable development of rain-fed runoff and spate irrigated farming The Wadis from upstream wadi Hadhramout are:

1 - Wadi Doaan (Wadi Laiman ,Wadi Laiser , and Hajrain) 2 - Wadi Alain (Sudbeh , Hourah , Almokhainig) 3 - Wadi Amed (Amed , Horaidhah , Aandel) 4 - Wadi Rakhyah 5 - Wadi Hainen 6 - Wadi Sur (Shibam) 7- Wadi Bin Ali . 8 - Wadi Aedim

In some areas the water management and water rights are known as the Habits

(ALAADAT) which are not documented from which other areas sometimes use these habits to solve unprecedented problems in water management and water rights in these areas . Some (Aadats) habits Known in Wadi Hadhramout are known as Follow from upstream Wadi Hadhramout :- 1-Aadat Alhajrain, 2-Aadat Gabdhain 3- Aadat Sudbeh, 4- Aadat Aandal, 5- Aadat Ghailan ,6 - Aadat Jomaileh,7- Aadat Shibam

2- THE PROBLEM:

A long experience in water harvesting and management as well as the maintenance of the irrigation structures systems are nearly to be disappeared and no record is known for this experience. During the period 1970 - 1990 of the Communist Regime in the Southern Governorate, the agricultural land was taken from its owners and distributed to others, thus participated in the negligence of the traditions if not add new problems. After the Unity the lands were returned back to its owners. A new problem started with the oil production in Masilah (1993) when the oil produced acompany the water. As the irrigation systems and the agricultural activities in this area is very old the agricultural lands became widely distributed and rarely one land owner own (0.2) hectare in one place, more over due to cultural complication, it is very difficult to give up the land. The lands are spate irrigated excellent land. The ground water is available and the mean activities of the people is cultivation. It is required to test an unprecedented relationship for irrigation with ground water in scattered land ownership.

3 – METHODOLGY

This study has been reached by reviewing the literature in hand about Wadi Hadhramout, with field visits by the authors and personal experience and observations. Consultancy works done by authors in Wadi Hadhramout and other Yemen regions.

4 – WATER RESOURCES IN WADI HADHRAMOUT

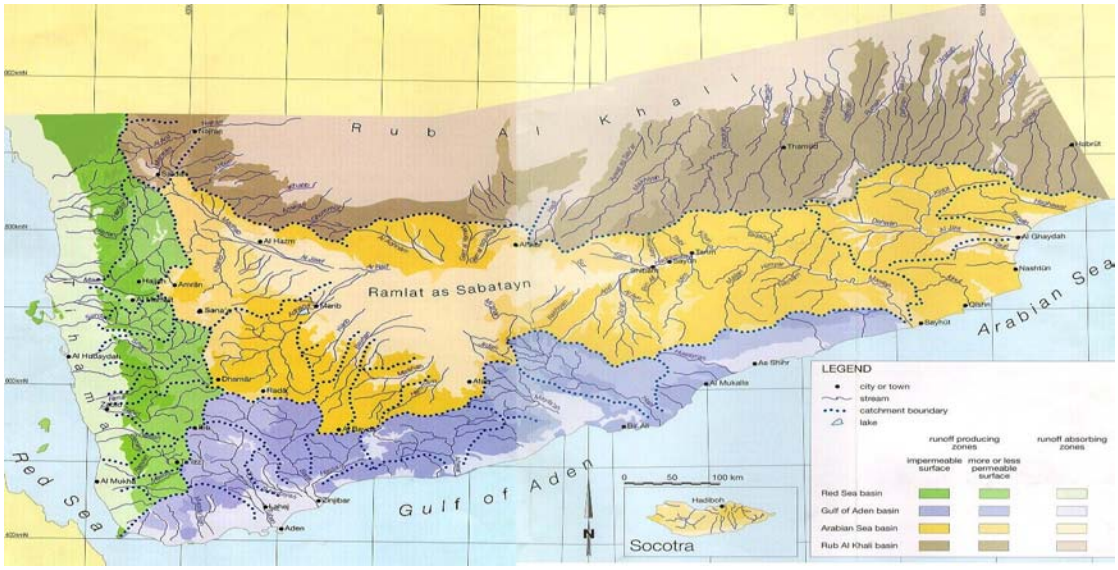
4 – a - Surface

Water 4-a-1- Rain water:

The rain source is mostly the isolated cumulative clouds, this phenomena caused the rain fall on different isolated places which caused floods in some branches of wadi Hadhramout while other branches are dry. If it happened the clouds and then the rain spread over different branches simultaneously the floods from different branches accumulate and caused sever damage as it happened in the seventies. Wadi Hadhramout

catchment area receives main annual rainfall of a density ranges between 50 mm and 300 mm, the catchment lays over mountains in the west and far north west ,desert in northwest and wadi course and tributaries in the north and south plateau .

The catchment area is the largest in the Arab Peninsula.



The Wadi characteristic is unic in the world. In all wet or dry water courses the size of the wadi course at the beginning of the wadi is narrow and enlarged to the maximum size at the end which is not the case in wadi Hadhramout A long the wadi course there are many tributaries / branches counted more than fifty just down stream of Tarim Town.

4 - a - 2 – Floods

The rain source is mostly the isolated cumulative clouds, this phenomena caused the floods in some branches of wadi Hadhramout while the others are dry. If it happened the clouds and then the rain spread over different branches the floods from different branches accumulate and caused sever damage as it happened in the seventies.

Spate irrigation is an ancient form of water management, involving the diversion of flashy spate floods running off from mountainous catchments, using simple deflectors of bunds constructed from sand, stones and brushwood on the beds of normally dry wadis. Flood flows, usually flowing for only a few hours with appreciable discharges, and wit recession flows lasting for only one day to a few days, are channeled through short steep canals to bonded basins, which are flooded to depths of 0.75 m or more.

Subsistence crops, often cereals, are planted only after irrigation has occurred. Crops are grown from one or more irrigations using residual moisture stored in the deep alluvial soils formed from the sediments deposited from previous irrigations. This type of agriculture is very risk-prone and requires high levels of co-operation between farmers to divert and manage the distribution of flood flows. The Hadhramis community had ran the system, until the period 1970 - 1990 of the Communist Regime in the Southern Governorate, the agricultural land was taken from its owners and distributed to others, thus participated in the negligence of the traditional system since then spate irrigation system in Hadhramout is started degradation, **the damage to the irrigation infrastructure are from absent of maintenances** and poverty has increased. Most households in spate-irrigated areas are poor, with a per capita income generally less and in some cases far less, than US$1 per day.[1] Estimated net household revenues derived for some spate-irrigated systems 1 Traditional intakes are constructed from locally

1- Al- Hebshi Mohamed Abdul-Rahman Hashm, THE CYCLE OF POVERTY IN YEMEN, Sana’a, 2004

available materials. Large embankments (diversion bunds) are constructed with animal powered scraper boards, but this type of equipment cannot easily handle coarse gravel and cobbles. Diversion bunds are found on lower reaches of wadis, where the bed slopes, bed material sediment sizes and the flood peak discharges, are all lower than at the mountain fronts.[1]

The Average annual surface flow in Wadi Hadhramout is shown in the following table[2]:

Catchment Area (km2)	Mean Annual precipitation (mm/year)[a]	Average Annual surface flow (Mm3)[3]	Rechareg (Mm3)/year[3]	Net Abstraction (Mm3)/year[3]
46075	54	161	180	144

In Wadi Hadhramout branches the wadi flood is intercepted to divert the flood water for irrigation using various types of diversion structures through canals to the fields. Some structures such as drop structures, weirs, control structures.

1- www.metameta.nl/spate irrigation systems.
2- Tahir, T., "Water Harvesting Techniques in Yemen and Their Prospects in the Scaes Environment of Yemen" Water Harvesting Conference, Khartoum, Sudan, 19-20, Aug., 2003.

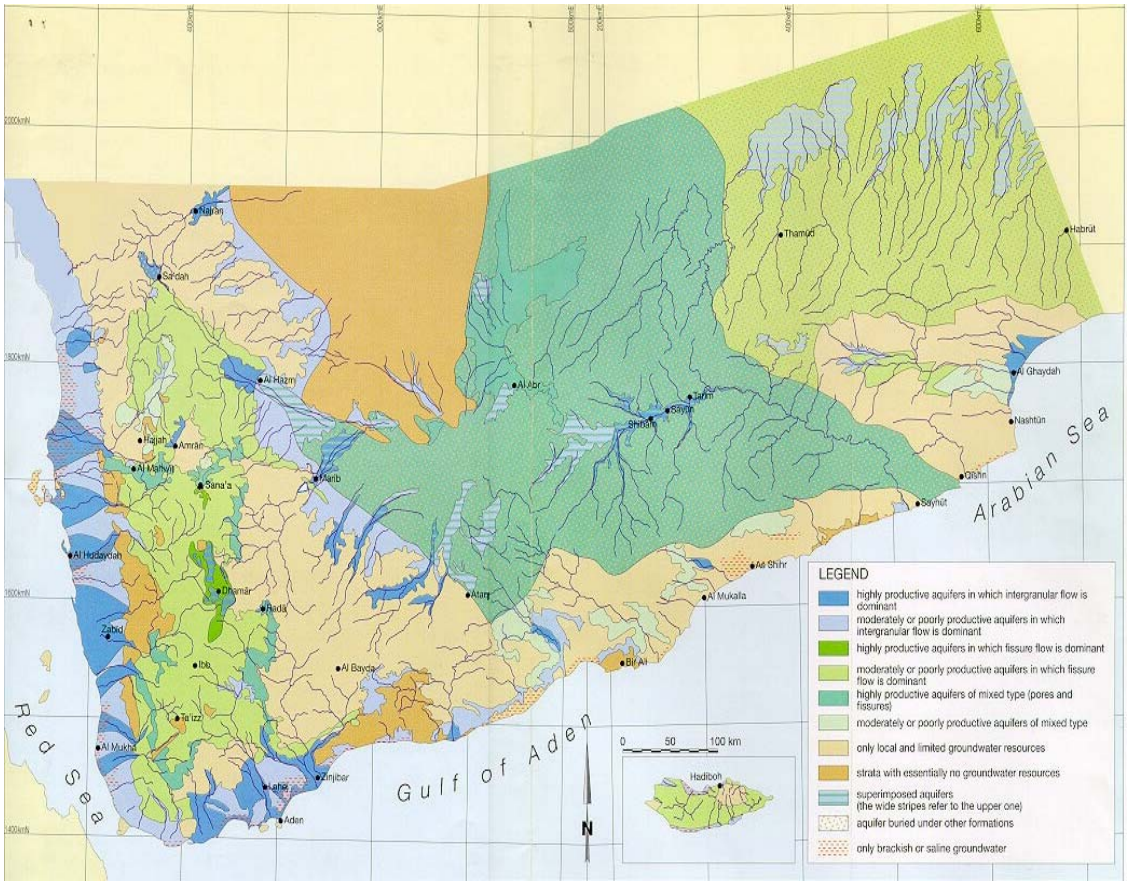
Farmer improved spate irrigation structures in the Hadramawt in Yemen
Diversion Weir with a stepped downstream face

4 – b - 1 – GROUND WATER

Since early times the farmers in wadi Hadhramout used to draw the ground water using labours and animals. Since early 50 s the mechanical engines started in wadi Hadhramout to be used to drew ground water for irrigation and for drinking purposes. A major groundwater aquifer was recently discovered in the eastern part of the country with an estimated storage of 360 billion m3 [1]. Table 1 explains deferent aquifers of Hadramout area, Aquifers Depth, Water by Millions Barrel In square mile.

1- LAHLOU ABDELHADI, WATER RESOURCES OF 11 WATERSHEDS IN NORTH YEMEN, 3rd International Conference on Wadi Hydrology, 12-15 December 2005, Sanaa, Yemen, lahlouhadi2004@Yahoo.fr

Groundwater Map –Yemen



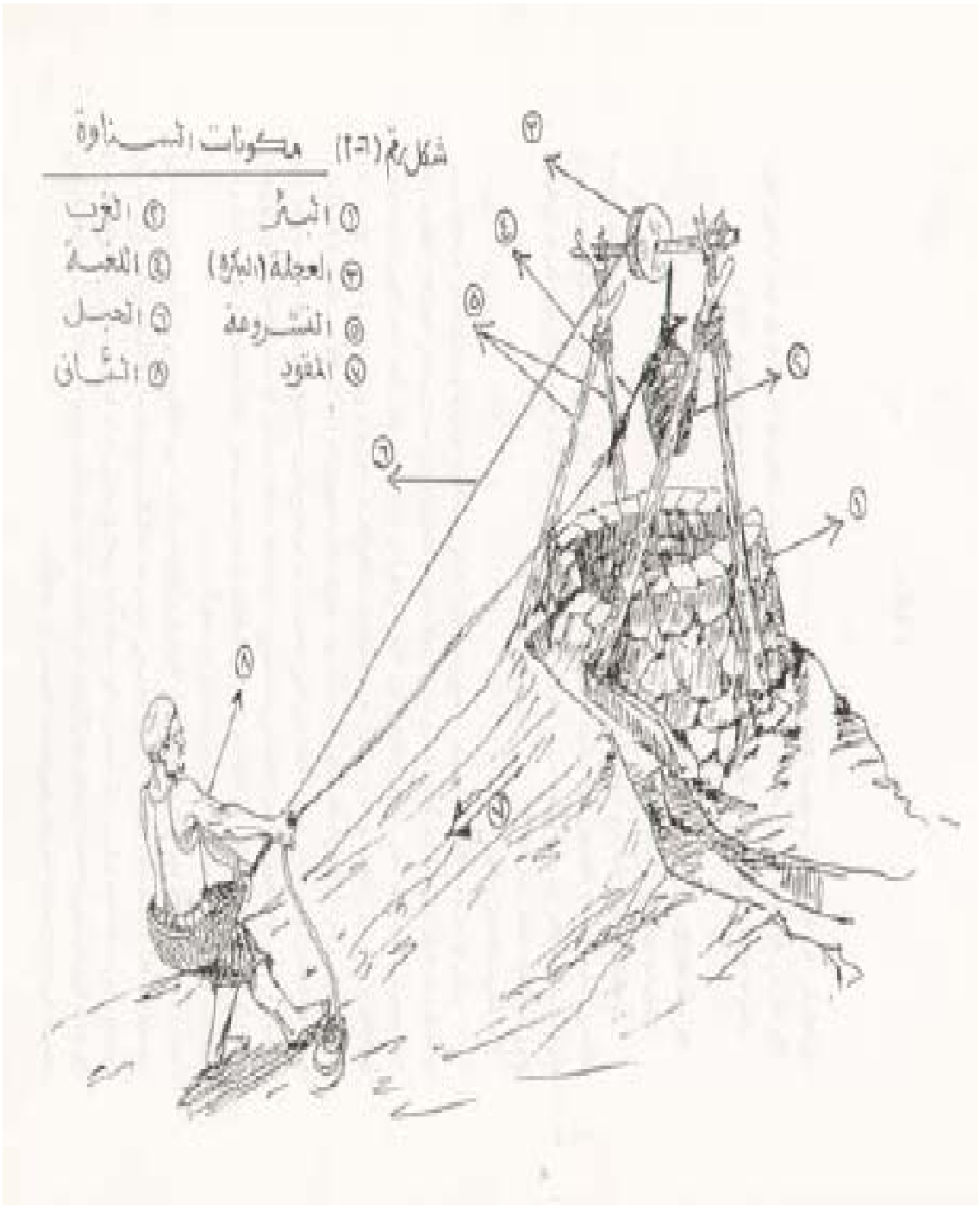

شكل رقم (٢-٦) مكونات السناوة
① البئر
② العجلة (البكرة)
③ المشروعة
④ المقود
⑤ الغرب
⑥ اللغبة
⑦ الحبل
⑧ الثاني

Table (1) Typical Rock Formations In Masila Block Hadramout 1

No.	Aquifers	Aquifers Depth By Mater	Water by Millions Barrel In a squire Mail	Water Quality
1	Jeza	0 – 120		
2	Umm Eradhuma	180 – 270	Un-Know	Potable
3	Sharwayn	25 –50		
4	Mukalla	300 – 600	640	Potable
5	Fartaq	40 – 55		
6	Harshiyat	700 – 900	742	Potable
7	Qishn		96	Water & Oil

4 – b – 2 – DISPOSAL OF THE WATER ACCOMPANYING MASILAA OIL

Canadian Occidental Petroleum Ltd. (Canoxy), major operators in the Hadhramout-Masila block region of Yemen in 1992, retain Komex International Ltd (Komex) to provide an assessment of the ground water resources in the area. Komex year long study determine the existence of two previously unexplored major deep aquifers. Draw from this study suggest that these aquifers, which exist at over 800 m depth in most of the study area, offer excellent potential for good quality groundwater for potable supply and industrial or agricultural purposes. Initial estimates suggest that annuapotential safe yields from the aquifer could exceed several hundreds of millions of cubic meters, if properly developed.

Canoxy has retained Stanley International Consultants Ltd (Stanley) to conduct a study on the potential impacts of disposing of the produced Qishn water into the Harshiyat formation in the N.W Masila Block, Yemen. The study should, in particular, address the concern that disposal operations may impact the overlying Mukalla aquifer& the others, which contains potable water. For instance in table 2, when the oil is sold, a country appears to grow richer, even though depreciation of the natural capital - soils, and water - may create future losses several times greater than the present gain.[2]

5 – THE WATER RESOURSES DEVELOPMENT

Before the unity in 1990, the water recourse devin two opposite directions, In the north part of the country developing project concentrating on the wadi and flood control project and the exploitation of the ground water was left to the privet sector, while in the south the Government concentrate on the ground water exploitation neglecting the floods the wadi development although land reclamation projects were implemented depending on ground water. The privet sector was out of the equation in this field.

1- Canadian Occidental Petroleum, HYDROGEOLOCAL ASSESSMENT OF PRODUCED WATER DISPOSAL, Yemen Masila Project, April 1994, (p 48)

2- Dr Mohamed A. Al- Hebshi, Eng. Saleh Ahmed Bin Rabaa, Disposal of the Water Accompanying Masila Oil in Yemen, International Conference On Soil & Groundwater Contamination & Clean-up in Arid Countries, Sultan Qaboos, University, Oman, 20 – 23 January 2003

In early 1990 after the unity the situation was in the north part the ground water was exploited and in many regions it reached grave situation. and in the south the land ownership started and all the gained developed land became gradually desert.

And the wadis flood structures need heavy rehabilitation and maintenance while most of the people did not know how such structures used to be maintained.

Table (2) the Cost of Injection & Opportunity Costs of Masila Water Disposal

Total Cost	Opportunity Costs	Cost of Injection	Quantity Per Year	Injection Rate (BWPD.000)♣	Years
1029300	343100	686200	17155	47	1994
3153600	1051200	2102400	52560	144	1995
4730400	1576800	3153600	78840	216	1996
5825400	1941800	3883600	97090	266	1997
6942300	2314100	4628200	115705	317	1998
7402200	2467400	4934800	123370	338	1999
7840200	2613400	5226800	130670	358	2000
8081100	2693700	5387400	134685	369	2001
8256300	2752100	5504200	137605	377	2002
8015400	2671800	5343600	133590	366	2003
5256000	1752000	3504000	87600	240	2004
3766800	1255600	2511200	62780	172	2005
3438300	1146100	2292200	57305	157	2006
2868900	956300	1912600	47815	131	2007
2737500	912500	1825000	45625	125	2008
2387100	795700	1591400	39785	109	2009
1598700	532900	1065800	26645	73	2010
1554900	518300	1036600	25915	71	2011
1029300	343100	686200	17155	47	2012

1- Per day * by 365 Injection per Year
2- Estimated Cost of injection by 40 YR Per Barrel
3- Opportunity cost per Barrel of Water is estimated by 20 YR

6 – CONJUNCTIVE USE OF FLOOD AND GROUND WATER

The conjungtive use of flood and ground water was not experienced widely in wadi Hadhramout. There is an old saying farmers used to say if the rain does not come we will draw water from the ground using the humans and the animals (**أن مطرت و لا سنينا**)

The practice of using ground water and flood is widely experienced in Tihama region West of Yemen as the wadis flood is controlled by modern permanent structures which is not the case in Wadi Hadhramout.

7 – CONCLUSIONS

Soil and water management in spate systems is vital for three reasons. The first is the soils are largely induced by human activity. They are built up from the sediments transported with the spate flows that settle when water is bunds on bunds fields. The water holding capacity and fertility of these soils is usually excellent, but soil management is required to counter land rise, maintain fertility, and in some areas to avoid soil crusting and compaction. The second reason is the importance of moisture conservation in crop production. In spate systems irrigation before planting provides the main source of crop moisture. Conserving this moisture is essential to crop production. Good moisture conservation can have an impact on production often greater than improvements to the water diversion systems. The third is the positive and lasting impact by developing successful partnerships built on mutual trust and respect with farmers, land owners and the local communities where they work and live to gather peacefully. The lands are spate irrigated of excellent soil. The ground water is **Al-Hebshi &. Rabaa** available and the mean activities of the people is cultivation . It is required to test an unprecedented relationship for irrigation with ground water in scattered land ownership taking into consideration the possibility of flood irrigation as conjunctive use of ground and flood water.

The Water Company the oil production from a deep aquifer and it is effects in environment is scurries problem in Yemen.

8- REFERNCES:

1- Al- Hebshi Mohamed Abdul-Rahman Hashm, THE CYCLE OF POVERTY IN YEMEN, Sana'a, 2004

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3- CANADIAN OCCIDENTAL PETROLEUM, Hydrological Assessment of Produced Water Disposal Yemen Masila Project (April 1994)

4- CANADIAN OCCIDENTAL PETROLEUM. Yemen Masila Project Water Treatment Disposal options (April 1994)

5- David Brooks, "Oil and Water Can Mix", LEDS, Vol. 8 No. 4, Oct. 1997, Canada

6- LAHLOU ABDELHADI, WATER RESOURCES OF 11 WATERSHEDS IN NORTH YEMEN, 3rd International Conference on Wadi Hydrology, 12-15 December 2005, Sanaa, Yemen, lahlouhadi2004@Yahoo.fr

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8- www.metameta.nl/spate irrigation systems