




REALIZING EQUITY DISTRIBUTION OF SPATE IRRIGATION TO CEASE ENVIRONMENTAL DEGRADATION IN COASTAL AREA OF WADI Zabid

(Al-MOJYELIS CASE STUDY)

Prepared by

Omar Abdulaziz Alsabai

Mcs. Student in IWRM

WEC - Sana'a University

Supervision

Dr. Adel M. Alweshali

REALIZING EQUITY IN DISTRIBUTION OF SPATES TO CEASING THE ENVIRONMENTAL DEGRADATION IN WADI ZABID COASTAL AREAS

(AI-MOJYELIS CASE STUDY)

Prepared by

Omar Abdulaziz Alsabai

Mcs. Students in IWRM
WEC - Sana'a University

Supervision

Dr. Adel M. Alweshali

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PICTURES

ABBREVIATIONS

BCM	Billion Cubic Meter
EC	Electric Conductivity
ha	Hectare
HWSLC	Hodiedah Water &sanitation local Corporation
IIP	Irrigation Improvement Project
IWRM	Integrated Water Resources Management
K	Hydraulic Conductivity in meters per day (m/d)
Km	Kilometer
L/s	Liters per second
m	Meter
mm	Millimeter
mm/y	Millimeter per year
m^3/s	Cubic meters per second
Mm^3	Million Cubic Meters
MOA	Ministry of Agriculture
MWE	Ministry of Water and Environment
NWRA	National Water Resources Authority
NWRA-Hodiedah	National Water Resources Authority- Al-Hodiedah branch
PRA	Participation Rural Appraisal
TDA	Tihamah Development Authority
TDA-Zabid	Tihamah Development Authority-south region branch in Zabid
UNDP	United Nations Development Program
W.T	Water Table
Y.R.	Yemeni Real

Abstract

Wadi Zabid is one of seven wadis form the coastal Tihama plain that consider the food … of Yemen. The spate irrigation in Wadi Zabid has practiced since old times by the floods flowing from the catchment areas in mountains to the east of Zabid. The agriculture in wadi Zabid was and still main source to income and to security of population needs in wadi. Currently, about 75% of wadi residents depended on agriculture. The renowned Moslem scholar Sheikh Al-Gebrati devised the regulating rules to water distribution some 620 years ago. The system gave priority of water diversion to upstream then downstream users. Thus, wadi lands were divided into three groups, each group is irrigated during specified periods. With ends of seventies, traditional spate irrigation system was replaced by modern system comprised construction of permanent diversion structures (five weirs and channel network) provided by gates to distribution of water in accordance with the traditional rules. The objective of system development was increase of cultivated area, improving the agriculture production and then farmers' income. After construction of new system, TDA undertook the responsibility of supervising over water distribution as well as operation and maintenance of spate system. However, there are 16 WUAs were established to carrying the management of system (water allocation and operate and maintenance) at 16 sharij distributed within command area, but these associations (WUAs) still unable on those tasks. During last thirty years, since modernizing system, arrival spates to the downstream area minimized less by less and then increased inequity in water distribution. However, during this period, the environmental resources of coastal areas of wadi have deteriorated drastically. The present study researched the relationship between degradation in downstream and inequity in rights and rules of water distribution under the new spate system. The field findings indicated that modern system doubled inequity in water distribution through control the open and closure of the main gates during flood peaks and then capturing the water in this part of wadi. Reclamation wide area of Galal lands (common

lands located on the wadi stream) in upstream to irrigate at the expanse of downstream. The results also indicate that during last thirty years the cereal crops replaced entirely by banana and other high value crops in upstream area especially at first and second weirs and most of lands at weir No.3. Thus, banana fields need to irrigation every 4-5 days with much amount of water throughout the year. Cropping patterns and irrigation practices lead to most of violations in traditional rights. New spate system and current practices and cropping patterns etc. created new conditions or situations does not similar to those conditions that were prevailed in past and then led and still to inequity in water allocation. The consequences of inequity were very drastic on the downstream area of wadi. To determine of results of inequity, the present study chosen Al-Mojaylis village as model to the coastal villages located in downstream of wadi Zabid. The field findings indicated that about 75% of agricultural lands have been destroyed during thirty years ago due to drought, the falling of water levels (as the village depend on groundwater that was recharged from spate waters with much amount in the past, so, water levels in village remained near the land surface to centauries) and then sand dunes invasion. The bad environmental situations forced most of residents of Al-Mojaylis to immigration into other countries. The field findings indicated that more than 50% of people have immigrated far away from Al-Mojaylis. The study recommended by managing the water at wadi level in integral to achievement of environmental sustainability and social equity. Formation of wadi committee to managing the surface and groundwater not only within the command area of spate irrigation project but at the wadi level entirely is very necessary with take into consideration participation small users. After that, Wadi committee must prepare new rules to water distribution. Enforcement of water law to control drilling wells, determining the amount of water allowed to abstraction should be applied as quickly intervention to mitigating the degradation of environmental and social statue in downstream areas especially those nearby to the coast..

CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

The Yemen is one of countries characterized with arid and semiarid climate. Nevertheless, an old Yemenis overcame this problem by building several systems to harvesting the rainwater to provide their needs of water to the irrigation and drinking where believed that Yemenis were the oldest in practicing the spate irrigation and depended directly their old culture on development of spate irrigation. The irrigation practices were regulated by traditional rules used by community generation after other and are different from area to another.

Wadi Zabid is one of famous wadis in Yemen in which the agriculture depended on spates for centuries. The spates have been diversion into fields by earthen diversion structures build by farmers themselves. The spates under the traditional system have been distributed in according to traditional rules and regulations .

The practicing the traditional spate irrigation in wadi Zabid continued until the seventies of past century. After that, traditional spate system has changed by construction of permanent scheme, but this change did not associated by developing the governance instruments so created more of problems. As a

construction of five diversion weirs in wadi Zabid without taking into consideration development of the traditional rules that regulation and govern the distribution processes increased inequity in water distribution between upper and lower areas of wadi.

The present study used IWRM concept to identifying the causes of environmental degradation in downstream area of wadi Zabid. Al-Mojaylis village (located near the coast) was chosen by the present study as model for the degraded downstream area. To implementation this study, PRA techniques used in many of locations at the wadi level.

1.2 STUDY PROBLEM

Since the 1970s, Yemen has witnessed very rapid changes as a result to many factors may as all related to change in the water demand, and often unmatched by development of governance instruments.

For facing this change, the Yemeni government developed several spate irrigation schemes in many wadis. The spate irrigation scheme in Wadi Zabid is the first scheme developed with construction of concrete diversion structures.

Spate irrigation scheme developed without any develop to the traditional rules that was regulate the water distribution within the old system.

So, the construction of permanent spate irrigation scheme in wadi zabid lead to four main problems:

- Non-arrival the spates water to downstream of wadi Zabid, where the spats captured by the upstream farmers.
- Declining groundwater levels, then saline water intrusion in coastal areas (downstream)
- Desertification of lands and sand dune invasion to the most farmlands in the downstream areas.

- Abandonment of agriculture, migration of residents, and increase of poverty in downstream areas.

1.3 OBJECTIVES OF STUDY

Overall Objectives

- Using of IWRM approach to evaluating the efficiency and effectiveness of spate irrigation system of wadi Zabid to achieving the development and improving the livelihood.

Specific Objectives

The Study's specific objectives are:

- **To evaluation of** traditional water rights and rules that regulate the spates distribution between users and evaluating suitability those rights and rules to achieving the distribution equity.
- To evaluation of range of compliance to the traditional rules and identification of transgressing manners those rules if any.
- To identification and analysis the relation between the permanent diversions structures, water allocation rules and groundwater, then their influences together on the downstream areas.
- Deducing and setting up various options or alternatives **to** achieving the equitable distribution of the available water resource and ceasing the degradation of downstream environment.

1.4 WADI ZABID BACKGROUND

1.4.1 Location

Wadi Zabid is one of the seven major wadis, which form Tihama basin (Gun and Ahmed, 1995). Catchment area of wadi extends from the Yemen Highlands (around Ibb and Yarim) in the east into Tihama coastal plain in

the west and drains into the Red Sea. The total catchment area of wadi Zabid is about 4630 km^2 (Figure 1.1).

The study area comprises the main wadi only (wadi delta), which the spate irrigation system lie within it. This area is located in the southern part of Tihama plain between longitude 297,000 - 335,000 UTM-E and latitude 1558000-1570000 UTM-N. Wadi Zabid is located on distance about 100 km southeast of the port Al-Hodeida.

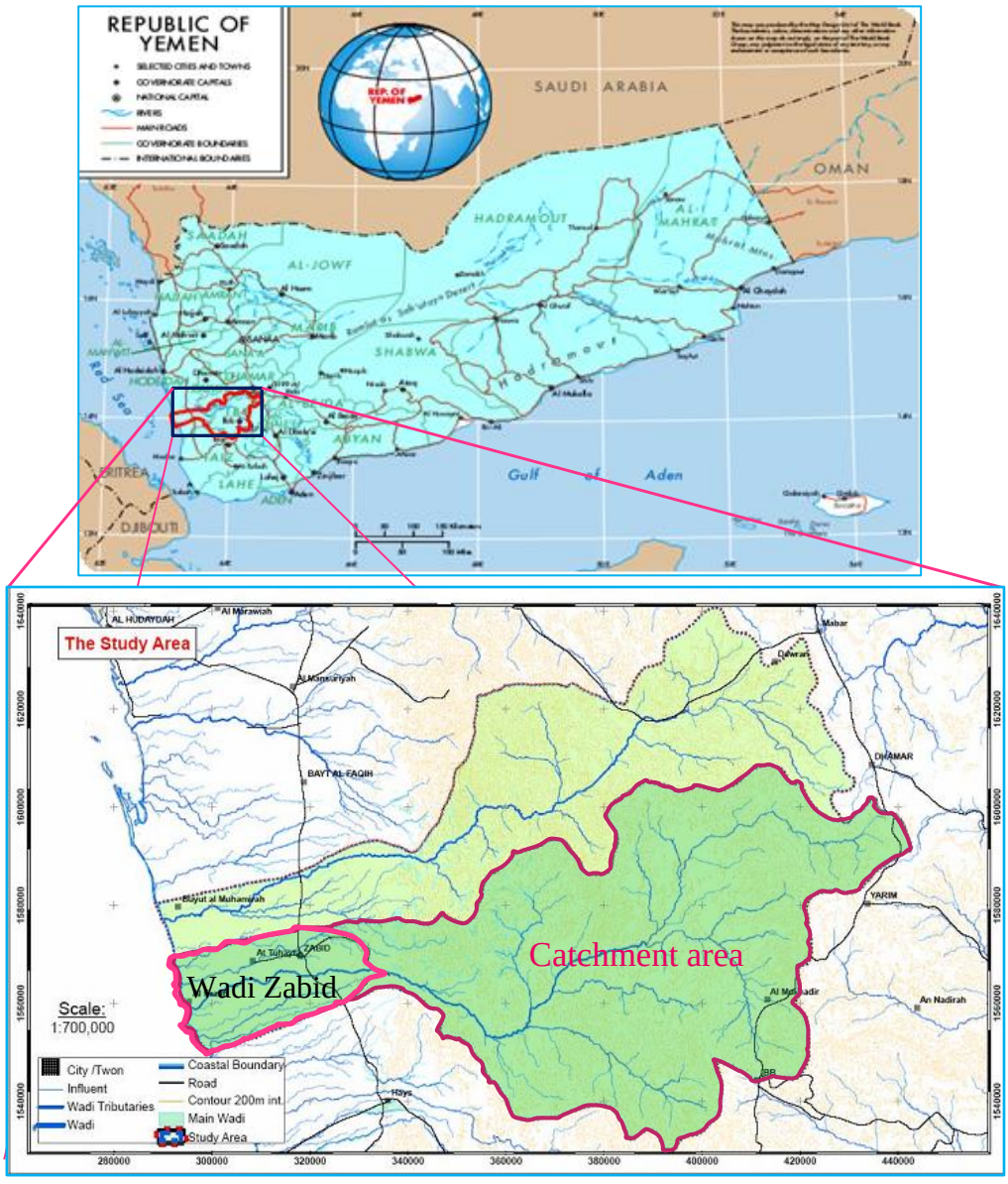


Figure (1.1) location map of wadi Zabid and its catchment area

1.4.2 Demographic Characteristics

The population of wadi Zabid about 160000 persons. The most of population lives in the ruler areas. Agriculture is the main income source to the population in the wadi, where 70-75% of the population work in agriculture. Income sources of population different between the wadi areas according to change the situations of agriculture. The pictures1.1 shows changes in the agricultural activity and indirect reveal the population status in those areas.
The populations of upstream are richmen of wadi because of capturing the spates in this part of wadi, while the population in downstream area considers the poorer at the wadi level.

More than 35% of the families in Wadi Zabid live below the poverty line, as well estimated that 55% of the families do not own any land but they laborers in the agriculture (Steenbergen, et al., 2010). Wadi zabid lies within two administrative district (Zabid and Tohaitah).

1.5 TOPOGRAPHY, GEOLOGY, AND CLIMATE OF WADI ZABID

1.5.1 Topography and Geology

According to Tesco, 1971, Wadi Zabid lie within Tihama plain that forms sedimentary basin consists of a continuous chain of vast alluvial fans (Al-Eryani, 1979). Quaternary sediments that cover the area are largely of continental origin. Stratigraphy of Zabid water resources management district comprised entirely of sedimentary deposits which are over (200 m) thick (NWRA, 2009).

The following four main physiographic units were recognized in wadi Zabid based on the change in grain size of depositions (NWRA, 2009).

- Alluvial fan
- Alluvial plain (Coarse to medium subsurface deposits).
- Alluvial sand deposits

- Alluvial marine platform (medium to fine subsurface deposits).

Seismic surveys conducted by Tesco (1971) clarified that basement rocks from the mountain front westward underlie the Quaternary section in wadi Zabid. This basement complex, which is the faults that appear in surface exposures of basement rocks at the mountains, was also shown by Tesco's survey to be faulted in the subsurface exposures under the Quaternary section (Al-Eryani, 1979). According to Italconsult (1973), the Quaternary sequence was accumulated in Tihama due to **two factors** (Al-Eryani, 1979)**:**

The first factor relates to the formation of the Red Sea Graben, which resulted in the Tihama being an area of rapid subsidence that was compensated by the accumulation of the Quaternary deposits.

The second factor relates to a climatic regimen, during the Quaternary, in which the climate was much less arid, thereby providing sufficient flow for the then predominantly perennial streams to transport huge quantities of sediments toward the Tihama. This process is believed to have been furthered by the big difference in relief between Tihama plain and the adjacent mountains, thereby permitting vigorous stream erosion along most of the stream courses. Moreover, it is also believed that the lower courses of the larger wadis near the coast were repeatedly captured by drainage flowing toward the west, northwest, and southwest. Figure 1.2 shows the stratigraphic and structural units in wadi Zabid.

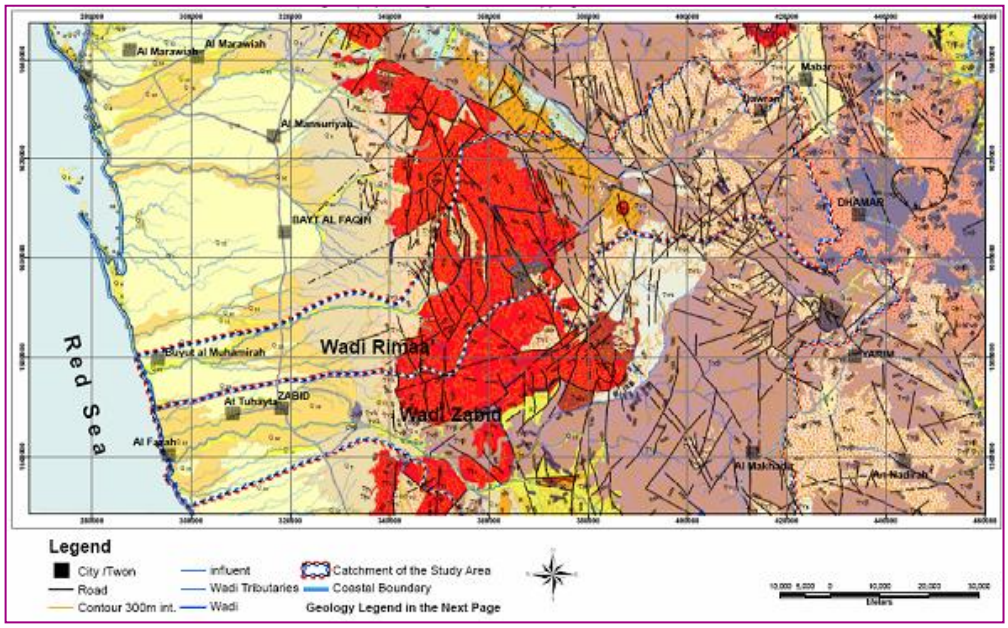


Figure1.2. Geological units of wad Zabid (after NWRA, 2009)

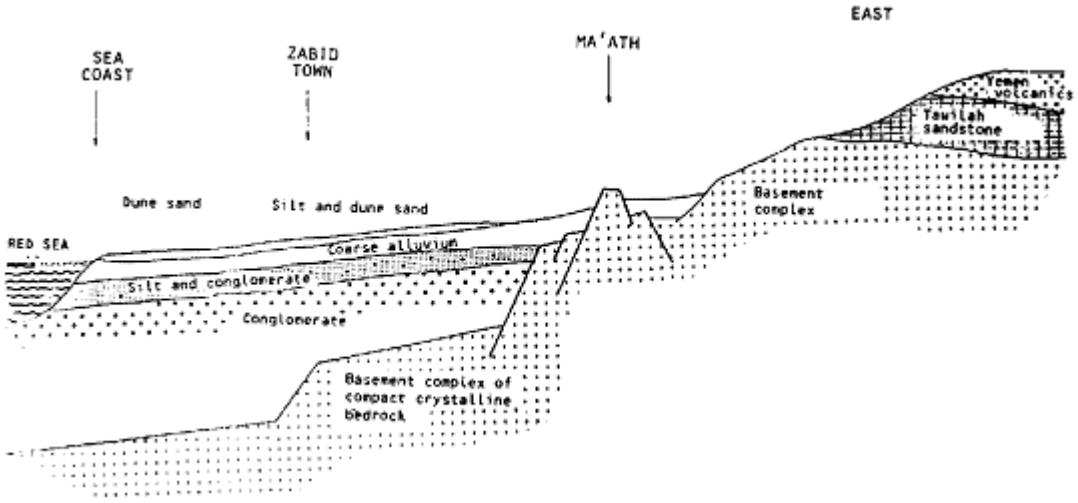


Figure 1.3 schematic geologic section of wadi Zabid in east-west direction (after Tesco-Viziterv-Vituki, 1971)

1.6 Climate:

Climate of Wadi Zabid delta is hot and arid, but may become semi-arid in highland of catchment area. In general, Yemen influenced by three climatic zones: the Red Sea convergence zone (RSCZ), the Intertropical convergence zone (ITCZ) that takes its moisture from the Indian Ocean, and the

occaqsional influx of cyclonic events from the Mediterranean. Rainfall occurs from March to May and in larger amount from Jul to October.

Table 1.1 and 1.2 presents a summary of metorological data for some stations in the study area, which geve annual values (average or total) for five climatic parameters (precipitation, air temperature, relative humidity, wind velocity,sunshine duration and pan evaporation).

Table (1.1) climatological variables of wadi Zabid (wary-35)

Station	**Elevation m+msl**	**Annual totals or averages**						**Year**
		P	T	RH	WS	SSD	ET_o	
Zabid	240	347.8	29.6	63.0	1.5	7.4	2147	
P= total precipitation mm, SSD= average sunshine duration (hrs/d), ET0=total potential evapotranspiration, WS= average wind speed (m/s), RH= average relative humidity (%), T= average temperature (C°)								

Table 1.2 Available climatic data for stations in the study area

station	Eto mm/y	Rainfall mm/y	Max temp.	Min temp.	Mean temp	Mean relative humidity %	Max relative humidity %	Min relative humidity %	Average sunshine hours
Zabid Jurbah	2447	348	36	23	29	64	71	55	7.4
Zabid town	2447	166	36	23	29	-	-	-	-

1.6.1 Precipitation:

Precipitation is one of the most important aspects of the wadi's hydrology, because of its control of the quantity of surface flow that will reach wadis.

Rainfall in Zabid increases eastward due to the geographic effect of the mountainous areas. The rain fall patterns are influenced by both the Red Sea convergence zone effect (RSCZ) and the inter tropical convergences zone (I.T.C.Z) effect, which produce to main rainfall periods, one from March to May and the other from July to September.

Several rainfall stations distributed in wadi Zabid and its catchment (table 1.3), which indicate that higher rainfall amount records in eastern highlands where maximum values recorded in Al-Odien and Ibb, while the rainfall

decrease gradually towards the western coastal plain areas to reach 209 mm in Zabid station on elevation about 105m above sea level. Figure 1.4 shows the location of observation stations, and further gives clear picture for the distribution of rainfall over the study area.

Table 1.3 Rainfall records for several stations distributed at the catchment area of Zabid

Rainfall Station	UTM-East	UTM-North	Mean annual rainfall (mm)
Zabid	321929	1568649	209.3
Al khmah	330986	1577807	288.3
Yarim	433489	1581012	330.4
Wadi Al har	417390	1605026	376.2
Al-jarubah	330899	1564899	398.8
Al dalil	411846	1560801	711.1
Ibb	411795	1546053	909.3
Al Odien	400979	1542405	948.9
			521.5mm

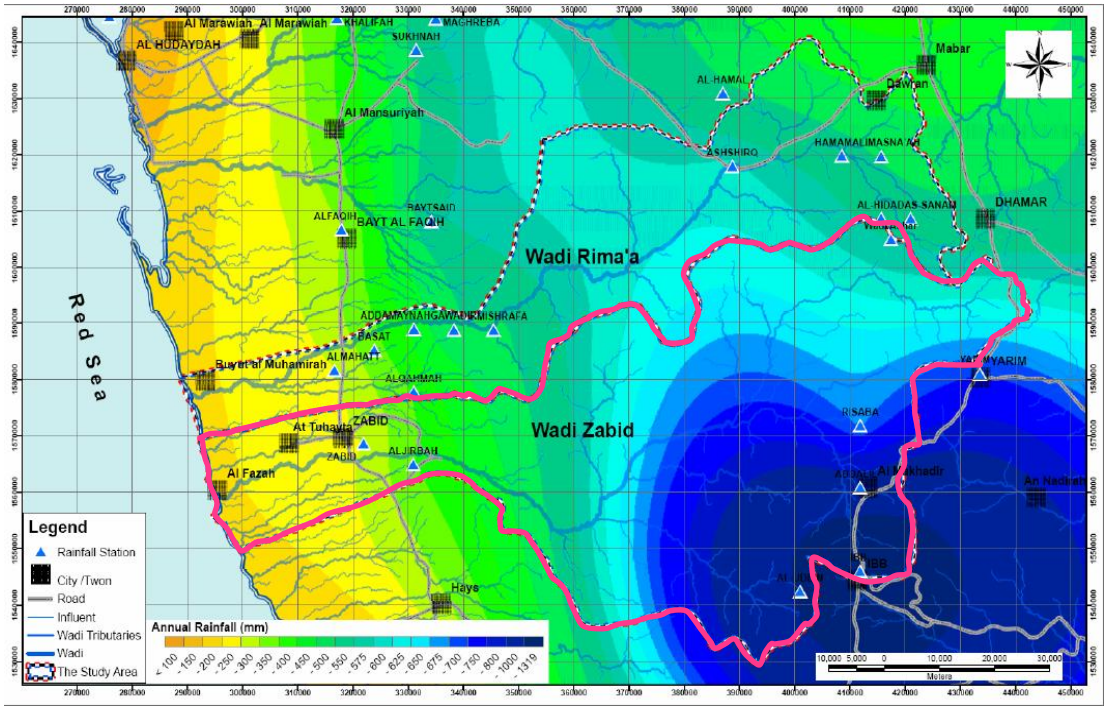


Figure 1.4 Isohyet map of Zabid WRM D (after NWRA, 2009)

1.6.2 Air temperature

Temperature is variability accordance to variability in time and space. Apart from long-term climatic changes, variability with time can further distinguished into annual and seasonal, while variability with space can be also distinguished as due to altitude or due to elevation variations.

The mean of temperature values per month in the wadi Zabid are available from Al-Jarubah station that locates on elevation about 230 meters above sea level (see table 1.4). Figure 1.5 shows the monthly mean for air temperature in the study area, based on table 1.4.

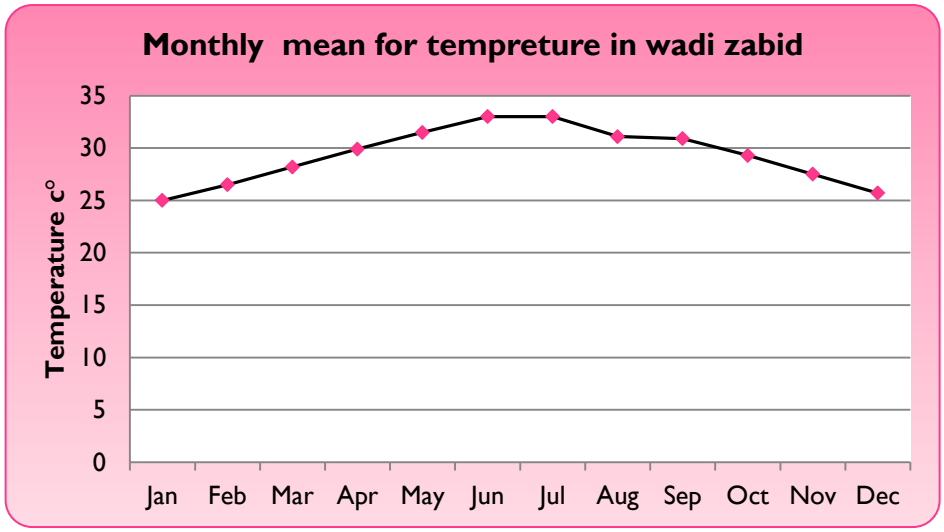


Figure 1.5 the monthly mean for air temperature in the study area

From the figure, we can notes that the temperature during the months from May to August is very high, with peak of temperature in June and July, while the temperature from September to April becomes moderate. According to these recorders, the annual average of temperature is about 29C°.

1.6.3 Humidity Percentage

An average humidity in wadi Zabid per month is illustrated in figure 1.4 according to metrological records of Al-Gerbah station to the period from 1970-1986. Depending on these records, the mean humidity of wadi Zabid range between 60-75%.

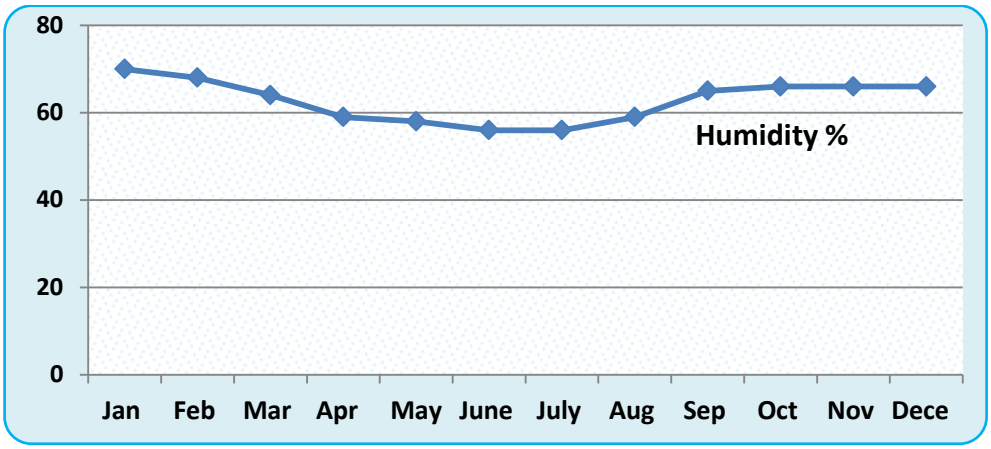


Figure 1.6 Mean monthly of Humidity inwadi zabid

It is interesting to note that the lowest mean monthly of relative humidity occur during July, which is one of the hottest months and highest rainfall in the area. Average annual humidity is typically between 70 and 80% for coast areas, and values of 50-70% for those parts of the coastal plains and deltas that are more than some 20 km from the sea (WRAY-35).

1.6.4 Wind velocity

Based on data from Al-Gerbah station, average annual of wind velocity in the study area is 1.4 m/s.

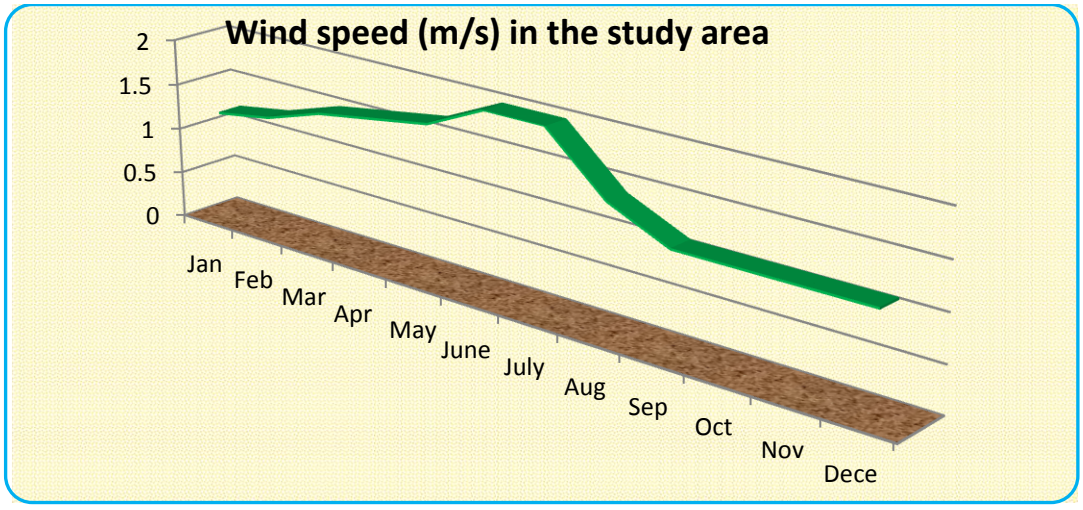


Figure 1.7 monthly average of wind vilocity inwadi zabid

1.6.5 Evaporation Value

According to the available data from Al-Jarubah (Al-Gerbah) station, the annual evaporation is about 3276mm. At this station, peak evaporation was in July. The high value of evaporation in this month (July) is accompanied by increase air temperature and wind velocity, and decrease of relative humidity at the same month. There are other values of Eto have been estimated by WRAY-35 about 2147mm/y.

Chapter two

WATER RESOURCES IN WADI ZABID

2.1 Rainfall

Mean annual rainfall in wadi Zabid (wadi delta) reach to about 209mm while increase the mean annual of rainfall when it estimated at the catchment level where the mean annual rainfall reach to 525mm (see section 1.6.1).

2.2 Surface Water Resources

Generally, surface water is all the water that flows on ground surface temporarily or perennially. Spate water and base flow represent the common surface water in wadi Zabid, which reflect the seasonal rainfall pattern in its catchment area.

2.2.1 Flow Volumes (Base Flow and Spate Water)

Flow volumes in wadi Zabid are recording by Tihama Development Authority (TDA) at Al-Kolah station.

The rainfalls within the middle and upper catchment areas generate runoff that supplies irrigation water into the wadi Zabid. Two flood seasons occur in spring and summer. The discharges during low (Base) flow also are reported typically in the order of 1-5 m^3/s (NWRA, 2009).

Figure 2.1 shows flows volume as an average per month during the period 1970-1997, which recorded at Al-Kholah station in wadi Zabid.

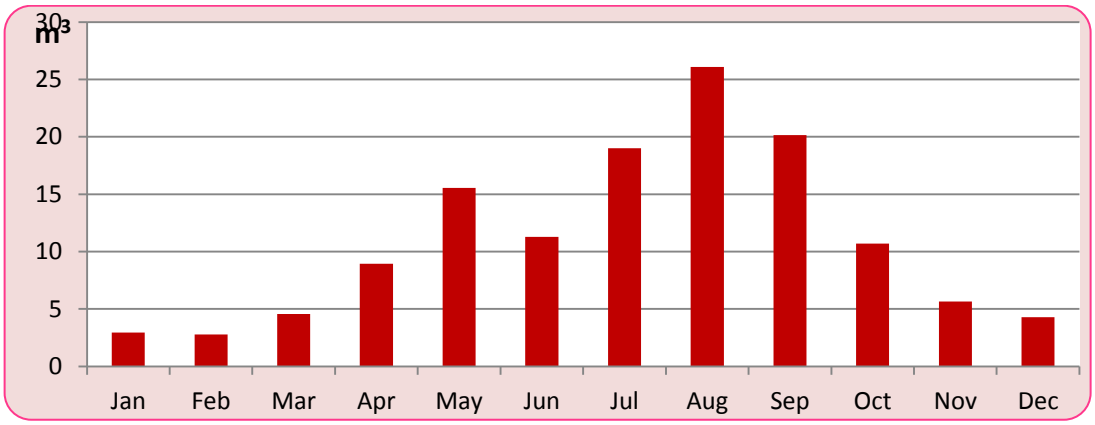


Figure 2.1 monthly average flows of wadi zabid during the period 1970-1997

From the figure, we can note that the peak floods occur in the period July to September (this period consider the second season or rather the wettest season), although the total flood season covers a period of about 6 months from April - sometimes-even March- to October. The annual average floods of wadi Zabid during 27 years was about 132Mcm.

The coefficient of variation in the annual volumes of runoff was estimated about 0.40, while the runoff coefficient 0.049. Table 2.1 gives the mean values and coefficients of variation of annual runoff volumes, together with the estimated annual average rainfall at the catchment area of wadi Zabid according to WRAY-35.

Table 2.1 total annual runoff of wadi Zabid (WRAY-35, 1995)

Wadi		Total annual runoff statistics					
	Catchment area (km^2)	No. of year	Mean -Mm^3	Mean- mm	C_v	Mean P (mm)	Mean RC
Zabid	4632	23	125	27	0.40	550	0.049

C_v = coefficient of variation of annual flow volumes. RC = runoff coefficient P = annual precipitation

2.3 Groundwater Resources

According to classification aquifer systems in Yemen, alluvial aquifer is major groundwater aquifer in Tihama (WRAY-35), which is recharged mainly from percolation of surface wadi flow in wadi beds, off-take canals and irrigated fields.

Alluvial aquifer is the main aquifer in wadi Zabid, which has thickness range from 25m in the east adjacent to the foothills, to 300m at the coast.

Groundwater has played a central role in agricultural development in the wadi and has encouraged the farmers (especially in upstream) to shifting from the seasonal cultivation into permanent cultivation.

2.3.1 Groundwater Levels and Its Variations

The depth to water level in wadi Zabid varies according to the location. Where groundwater level near the foothills in the east 0-50m below the ground surface, in the middle part between 70- 120 m, and in the coast area the groundwater level ranges from 100-300 m below ground surface (NWRA, 2009).

During the past 20 years (1985-2005), the declining the water levels were estimated 30 meter with an average annual decline 1m (NWRA, 2009).

The rapid falling in groundwater levels is still continuous. Figure 2.2 shows the variations of groundwater levels at the wadi Zabid level during 2007.

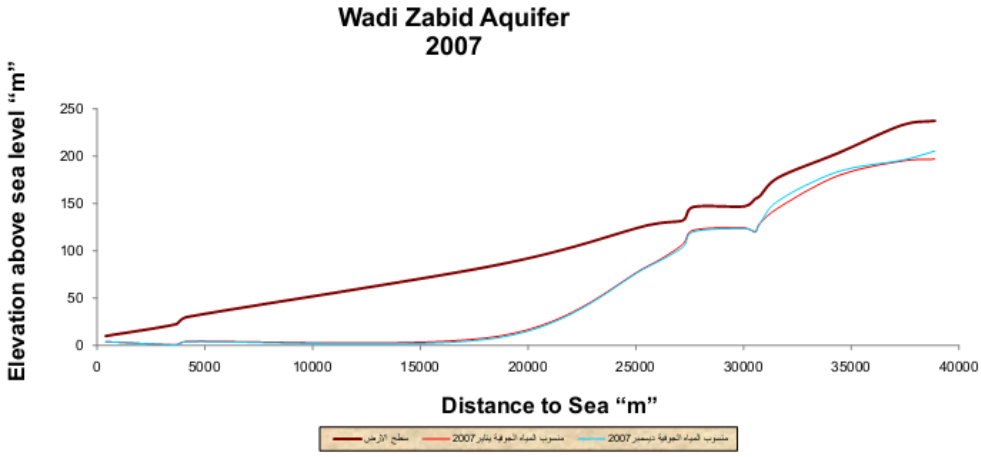


Figure 2.2 groundwater levels in wadi Zabid during 2007(after IIP-Yemen).

From the figure, the groundwater levels in coastal area of wadi Zabid have reached into the zero point (i.e. groundwater levels in this area equal the sea water level). This reveals that the saltwater intrusion is triggered in the coastal area of wadi Zabid.

The mentioned data of water levels emphasize that there are imbalance between the recharge and abstractions to and from the aquifer.

2.3.2 Change of wells number with time in wadi Zabid

Groundwater abstraction for agriculture becomes common in Wadi Zabid after the modernization of spate irrigation scheme with end of 70s. Where estimated that 1411wells were recorded in Wadi Zabid in 1988 (Steenbergen, et al., 2010). The increasing rate of wells in province Zabid/Rima was estimated 200 wells per year (Smith, et al., 1987). After this period, the increase in wells continued rapidly to reach about 12339 wells in both wadi Zabid and Rema'a according to 2006 inventory.

CHAPTER THREE

SPATE IRRIGATION SYSTEM IN WADI ZABID

3.1 Spate Irrigation History

The spate irrigation in wadi Zabid has been practiced since the old time. The rules that regulate the distribution process have been established before 600 years by **Shike Esmail bin Ibrahim Al-Gabarti**.

In the past, the upstream farmers have been able to manage the base flow and small spates without great difficulty, while was peak flood breach the diversion bunds and flow into downstream. Therefore, the spates were spread on wide area to cover the command area as all. Under the traditional system, the common crops in wadi Zabid were cereal crops (sorghum, maize) in addition to palms.

Since 1980, occurred large changes in spate irrigation system led to changes in irrigation practices and in cropping patterns. These changes created by several factors; the more important is modernization of spate system.

Under this a new conditions, happened many changes at the wadi level where the agriculture expanded in the upstream area with cultivation of banana, mango and other cash crops, while inverse occurred in the downstream area. The change in up-downstream areas that associated the development of spate scheme in Zabid is clear in the following.

3.1.1 Upstream Areas of wadi delta

After the modernization of spate irrigation system in wadi Zabid (with construction of permanent weirs) became the spate scheme most strength and durability. With noted that the upstream users have the absolute priority right on base flow in accordance with the traditional rules. This resulted in almost complete control the floodwater by the upstream users. So, upstream farmers got ahead with more reliability irrigation that encouraged them to change the cropping patterns from cereal crops into cash crops require the irrigation all year round (picture 3.1), in addition to the expansion and reclamation of new lands. That reliability irrigation was supported by drilling shallow wells.

As a result, the area under banana has increased in upstream area from 20 ha in 1980 to more than 3,500 ha in 2000 in Wadi Zabid ( ).

Whereby, the income of upstream farmer increased during that period from 53,038YR/3ha (1$ = 10 Y.R.) before implementation of the project into about 80,054 Y.R./3ha at full development (wadi development for agriculture in YAR, TDA, 1987).

Picture 3.1 prevailing crops in upstream area of wadi Zabid

3.1.2 Downstream Area

The modernization of spate irrigation scheme of wadi Zabid has been negative influencing on the downstream area, which maybe was caused by two following factors:

As a mentioned above, with the new spate scheme the upstream users captured the spates to irrigate their fields until in the allocated days to the downstream area and then depriving the downstream area from the spates gradually.

Capturing the floodwater in upstream minimized possibility recharging of groundwater aquifer (especially to downstream) and in the same time, there are overexploitation of groundwater by about 12339 wells which have been recorded by NWRA in both wadi Zabid and Rima'a during 2006. As a result, the groundwater resources rapidly depleted, (so many of the downstream farmers sold their fields to rich farmers who have ability to dig wells and then the water quality in the downstream wells has deteriorated, because of intrusion it with saline water.

3.2 Traditional and Modern Spate Irrigation System of wadi Zabid

- **Traditional Spate Irrigation System:**

Wadi Zabid contains one of the oldest spate irrigation systems (wadi development for agriculture, TDA). This old system was consisted of 16 main supply canals into which water was diverted from the wadi by the earthen bunds or deflector spurs (each canal has independent intake from the wadi). The old structures were made of earth materials (soil, brushwood) reinforced with boulders and boughs or trunks (E. L. Scheitze, 1987). Because of weakness of the construction matters in this system, the structures often penetrate by bigger floods and then the spate flow into downstream area (see picture 3.2).

Picture 3.2 spate diversion under traditional system of wadi zabid

Several permanent structures (drops, spillways and certain intake tubes) were equipped with stop-logs to control water levels in the canals or basins (E. L. Scheitze, 1987).

Within the Wadi Zabid area, basin irrigation had been practiced for centuries and water was distributed by a field- to-field method usually making temporary openings in the bunds borders of irrigated basins.

- **New Spate Irrigation Scheme**

Wadi Zabid was constructed between 1975- 1979 by support from the FAO and financed by the (UNDP) Special Fund. Kuwait Fund also introduced counterpart contribution ( ).

The system consists of five concrete diversion weirs with nine head regulators, serves 16 canals. The water is divert from the Wadi to the primary canals using five permanent diversion structures (weirs) across the Wadi, numbered from one to five from head to tail. Each structure serves combination of individual canals and then each channel diverts the water into group of fields only (the irrigated land by each channel has an area defined traditionally). Along of channels exist several intakes with mechanism gates

to distribution the spates between secondary or tertiary canals. Picture 3.3 shows some components of modern spate irrigation scheme of wadi Zabid.
Figure 3.1 shows schematic layout to new spate irrigation system of wadi Zabid including the new diversion weirs and primary, secondary and tertiary channels that are serving by each weir and the entitled land area to irrigation under each channel. Along the main canal, the water is diverted into the field through pipes in the bank of the canal. Due to accumulation of silt in the fields, the levels of the fields have increased that the water level in the canals. Therefore, the farmers have to construct temporary bunds across the canal to raise the water level. The local name for such a temporary bund is uqma (plural is ma'aqem). The diversion of water by weirs or within channels is in accordance with the traditional distribution rules (see table 3.1). A command area of the new scheme about 15,215 ha (with channel network 123km).

Picture 3.4 some components of modern spate irrigation scheme of wadi Zabid.

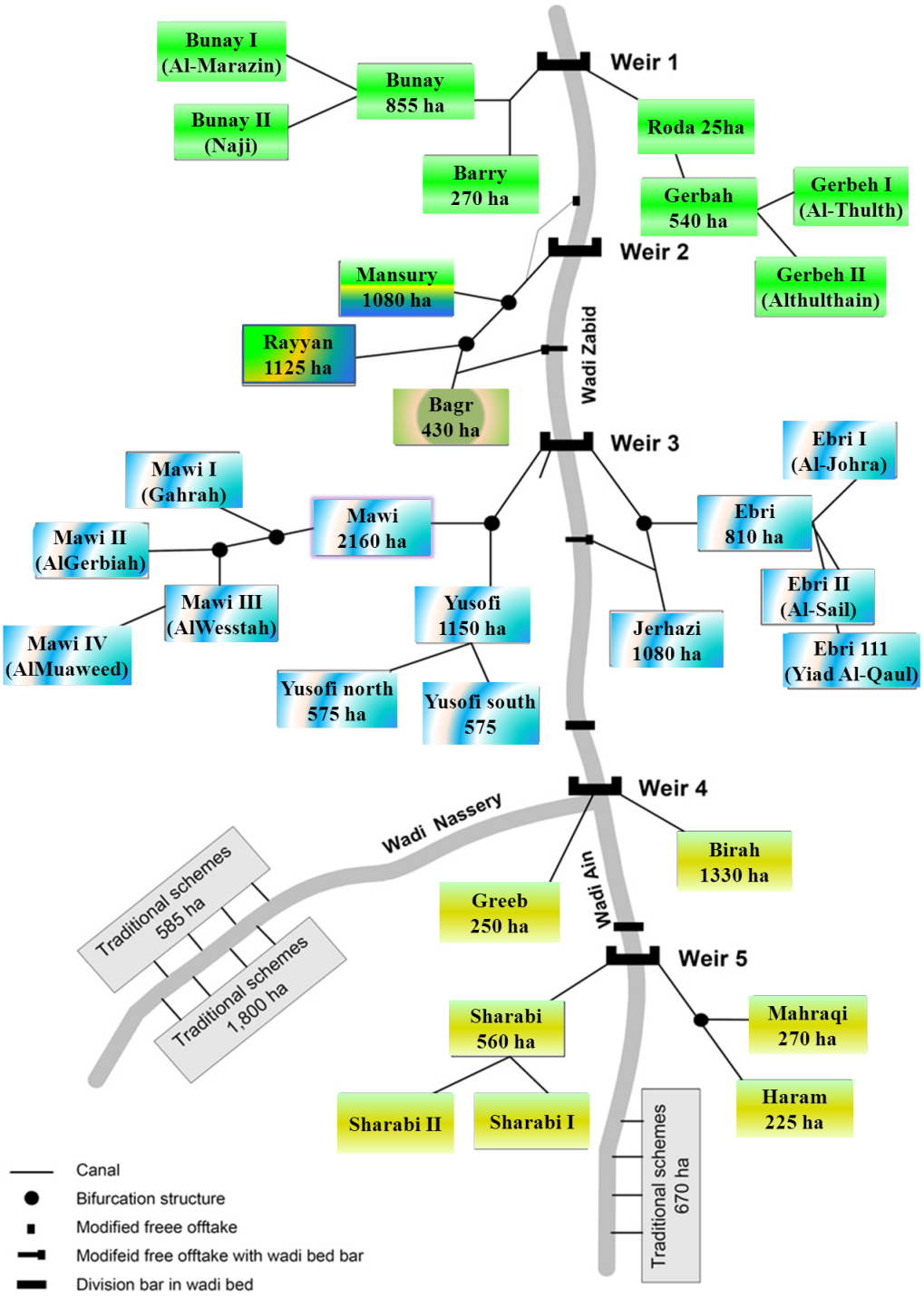


Figure 3.1 simplified layout to diversion structures and distribution channels within the new spate irrigation system of wadi Zabid

3.3 water rights in wadi Zabid

3.3.1 Water rights and allocation system in wadi Zabid

The regulated rights and rules for water distribution in Wadi Zabid were established by Sheikh Ismail Bin Ibrahim Al-Gabarty, where devised time system to water distribution and still practice until today. The system is depend on the Ala'ala Fala'ala rule, whereby the entitled areas to irrigation were divided into three groups (upper, middle, lower) as following (Bahamish, 2004):

- Group I: upper wadi has the right to receive spring (base flow) and spate water from 19 Oct. to 2 Aug. this group comprise six **shruj** (channels) are Raoda-Jerbah, Buni, Bari, Mansouri, Rayan and Bagr, with entitled area to irrigation within this group about 4,325ha.
- Group II: middle wadi receive the spates from 3Aug. to 13Sep. (42 days). This group comprise six channels are Mawi, Youssifi, Ebri, Jerhazi, Berah and Jeraeb and Wadi Nassri.
- Group III: lower wadi is entitled to receive floods from 14 Sep. to 18 Oct. (35 days). This comprises shareeg Al-Shara'abi and shareeg Al-Haram and Wadi Ain.

The Water also divided between shrog each group according fixed calendar (see table 3.2).

The worth mentioned that some references given other calendar to the spates distribution with different dates. This calendar is presented by (Al-Eryani, et al., 1998) and by (Bahamish, 2004). According to these references, the traditional allocation system divide the year into two seasons and each season is further sub-divided into certain periods as following:

- First season begin in 6 October and end in 15 March (with duration 5months and 9 days). The base flow only is existed during this season. The water in this season is allocated to the upper Wadi;

- Second season: from 16 March to 5 October, during which the water is allocated to the three areas within command area (upper, middle, down) according to the rule of priority as a following:
  - Upstream area receives water from 16 March to 20 July (97 days);
  - Middle area receives water from 21 July to 31 August (40 days). The peak floods occur during this period and it is more frequency (this period locally known as "forty rainy days" and
  - Lower area receives floods from 1 September to 5 October (35 days).

Although the spate irrigation system has changed with construction of permanent diversion structures during the period between 1975- 1979, the traditional rights and rules still applied under the new spate scheme. However, the design of new spate system was largely influenced by the traditional allocation system called Al-Gabarti system, where the five weirs were distributed a long of wadi to serve the three areas (upper, middle and down). Therefore, the water in the wadi distributed by these five modern diversion structures as follows (table 3.1):

- Weir 1 and weir 2 receive all base and spate flows from 19 October to 2 August (288 days). These weirs divert the water to channels within upper area (group 1), where the water to each channel is allocated for a specified number of days in depending on the location of intakes according to the Ala'ala Fala'ala rule.
- Weir 3 and weir 4 divert the spates for group 2 (9165 ha) from 3August to 13 September (for period 42 days). Whereby the water is allocated for the first five channels according to Ala'ala Fala'ala rule while the two lower intakes share surplus water in equal amounts.
- Weir 5 and four *uqum* receive the late spates from 14 Sep to 18 Oct. (35 days) to be diverted into group 3 (1725 ha). 50% of the low flood is allocated to the first two intakes and the surplus is divided equally

between the next lower two canals and when the floods fills the upper three canals, the surplus flows to the lowest intake

Under the main diversion structures, water is allocated to the outlets in turn from head to tail. During peak periods of spate water, these traditional rules are combined with the al a'la fal a'la rules.

The following table (3.1) summarizes the numbers of days allocated for each group with its channels in Wadi Zabid, according to Al-Gabarti system.

Table 3.1 Al-Gabarti system to distribution of water in wadi Zabid under the new spate irrigation scheme

Groups	Diversion Structures	Canals Name	Wadi Bank	Allocated Periods		Total days	Irrigation Water Source	Remarks
				From	To			
UPPER WADI (GROUP I)	Weir # 1	Al- Raodah.	Left	19th October (6th Tachrain I)	18th March (5th Adhar)	151 days	Stream Water (Base Flow)	First Irrigation Season
		Al- Gerbah.	Left					
		Al- Buny.	Right					
		Al- Bary.	Right					
	Weir # 2	Al- manssury.	Right					
		Al- Rayan & Al- Baqr.	Right					
	Weir # 1	Al- Raodah.	Left	19Th March. (6th Adhar)	28th July. (15th Tammuz)	132 days	Spate Water	Second Irrigation season
		Al- Gerbah.	Left					
		Al- Buny.	Right					
		Al- Bary.	Right					
	Weir # 2	Al- manssury.	Right					
		Al- Rayan & Al- Baqr.	Right					
	Weir # 2	Al- Rayan & Al- Baqr.	Right	29th July. (16th Tammuz)	2nd Aujust. (20th Tammuz)	5 days		
MIDDLE WADI GROUP (II)	Weir # 3	Al- Mawi.	Right	3rd August. (21st Tammuz)	13th September. (31st A abb)	42 days		
		Al- Yusofi.	Right					
		AL- Ebri.	Left					
		Al- Jarhazi.	Left					
	Weir # 4	Greeb.	Middle					
		Bira.	Left					
		Wadi Nassiry	Right					
LOWER WADI GROUP (III)	Weir # 5	Al- Sharabi.	Right	14th September. (1st Aylul)	13th October. (30th Aylul)	30 days		
		Al- Mahraqi.	Left					
		Haram.	Left					
		Wadi Ain.	Middle					
		Al- Musharia Family.		14th October. (1st Tachrain I)	18th October. (5th Tachrain I)	5 days	Spate Water & Stream Water	

3.3.2 Other traditional rules that regulate/govern water distribution in the spate irrigation system of wadi Zabid

There are many traditional rules govern the spate irrigation system in wadi Zabid. These rules were created to purpose of manage the unpredictable nature of flood and reduce the risk of conflicts. These rules were associated the traditional system and are as the following:

- Traditionally, prohibit irrigation of land by spate water more than once in 14 days period (IIP Sana'a, August 2004).
- Traditionally, prohibit adding new fields to the command area or construction of a new canal for the irrigation of new land that is not part of the command area (IIP Sana'a, August 2004).
- The sequence of spate distribution within spate system of wadi Zabid is defined by Ala'ala Fala'ala rule, whereby the priority right to water give to upper channels and also the first fields at the channel level have the priority to irrigation then next fields etc.
- In Tihama Plain, the rule on irrigation depth states that each field is entitled to a depth of a knee-height (about 0.5 m) at each turn (Mehari, 2007).

3.3.3 Assessing the Extent of Compliance with Enforcement of Rules in Spate Irrigation System

The field findings indicate that the traditional rules violated and do not respected by most of farmers in the upper areas. The results of interviews and discussions and other PRA techniques indicate that the most violations of traditional water rules are as a following:

- Most of farmers, or rather large landholders in the upper part of the wadi divert water even when water is allocated to other fields or channels in the middle or lower parts of the wadi.

- The reclamation of new lands out of command area, such most of the common lands which is located in sides of main stream channels along the wadi they have been reclaimed (these lands are locally known as Galal). About 480ha of Galal have been reclaimed by large landholders (Paper on Water Rights and Irrigation Management In Wadi Tuban and Wadi Zabid (IIP Sana'a, August 2004).
- Some farmers in upstream create new openings in the channel body to divert the water directly into their fields.

Finally, we can note that violation of traditional water rights and rules linked with many factors, the more important is changes in spate system from traditional into new with more permanent spate diversion structures, in addition to weakness of responsible government institutions and inefficiency of WUAs.

3.3.4 Evaluetion of Equity in Water Rights and Distribution Rules Between the Upstream and Downstream Areas

Evaluation of equity in water rights and allocation:

The basic goal of allocation system is ensuring of achieving equity in water distribution among the farming community.

Whereas the Water distribution in wadi Zabid depend on Ala′ala Fal a′ala rule, as the upstream area gives absolute priority on the base flow (i.e. the base flow is own the upstream area only). The upstream area also gives priority in distribution of spate water, then to middle areas, and finally to downstream area. Beside priority rule, the water is distributed between three areas according to specified time periods.

To evaluating the water rights and allocation, we must be answer for some questions, what the main goal to formulation of rules and regulations in any spate system? If we were answered that the goals is equity, what is equity that should to be achieved. According to IWRM approach, equity means that

everyone has fair opportunities to access, use and control of the water resources with maintaining necessary levels for basic needs and the environment. So, in the following will discuss the traditional water rights and rules in order to determine correspond those rules with the mentioned equity approach.

- The traditional system which established by Al-Gabarti to allocating water within spate irrigation scheme of wadi zabid is based on ala'la fala'la rule, according to this rule the priority gives to upstream and then the farmers in upstream divert the spates according to need their crops. The upstream farmers during the recently years replaced the cereal crops (which require limited amounts of water) by crops require to irrigate every four days (banana and other cash crops). So, this system become fully to the advantage of upstream farmers. However, the new cropping pattern imposed diversion of large amounts of spates to longer time period.
- The traditional rules in wadi Zabid prohibit the expansion out the commend area, nevertheless some farmers in upstream reclaimed new lands, which is irrigated at the expense of downstream fields. Generally, the expansion and reclamation of new lands in upstream area compare by the desertification and abandoning the agriculture in the downstream area.
- The downstream user receives late floods from 14 September to 18 October (35 days). This period often comes in the end of rainy season. Therefore, the downstream receive little amount of spates or may not receive. Whereby, the upstream users are the main beneficiaries from this traditional rule. So, we can say that ala'la fala'la rule became ala'la and ala'la only.
- Some farmers in wadi Zabid contend that the water rights and rules not equitable or rather it may setup to satisfy the people elites (Bahamish, 2004).

3.3.5 Effects of New Diversion Structres on Water Distribution Equity

In 1979, the modernization of the irrigation system of wadi Zabid has completed with construction of concrete diversion structures (weirs, channels, gates, etc.). In that period, the goal of replacing the traditional system by new system was increasing the agriculture producing, increase irrigated area and improvement of community livelihood.

During last thirty years, that followed constructing the new scheme, happened several changes in environmental and social situations at the wadi level. These changes were negative in the downstream areas while were very positive in limited area in upstream area only.

The results of PRA survey in wadi Zabid with samples of stakeholders reveals that the **New Permanent Diversion Structures** lead to many of changes in:

- **The irrigation practices and**
- **Capacity farmers to control the spates**
- **Farmer behavior and its thinking**
- **System capacity itself**

In reality, when modernized the spate irrigation scheme of wadi Zabid replaced the earthen and brushwood structures with concrete weirs with regulation headworks. These changes resulted in almost complete control the floodwater in the upstream; where the concrete structures withstand breaching strongly until with peak floods. Thus the modern spate system became has high capacity to divert the spates without breaching as it was in the past under the traditional system.

However, the new spate irrigation system gave the upstream farmers the possibility of controlling the diversion of spate water. For example, installation of mechanism gates in new diversion weirs encouraged the large landowners to control the opening/closure of the main gates. Often the large landowners disrupt the gates by cutting the cables.

Under the modern system, several independent intakes replaced by one flood channel, which divert the floodwater into a main channel to be then divided on several channels. Whereby, distribution of spate in this way decrease flow volume and its velocity and then the possibility an arrival of flow to the downstream fields maybe improbability. This create more inequitable in the water distribution, as a result the fields in downstream remain for years without irrigation.

We can also understanding the effect of modern system on equity by fast view to impaction of project on **the community** and **environment**.

In general, is a modern system improved the livelihood of community? How become the poor status after the construction of permanent structure?

The present study give clear answer for these questions through the PRA carried out in wadi Zabid. According to that:

- The farmers downstream of command area (at the weir no. 5) clarified that the spates after construction of new concrete diversion structures arrive once per year and with small quantity while in the past the spates were came more than three times per year. Furthermore, the respondents shown that the spates in the past were come not only in the allocated period to the downstream (35 days) but also were come continuously round the year. So, they in the past were cultivating three seasons (Sorghum in Aylul- second season- and maize (locally red durra) in summer and pearl millet (locally gharib and dukhen) before the summer, but currently they are cultivate and don't harvest.

The field finding indicates that the farmer behavior also changed during last thirty years. In reality, when the force tools are available to human while prevail an unawareness and egoism, the human become hostile. This what happened after construction of concrete diversion structures in wadi Zabid, where the farmers in upstream became most power and capacity and then they:

- Captured the spates in the upper area of wadi for irrigate their farms.
- Violated the traditional water rights and rules which gave them the priority
- They cultivated the high value crops that consume large amounts of water (banana, etc.) throughout the year and then they drilled the wells and they overused the groundwater without the thinking in those small farmers or rather poorer in downstream areas.

Thus, we can say that the new system in wadi Zabid caused deterioration of livelihood status of the majority of the population in addition to environmental destruction in downstream areas especially the areas that benefit from spates in recharging the groundwater aquifer.

The present study will introduce Al-Mojyelis village in coastal area of wadi Zabid as witness on that. The following chapter will shows Al-Mojaylis case in downstream which consider one of villages located in the coast as witness on inequity in spate system of wadi Zabid and inequity that doubled by new spate system.

CHAPTER FOUR

ENVIRONMENTAL DEGRADATION IN Al-MOJYELIS AS ONE COASTAL VILIGES OF WADI ZABID

4.1 Al-MOJYELIS BACKGROUND

4.1.1 Location

Al-Mojyelis is located in the northwestern end of the wadi Zabid between latitudes 1567800 - 1571500 UTM-N, and longitude 292500 - 299800UTM-E (figure 4.1). Al-Mojyelis is located in the downstream area of wadi Zabid and it considers one of its coastal villages and it at distance of 60-70 km south Al-Hodiedah governorate (Figure 4.2). It is manage locally by the local council of Al-Tuhaita district.

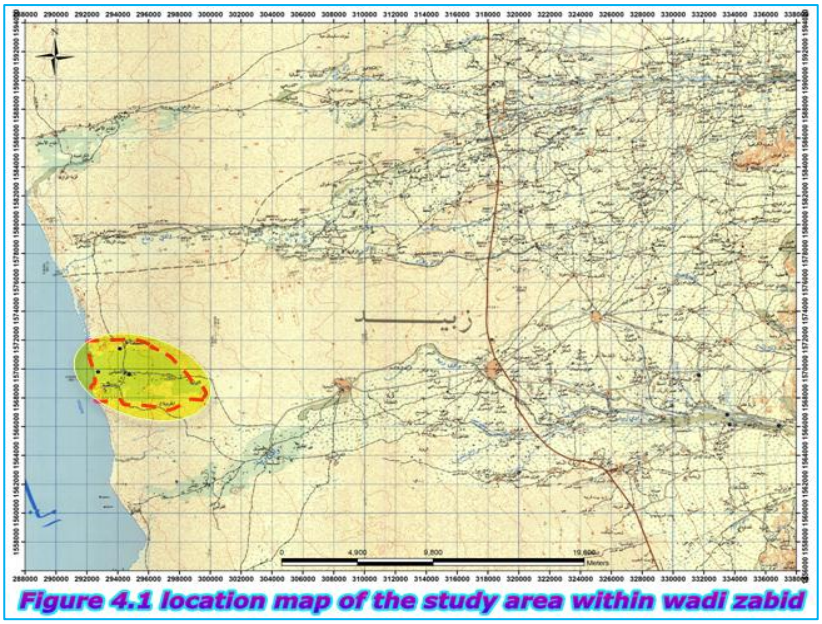


Figure 4.1 location map of the study area within wadi zabid

Figure 4.2 ..... (Google earth)

4.1.2 Socio-Economic

According to census 2004, the number of resident in Al-Mojaylis about 2641 persons, from which 1328 male and about 1314 female. Al-Mojaylis include many sub-village. Table 4.1 shows the population data to study area according to census 2004.

Table 4.1 population data to Al-Mojaylis (census 2004)

			Houses no.	Household no.	male	female	total
District	**Sub-district village**	**Sub-village**					
Al-Tohita	**Al-Qurshiah alsofla / Al-Mojaylis**	Mojaylis center	*70*	*67*	*186*	*187*	*373*
		Alzakham	*22*	*22*	*74*	*51*	*125*
		Alhariah	*53*	*53*	*173*	*163*	*336*
		AlShafayah	*20*	*20*	*62*	*51*	*113*
		Alsahel	*130*	*129*	*326*	*350*	*676*
		Bani Baksh	*8*	*8*	*20*	*16*	*36*
		Al Garobah	*41*	*41*	*111*	*106*	*217*
		Al Thwabia	*22*	*22*	*49*	*52*	*101*
		Al Te'afaf	*166*	*125*	*280*	*275*	*55*
		Al Mafgur	*22*	*22*	*47*	*63*	*110*
	Total of village		554	*509*	*1328*	*1314*	2642

In general, the main source of income in Al-Mojaylis is coming from migration agriculture, handicrafts, fishing, and daily wage. The worth mentioned that the most of people depend on **their migrants' sons** or relatives.

The man and women in Al-Mojaylis have the skill in handcrafts, where utilize palm leaves to making mats and ropes for bedstead, and baskets.

After degradation of farms productivity, the people in Al-Mojaylis and especially the women worked in handicrafts and fishing picture 4.1 shows some artisan women and man. However, this career became uselessness now because to less income and degradation of palms (see section 4…).

Picture 4.1 handicrafts women and men in Al-Mojaylis

4.1.3 Irrigation water resources

Since the old time, the groundwater is the main source for irrigation in the study area. According to the interviewed farmers, with declining of water levels increased the pumping costs and in return, the farms yields and farmer income become very little.

According to PRA, in the past the palm groves were irrigated from the groundwater, which was on the depth less than one meter from the land surface, but now the water level dropped and needs to huge motors to pumping. When we asked one of large landowners in Al-Mojaylis about the water level in his well, he answered, now we need drill-rags to find water as well we need to large pumps. According to the wells inventory data, About 90 wells (from total 289wells) currently use to irrigation purposes. However, these wells pump only few hours and irrigate small areas.

The worth mention that the spates allocation system that established by sheikh Al-Gabart, which divided wadi Zabid to three groups (upstream, middle and downstream) benefits from the spate water in accordance scheduling, did not included/implied Al-Mojaylis i.e. Al-Mojaylis has not traditional right on the spate water. Although, the interviewed farmers shown that in the past was occur runoff due to the heavy rainfall in Al-Mojaylis and the surrounded areas in addition to saturating/ filling the soil by water due to high rate of recharge by flowed spates into surrounded areas of downstream.

4.1.4 Drinking and houses water resources

The wells are the main sources of water in Al-Mojaylis whether for drinking or other household uses.

There are three government projects (wells and supplying network) these wells used to provide potable water to the village inhabitants. Two of these water wells have been drilled by environment protection project to irrigate trees planted to protection against desertification, and after stopping the project, these wells used to supply of potable water to population. GARWSP and local council have drilled the third well. The operation costs are paying population where each house pays 1000Y.R per month. However, the people in Al-Mojaylis complains stopping of the pumping continuously because the most of people have not the operation costs. Picture 4.2 shows the current state to one of water projects in Al-Mojaylis village.

Picture 4. Water project in Al-Mojaylis center (the need for maintenance and operation)

4.1.5 Women and Water Supply

The results of PRA survey in Al-Mojaylis indicate that the water supply to houses non-continuously and often the pumping stops to several days. However, the water does not to most of houses due to the bad designing of the supplying network. Because of stopping the pump frequently, the women walk for distance so that bringing the water from private wells, which often owned to the others.

The women and girls always are responsible to bringing the water. Woman spent some of time to bring the water but this at the expense of her health

and health and education of her sons. During interviews and discussions with women, the most indicated that they often oblige to preventing their girls from going to school because they need to help their girls in bringing of water.

Others working to women: the woman in Al-Mojaylis village also has other works. During implement PRA surveys , the daily routine to woman's work was prepared with group of women, which indicate that the woman in Al-Mojaylis has much works and she contribute in improving the household income, as a total time spent by women on various activities about 10-12 hours. Table 4.2 shows distributing woman's time among various activities according to daily routine.

Table 4.2 daily routine to woman work in Al-Mojaylis village

Hours (am)	**5-6**	**6-10**	**10-12**
Activities	- Prayer - Gather firewood - Handicraft	- Bringing water - Milking Cattle - Preparation of breakfast	- House works - Washing clothes - Grinding maize

Hours (pm)	**12-3**	**3-6**	**6-9**	**9-5**
Activities	- Cooking and Lunch - Prayer - Gather fodder - Cleaning her child	- Gather firewood - Prayer - Bringing water	- Prayer, Handicraft, Prayer - Dinner - milking Cattle - Grinding maize to next day	- Leisure time - Sleep

4.1.6 Education and health status:

There are two schools in Al-Mojaylis, Al-Shatti school in center of Al-Mojaylis village and Al-Fattih school in Al-Te'afaf sup-village, which had built by social development fund and public works in respectively.

Picture 4.3 an infrastructure to education in Al-Mojaylis

The people especially the women complain of bad health situation. There is one health unit in Al-Mojaylis in and exist healthy advisor and one midwife. They do not introduce any health service to community because the healthy unit destitute to the least of medical tools. However, the healthy unit besieged by mesquite trees and cannot arrival into it (picture 4.4). So, we can say that the health services in Al-Mojaylis has been deteriorated due to environmental degradation.

Picture 4.4 The health unit in Al-Mojaylis fall prey to mesquite trees

4.1.7 Wells inventory

According to the wells inventory that carried out by NWRA in 2006, the number of wells in Al-Mojaylis was 289 wells. Average wells depth about 8.2 m. In the following table, the wells classified accordance its depths to five orders.

Table 4.3 classification of wells in Al-Mojaylis in accordance with the depths (wells inventory data, NWRA, 2006)

Well depth	Total No. of wells	Wells operate	Dry wells	Non operation /dry	Average of depth	Average of w.l	Average of conductivity	T°	pH	Actual yield	Pump hours
0-5m	70 well	17	52	2	3.3		2142.9	32.3	7.6		
5.1-10	108	48	44	16	8.2	7.4	2008.6	33	7.6	5.5	6
10.1-15	80	65	1	14	11.9	6.7	1783.8	32.7	7.6	5.4	5.7
15.1-20	4	4	-	-	17.13	6.6	4040	33.4	8.04	4.4	4.7
20-50	5	5	-	-	32.5	7.6	1303	31.8	7.7	6.4	6.3

From the table, we can note that majority of wells that their depths less than 10m have dried up. However, the majority the wells with depths don't exceed 15m. The noteworthy, that majority of wells are hand dug wells.

The following figure shows the historical change to the well numbers in the study area. The noting in this figure, that the wells numbers increased rapidly after seventies and maximum number of wells was recorded during the eighties after that deceased numbers of drilled wells but at high rate compared with the period before seventies.

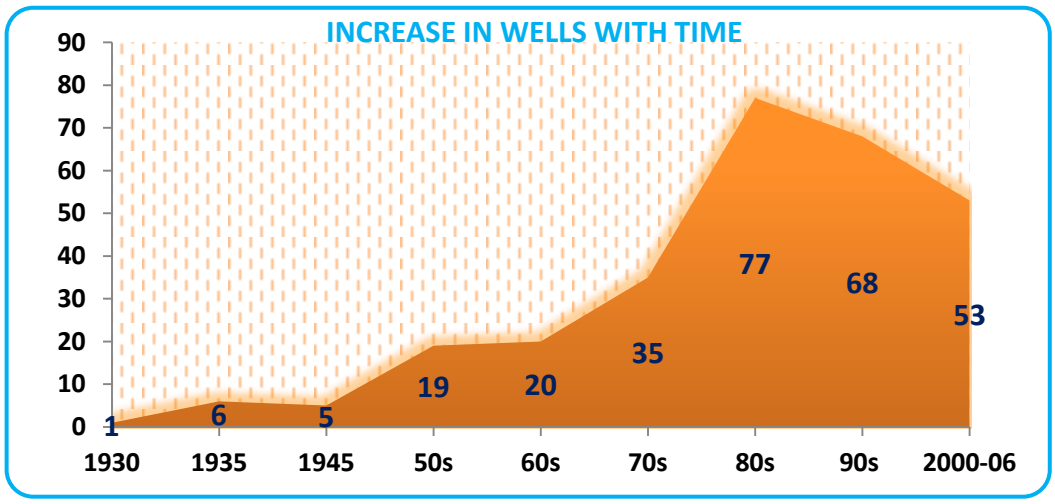


Figure 4.3 historical changes of wells numbers **in Al-Mojaylis**.

4.2 ENVIRONMENTAL DEGRADATION

As mentioned in the previous chapters that the new spate scheme caused several changes at the wadi level, such as change in the flow regime (the wadi morphology regime), change in the water rights, change in ecology and

change in the uses of floodwater as well as change in users' thinks, conducts and practices. *Ideally, any investment in spate irrigation should be improve the livelihood status to community and conserve the environment (i.e. any developing must be maximizing the social welfare and environmental sustainable). Otherwise, will occurring social degradation and environmental destroying. This exactly which happened after modernization of spate scheme in wadi Zabid.*

Over the last thirty years, cropping patterns that had been irrigated spates under the traditional spate system of wadi zabid changed and happened rapid expansion of the irrigated area particularly in the command area of the first three weirs. Then the use of groundwater in this area of wadi has intensified tremendously, to irrigating the high value crops (bananas, mangoes). The over-exploitation of groundwater and then the mining of aquifer in those areas of the valley led to unsustainability of agriculture and then destruction of environment in the downstream area of wadi especially those areas that traditionally depended only on the groundwater that was flowing out on the surface.

These changes leaded to negative impacts to society and environment in the downstream area of wadi, especially in the coastal villages. In this chapter will shows the environmental degradation that occurred after developing the spate system in one of coastal villages of wadi Zabid namely Al-Mojyelis village.

Because of non-available studies about the environmental situation in Al-Mojaylis village, the present study depended on the PRA techniques to studying the land deterioration through comparing the past with present.

4.2.1 Water Resources Degradation

The water is important environmental element can be subject to negative impacts associated with any change or developing in the human activities. To recognizing the range degradation of water resources in the study area, we

must look for its quantity and quality. Al-Mojaylis is one the coastal villages that lies in tail end of wadi Zabid. It is correlated with hydrogeology system of wadi Zabid. Then any activities or changes cause stress on the hydrology system in any place of wadi will lead to disorder in the system as all at the wadi level.

Since the modernization of Wadi Zabid spate irrigation system, happened large changes in agriculture practices and then in usage of groundwater at the wadi level. Before 1980, the agriculture in wadi Zabid was mainly depended on spates. Under traditional system, the spates were spread over wide area, as an earthen diversion bunds or deflection-spurs were breach by peak flows to flow into downstream area of wadi. Then, the rate recharging the groundwater was high under the traditional system. But this setting has changed after eighties where the spates captured in upstream as well as the groundwater become used in conjunctive with spate water to irrigation of high value crops which require a large amounts of water all the year round.

Because the spates flow only in limited periods of the year, about 4 months (rainy season), the groundwater was used throughout the year as a supplementary and/or essentially irrigation source.

Thus, capturing spate in the upstream and over-abstraction to groundwater led to negative impacts on water resources of downstream areas whether those areas that traditionally entitled to irrigation from the spate water or those benefited from the spates in recharging its groundwater such as Al-Mojaylis village.

The field finding indicates that water degradation has started in Al-Mojaylis since eighties, and that the degradation of water represent in declining the water levels only, while water quality is still good (fresh).

In relation to degradation of water levels, most of interviewed people in Al-Mojyelis indicated that the water currently in their wells on depth range 10-20meter under the ground surface, while it was on depth less than one meter in/and before eighties. Furthermore, some old men and women in Al-

Mojaylis described water situation in the past, where said ‘we were dig small hole in the soil and find water, but now the water dropped away’.

During the interview with farmers in Al-Mojyelis village described to us, the historical gradation of water degradation in their coastal village. Table 4.4 shows the history of water degradation, which was prepared by Al-Mojaylis community.

Table 4.4 change of water levels, well depths and quality with time line

Time line	Water levels (m)					Well depths (m)					Quality
1962	Near land surface					0.5					Good
1979											
1985		5					6-8				
1990			7-8					12			
2000				8-9					16-17		
2011					12					30-50	

The most of interviewed clarified that the main causes to declining the water levels are shortage of rainfall and over-exploitation of groundwater in the upstream area. Some of them also explained that capturing the spates in upstream areas, which associated with construction of concrete diversion structures in the first of eighties lead to decrease of groundwater recharge in Al-Mojaylis and the other coastal areas of wadi.

According to wells inventory data, about 109 wells (from total 289 wells) in Al-Mojaylis have dried up. PRA surveys in Al-Mojaylis clarified also that during the last thirty years, the most of shallow wells have dried up (picture 4.5).

Therefore, the dipping the wells and/or drilling new wells were needful to continuance the agriculture process. Then change of pumping instruments by buying motors and pumps have higher capacities was also necessary to water pump from the deep wells. This means that the farmer must carry high costs for facing these changes (figure 4.4). This was not possible to most farmers in Al-Mojaylis, so most of farmers abandoned the agriculture and immigrated.

In briefly, because of degradation of groundwater changed the types of wells from shallow for deep and changed also type of pumps and then the farmer carried high additional costs to operation, maintenance and reforming of pump and often replacing of pump.

Figure 4.4 development of wells and pumps type for facing water levels declining and continuance of agricultural process

Lowering the water table in Al-Mojaylis village from 1 meter to about 15 m as average, reveals that water users (human, animal, and plant, etc.) in Al-Mojaylis suffered very adverse effects.

During the discussion and interview with stakeholders in Al-Mojaylis (farmers, teachers, sheikhs, women), the most of they said that the migration of people from Al-Mojaylis refer mainly to falling water table (or rather, water scarcity) and they attributed to it the damages that befell the date groves and animals.

In relation of water quality, most of interviewed peoples showed that quality of water still good. Nevertheless, theoretical the falling of water levels often

is associated with change in its quality. Especially that Al-Mojaylis located near the coast, so any dropping in water levels can lead to saltwater intrusion into the fresh water. The simple mechanism that explains and affirms the intrusion of seawater into the groundwater in any area is that when the water level drops, the seawater thereby intrudes the aquifer by lateral or horizontal replenishment.

Thus, maybe there is deterioration in the water quality, but maybe the people do not recognize this problem.

The worth mentioning that NWRA in 2009 carried out study about the water quality of wadi Zabid and Rimah included the coastal zone to the two wadis.

Within samples collected by NWRA, about nine samples have taken from Al-Mojaylis. Table 4.5 and 4.6 show the coordinates of samples locations and the results of analysis.

The results of analysis to some elements illustrated in figures (4.5, a, b, c) in which the results were compared with minimum and/or maximum limitations of W.H.O standards.

Figure 4.5 shows that the Na values is higher than allowed limit by W.H.O in three samples while are equal to maximum limit of W.H.O in two samples. The increase in Na appears in southwest of Al-Mojaylis village. This increasing is clear indicator for seawater intrusion.

According to NWRA 2009, the sodium element rise in the extended coastal area between wadi Zabid and wadi Rima (from east-west of Wadi Rima to south-west of Wadi Zabid).

The values of nitrate increase towards Al-Te'afaf sup-village that locate in the northwest part of Al-Mojaylis village. The increase of nitrate values in this part of Al-Mojaylis may be due to usage of nitrogenous fertilizers, where some agricultural activities still continuous in this part

Table 4.5 Water-points sampled, analyzed by NWRA in the study area (after NWRA, 2009)

Sample No.	Well No.	Site	Well Type	UTM-E	UTM-N	Total Depth (m)	Water use
ZA-026	D-0905	Al Mojailis	Dug	294032	1561812	8	Domestic
ZA-027	E-1446A	Al-Garobah Village	Bore	296012	1567672	50	Supply
ZA-030	E-1419	Al Mojailis	Dug	295978	1569270	15	Irrigation
ZA-031	E-1681	Al-Habshah Al-Mojailis	Dug	294409	1569143		Domestic
ZA-032	E-0785	Al Noktah	Dug	292472	1568603		Domestic
ZA-033	E-1199	Wadi Al-Mojailis	Dug/Bore	293554	1570273	10	Irrigation
ZA-034	E-0854	Al-Te'afaf	Bore	294973	1571921	60	Supply
ZA-035	E-0881	Al Te'afaf	Dug	293622	1572779	14	Domestic
ZA-036	E-0952	Wadi Al Mojailis	Dug	291948	1573702		Cleaning

Table 4.6 Chemical Analysis Results for samples collected from the study area (mg/l) (NWRA, 2009)

Sample No.	Ec	pH	TDS	DO	Ca	Mg	Na	K	Fe	CL	So4	Hco3	Co3	No3	F	SAR	TA	TH
ZA-026	1323	7.4	874	4.9	58	31	175	4.7	0.44	149	187	305	Nil	6.8	0.35	4.59	220	156
ZA-027	1323	7.4	874	3.13	58	31	175	4.7	0.44	149	187	305	Nil	6.8	0.35	4.59	220	156
ZA-030	1376	7.6	881	2.93	62	36	173	4.7	0.55	160	144	366	Nil	15	0.54	4.3	160	306
ZA-031	1198	7.6	767	2.55	52	26	161	5.46	0.54	107	134	366	Nil	10	0.45	4.5	200	224
ZA-32	4010	8.2	2566	4.61	66	58	725	18.33	0.33	852	307	488	15	69	0.89	15.66	160	409
ZA-033	1042	7.9	667	3.69	30	22	161	4.1	0.72	89	110	305	Nil	37.57	0.5	5.4	200	167
ZA-034	954	7.7	611	3.11	32	24	133	3.393	1.13	85	96	305	Nil	8.742	0.45	4.3	160	181
ZA-035	1663	8.2	1064	4.13	40	17	299	7.6	0.62	337	96	244	15	35	0.55	10	120	171
ZA-036	1706	7.7	1092	5.64	54	32	265	6.7	0.62	320	149	275	Nil	25	1.349	7.18	120	269

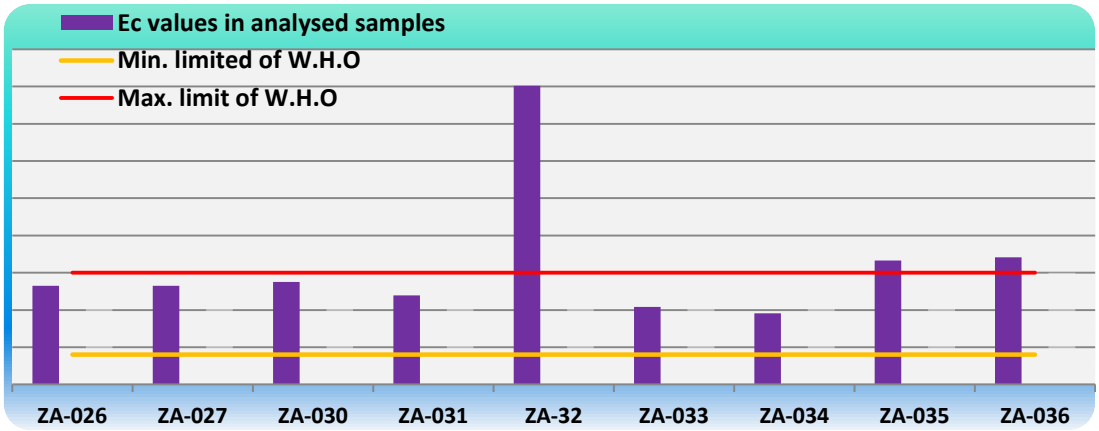


Figure 4.5 (a) comparing of Ec. values with minimum and maximum limits to WHO standards for drinking.

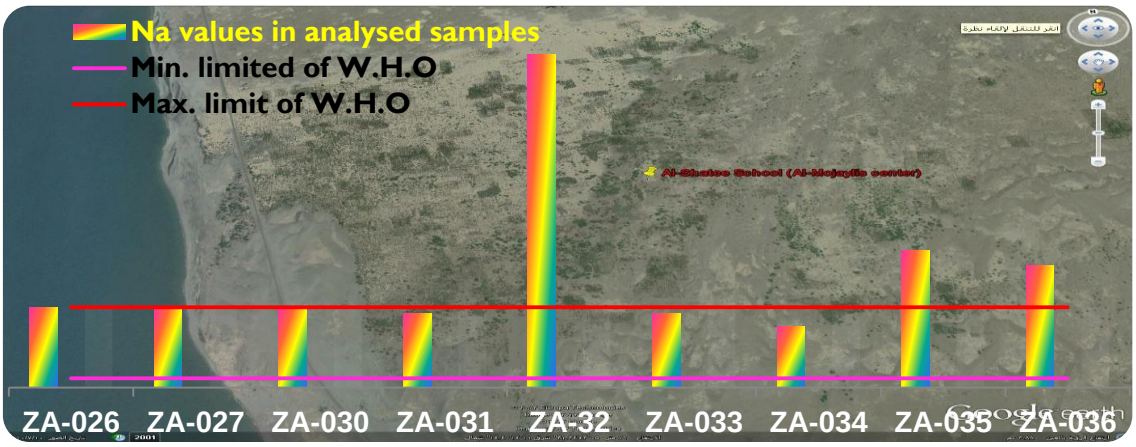


Figure 4.5 (b) Na values in analyzed samples

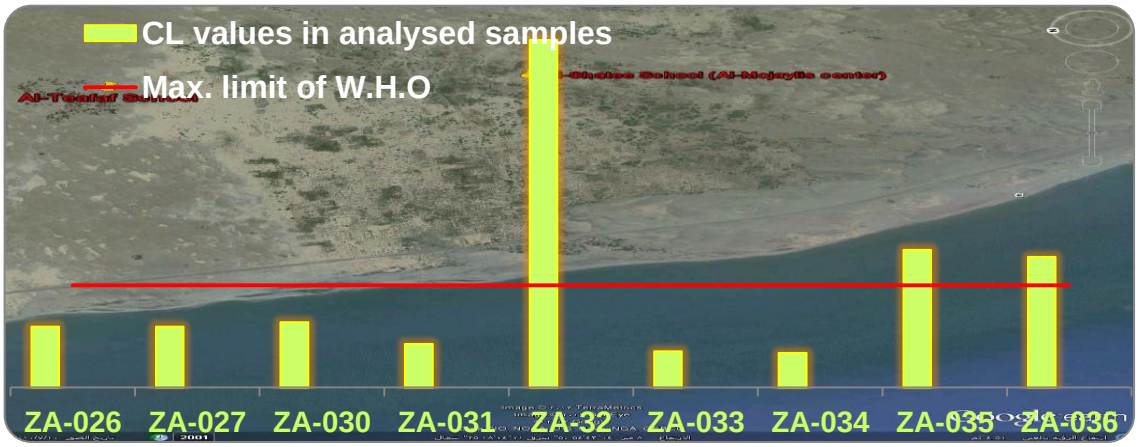


Figure 4.5(c) CL values in analyzed samples

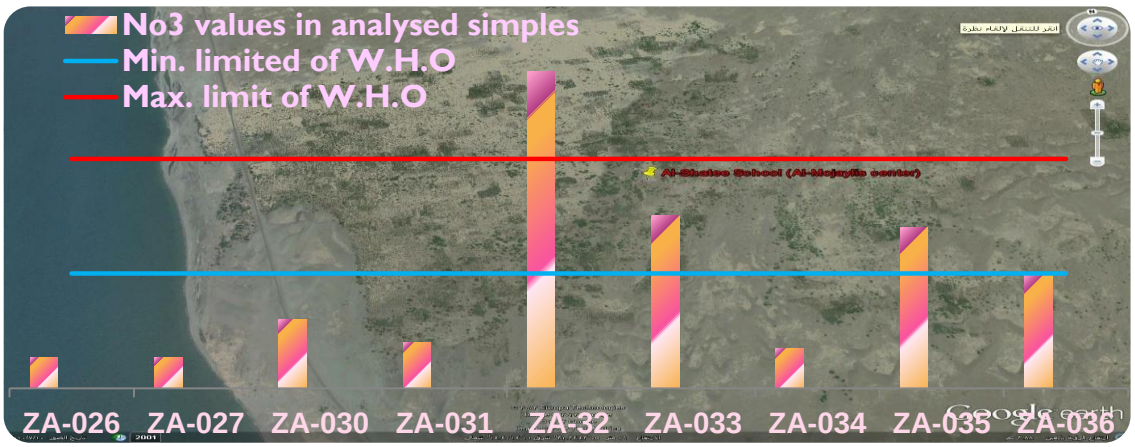


Figure 4.5 (d) No^3 values in analyzed samples

4.2.2 Land and Agriculture Degradation

'Land degradation' means reduction or loss, in arid, semi-arid and dry sub-humid areas, of the biological or economic productivity and complexity of rain-fed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns (UNCCD, 1992).

In briefly, land deterioration means reducing biological productivity and environmental moderating capacity of land and the land degradation and water are interrelated issues.

Al-Mojaylis village in tail end of wadi Zabid can introduce as model to the mentioned defining. The present study researched the problem of land degradation in this village by using PRA techniques.

However, during fieldwork, we viewed the environmental destruction that befell/strike Al-Mojaylis village and most of field visions have been documented by pictures and video. Thus, we can outline the destroying that befell the land in Al-Mojaylis by three forms as a following:

- Deteriorating of agricultural lands (date groves).
- Degradation the productivity of farms.
- Degradation of vegetation cover

The large area of date groves in Al-Mojaylis village have destroyed as a result of several factors, the most important are the drought and water table decline, sand dune invasion and spreading mesquite trees.

The field findings indicate that about **75%** of agricultural lands in Al-Mojaylis have destroyed during the last thirty years. The results of PRA indicate that first cause to the environmental deterioration is water scarcity or rather falling of water levels. For this cause also created other factors

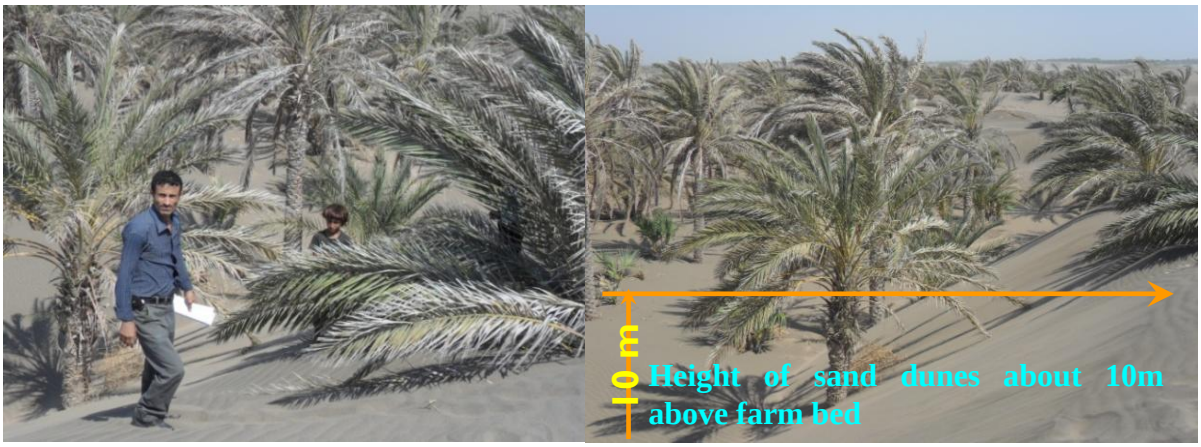
aggravated the degradation problem such as sand dunes invasion and spreading of mesquite trees.

Picture 4.5 Date palms have perished due to drought

Picture 4.6 Date palms buried by sands dunes

Furthermore, the most of date groves are still suffering every day to losing some its parts as result to sand dunes invasion or by drought. Pictures (4. 7) and (4.8) below give clear vision to the deterioration volume that suffered and still suffering from it Al-Mojaylis. In the past, the palms trees were covered the visible land in the picture 4.7 completely, but now you are see it.

Picture 4.7 dates grove destroyed due to the drought



Picture 4.8 date grove lose every day some its palms prey to sand dunes invasion

The field finding reveals that there were historical linkage between degradation of agricultural lands and the falling of water levels and modernization of spate irrigation scheme since eighties.

Most of reviewed farmers clarified that the deterioration begun with beginning declining the water levels. For this reason some farmers have neglected their farms (they worked in other professions), not this only but also most of farmers migrated far away for other countries. Those who migrated, their lands have destroyed and also led to destroying of the neighboring farms (i.e. the neglect of agricultural land made it subject to the erosion easily through the strong storm that prevail Al-Mojaylis for about five months, then the sand dunes accumulate with large volumes. During the fieldwork, the height of sand dune has estimated in one of farms about 10m above field bed.

Consequently, majority the farms in Al-Mojaylis have been buried by the sand dunes. The following picture (4.9) gives clear view for risk that threatening agricultural lands in Al-Mojaylis village due to sand dunes invasion.

Picture 4.9 continued destroying to the date groves by sand duns invasion

The second form of deterioration in Al-Mojaylis is deterioration of farms' productivity. The range of economic productivity of farms is important indicator to deterioration. However, this indicator helps on understand of reasons beyond the immigration of people from Al-Mojaylis and abandoning the agriculture. During the discussions with the farmers showed that most of households get from the farming on what meet needs them for about 3-4 months during good years. So, the most of people in Al-Mojaylis abandoned an agriculture and seek about other careers, as fishing, handcrafts and labors in daily wage, in addition to immigration of family man or some sons to cover the food shortage of their households.

The most of respondents showed that degradation of yield is due to falling water table, and then increase of pumping costs in addition to raise of diesel price.

The field finding indicate that yield of date palms, compared with the past, is very little. The respondents showed that most of farmers in the past were harvest large amounts of dates but now they are not reaping anything.

The degradation of land cover is one of forms of lands deterioration in Al-Mojaylis. The results of PRA surveys indicate that since the last 30 years happened large change in the land cover. The most of respondents in Al-Mojaylis cleared that vegetation and grass were cover an area but now there

is no anything from that. The degradation of pasturelands in Al-Mojaylis led to degradation of livestock and cattle, although the livestock are important source to income and to sustaining the community livelihood.

The rangelands or pasturelands in the study area are the land that the people have depended on them to the grazing. These lands were derived its water from the rainfall and from soil moisture (where the groundwater level was near the land surface). So, the rangelands have disappeared with shortage of rainfall and falling of groundwater levels. Consequences, the vegetative cover that characterized by it Al-Mojaylis since old time, disappeared and destroyed during the recent thirty years.

The final form of degradation in the study area is spreading the mesquite trees on the wide areas. The mesquite is one the main problems that lead to destroying the dates groves (picture 4.11). The field finding indicate that mesquite trees is one of main problems in Al-Mojaylis where spread on most of lands, thus the mesquite trees lead to deterioration of agricultural lands and contributed in depletion of soil moisture and then declining of water level, especially that the mesquite roots extend to large depths .

Picture 4.11 Mesquite dominate on most of date groves while other farms still in opposite with it

2.3.3 Socio-Economic Changes

The people in Al-Mujaylis village and, in general, in the tail-end of wadi Zabid have been suffering drastic impacts as a result of deteriorating the environmental resources. The bad environmental state in Al-Mojaylis at least led to two bad cases.

First, most of people compulsory immigrated to other areas to much their humble needs. Certainly, when the people resort the immigration from motherland this means that they suffered from conditions were very drastic. The migration does not jaunt but it is vagrancy and estrangement. The migration causes the most of suffering and even death to hundreds of thousands of people worldwide.

According to the results of PRA, about the half of people has immigrated. Most of migrants their state is bad, while some improved their state, but after years sweating and suffering. Picture 4.12 display snapshots with some migrants from Al-Mojaylis village. However, migrants showed that they want return to their village.

Picture 4.12 migrants from Al-Mojaylis village

Second, the poverty in Al-Mojaylis is one of main problems or rather is resultant to many problems, which created since thirty years ago. The society in Al-Mojaylis was agricultural society mainly. So, with degradation of environmental resources in Al-Mojaylis since eighties, the main income sources also deteriorated, then the people became empty-handed. Some farmers sold most of their lands to subsist their families.

After degradation of agriculture, the people in Al-Mojaylis looked for other works such as fishing, handicraft and daily wage laborers. Nevertheless, the results of PRA indicate that all these sources degraded less by less and are currently uselessness. For example, handcrafts in the past were better, then most of the people worked in this career but now, because of the rarity of palms, those who have a palm trees benefits from them for themselves only.

In briefly, the living standards in Al-Mojaylis are very difficult, but their status in the past was better. Currently, the residents of Al-Mojaylis their houses threatened by mesquite trees and sand dunes invasion.

CHAPTER FIVE

METHODOLOGY, RESULTS ANALYSIS AND DISCUSSION

5.1 METHODOLOGY

5.1.1 Study Plan and Methodology

The study passed in several stages and each stage included different tasks and works. The main stages are collect and review of previous studies, preparing to fieldwork, fieldworks, and analysis of collected field data and finally writing stage. The employed methodologies in this study are detailed in the following.

- **Collection and Reviewing the previous studies:**

  The sufficient review for previous reports and studies about the study area is very important to formation initial vision about the area and understanding the problems of water and environment that suffer the area from it. The results and recommendations that arrived at it the previous studies are useful in puts the priorities the present study. Utilization of available data and information about the area is very important to chasing the changes in environmental resources in the study area from the outset.

  to purpose identify the key indicators of the existing state of the study area environment, identification of the areas and resources under

stress or at risk, and level of their vulnerability or risk of degradation due to capture of flood water in upstream. Also during the desk-study may can set up some options for followed work method and work requesting.

- **preparing to fieldworks**
  The main task in this stage is designing the questionnaires that achieve the objectives of study through search the problem and causes with stakeholders and especially the concerned society. In this phase, four forms of questionnaires have been prepared which involved (upstream, middle and downstream farmers, and key persons). In this phase, I was coordinated with CoCoon team that also was targeted wadi Zabid and Rima to research.
- **Fieldwork method:**
  During the present study, **P**articipatory **R**ural **A**ppraisal (**PRA**) techniques were employed to collection of field data. The **PRA** techniques included
  - Interviews and group discussion with stakeholders
  - Problems and solutions tree
  - Social-resources maps
  - transect walks
  - time line
  - daily routine for woman and man works

  Selecting the techniques was depended on a manner that can by it collecting of reliable data.
  The PRA tools were used to instantly determine the main problems of the study area and then rank priorities. Change in spate irrigation system, arrival spates quantities and agriculture practices at the wadi level and linkage with events were done with people during sessions of Qat shewing or during gathering of people. The following figures and pictures show examples to some PRA techniques that have used by present study during the fieldwork.

Picture 5.1 partially vision to the Al-Mojaylis community during drawing of resources map with one of CoCoon team members

Figure 5.1 resources map of Al-Mojaylis village

Land and water resources and its uses, and cropping patterns, etc. clarified by resources map that were done by the villagers themselves in Al-Mojaylis village.

Transect walks in the most of sites at the wadi level were also done with a group of villagers through walking to study natural resources, and degradation of resources and farming practices, problems.

Picture 5.2 transect walk in center of Al-Mojaylis village

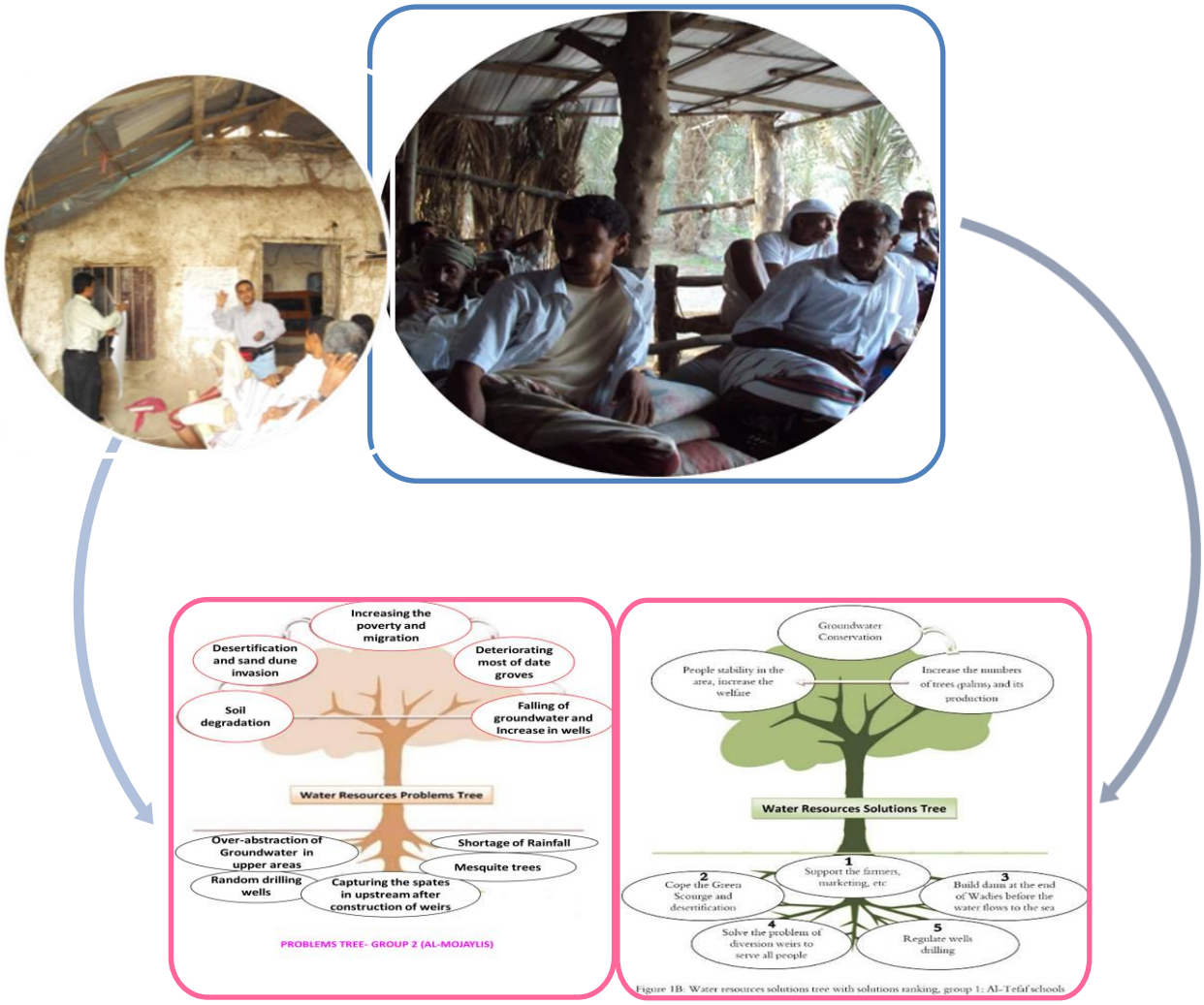


Figure 5.2 preparation of problems and solutions tree with community in Al-Mojaylis

...e line at Al-Mujellis:

Time	Spat water	Agriculture activities			Groundwater status			Des.	Imm.
		Area	C.T	Yield	Total Depth	W.L	W.Q		
1962	Floods comes from the heavy rainfall around the area	All agriculture lands	Palm	100%	0.5m No drilling till 1975	Near the surface till (<0.5m)	Fresh	Non	Non
1979	Same as above	All agriculture lands	Palm	100%	As above	0.5m	Fresh	Non	Few (10 P.)
1985	Same as above	The start of agriculture lands shrinking	Palm	100%	6- 8m	5m	Fresh	Start to cover Palms	
1990	Same as above	As above	Palm	25%	12m	7- 8m	Fresh	As above	30%
2000	Rainfall shortage	Continuous decreased in agriculture lands	Palm	25%	16- 17m	5- 9m	Fresh	Continuous cover Palms	60%
2011	Rainfall shortage	The most decreased in agriculture lands	Palm	10%	30- 50m	12	Fresh	It remain 15% Palms	

C.T= Crop type, W.L= water level, W.Q= water quality, Des.= Desertification, Imm.= Immigration, P= Persons

Figure5.3 environmental and social changes with time in Al-Mojaylis village (time line of Al-Mojaylis)

Discussion with stakeholders concentrated about the water resources status, spate irrigation system, spate allocation system and equity in distribution system, the environmental degradation in Al-Mojaylis and linkage of degradation with distribution system and construction of permanent structures, land use patterns and changes in it, etc.
During the survey, the women were important element to research.

Picture 5.3 some PRA techniques used with women in the study area

Surveys involved many different locations along (upstream, middle and downstream) of wadi Zabid and wadi Rima to exploring the opinions of stakeholders about the problems and possible solutions.
Direct field observations were one of utilized methods, together with the farmers to describe the overall environmental setting.
Questionnaires were designed to suitability with various stakeholders and to acquiring sufficient information for the problems of study area.
More than 40 interviews were carried out in wadi Zabid (15 in Al-Mojaylis village and 15 in upstream and middle of wadi) and ten other activities included varied techniques of PRA which were distributed in same method (namely five activates in Al-Mojaylis and five activities in upper and middle areas of wadi).
The worth noting, that during the fieldwork, I have worked with CoCoon team which was consisted of three members (Mr. Wahib Al-Qubatee, Mr. Abdullah Ibrahim and Ms. Nadia Alhindi).

5.2 RESULTS ANALYSIS AND DISCUSSION

5.2.1 EFFECT OF APPLIED RULES ON WATER RIGHTS

The ward of rules here meant those rules that regulate and govern the spate distribution between the users, several areas, within the spate irrigation system. Rationally, when setting rules to regulating the spate using, the basic goal is ensuring the achievement of equity between the users and uses. The important question is 'did traditional rules to water distribution in wadi Zabid achieve the equity in water distribution among upstream and downstream users?'.

The main rule that regulate water distribution within spate irrigation system of wadi Zabid is Ala′ala Fala′ala rule.

According to this rule, the users in the upstream area own the spring and base flow. Also, the upstream area gives priority on diversion of spate water but accordance time schedule (see chapter three). During interviews and discussion, the most of stakeholders shown that the farmers in upstream area utilized this rule to irrigate the banana farms in any time under the pretext that the priority for Ala′ala (upstream). The traditional rules given the downstream users the right to receiving of late floods from 1 September to 5 October (35 days). This often comes in the end rainy season.

5.2.2 Effect of Human Activities on Water Rights

The human affected the water rights by several activities and practices, at the head violation of regulated rules and rights although the most of these rules inequitable.

Since thirty years ago happened several changes in human activities which affected the water rights and then in accessibility downstream users to water.

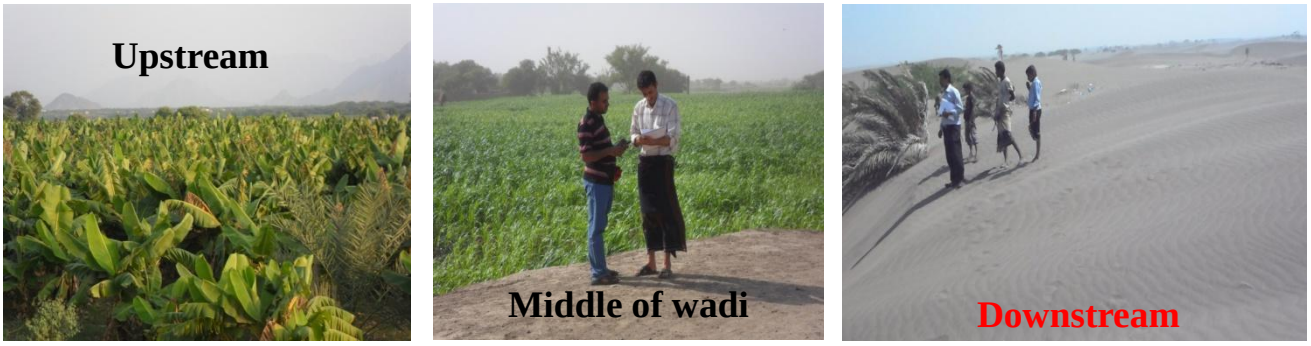
In wadi Zabid, the rights of spate water and groundwater have been affected by the people activities and /or by changes in people activities and practices.

The results of PRA surveys in wadi Zabid indicate that the practices and activities of farmers in upstream area of wadi changed since 30 years ago and these changes affected the water right of downstream users. As construction of concrete diversion structures and changes of crop patterns, pumping the groundwater, random drilling wells and reclamation of new lands are the most important activities of human that created since last thirty years.

The field findings indicate that the farmers in upstream has changed cropping patterns from cereal crops (require limited amounts of water) into banana crops requires irrigate every four days with much amount of water throughout the year.

This meant than the farmer in upstream needs much water to irrigate his farm. Thus, changing the cropping pattern compelled the farmer to diversion of large amounts of spates to long time period. Consequences, the water rights of downstream users pillaged and their land destroyed and deserted.

During the field survey, we observed that the banana crops are most spreading in upstream areas and decrease gradually untill disappear fully in the middle of wadi (downstream of command area), while there were environmental destruction in downstream area of wadi zabid. So, differing of crop patterns from area to other reveal differing of water rights and accessibility to water between upstream and downstream areas at the wadi level, as indicate also that change of upstream crops affected the water rights of downstream and their crops.



Picture 5.4 differences of agricultural status between upstream and downstream

The results of interviews and discussion and PRA indicate that the most of farmers in upstream have reclaimed new lands out the command area and in the Galal lands which traditionally does not irrigate. The expanding or reclamation of new lands in upstream was at the expense of spates water that had been arrived to the downstream area in the past. These practices consider violation to the water rights of downstream area.

According to interviewed, there are many forms to violations of traditional water rights by most of farmers especially in upstream area. Most of complaints against violations some farmers to water rights are documenting in TDA-Zabid. Some of these documents indicate that some farmers created new intakes from channel to their farms directly.

5.2.3 Effect of Water Structures on Water Rights

We can outline effect of permanent diversion structures on water rights in speaking one the respondents in upstream area of wadi, where he said ‘after construction of permanent structures, we in upstream benefited from the new structures in the same degree that the downstream users damaged’.

The results of field surveys indicate that concrete diversion structures increased possibility controlling the spates in upstream. So, the users of lower channel complain from violations of upper channel users.

The New ‘modernized’ diversion structures have doubled inequity in the distribution of water between upstream and downstream areas, as Gated control structures make encouraged the upstream farmers to divert water at any time.

Thus, we can say that permanent structures affect the water rights through:

- Increase of control the spate water in one point in upstream
- Almost complete control the floodwater in the upstream, where the concrete structures are strongly withstand breaching until with peak

floods. Then the downstream area deprived even from large spates that was arrive it in the past.

- Distribution of spate water between several channels slows the arrival of flows to the downstream fields. This create more inequitable in the water distribution, as a result the fields in downstream remain for years without irrigation.

Finally, we can say that the consequences of development of spate system in wadi Zabid disturb traditional rules and provide the most of injustice and inequity in the water distribution.

With a new diversion structures the upstream users become able on diversion large proportion of flows, which in turn leads to an increase in the inequity between upstream and downstream users' in access to water. While in the traditional system (with earthen diversion bund) the possibility of control was difficult as the earthen diversion bunds were breach by large floods to pass water to downstream. This means that downstream area has tradition right in the peak floods but this right was invisible. Currently this right collapsed by the new diversion system as other traditional rights.

An interviewed people at weir number 5, clarified that the spates in the past were not come only during the allocated time to the downstream (35 days) but also they flow in other times all year round, but now after construction of weirs the floods come for once per year.

5.2.4 Evaluation of Integrated Water Resources Management Degree in Wadi Zabid

The results of questionnaires and PRA survey were used to identify the degree of IWRM in wadi zabid. A review of available documentary sources was also used to this purpose. However, IWRM framework is our guide to evaluating the IWRM in wadi zabid.

According to Dublin conference 1992, IWRM defined as "a process which promotes the coordinated development and management of water, land, and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems".

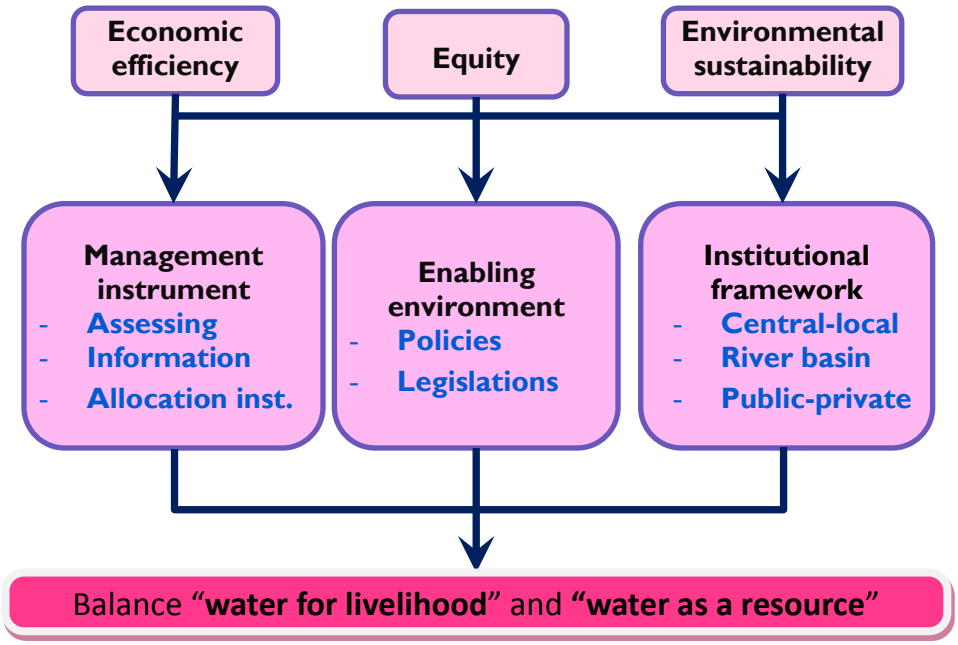


Figure 5.4 IWRM framework (after …….)

According to this Figure, can evaluation of current situation to water resources management in the study area. The results of interviews with stakeholders and the present status to environmental resources will reflected in this evaluating.

- During the past two decades, Yemen government has formulated policies intended to deal with various aspects of water resources management in the context of the National Development Objectives. **NWSSIP, 2005** is the more important action to Yemeni government and consider road map to water polices in Yemen. Nevertheless, these policies are not enforced and conceder mere ink on paper.

At the national level, several legislations interested in or addressed issues of water management such as Water law No.33 and local authority law No.44.

In addition to the previous laws, in wadi zabid there is especial system governing distribution of surface water (Al-Gabarty system). The field findings indicate that this system violated by most of farmers in the upper and middle of wadi. However, this system does not agreed with the integrity approach to managing the water resources at the wadi level. However, the water law still surround by insufficiency and unintelligibility especially in relation of water property or in punishments.

Institutional Framework to present management of water resources in wadi Zabid contain many of institutions, such as:

- TDA-Zabid is responsible to supervision and regulating the distribution of spates water, in addition to maintenance and operating concrete diversion weirs.
- The branch of National Water Resources Authority in Al-Hodiedah (NWRA- Al-Hodiedah) has responsible for water resource planning, monitoring groundwater use and regulating the drilling wells according to water law. In general, NWRA is responsible enforcement of water law.
- Environment Protection Authority Branch in Al-Hodiedah (EPA- Al-Hodiedah) is responsible to the issues related to applying the Environment Protection Law of 1995 at the level of Al-Hodiedah governorate.
- Wadi Zabid is located under two local administrations is local council of Zabid district and local council of Al-Tohitah district. Two local councils are responsible to enforcing the Local Authority Law within wadi Zabid and they work at the local level to manage and control the water resources in coordination and cooperation with NWRA, Al-Hodiedah and TDA-Zabid.

- WUAs, there are 16 water use associations are responsible to managing spate water at 16 Sharij or diversion channel of spates at level of command area.

The worth mention here, that there are not cooperation or coordinate among the mentioned institutions. Most of interviewed people shown that the institutional role to government offices is fully absent except simple role to TDA-Zabid or some the other projects which often fail here or there.

In the present institutional structure there are no special structures has created for multi-stakeholder involvement in water resources development and management at the wadi level.

There is not integration in management of upstream and downstream of wadi. The water value does not enter within farmer accounts when looking in productivity of unit area from a cubic meter.

Information about water resources of wadi Zabid is available in TDA, which has wells monitoring, metrological stations and station of measuring floods (Al-Khoulah station). NWRA also has been inventoried wells in wadi Zabid and has much data about Tihama plain.

However, there is no unified information system to managing and circulating of data among institutions. The management practices currently reveal that the information does not utilize or maybe it formed incorrectly to the decision makers.

Current instruments of water resources management in wadi Zabid:

5.2.5 IWRM Concept to Realizing the Water Equity in Wadi Zabid

In most of world countries especially that suffer water scarcity, or will be in the future the water is managed at the basins level by usage of IWRM approach. Therefore, in wadi Zabid there is urgent need to applying this approach to ceasing the environmental destruction in downstream areas

especially those located near the coast through ensuring sustainable, equitable and efficient utilization of the water resources.

In water scarce regions, equitable and reasonable utilization of the water resources is one of the key parts of IWRM. Equity in this sense does not mean that everyone must be give an equal amount of water but it means that everyone has fair opportunities to access, use and control of the water resources. It means also that everyone must take the responsibility for the negative side effects of abstracting water so that no part of the society will be disadvantaged (RBO, 2008). For equitable water allocation in wadi Zabid, the following three steps are most important. Integrated Water Resources Management for River Basin Organisations

5.2.6 Step one: Increase Water Resources

In the simplified form to hydrological system, water basin receives water from rain and by inflow (groundwater, surface water) and loss the water from the basin system by outflow and evaporation. So, must managing the water system by technical measures improve its storage and reducing its outflow and evaporation. This increases the amount of available water. Increasing water use efficiency is important instrument to increase the available water, which can be achieve by the following measures:

Demand management measures: unproductive losses of agricultural water have to be reduced to a minimum. This can be realized by improving irrigation efficiencies through introduction of water-saving technologies, and encouraging the farmers to adopting improvements in the farming practices. Such improvements include:

- Replacing the flood irrigation by furrow, sprinkler or drip irrigation methodss.
- Improve an on-farm water management.
- Change to crops with relatively high economic returns per unit of water used (figure 5.4).

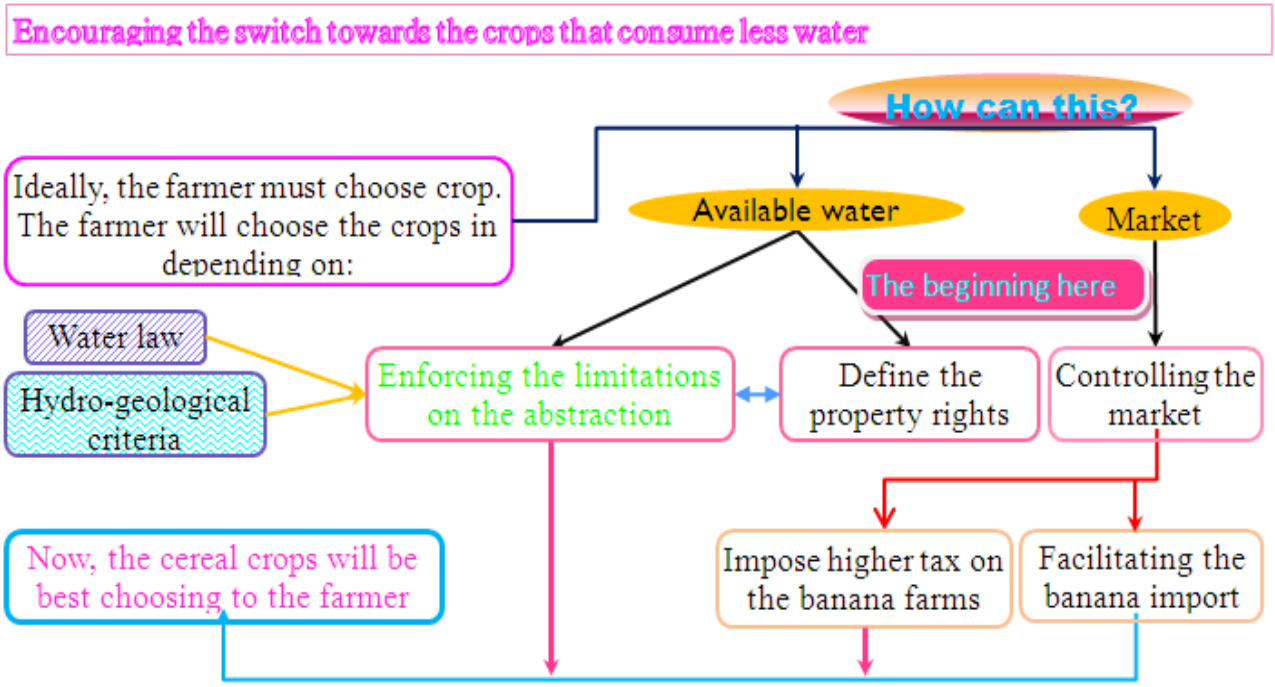


Figure 5.4 plan to switching into crops consume less water

One of methods to reduce agricultural water demands is encouraging the switch towards the crops that consume less water.

How this can?. Ideally, the choice of cropping patterns should be let to the farmers who would choose the crop-mix that suitability with their objectives (e.g. household food security, income generation). Choosing the farmers to crops will depend on the available water and on the market. Thus, we can impose the switch to crops that consume less water through define the property rights over resources and enforcing the limitations on the abstraction of groundwater in accordance to hydro-geological criteria (water law given the legal basis to this procedure). Another tools is control the market either by facilitating the banana import. The other option is to impose higher tax on the banana farms.

Establishing regulatory frameworks for conserving groundwater for sustainable: The main purpose of the regulatory framework is to prevent groundwater overexploitation, thus ensuring a sustainable source of water

and protect the users' rights in the downstream area. This is also important to ceasing the environmental degradation in downstream.

The regulatory instrument has important role in integrated water resources management, which establishes limits to water allocation and land use.

Direct Regulations involve the laws, rules or standards, which must comply with them all water and land users. Yemeni Water Law No. 33 gave the legal basis to this framework (permits system over drilling the wells and water pumping).

Although this type of regulations is existed in Yemen, but unfortunately the results of PRA indicate that water law or other related laws are not applying in wadi Zabid. Therefore, branch of NWRA in Al-Hodiedah must carrying its responsible to enforcement the law.

Controlling abstractions through self-imposed restrictions: An alternative to regulatory approach is agreeing the community voluntarily to limit groundwater abstractions. In this case, each community would take the responsibility for monitoring the compliance and punishing non-compliance within Its Jurisdictions (village, wadl etc.). Under this option NWRA-AlHodiedah and TDA-Zabid and WUA′s in wadi Zabid shall arrive to agreement to persuading the community about putting limitations on the pumping rate, either through establishing metering of wells or by deciding certain limit to water level must no exceeding in end winter otherwise will be the pumping not allowed to summer crops. This the indicator decide to each area independently in order to create rivalry between the different areas along of wadi to water conservation. All of these options must be compatible with measures to increase the efficiency of irrigated agriculture.

5.2.7 Step Two: Ceasing Environmental Degradation

The results of interviews and discussions and PRA survey in addition to field observations clarified that the more forms of environmental deterioration in the study area are as a following:

- **Declining of the water levels**
- **Decreasing the cultivated area and degradation of crop yields**
- **Desertification and accumulation of sand dunes in the downstream area**
- **Poverty and Migration of majority of households in downstream area**
- **Deterioration of land cover and biodiversity**

Field findings reveal that spate irrigation and groundwater are the major sources of irrigation in the study area. Agriculture is the main source of livelihood of population in area. The results of field survey indicate that the environmental degradation begun since twenty years ago, namely after modernization of traditional spate irrigation system.

It seems that the development policy of Yemeni's government during construction of permanent diversion structures in wadi Zabid was "unsustainable" where focused on provide immediate economic benefits touch it the people at that time (i.e. it provided the instantaneous needs of people in conformity with short-term objectives), while the impact of this development process on the environment was ignored. As a result, destruction and degradation of natural resources and damages to downstream' communities have reached a critical level.

In general, adopting approach of IWRM is peerless solving to ceasing the environmental degradation**.** As an integration approach take into consider the economic, social and environmental issues**.**

To purpose ceasing the environmental degradation must to deal the five degradation forms mentioned above in accordance to IWRM approach.

To mitigating the desertification and movement of sand dunes in Al-Mojaylis village and other coast villages of wadi Zabid, must managing the upstream area and downstream area as a one unit.

During the field survey in the study area, the causes or factors that lead to degradation of downstream area have been discussed with stakeholders. According to stakeholders there are three main causes led to environmental degradation are outlined in the following:

- Natural causes: shortage of rainfall and climate change
- Human factors: represent over-exploitation of groundwater in upstream area in addition to inefficient its use.
- Socio-economic factors: the high price of cash crops such as banana and mango encouraged the farmers in upstream and middle of wadi to cultivation those crops this also was supported by the traditional spate allocation system.

In the following will some measures that must be followed up to facing the environmental degradation in general and to confrontation of sand dunes movement and the worth mention here all options or scenarios to ceasing the environmental degradation must be undertaken within an integrated and multi-sector approach. …

The range of success these options will be depended on range the effective community participation in implementation.

5.2.8 STEP THREE: GOOD ENVIRONMENT AND HUMEN ACTIVITIES RELATION

The human are the more activity component within the environment. As demographic growth in high rate means there are vigorous stress on environment to satisfying the primary needs of populations faced with ever increasing food, fodder, firewood, infrastructure requirements, etc.

So, the behavior of people in using the natural resources to satisfying their needs at regional and/or local levels certainly will affect the environment resources either negative or positive.

Practically, in wadi Zabid there is large linking between population activities in exploiting the wadi resources and degradation its environment. At examining closely in to the results of PRA survey, appear prominently that the human activities from the **direct causes of environment degradation** in downstream area of wadi Zabid. The human activities to construction of

concrete spate diversion structures with end the seventies without the efficient hydrological data to the design consider the first spark to the wrong human behaviors where encouraged the upstream farmers to capturing the spate water in upstream and then deprivation the downstream area from arrival of spates. This, combined with important declines in groundwater levels and destruction of fauna and flora. The over-exploitation of groundwater and some inadequate agriculture practices is also of the mistaken people behaviors that lead to the destroying the downstream environment.

The reciting these error practices do not to purpose the enumerating but to emphasizing over importance the focusing on modification of community behaviors to water resources management, through awareness campaigns to catalyzing the community to adopting self-deciders to conservation of environment.

5.3 CONCLUSION

- The traditional rules of distribution of spate water in Wadi Zabid do not achieving the equity between upstream and downstream areas.
- The permanent structures lead to more inequitable in distribution of spates
- The new spate scheme of wadi Zabid serve the upstream area only
- The field findings indicate that the environmental degradation in downstream area connected historically with construction of permanent spate irrigation scheme.
- During the last thirty years happened large development in upstream area, while in the downstream have been happened drastic environmental destruction.

- The traditional rules and rights in wadi Zabid did not suit with the recently changes in the spate scheme of wadi Zabid.
- The traditional rules and rights have violated and not respected especially in upstream area.

5.4 RECOMMENDATION

- Using IWRM concept to managing the surface water and groundwater and other environmental as one unit at the wadi level
- TDA should be carrying its role in supervision, monitoring over water distribution, and imposing punishments on the violators, in addition to activating of agricultural guidance and promotion of water use efficiency.
- NWRA must be enforcement water law to controlling of drilling wells, and groundwater over-abstraction.
- NWRA must be prepare to establishment of wadi committee (basin committee) involvement all stakeholders in the water sectors with ensuring an effective participation to water users at the wadi level (from coast into upstream- not only the existing 16 WUAs). this phase require the following procedures:
- Establishing the water use associations at the wadi level and certifying them by the social affair office.
- Introduce list of chairmen, deputy and members of wadi committee to the court to issue decree determine the functions and jurisdictions of committee in the planning the water resources and in making any modification to ensuring the conservation of water and achieving the equity. This may easy making any modifications in the traditional water rules.

References

Al-Eryani, Dr.Mohamed and Al-Amrani, Mohamed. 1998. *Social And Organisational Aspects* . 1998.

Al-Eryani, Mohamed. 1979. *Hydrology And Ground Water Potential Of The Tihama-Yemen Arab Republic.* 1979.

Bahamish, Awadh A. 2004. *Legal Survey of Existing Traditional Water Rights in the Spate Irrigation Systems in Wadi Zabid and Wadi Tuban.* 2004. IIP, Credit No. 3412-YEM.

Cap-Net. 2008. Integrated Water Resources Management for River Basin Organisations. (RBO, 2008). Website: www.cap-net.org

Christopher Ward, et al. 2007. *Poverty and Social Impact Analysis (PSIA).* 2007.

E. L. Scheitze, water engineer, viziterv consulting company, Budapest, Hungary. 1987. Certain Aspects And Problems Of Wadi Development. 1987.

El-Hassan, Dr.Babiker. Environmental Protection Study And Activities In The Tihama Plains Of Yemen.

IIP. 2003. Hydrological Analysis. 2003. revised following John Ratsey's comments.

IIP Sana'a. August 2004. Paper on Water Rights and Irrigation Management In Wadi Tuban and Wadi Zabid. August 2004.

NWRA. 2009. Wadi Zabid And Wadi Rema 'A Water Quality. 2009.

Smith, G. V. and AI-Mooji, Y. A. 1987. Groundwater Development Inthe Tihama Coastal Plain. 1987.

Steenbergen, Frank, et al. 2010. *Guidelines On Spate Irrigation.* 2010.

T.C. Dougherty and A.W.Hall. 1995. Environmental Impact Assessment Of Irrigation And Drainage Projects, T.C. Dougherty and A.W. Hall, HR Wallingford United Kingdom. 1995.

Water Resources Of Yemen WRAY-35,1995.

World Bank. 2009. Investigation Of Sea Water Intrusion In Yemen Republic, . 2009. Final Report.