



Groundwater in the Political Domain

Al-Mujaylis Case Study

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Photo: From 'Al-Gah, wadi Rima', WEC & MetaMeta

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1. Introduction:

1.1 background:

The coastal plains in Yemen suffer from many problems such as desertification and sand dunes movement, seawater intrusions, sinking groundwater table, among others. These problems are a result of drought and floodwater shortage, changing irrigation practices, as well as the unequal rights of water distributions between the water users upstream and downstream of the wadis in addition to an increasing number of dams in the mountainous areas often built without adequate water management strategies.

Two wadis in the area, wadi Zabid and wadi Rima' have seen large scale irrigation projects affecting the flow of spate water. These areas have seen less rainfall over the past decades, and constructions in the upstream areas have resulted in less water in the wadis. This does not only cause trouble amongst the farmers in the wadis themselves, but also for the areas further downstream which face water shortage as a result.

One such area is Al-Mujaylis. According to the previous studies Al-Mujaylis, IFAD (2003) and GP-CooCoN (2011), the village suffers from the problems of the coastal plains: desertification and sand dunes movements, and an increase in the depth of shallow groundwater. This has led to an increased migration from the area.

The geologic setting of the study areas Al-Mujaylis and wadi Zabid and Rima' which represent by thick alluvial deposit with some exposure of highly fractured tertiary volcanic rocks (as in the geologic map of Robertson Group, 1991, in the appendix 1 and DHV, 1986?). This indicate the possible recharge of the study area by the floodwater flow from Wadi Zabid and Rima' in the rainy seasons. In addition to the recharge by water returned back from the intensive irrigation practices in wadi Zabid and wadi Rima in the dry and rainy seasons. This recharge may be affected by the constructed weirs in wadi Zabid and Rima'. Fife weirs was constructed in wadi Zabid and one weir in wadi Rima' after the year of 1979.

Therefore, this research study aims to know the exact problems in the area and to map the causes and solutions to those problems by using Participatory Rural Appraisal (PRA). In addition, the study aims to formulate an action plan to discuss the recommendations to implement them in order to solve or mitigate those problems in the study area. The study covers the central parts of Al-Mujaylis village (Al-Mujaylis hamlet and its surrounding areas) in addition to wadi Zabid and wadi Rima'

1.2 The study area:

Al-Mujaylis village is located in the Tihama coastal plain by the Red Sea, between the end of wadi Rima' and wadi Zabid. It is consists of ten hamlets and the total population of the village is about 2642 (1328 male, 1314 female), according to the last Yemen census (Census, 2004). The administrative division and the topographic map are illustrated in appx. 2 and 3.

Wadi Zabid originates from the area around Ibb and Dhammar (Yarim) in the southern highlands. The Wadi flows westward until it enters the Tihama coastal plain and discharges into the Red Sea. Total length of the wadi is about 140km (about 50km from the foothills to the Red Sea gradually sloping from an elevation of 270m above sea level in the East, to sea level in the West (shown in the topographic map, appx. 3). The

planted area in the wadi is estimated of 17 thousand ha. The annual flow of the wadi is about 135 million m³. The catchment area of the flow is an estimated 4450km² with an annual average of precipitation of 550 mm (IDP, 2007). The annual precipitation varies from 100 mm in the West to 550 mm in the East.

The current system for distribution of irrigation water in wadi Zabid was defined by Moslem scholar, Sheikh Al-Jabarti, more than 600 years ago. This rule gives the priority of spate water rights to the people upstream, according to the traditional "al 'ala fa al 'ala" principle. The rule divides the upstream waters of wadi Zabid (the area along 20km from the foothills, at weir 1 in the East of the Wadi to weir 5 at the West) among three "groups."

In the dry season there are base flows from Jan. 1st. to Mar. 28th and from Oct. 19th to Dec. 30th (161 days). The rainy season, when the floods come lasts from Mar. 29th to Oct. 18th (204 days). The spate water is divided among the three groups as follows: The upper part, or group 1, by weir 1 and 2 get the water from Oct. 19th to Aug. 2nd (288 days). This water is used to irrigate 4,805ha. (27% of irrigated area). The middle part, or group 2, by weir 3 and 4 get the water from Aug. 3rd to Sept. 13th (42 days), and irrigate 10,175ha. (60% of the irrigated area). The lower part, or group 3, by weir 5 have the water from Sept. 14th to Oct. 18th (35 day), and irrigate 1450ha. (8% of the area irrigated) (Tipton et al., 1974), and (IIP, 2005). Details about water allocation of wadi Zabid is illustrated in appx 4. What exceeds the needs of these groups will go to the downstream areas or reach the Red Sea, 50km from the foothills.

Wadi Rima' originates from the mountain plains, Dhamar and Raymah. The location of wadi Rima is shown in the topographic map in appx 3 and 5. According to the study done by LRD (1977), wadi Rima's catchment is about 2900km², most of which (2500km²) lies in broken and generally inaccessible country. The main part of the area which lies below the hill front of wadi Rima' comprises an extensive alluvial fan and plain with few impediments to cultivation except toward the coast where there is extensive dune field and areas of salinity and alkalinity. The mean annual rainfall is probably no more than 350 mm at the hill front, and nearer 100 mm at the coast. Evaporation exceeds 2500 mm/yr. The mean annual discharge from wadi Rima' is about 80 million m³, an estimated 54 million m³ is diverted onto irrigated fields, and 25 million m³ passes direct to groundwater (allowing for 1 million m³ evaporating). This is supplemented by an additional 6 million m³ percolating through the wadi-irrigated fields including the increment from direct rainfall.

Wadi Rima irrigation water rights goes under many historic developments, according the study done by LRD (1977), these rights can be summarizes as the following:

By 1690: There was already major canal system on the south side of the wadi feeding the farmlands of Turaybah and Salamah, other smaller canal, Sugail and Raymah canal precursors of the present day Al-Ashraf and Al-Hudayd, and also major diversion structures (is built of stone, gravel and brushwood and take the form of groyne). Turaybah and Salamah held the know record rights to abstract the waters of wadi Rima.

Then, in 1703, Imam al Mahdi Muhammad, ruler of Yemen at that time extended the wright of abstraction to downstream farmers for two months, rights to the peak flows

period were subdivided to accommodate the Qurshiyah sheikhdom further downstream). So that in 1809, the month period was divided successfully between:

Musawfah	10 days,
Basat	20 days,
Badwah	6 days,
Mahatt	20 days,
Downstream users	10 days.

Throughout the period, Turaybah and Salamah maintained the right of the abstraction for the rest of the year, including all the dry-season flows. This irrigation system continued without any major changes for further hundred years, until well into the present century.

In 1900, the two upstream canals of Al-Ashraf and Al-Fari'i was installed but did not at first disturb the system downstream because they took only flood flows.

In 1928- 1929, the civil war between the Imam and Zaraniq tribe resulted in the exportation by Imam of the a tract of land on the north bank of the wadi and the extension and improvement of the Raymah canal to irrigate small garden at Al-Jarubah. The new canal is called Al Hudayd after its builder. Although Al Hudayd canal took only a small quantity of water, it took water year-around and created a precedent which was used by the owners of Al Ashraf and Al Fari'i to begin also to abstract dry-season flow.

According to the study done by USAID (United States Agency for International Development), the 2000 ha out of 7000 ha which was taken by Imam and the constructed canal creating a special water right system and resulted in abandoned of an important irrigable and cultivable areas. The land that was token by Imam operated as Al-Jarubah state farm (nowadays under Yemen Economic Corporation) and accommodating some 200 sharecroppers. The state charges sharecroppers 50% of their crops plus 10% zakat tax (this the standard rate of rain fed land) (USAID, 1980).

In 1931, an orientation to close Al Hudayd canal signed by the two of Imam's sons, but no firm action was taken.

Instead, in 1952, works was authorized by the Imam to enlarge Al Hudayd canal and its irrigated land which when completed, resulted in most of the low flows being diverted at Mishrafah to serve the north side of the wadi. The Imam ruled that four days flow a month should be allowed to pass down the wadi for use on the South side, which is useful for Al Ashraf canal but not for those farther downstream.

This situation continued until seventeenth. The government used Al Hudayd canal to get as much water as possible onto the North bank (and that, apart from when Al Ashraf receives the allocation of 4 days per months or when extra days of water are bought from Al Jarubah). The only flows which pass the downstream are those which overtop or breach the temporary diversion structure upstream.

When functioning, each structure diverted part of the wadi flow into its own canal system. The larger canal has several branches; the water is turned directly from the canal into bonded field and then conveyed from field to field by breaking the connecting bunds. As a result, most canals has been eroded to several meters below the field levels, such that temporary earthen dams are required to raise the water level in the canals. As

a rule, users near the head of the canal take the water first after that allowing water to flow down the canal system. However, this traditional does not apply to Al Hudayd canal (under the control of the manger of Al Jarubah state farm).

In the 1970's, the government oriented to improve the agriculture and public services, so many studies have been carried out which resulted in the construction of many diversion structures and canals in many wadies in Tihama coastal plain, one of these diversion structures (weir) was constructed at the foothill of the mountain area of wadi Rima in 1983.

"The system consists of one a diversion structure, main supply canal, a division structure, an inverted syphon and two canal system on left and right sides of the wadi. The main supply canal, after about 5 km is divided into the North and South Bank Supply Canals, of 5 and 10 m³/s respectively. An inverted syphon, containing two steel pipes 1.2 m diameter, conveys the flow across wadi Rima. Eight primary canals off- take from the South supply canal and five from the North Supply Canal." (TDA, 1988?).

2. Findings:

2.1 The problems in Al-Mujaylis area:

Using different PRA activities, individual and group interview, discussion groups with different PRA techniques such as direct observation, transect walk, problems and solutions tree, resources map, time line and daily calendar, people ranked the problems according to which, from their point of view, are the toughest and have the biggest effect on them (appx. 6). These problems varied from more local problems such as poverty, vegetation problems, sinking groundwater levels and sand dune movement, to the more regional problems such as rainfall shortage and problems of groundwater recharge. The problems were ranked as following:

2.1.1 Poverty:

All people agreed that the problems of water resources in their areas first and foremost are because of poverty. While it is true that the groundwater levels are sinking, they are still not very deep (around 9 m to 12 m), but they cannot afford the cost of rotary drilling down to 40 m to 50 m in addition to the pumping machine, and the engine.

2.1.2 Rainfall shortage:

The second problem that people agreed on was rainfall shortage. In the past, the rainfall was heavy and had more frequency than nowadays. While still undocumented this might well be true, as rainfall records of two year means from 1975 and 1976 (LRD, 1977), and rainfall recorded for 1975, 1976 and 1977 (LRD, 1980) shows a difference from the recorded rainfall means of the years 1984 - 1988 (NWRA, 2009), as seen in appx 7.

The spates, which used to reach the area are caused by rainfall directly, and have decreased significantly in the last period about thirty years ago due to lack of rainfall. Besides the actual shortage in rainfall comparing with previous years, the shortage in spate water around the area (due to interception by weirs and dams) decreased the recharge amounts for the groundwater aquifers, causing groundwater level drawdown, and might give the feeling of the droughts comparing to the previous years.

2.1.3 Fast and heavy spread of Prosopis Juliflora trees:

The third problem that people face is the increasing numbers of the Prosopis Juliflora trees in their areas. These kinds of trees spread quickly and heavily and have deep roots which suck the water from a large surrounding area, thereby affect other nearby trees such as palms trees. Therefore, these trees will remain green even when neighbouring palm trees are dead. It was noticed the Prosopis Juliflora had spread over a large area in Al-Mujaylis. The photos in figure 2.1, show the clinic center (photo A) and dry and dead palm trees (photo B), both surrounded by Prosopis Juliflora.



Figure 2.1: Photo A: The clinical center surrounded by Prosopis Juliflora. Photo B: Dead palm trees surrounded by Prosopis Juliflora.

2.1.4 Decrease the amount of groundwater recharge:

Groundwater is the main source of water for drinking, and domestic and agricultural purposes (livestock and irrigation). There are three types of wells in Al-Mujaylis: dug wells with depths ranging between 8 m - 15 m, borehole and borehole dug wells with depths ranging between 40 m - 70 m. We were told that the two wadis do not have branches to their areas. Wadi Zabid and wadi Rima' flow South and North of Al-Mujaylis village respectively and discharge into the Red Sea. The nearest branch of wadi Zabid is Al-Nasary canal, and the nearest place of wadi Rima' is Al-Tur.

One Key informant said that a long time ago (more than 60 years), there was a wadi, wadi Al-Mughider which was a branch of wadi Agee, that flowed from North to South through Al-Mujaylis and discharge to wadi Zabid.

A few people mentioned that some interventions and changes in agricultural practices upstream of the wadis might affect the amount of water flowing downstream, which would in turn recharge their area. For example the construction of diversion weirs and dams in the mountains upstream of the wadis, as well as the changes in agriculture practices such as crop pattern change and increase in the agriculture areas irrigated by flood irrigation.

Al-Mujaylis is part of the Tihama coastal plain which is characterized by thick alluvial deposits and is the best aquifer in the country (DHV, 1986?). The thickness of the quaternary upper part of the alluvial deposits in Tihama is 50 m - 200 m while it reaches 3500 m for the lower sequence (shallow marine deposits) of Tertiary (Miocene) age. In the middle part of wadi Zabid and wadi Rima', beside the alluvial deposits, there is some highly fractured tertiary volcanic rocks exposure (as seen in the geologic map of Robertson Group, 1991 (appx. 1).

This draws a picture of the possible recharge of the study area by the floodwater flow from wadi Zabid and Rima' in the rainy seasons, as well as the recharge by water returned from the intensive irrigation practices in wadi Zabid and wadi Rima' in the dry and rainy seasons. The recharge may decrease as a result of the constructed weirs in wadi Zabid in 1979 (five weirs) and the single constructed weir built in 1983 in the upstream area of wadi Rima'. Possible evidence for this is that the groundwater table has changed from 0.5 m to be 12 m, but it is more fresh than in the past, both according to the people interviewed and the recent electric conductivity (EC) which is between 800 $\mu\text{s/cm}$ to 1800 $\mu\text{s/cm}$ (Nwra, 2006). Other evidence that the water salinity was higher in the past is that people only farm date palms as it tolerates harsh weather and high levels of water salinity reach to 6000 $\mu\text{s/cm}$. Beside that it is mentioned by the LRD study that the soil is saline-sodic soil. (LRD, 1977).

2.1.5 Drought and groundwater levels drawdown:

As a consequence of the above mentioned problems, the area is facing drought and groundwater level drawdown. The older men and women said that fifty to sixty years ago, water was found at depths of less than 0.5 m. At that time, if you dug a shallow pit by hand or when the wind blew away palm leaves covering the ground, one would find water. Therefore, people used their hands or animals such as cows to plow or dig small holes in their field or houses to access the water. Farming practices differed as well, and palm seeds were sowed and would grow directly without requiring more labour. The

productivity of the palms trees was at its maximum rates, of 40 kg to 50 kg by one palm in a season. Livestock were present in abundance at that time as well as some wild animals such as deer.

The groundwater levels dropped to 5 m – 8 m between 1985 to 1990, and reached 9 m in 2000. Nowadays, the groundwater table is at a depth of 12 m in Al-Mujaylis hamlet and the surrounding areas. This level increases or decreases with a few meters towards East and West respectively. As the level of the water drops, people increase the diameter of the wells to install pumping machines a few meters down in the well to enhance the pumping pressure.

In the past, people used a bucket to lift the water from the shallow wells. Then they changed to small pumping machines (oil machines) to get the water from a depth of 5 m, and after that they changed to Hindi diesel pumping machines to lift the water from depths of 8 m. Nowadays, people have to drill tube wells or to deepen their wells and install modern water pumping machines (pump machines with engines) to get the water from depths of 12 m to 30 m. Photos A, B, C, and D in figure 2.2 shows the different water lifting techniques which reflect the changes in groundwater levels. Most people cannot afford the cost of rotary rig drilling, and the dug well drilling is not possible because of the high thickness of alluvial deposits which constitute a threat to them in the case of collapse. They sometimes use local techniques to deepen the wells by using iron cases (8 m length) which are pushed inside the dug wells by hammers, and the deposits are pumped out of the case by suck pumps. This method does not always succeed because the casing sometimes is hits big stones and cannot penetrate the earth further.

Regarding the groundwater salinity, the groundwater is more fresh than in the past, both according to the people interviewed and the recent electric conductivity (EC) which is between 800 $\mu\text{s}/\text{cm}$ to 1800 $\mu\text{s}/\text{cm}$ (NWRA, 2006). The groundwater in Al-Mujaylis is fresh because it expected to still recharged by the two wadis Zabid and Rima' which locate South and North of Al-Mujaylis village respectively. Beside that, the water get sink below the "saline-sodic soil" (LRD, 1977).

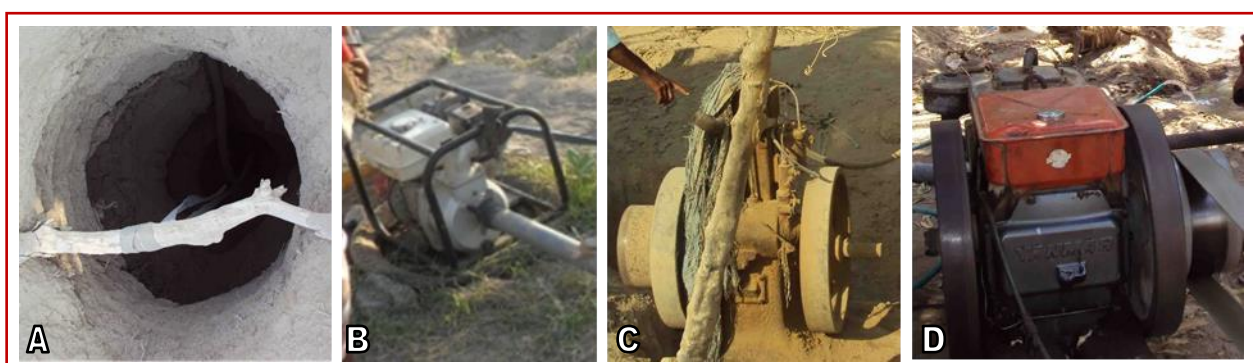


Figure 2.2: The changes in the water left techniques as a result of continuous groundwater drawdown. A: bucket, B: small oil pump, C: Hindi diesel pumping, D: pump machine with engine

2.1.6 Sand dunes movement and increased desertification:

Sand dune movement presents a big problem in Al-Mujaylis. The sand dunes started to cover some palm tree farms between 1985 and 1990. Most people interviewed, agreed that the sand dunes cover 50% to 70% of the areas. The desertification started from the south of Al-Mujaylis toward the North. The hamlets Al-Shafeiah and Al-Groubah are completely invaded by sand dunes. The sand dunes are now moving towards the central parts of Al-Mujaylis village, toward Al-Zakham and Al-Mujaylis hamlet and represent a catastrophe. Figure 2.3 shows some sites from the area. Photo A shows the palm trees in Al-Zakham hamlet completely covered by sand dunes reaching 10 m in height. Photo B shows the other green palm farms which will be covered by sand dunes. Photo C, shows the beginning of desertification at some sites in Al-Mujaylis hamlet. Photo D shows the areas in Al-Tefaf hamlet (North of Al-Mujaylis village) which still have not been invaded by sand dunes.

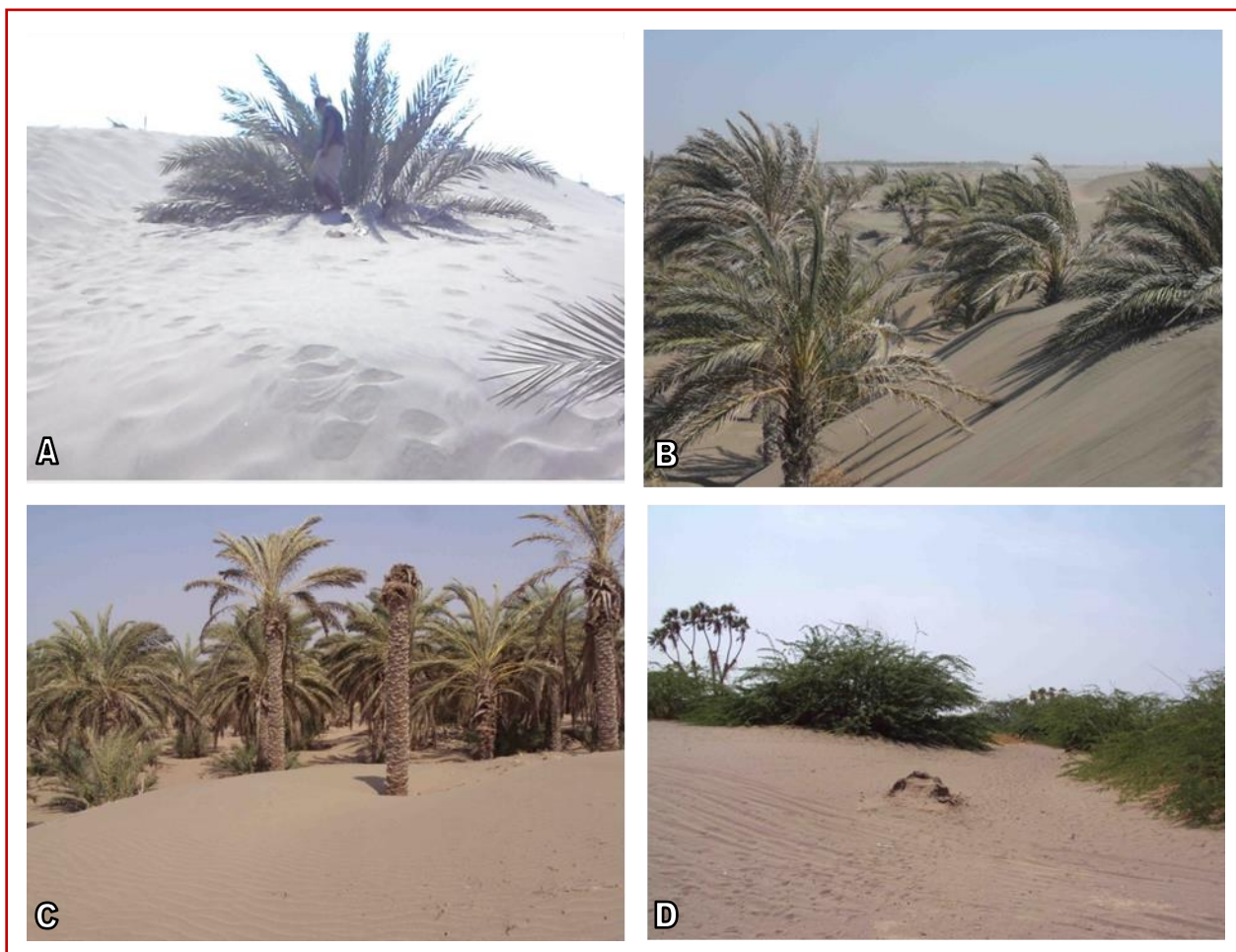


Figure 2.3: photo A: the palm trees in Al-Zakham hamlet completely covered by sand dunes. Photo B: green palm farms being covered by sand dunes. Photo C: the desertification moving towards Al-Mujaylis hamlet, photo D: areas in Al-Tefaf hamlet still not invaded by sand dunes.

People try to stop this disaster by building walls of palm leaves and increasing the height of existing walls, but the sand dunes pass through.

Figure 2.4 shows some of these attempts. People said that the sand dunes come from the Red Sea coast. This may be because of the seasonal wind which moves from Southwest toward Northeast.



Figure 2.4: Some palm leaves belts made by people to stop the sand dunes movements, but it does not succeed.

2.1.7 Scio-economic situation:

According to a key informant, in Al-Mujaylis area, 85% of the people are living in extreme economic poverty and the other 15% living in moderate economic poverty. The houses in the Al-Mujaylis hamlet are straw houses or concrete brick houses. There is a drinking water project there but there is a weakness in the construction of the pipe network.

Regarding social infrastructure there are two schools. Al-Shate school in Al-Mujaylis hamlet, a primary and secondary school, was built in 2009 and Al-Fateh school in Al-Tefaf hamlet, a primary school, was built in 2010. There is also small medical center but it was surrounded by the *Prosopis Juliflora* trees and it has stopped working. The land is owned by the people living on it. After the coast road, which passes West of Al-Mujellies and links Hodeida governorate with Taiz governorate, was constructed and paved the value of the land went up.

Agriculture has been the main source of income for people in Al-Mujaylis but as a result of the deteriorating environmental situation in the region, many have had to look for other work. The lack of rain, falling water tables, drought, sand dune movements and the spread of *Prosopis Juliflora* has impacted heavily on agricultural activity and some people have left the area in search of a better source of income or turned to fishing, working as daily workers, bus drivers or motorcycle driver.

People in the Al-Mujaylis area farm only date palms and some fodder for the animals. In the past, palm farming generated a good income. Production of dates cost 2500 YR per palm tree a year (for watering, weed control, pruning, control of pests and diseases,

pollination, and so forth until it reached the harvesting stage). The trees would each produce 30 kg of fruit which was sold in total for 5000 YR).

Nowadays, the production cost of palm tree agriculture has increased due to harsh natural conditions, and the yeild of the palm trees has gone down to only 5 kg per palm tree per year. Besides this, there are the political and economic conditions which cause difficulties, such as the absence of a marketing policy for palm products, price instability, competition with imported foreign products, and the absence of government support for farmers through loans, marketing or other technical support.

As the groundwater continues to fall, people need to deepen their wells to 40 m to 50 m by rotary drilling to reach to the water. The respondents estimated the cost of rotary drilling with casing to about 1 million YR in addition to the cost of pumping machine, engine, and pipes, which are estimated to cost 250, 350, and 200 thousand YR respectively. One well could irrigate 3000 date palms if it was supported by high efficiency irrigation techniques. The lifespan (depreciation) of a china generator is about two years. With good fruit production and marketing all cost will be covered after one year. As one respondent said: if the government support framers through white loans (loans without interest rates), the farmers will be able to farm their lands and realise profits.

Although the fishing requires substantial structural costs such as a boat, motor, and fishing gear in addition to operating expenses (fuel, workers, etc.) amounting to 2 million YR or more. The daylily fisher generates more income than a palm cultivator during the months suitable for fishing. People tend to work as daily fishers, with 50% of the net sales going to the owner of the boat and the other 50% for themselves. The average daily income of a family working in fishing is about 5000 YR per day. However, in the windy season (three months every year) fishing is difficult and there is no anchorage for large yacht, and the fishermen also suffer from contract given to the large, foreign company, fishing off Yemen's shore.

2.1.8 Migration:

The results of the survey show significant migration from the region to major cities or to the neighbor countries, especially the kingdom of Saudi Arabia and other Arab Gulf countries. Migration started in the 70s and has increased in the recent years. Respondents said that in the 70s around 10% migrated from the area, however according to LRD (1977) around 40% of the working male population left Al-Mujaylis at this time for employment abroad. Recently, around 60% of the total population in Al-Mujaylis have emigrated according to our respondents.

Many of the international emigrants are among the poor who could not adapt to the difficult conditions in the region, but the poorest people stayed in the area or emigrated to neighbor directorates or cities. That is because of the high cost of emigration to neighbor countries. Illegal migration cost about 200,000 YR and legal migration is far more expensive and comes with numerous restrictions. Therefore, many migrants from the area are illegal.

Most migrants are young men from different families; it rarely occurs that all family members migrate. The main reasons for migrating was to look for a better and easier source of income, especially after the deterioration of the environment and economic

situation in the region. Most of the migrants are now in a stable situation which deem better than in the past, and they prefer because of the availability of education, health services, and infrastructure. The agricultural land owned by immigrants is deserted and in some cases it is being covered by sand. A few of them have sold their land, but there is still a link between immigrants and relatives in Al-Mujaylis through communication and sending remittances.

The immigrants do work that does not require experience or certificates, for example guarding buildings, washing cars, driving busses, and daily wage work. Despite the limited income of these occupations, they feel that their situation is better than before. It is worth mentioning that the immigrants have the desire to return to their country or area of origin if all the problems related to water, sand encroachment and support for farmers are solved.

Those who continued to live in the region are those able to adapt to the situation. They have the possibility to dig new wells or deepen existing wells and buy pumps for drought resistance. Some of them have given up farming and started fishing, and some of them have relative immigrants who send the money necessary to help them overcome the harsh conditions and cover their living costs.

2.2 The role of institutions in Al-Mujaylis village:

The latest intervention by the government in the area, according to the respondents, is a project titled Poverty Alleviation and Land Resources Deterioration Reduction. According to the Interim Evaluation Report (IFAD 2003), this project is designed to support poor people in Tihama, consistent with the government's objective of improving the standards of living of the rural population and the Interim Poverty Reduction Strategy Paper. About 47 villages located between the sand plain and flood plain of wadi Siham and wadi Zabid are beneficiaries to this project.

The project's specific objectives are, amongst others, to prevent further encroachment of sand dunes on to farming land and to increase water use efficiency. The project cost was USD 11.7 million with an IFAD loan of USD 9.8 million, the Yemeni Government contributing USD 1.8 million and the UNDP with USD 86 000. The project was implemented by the Tihama Development Authority (TDA). In Al-mujaylis village, five wells were drilled under this project and installed with pumps, engines, and tanks (except one well is without pump and engine) to help form a green belt to stop the sand dunes movements, but most people said that this project was not a success.

The people said that the causes of the failure of this project was first of all that some of these wells were constructed in the areas where there is no drinking water projects to address the far more pressing need of the population. Also, in some places such as Al-Tefaf hamlet, the sand dunes have still not reached the area. Therefore, one well is utilized for the drinking water project after they get permission from TDA. Secondly, an association has been established for this project, but there is no continuous budget for operation and maintenance. The government covered the cost of diesel, laborers to take care of the trees (irrigate them) and guards for one to two years, but after that the support ended. Thirdly, there is no modern irrigation system for the green belts, so it requires more labour and for this there is not enough money. The other wells are still protected by guards and temporarily used for drinking water, but all trees of the green belt have died.

In Al-Mujaylis hamlet, there is a water project construct by General Authority for Rural Water Supply Projects (GARWSP), the TDA, and the Local Council, but there is a weakness in the construction of the pipe network. Currently the network is very small and the water only comes every four days (3 - 4 hours a day) and the pressure is very low. There is a monthly fee for operation and maintenance.

Regarding social infrastructure, there are as mentioned two schools in Al-Mujaylis village: Al-Shate schools in Al-Mujaylis hamlet, a primary and secondary school, built in 2009 by the Social Fund for Development (SFD) to replace the old school, and Al-Fateh school in Al-Tefaf hamlet, a primary school, built in 2010 by the Public works Project (PWP). There is also small medical center but it is surrounded by the Prosopis Juliflora trees, all of its equipment has been stolen and it has stopped working.

2.3 The role of powerful people in the area:

Most people responded that the role of powerful people like parliament representatives, associations representatives, sheikhs, and imams in the area is weak, and everyone acts to maximize their personal benefit. On the other hand, a few people responded that powerful people play a role in solving problems that may arise among people and follow up applications to the government institutions to seek projects to the area even if there is no response from these authorities.

Regarding associations in the study area, there is an association responsible for the Poverty Alleviation and Land Deterioration Reduction Project. Most people said that this association failed because there was no financial support for the operation of the project. Because most people are poor they themselves cannot support the associations. One respondent took a different view and said the association did not have any role and was founded only to be "a decoration" to convince donors to implement projects there.

Powerful people were asked about their role and the solutions for all of the above mentioned problems. The response was that each institution should take their responsibility to enhance the situation. Government related institutions should cooperate and find the weak points in the laws (formal laws or tradition laws) and suggest changes or new laws to be discussed and approved by the parliament.

2.4 The role of women regarding water issues:

The study also included women to learn about their opinions and roles in relation to water issues from their own point of view in addition to what the men said. Most of the interviewed men said that women are responsible only for household work, to bring water from the nearest wells with help from their children, in the cases when the house is not connected the drinking water project or when this project is not functioning. The women do not have a role in any water associations.

The interviewed women had the same opinion regarding water resources problems and the suggested solutions. Poverty, Persopis Juliflora trees, desertification and sand dunes movements, drought, shortage in rainfall were all problems mentioned by the women. Another problem the women brought up concerned education. There is no separate school for the girls in the area and there are no government employees, especially teachers there. Eight women from the area have graduated from high school, but they have not found employment.

Women contribute to the income of the family by producing handicrafts (making ropes for mats and making baskets) and sewing. These products are however sold at very low prices and for some families women lovely forced themselves to spend the many hours to get the least income to share in helping their family. Photos in figure 2.5 shows women in Al-Mujaylis working with handicrafts.



Figure 2.5: A: Group interview with women in Al-Mujaylis. B: Women making baskets.

2.5 The suggested solutions by the community:

People in Al-Mujaylis ranked the solutions to their problems as shown in the solution trees in appendix 3. According to them the solutions were the following:

1. To support farmers with modern irrigation systems as there are no modern irrigation techniques in the area. Also, to give loans without interest rates so they are able to drill rotary wells and farm their lands. In relation to this people said that the role of Cooperative and Agriculture Credit Bank (CAC bank) which in the past is limited to large-scale farmers and power people, now has changed from a cooperative bank to a commercial bank.
2. To combat the Persopis Juliflora trees and desertification.
3. To choose suitable locations for the new construction of water harvesting structures (dams) at the end of wadis to benefit from water which otherwise would flow to the sea. Regarding the previous dams and diversion structures, people said that the government should solve the problems associated with those structures so that all people are served by the management of the water.
4. To implement the water law fairly by regulating well drilling and implementing the legal distance between these wells.

2.6 The links between downstream and upstream areas in wadi Zabid and wadi Rima':

In wadi Zabid, the project to improve the irrigation infrastructure in the 1970s changed the control and flow of water in the valley resulting in what many feel is a disruption of the traditional water rights. While there is a general understanding that the current situation harbors potential difficulties, the changes people are experiencing are perceived differently. On the one hand there is the view that the problem is related to the climate and beyond the control of the individual farmers, on the other hand there is the view that some form of control is needed to stop people from violating the system and others' rights.

2.6.1 Background:

The Tihama, also known as Yemen's breadbasket, was targeted as an area which through improvement could help the country with its food security problems. In the early 70s Yemen was seeing large scale labor migration from the agricultural sector to the Kingdom of Saudi Arabia, and the production of food domestically was not keeping up with population growth (Cohen and Lewis, 1979).

In 1969 the FAO had decided that the best way to improve agricultural production was by improving the irrigation system in the area. A study of wadi Zabid concluded that the best way forward was to build ten diversion dams along the valley which would lead the water into the existing canals, as well as building structures within the system to facilitate the control and distribution of water (Tipton and Kalambach, Inc. 1974, 1). This was the first part of the Tihama Development Project which in all includes five similar projects in different wadis in the Tihama.

A study done by Tipton and Kalambach in 1974 stressed that the current system for water distribution was inefficient and inequitable, and proposed a change in the water allocation. However it was recommended that no land was to be deprived of water to the extent that it could not maintain the same production level as it had had before (Tipton and Kalambach Inc. 1974, 15).

2.6.2 Water rights and water distribution rules:

The management of surface water in Yemen has a long tradition and involves a well-established system of rules (see for example Varisco 1983; Lichtenthäler 2000; Cohen, 1979, 524). There are about 18 different water distribution rules in the wadies (Al-Shaybani, 2003). There is a general rule *Al-a'la fi-l-a'la* giving upper riparian dwellers the primary right to abstract water according to their need. When they have taken what is needed they let the water pass to lower riparian dwellers (Lichtenthäler 2000, 145).

Approximately 600 years ago a sheikh in the area, Ismail Al-Jabarti modified the rule by dividing the area into three, and allocating three different times of the year when each area could irrigate. The flood season (March 29th – October 18th) was divided into three: giving the upper part of the wadi 127 days of water, the middle part 42 days and the lower part 35 days ((Tipton and Kalambach, 1974). The upper part of the wadi was in addition to this allowed to irrigate outside of the flood-season (October 6th – March 15th) as they would have been traditionally. This practice is, according to Tipton and Kalambach, not uncommon and water conflicts were often solved by those living upstream conceding amounts of water or a time allocation of water to the lower riparian dwellers (1974, 12). Interestingly, there is also a provision in the Al-Jabarti rule to allow the remaining five days of the flood period to continue to people further downstream. While this theoretically could mean that the taking further downstream areas into consideration, although it is not part of the three groups, might fit with traditional practices, one must remember two things. Firstly, none of the surface water from wadi Zabid reaches Al-Mujaylis, making the connection far more vague. Secondly, with the current agriculture upstream very rarely is there any water left over.

Before the project, the farmers in the area would collect the flood water by building temporary dikes or diversion structures across the wadi. These would then lead the water into the desired canal of the farmer and from there water could be diverted to the fields (Tipton and Kalambach, Inc. 1974, 4). These structures were made of earth and after a

while they would give way to the pressure of the water. This, in combination with the allocation system explained below, was seen as problematic in the study carried out as it could result in a dike breaking and the farmer losing his share of the water (Tipton and Kalambach, Inc. 1974). There is however another side to this as one of the farmers in our study pointed out. He said that while the new weirs required less labor, they also remained intact instead of breaking and providing those downstream with access to the flood water.

In the study carried out in 1973, the very limited time periods groups 2 and 3 to get the benefit of the water, in addition to the physical features of the valley and the uncertainty of water amount and occurrence, made the system non equitable (Tipton and Kalambach Inc. 1974). In their study they argued that the relative water needs of the different groups meant that while group 2 never received the required amount, group 1 and 3 received more than they required. This because of the gross area irrigated under group 1, 2 and 3 are 4805 ha, 10,175 ha and 1450 ha respectively. (Tipton and Kalambach Inc. 1974, 14)

2.6.3 Changes in traditional water rights:

Wadi Zabid:

In general, there seems to be consensus that the weirs have disrupted the flow of the water. As one respondent said, now 70% of the flood water goes into areas that were originally dry and could not be irrigated before. Previously the main crops in wadi Zabid were sorghum and millet (Tipton and Kalambach, Inc. 1974, 3). Now however, all of the farmers questioned in wadi Zabid said that banana was a main crop. The bananas are extremely profitable but require a lot of water. This brings us to one of the solutions mentioned by several, which was that one should ensure that people only irrigated their crops once.

The absolute majority of people who claimed to be satisfied with the current system saw more rain as the solution to the wadi's water problems. They also blamed dams upstream of the area for decreasing the amount of water to be shared. Those who were unsatisfied on the other hand stressed the need for government control, limited irrigation upstream and education of people as to the consequences of upstream abstraction.

While some saw the weirs as disrupting the whole system of distribution, others saw it as a violation of their right. In wadi Zabid as well as wadi Rima', those who were unsatisfied or recognized that there was dissatisfaction with the current water distribution, often saw 'control' as a solution to the problem. When asked about the changes in water rights, the majority of the respondents named the Al-Jabarti ruling or *Al-a'la fi-l-a'la*, or both, as the current system. It was stressed by most that there was no change in the system per se, rather that the system was being violated. The majority claimed they were satisfied with the current system, and while it was recognized that not everyone else was satisfied, several respondents raised concern of what would happen without the system.

The reality of potential violent conflict was described during an informal interview with an inhabitant of wadi Zabid. He said that two families in the wadi had taken up arms against each other over access to water. There were several casualties and the conflict had escalated. The local sheikh who might otherwise be expected to take on a mediating role was himself involved in the conflict. It was a recurring impression among our respondents, that the sheikhs first and foremost sought to look after their own interests.

The same was true in wadi Rima' where the role of sheikhs and other "effective people" were mentioned as problematic. One respondent informed us that the sheikh of his area was put in charge of a drinking well from a project. The result was, according to the respondent, unfair distribution of water and it ended in the closure of the well. There were however others who mentioned the sheikhs' role as satisfactory and one respondent pointed out that the WUAs in the region anyway had the function of curbing the power of the sheikhs.

While close to all of the respondents in wadi Zabid said that there was no cooperation between them and people downstream, there was some understanding of the problem. Several mentioned that while they themselves were satisfied they were aware that not everyone was, and one respondent pointed out that the system they were following (the Al-Jabarti ruling) was probably made for irrigation of different crops than bananas.

While close to everyone asked in wadi Zabid said that WUAs were active in the region, opinions about their effectiveness varied. There is a general sense that institutions are lacking in the area. Several people in wadi Rima' pointed to the lack of public services like schools and hospitals, and in answer to questions about institutions in the area the most common reply was that they did not exist. Overall there seems to be a sense of neglect. However, several institutions were mentioned as active in the area in response to other questions, and therefore it seems that the term "institution" is understood as more of an outside body as opposed to the local WUAs. Nor were the WUAs perceived to do any of the work expected to be done by "institutions".

The local council was almost without exception said to have no effect in the area. Many bemoaned this and there seemed to be dissatisfaction with the lacking presence of the council. One respondent claimed that the local council only assisted the big farms, while a farmer in wadi Rima' said they were absent from the area except when there was an election. On the other hand, some respondents from wadi Zabid said the local council played a role in solving disputes and following up on projects as well as overseeing the opening of the canal. The local council was however never mentioned specifically as a solution to the problems regarding spate water distribution.

The TDA was only mentioned by two respondents as an institution operating in the area. One of them however said that the role of the TDA, which was within maintenance, had become weak due to the presence of WUAs.

In summary, there is wide recognition that the weirs have caused a disruption to the water flow and a situation that for some is disadvantageous. The solution however, from the point of view of those who are unsatisfied with the current scenario, lies not with the removal of the weirs, but rather the control of people taking advantage of the weirs.

The suggested solutions of water distribution in wadi Zabid:

There were several proposals made by the farmers for the distribution of spate in the wadis. The farmers' opinion and suggestions in wadi Zabid could more or less be divided into four groups:

- 1 - The farmers who were satisfied with the existing rule if it was completely implemented without violations. They felt that if this rule changed, it will cause big conflicts.

- 2- The farmers who suggested that the farmers upstream use the spate for irrigation only once, thereafter letting it pass to the next farm and so on until it reaches the last beneficiary; who that is will depend on the amount of spate. The second spate would then begin from the farmer after the last one to receive the previous spate, and so on.
- 3 - The farmers who said that the problems were because of the rainfall shortage and if there is more rainfall the situation will be better. And finally,
- 4 – The farmers who suggested that the government should make a committee to study the situation and enhance the current rule.

The Irrigation Council representative had suggested a number of enhancements to the current rule. For example redistribution of spate water days, or to decrease the banana farming under a support from the government to compensate the farmers, but some of WUA's representatives did not agree to this.

Wadi Rima':

In wadi Rima', people have a different opinions regarding to the water rights in the wadi. In Al-Jarubah area, farmers and the responsible people about Al-Jarubah state farm suffer from the irrigation improvements that were done by the government in 1983, which is the diversion structure and its canals. They mentioned different opinions from what was mentioned by LRD study (LRD, 1977); they responded that those improvements were done for the power people in the Southern area which leads to change the water rights of the North area to the south area. They said that South area only have water rights from the lower part of the wadi and there was an exaggeration in water rights of the South area which described by the study that done in that time.

The inverted syphoned divided the spate water of the North canal third by two third between North and South canal respectively. After 1990, by the efforts done by the representative of state farm, they success to divide the North canal water half by have between the two side of the wadi.

They also mentioned that TDA improved only the southern area canals by building the diversion gabions structures in the main wadi to divert the water to the southern area. When Transact walk was done, it was noticed that in the southern part of wadi Rima' there is new gabion diversion structure while in the north part it still earth diversion structures as in the photo figure 2.6 .



Figure 2.6: A: the constructed gabions diversion structure in the southern side of wadi Rima'a, and the earth diversion structure in North side of the wadi.

On the other hand some people said that Al-Jarubah state farm change the water rights through Al-Hudayd canal to irrigate the state farm against the rule of the priority for the upstream.

People at Al-Jarubah said, beside the major cause of spate shortage (inverted syphon, and the frequently irrigation in the upstream, rainfall shortage), in the past before 18 years, the situation is better, the base flow continue for 3 to 4 months. After 2000, the situation become worse because of the following:

- 1- Spate water decreased in the north canal, it is only 20 days which not enough for the state farm as well as the spate in the main canal of wadi Rima'. Currently they only irrigate one or two times by earth structure.
- 2- Springs, which flows in the most months of the year, gets dry.
- 3- The illegal spate water abstraction in the upstream,
- 4- In the past there was a cooperative from the responsible person (the manager) of the state farm who irrigated the land of the farmers from the North canal, when he replaced after the year 2000, more restrictions was made to water distributions.
- 5- The rule of government supervision on the water distribution become very weak.
- 6- The government claimed that its own the land where we inherited it one by one from the old time.
- 7- Investors of big farms or state farm who convey the spate water through a canal against the role of priority to the upstream, the water pass by our land to irrigate those big farms.

As a result of the interview that was done with the responsible people of Al-Jarubah state farm, they said that the most land in Al-Jarubah is belong to the government. They added that there is about 362 sharecroppers, the state farm was irrigated first after that the land of sharecroppers.

They said, the problem of spate water or groundwater are because of the change in crops pattern, banana instead of cereals, even if it provides high number of work opportunities, but it has great effect on water resource.

Connecting to downstream, when they people was asked about Al-Mujellis, most of them don't know about it and about the problems there, and few of them said it belong to Zabid.

The suggested solution of water distribution of wadi Rima':

In wadi Rima', most people suggest that the government (through the TDA) should make a committee to study the situation and enhance the current water distribution rules with strong implementation with continuous monitoring.

Other suggestions by the some farmers from wadi Zabid and wadi Rima':

- 1- Al-Zakat giving.
- 2- Distributive justice and law enforcement and to regulate well drilling.
- 3- Supporting farmers with modern irrigation systems.
- 4- Stop the building of harvesting dams in the catchment areas of the wadis and regulate the construction of dams and management of the water in constructed dams As well as choosing more suitable locations for water constructions.
- 5- Reduce the area planted with bananas by cultivating alternative crops which require less water.
- 6- Raise awareness about the water scarcity and the importance of water conservation.
- 7- Forming a committee consisting of government representatives from related sectors such as Ministry of Agriculture and Irrigation, and the Ministry of Water and Environment and the TDA, as well as representatives of farmers from the upstream, middle and downstream areas, and representatives of the local councils for the wadis. In order to control influential sheikhs they should be excluded from such a committee. This committee would discuss the situation seriously and in accordance with regulations which are binding to all, and make decisions which everyone finds satisfying and which are binding for everyone. These results should be monitored and managed by a committee with representatives from all parties concerned.
- 8- Maintaining the status quo, but making sure that the regulations already in place are adhered to and the law implemented.

2.6.4 Changes induced by changing in agriculture practices in the upstream:

In the past and until the beginning of the 70s, spate water was the major source for irrigation in wadi Zabid and wadi Rima'. The spate water was more or less predictable and benefitted almost all the farmers in the wadis. Then, forty years ago, there was change in the spate flow primarily because of lack of rain, and a change in the cropping pattern in the region. Where grain was cultivated in the past, now farmers turned to crops yielding significantly more economically, and requiring large amounts of water for irrigation, such as bananas and mangoes. Photos in figure 2.7 shows the crop pattern change, photo from the right is the banana farms near weir 3 where there is sufficient spate water; the other photo near weir 5, is cereals farms where spate water decreased.

In the upstream areas this led to farmers taking more of the spate water to cover the water needs of their crops at the expense of farmers downstream, in accordance with the Al-a'la fi-l-a'la rule which has been the norm within spate water distribution since ancient times.

The increase in agricultural area and investment upstream also impacted heavily on the water available to farmers downstream. Where the was expanded investments in large mango farms, the building of dams and canals affected the water distribution rights in the wadi as people upstream were controlling the spate water and restricting the access to farmers downstream.



Figure 2.7: Crop Pattern change, photo from the right is banana farms near weir 3 where there is sufficient spate water; the other photo near weir 5 is cereals farms where spate water decreased.

2.6.5 Conflicts and cooperation between people upstream and downstream:

The people in the upper part of wadi Zabid and wadi Rima' are not aware of what happens far downstream. They have many problems among themselves, even between the same canal group, and between the three canal groups in the upper part of wadi Zabid. In the past, before the weirs were constructed and before the banana farming, the people upstream got water by soil diversion structures. When there was a flood the soil structures would break and the water passed downstream. After the concrete weirs were constructed the pressure from the water could be withstood, and there was no such flood reaching the downstream areas of the wadi. Furthermore, between 2004 and 2006 the body of weir 1 and weir 3 (shown in figure 2.8) were raised by one meter because of sediments which had accumulated in front of it. People downstream were unhappy with this, but on the other hand people on both sides of the weirs suffer from the sediment accumulation in front of the weir. So, here a more detailed study will be required to see the relationship between the new height of the weir, the accumulated sediments per year and the satisfactions of farmers downstream and on both sides of the weir with the current rule of spate water distribution.



Figure 2.8: Photos shows the raised body of weir 1 and the current sediments accumulation.

2.6.6 Water conflicts court cases and implementation of court decisions:

In the Al-Mujaylis area there are no conflicts between the people over spate water because no branch of the wadis reaches the area anymore. Only two cases were mentioned during the survey which were related to land ownership. First, one case about land ownership that lead to the killing of one inhabitant of Al-Mujaylis. The other case was between the government and one of Al-Tefaf inhabitant. It was related to the land which was taken by the government for the construction of the coast road between Hodeida and Taiz. According to the landowner the government issued a law which stated that all land covered by sand dunes would fall into government ownership; this case is now in the court for the decision.

In the upper part of wadi Zabid there are daily conflicts over the spate water and many violations of the Al-Jabarti ruling on water distribution rights. Both by farmers upstream in the wadi and between the people in the same canal and between groups. Many of these problems were solved by WUA's or the TDA-SA. One case of strong conflict is

between Al-Mawi on the right side of wadi Zabid with both Al-Ebri and Al-Jarhazi on the left side which is still not solved. As Sheikh Al-Mawi said Al-Ebri and Al-Jarhazi use the spate water in violation of the traditional water rights which gives the priority to Al-Mawi as stated in TDA-SA official letter 2012, in the appx. 8. So far there has been a serious conflict. While Al-Mawi got the court decision in their favour, it is still not implemented despite a second court decision to force the implementation.

2.6.7 The roles of WUA's upstream:

In the upper part of wadi Zabid 16 water user associations (WUAs) exist. These associations enhance the distribution of water among the different canals, and decrease the sheikhs' interventions in addition to solving the conflicts between farmers according to some people said. The disadvantage is that the role of TDA-SA within maintenance has decreased after the WUA's was created.

2.7 The effect of political decisions:

2.7.1 Background:

During the survey, sheikhs, parliament representatives and teachers were interviewed; many issues and problems that the area suffers from were raised and discussed. The biggest of these raised problems is poverty, which forces many people to leave their land and migrate to another area or other countries. They agreed that although the groundwater is not very deep people could not afford the cost to get the groundwater because of poverty, and the absence of the government institutions to subsidize the farmers and fishermen. One of these institutions is the Cooperative and Agriculture Credit Bank (CAC bank) which was set up to perform this function, but has now changed from a cooperative bank to a commercial bank. Other government policies which have had an effect on the farmers and fishermen were also discussed which are described in this section.

2.7.2 Fruit import ban:

This decision was issued in 1985 by the government and has, according to the farmers, had a bad effect on Al-Mujaylis village, where the crop pattern is date palm, but it has had a good effect on the areas upstream in wadi Zabid and Rima' where the crop pattern is banana and. It was said that despite the **fruit import ban**, dates are still imported from neighbouring countries and this pushes the price of local dates down, while increasing the profitability of water consuming crops such as banana which is exported to neighboring countries. Beside that, the **absence of marketing** for the local dates compared with banana crops and the **absence of agriculture farming strategies make the situation worse**. In Al-Tuhitah directorate, there is a government date factory which buys the dates from the farmers and manufactures it to be sold in the market. However, the people suffer from the corruption associated with this factory: the factory's staff buys the dates at (100 to 150YR) a price lower than it supposed to (200YR) and for deferred payment.

2.7.3 Diesel subsidy:

Most farmers agreed that the decrease in the subsidy on diesel price affected them badly, especially small farmers. On the other hand a few of them said that it is now better than the past when the diesel disappeared from the markets to the black market, but they still hope the diesel price will return to the previous level. Few farmers said that if there is no way to subsidize the diesel price, the government should support farmers by for example giving them loans without interest rate, farming machines or pumps, farming strategies to stop the crop price going down like stopping fruit import, and by helping farmers export their crops.

The people and farmers did not agree that raising the diesel price would make them conserve more water. Most of them claimed there were many other ways to make people do this, such as raising awareness, supporting farmers by modern irrigation techniques or use a reward and punishment system. They also pointed out that many farms would suffer losses if they irrigated more than required. However, one farmer said that the increase in diesel prices forced farmers to plant bananas, as it was the only crop which generated enough money for the diesel. Diesel also affects the small-scale fishermen who use small diesel boats. In addition to that, as mentioned, the government's decision to grant foreign companies fishing licences in these waters has affected the fishermen badly.

2.7.4 The construction of the dams:

In the 70s the government encouraged the construction of dams as one method of water conservation, without adequate environmental studies. so many problems appears associated with that dams. People in Al-Mujaylis did not realize what effect the dams and weirs had on the area downstream because their area is locate faraway near the Red Sea coast between the two wadis and there is no direct branch of these wadis to their areas. In the upper part of wadi Zabid near the weirs, people complain from the dams that are constructed in the catchment areas of wadi Zabid, in Ibb and Dhamar governorate. Many of them said that these dams, together with wells with motor pumps, reduced the amount of water that flows to wadi Zabid and to their areas. Many of these dams were constructed for a few powerful people in these mountainous areas in order to irrigate their qat crop. The TDA has raised these problems before the Ministry of Agriculture (see the letter in appx. 9).

2.7.5 The implementation of the law and court decision:

The weak implementation of the laws and of court decisions with the absence of the principle of reward and punishment, encourages water rights violators to continue their practices and has led to an increase in such cases. Therefore, people in the upstream areas have daily conflicts over spate water. Regarding the other government laws such as the water law, one respondent complained that laws were being implemented in Tihama, but not in other governorates, which suffer from critical water resources problems like Sana'a and Sadah.

3. Conclusion:

People in Al-Mujaylis hamlet do not irrigate their land from spate water now or in the past. They depend on the groundwater which used to be very shallow. The water table was at a depth of between 0.5 m to 1 m 50 to 60 years ago. Nowadays, the water table has sunk to 12 m in Al-Mujaylis hamlet and the surrounding areas. The quality of the groundwater has however improved and is better than in the past.

Most people in Al-Mujaylis hamlet responded that they do not have spate water rights because there is not any branch of wadi Zabid and wadi Rema'a in their areas. From the past, they depend on the very shallow groundwater. However, few of them realized that there is an effect on the amount of groundwater recharge in their areas from the spate water shortage in wadi Zabid and wadi Rema'a around the area due to shortage in rainfall and the construction of dams and diversions structures.

People in Al-Mujaylis area depend on agriculture for their income. They farm only date palms and some fodder for the animals. In the past, palm farming generated a good income, but nowadays it does not cover the cost of farming because the groundwater lies deeper and they have to spend more money to deepen their wells and buy modern water lifting technology (pump and generator). Furthermore, the fruit import ban, which was issued in 1985 has not been implemented for date import which is still heavy from Saudi Arabia. Besides that, there are some associations which support the import of dates cost free, on some Islamic occasions like Ramadan. In addition to this the change in diesel price also affects them and there is no support for the farmers in the area: There are no activities for GWSCP or for NIP or any organizations, and the CAC bank has now changed from an agriculture cooperative bank to a trading bank.

Many people in the area are satisfied with the current traditional water rights in wadi Zabid set down by sheikh Al-Jabarti, because they do not want any violent conflicts, but they are against changes to the rule. There are primarily five changes: Firstly, an increase in banana crop farming instead of cereal crops upstream in wadi Zabid which requires more water as well as irrigation every 15 days with twelve to eighteen crops a year. Secondly, the diversion structures represent a strong control of the water compared to the old earthen dikes, and so does the raising of weirs which decreased the floodwater that goes downstream. Thirdly, repeated violations of the existing rule by some farmers coupled with the weak implementation of the law and court decisions. Fourthly, the construction of dams in the mountain areas of wadi Zabid which decrease the amount of water that reaches to middle stream and downstream of the wadis.

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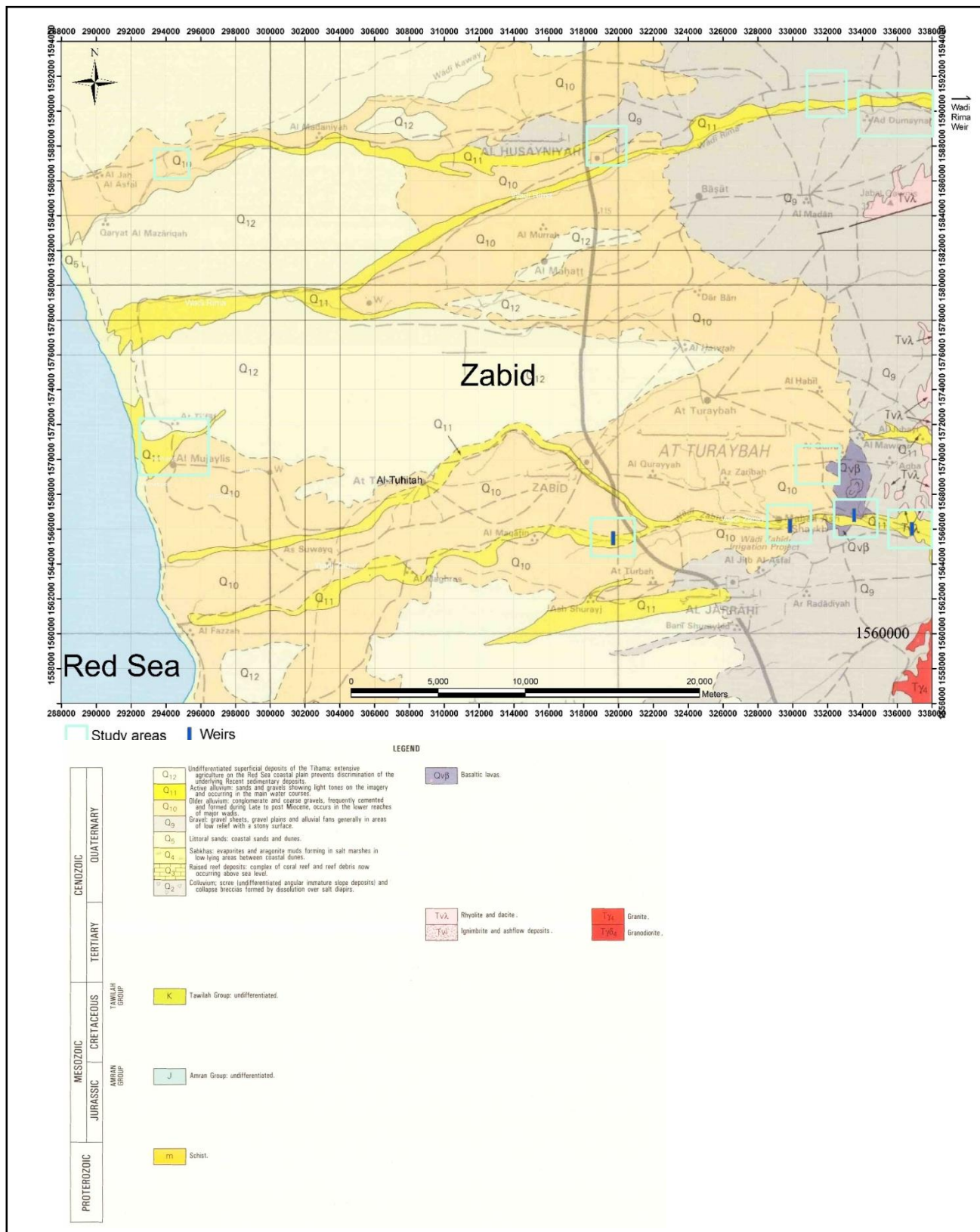
Varisco, Daniel M., 1983, Sayl and Ghayl: The Ecology of Water Allocation in Yemen, *Human Ecology*, Vol. 11, No. 4 (December): 365-383.

6. Appendixes:

It will included in the separate document because the size is big.

6. Appendices:

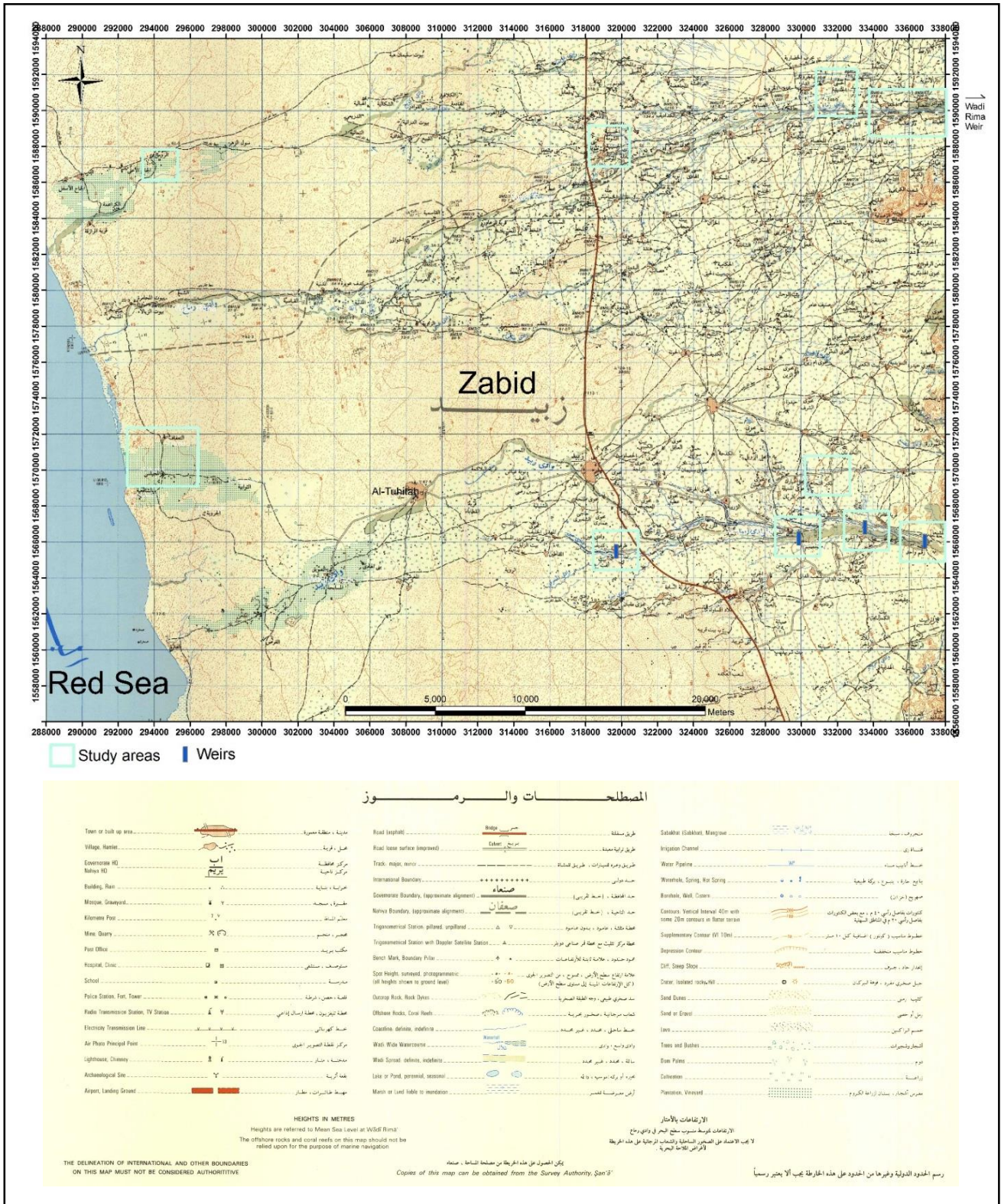
Appendix 1: geologic map of the study areas, part of Hodydah sheet no. 14F (1:250,000), Robertson Group, 1991.



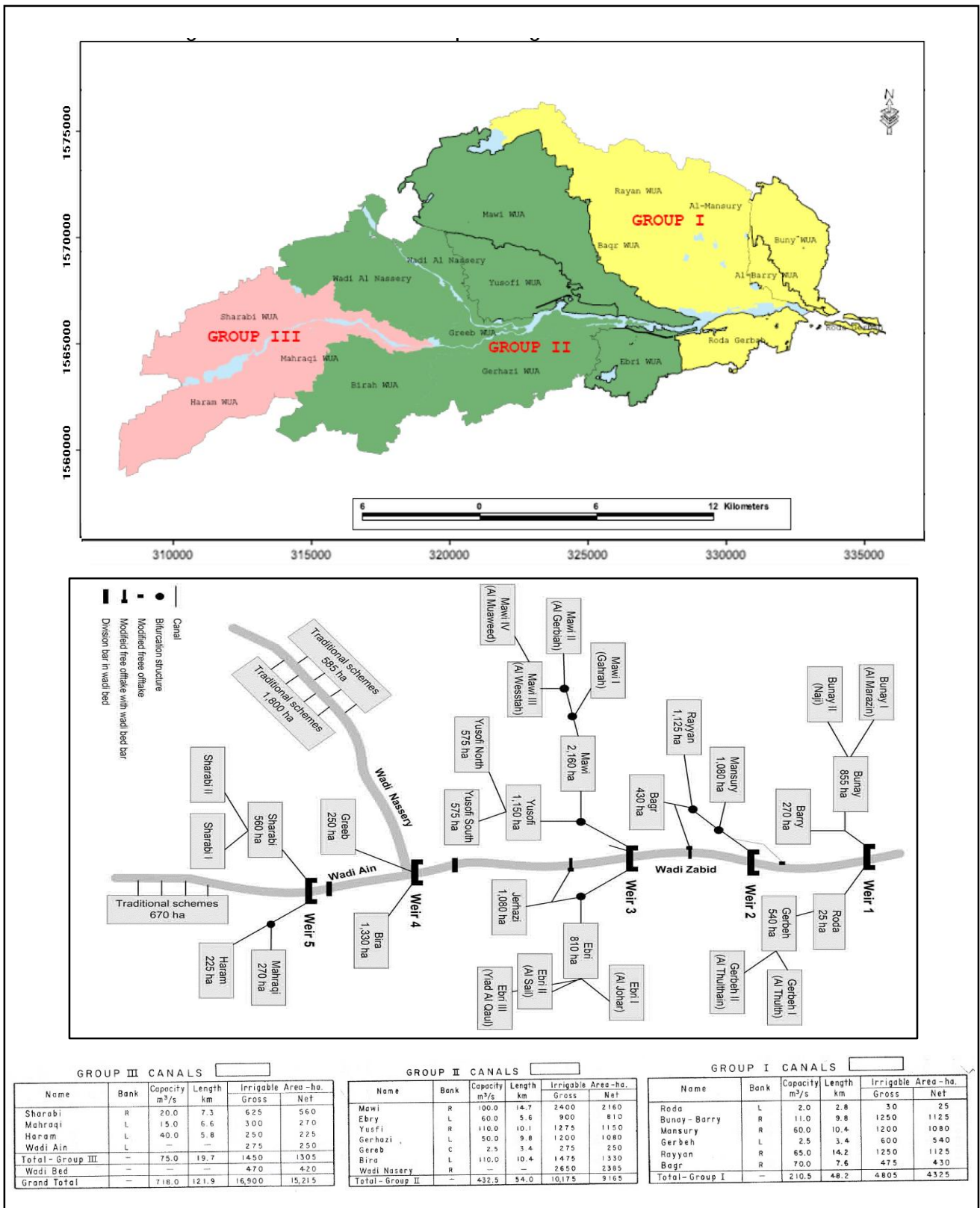
Appendix 2: The population of Al-Mujaylis village distributed in its hamlets

Directorate	Privacy	Village City	Hamlet	Number of building	No. of families	Male	Female	Total
Al-Tuहितah	Al-Karashiah Al-Sufia	Al-Mujaylis	Al-Mujaylis	70	67	186	187	373
			Al-Zakham	22	22	74	51	125
			Al-Hariah	53	53	173	163	336
			Al-Shafeeiah	20	20	62	51	113
			Al-Sahel	130	129	326	350	676
			Bani Bukash	8	8	20	16	36
			Al-Garubah	41	41	111	106	217
			Al-Thwabiah	22	22	49	52	101
			Al-Tefaf	166	125	280	275	555
			Al-Mfger	22	22	47	63	110
Total in Al-Mujaylis Village				554	509	1328	1314	2642

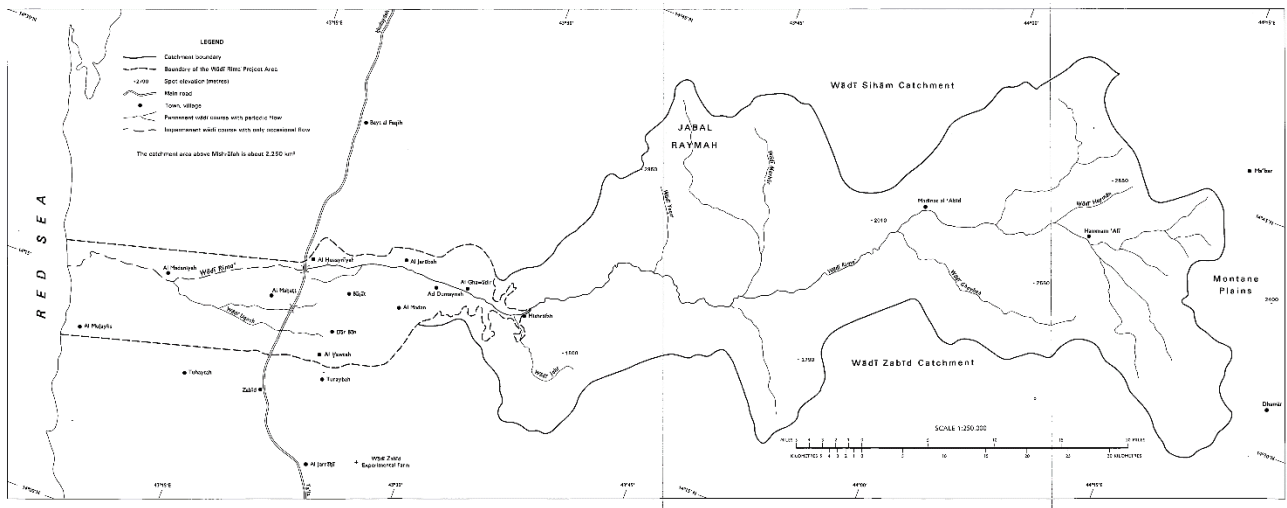
Appendix 3: topographic map shows the location of the study areas and the diversion structures, part of Zabid sheet no. D38-39 (1:100,000), SA, 1986.



Appendix 4: Water allocation of wadi Zabid within the three groups in the upper part of wadi (Tipton, et al, 1975) and (IIP, 2005).



Appendix 5: wadi Rima' (LRD, 1979)



Appendix 6: PRA in Al-Mujaylis:

Time line at Al-Mujaylis:

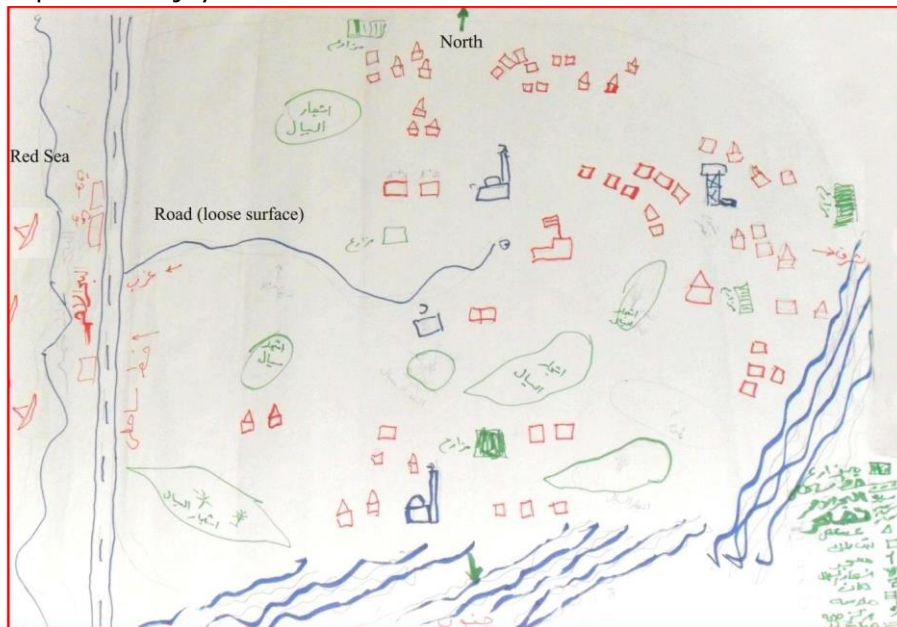
Time	Spat water	Agriculture activities			Groundwater status			Des.	Imm.
		Area	C.T	Yield	Total Depth	W.L	W.Q		
1962	Floods comes from the heavy rainfall around the area	All agriculture lands	Palm	100%	0.5m No drilling till 1975	Near the surface till (<0.5m)	Fresh	Non	Non
1979	Same as above	All agriculture 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

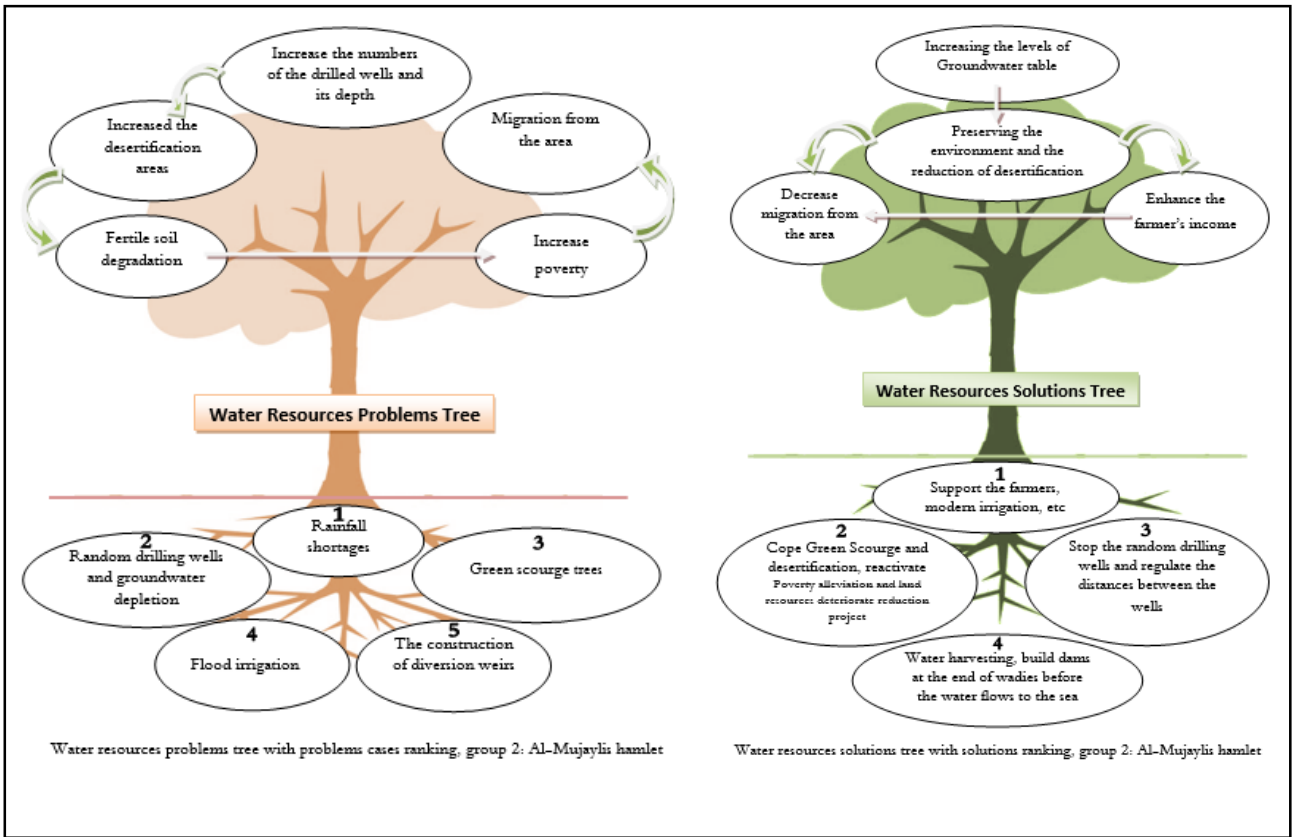
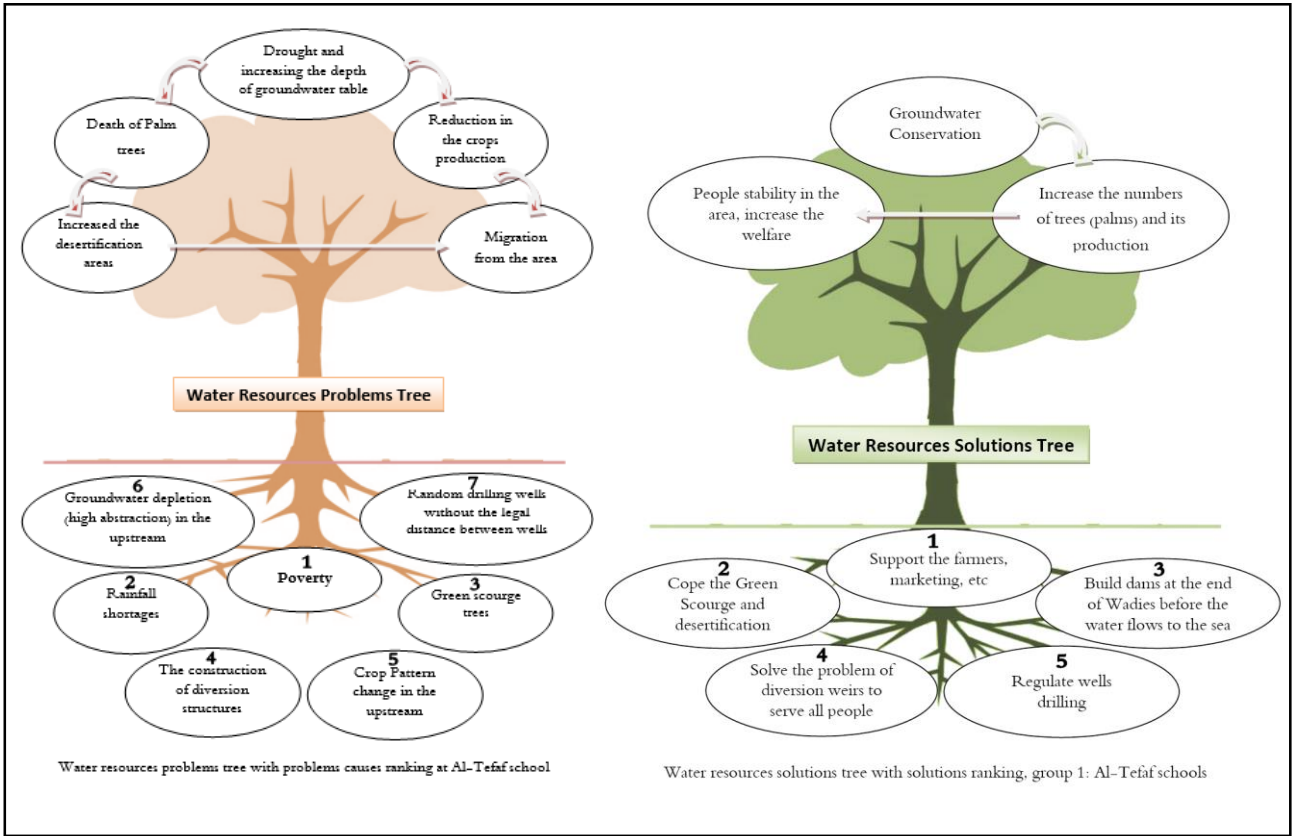
- Daily calendar at Al-Mujaylis:

Career	Time (hr) and daily activities				
	5:00 AM- 6:00 AM	6:00 AM- 9:00 AM	10:00AM- 12:00 AM	1:00 PM - 3:00 PM	3:00 PM- 6:00 PM
Farmer	Dawn Prayer	Farm work	Shopping	Rest	Chewing Qat
Employer or worker	Dawn Prayer	Go to the work	At work	Rest	Chewing Qat
Jobless	Don't do anything				
Fisherman	Go to the sea for fishing in the fishing seasons				

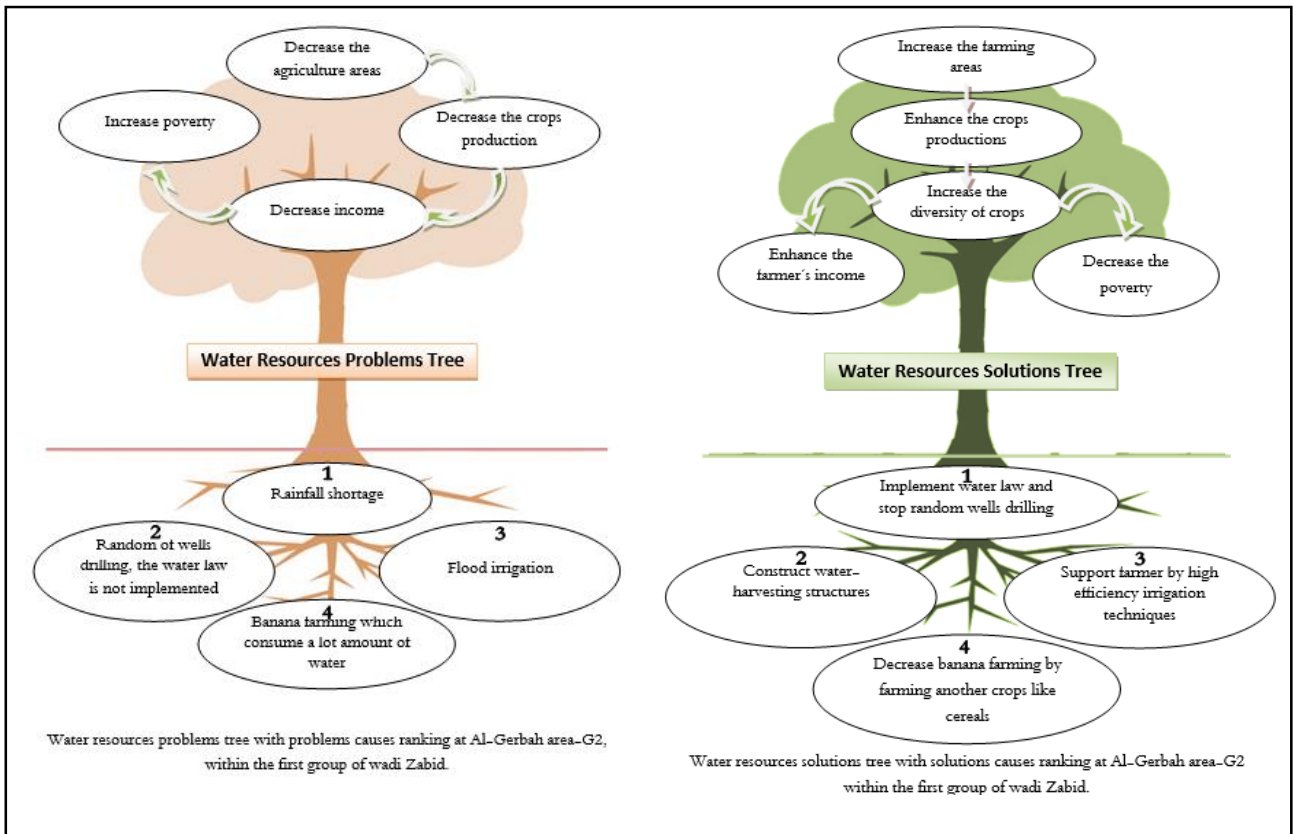
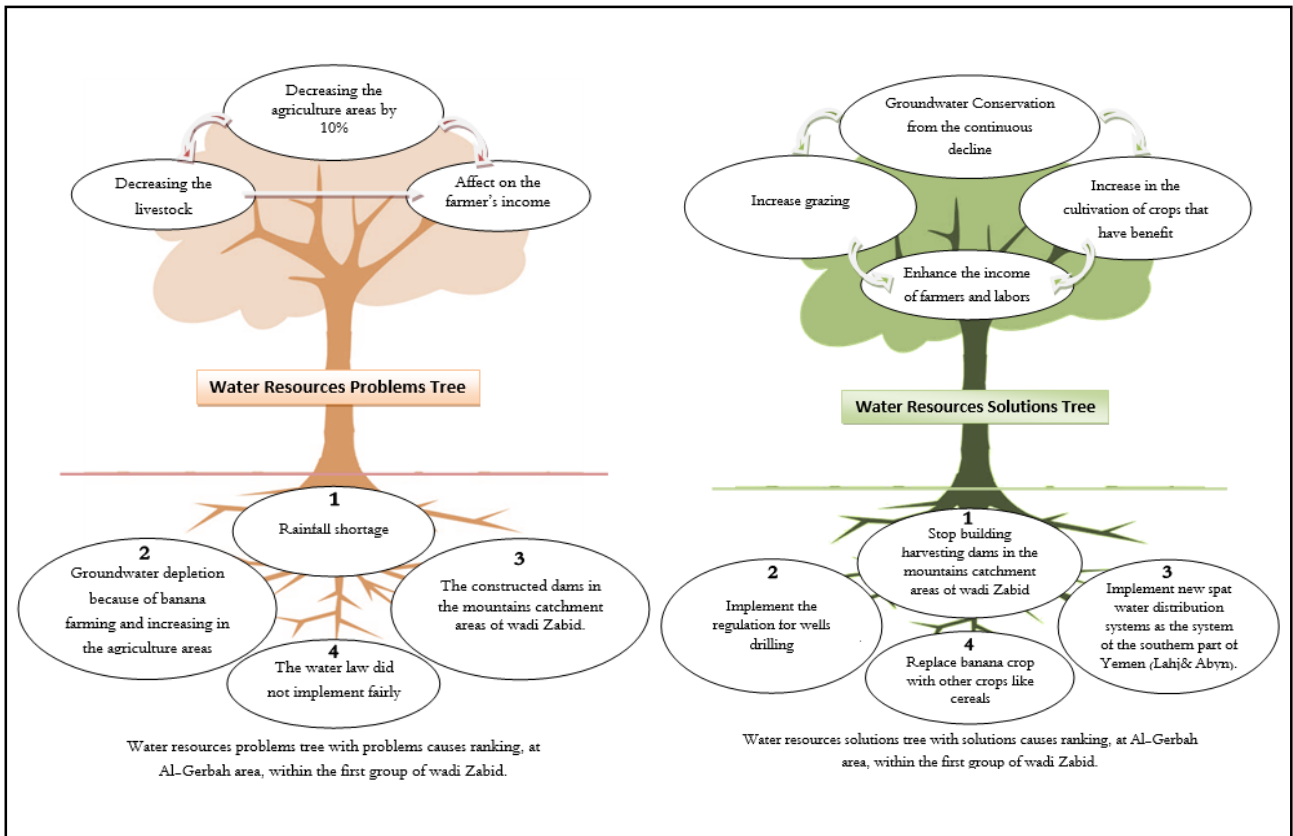
Resources map of Al-Mujaylis:

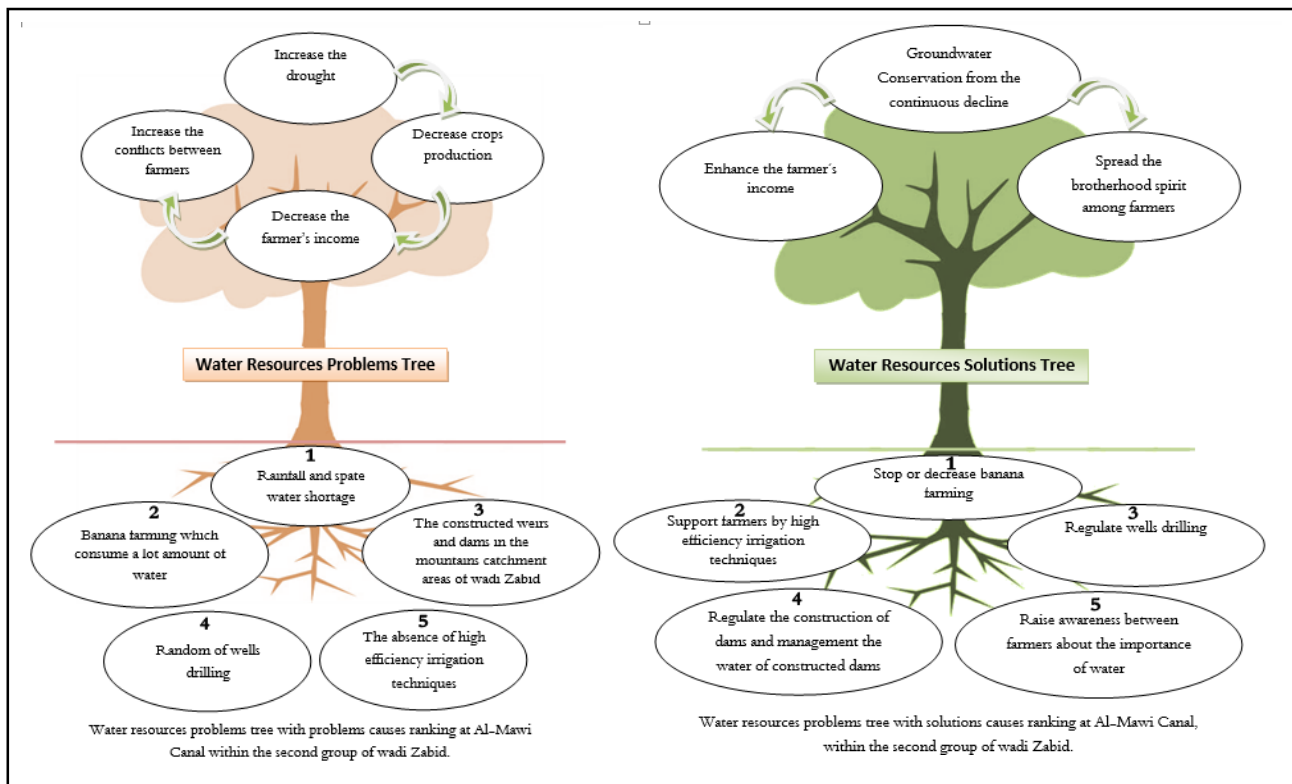


-  Farms
-  Desertification
-  Clinic
-  Houses (concrete brick)
-  Road
-  Green scourage trees
-  Drinking water project
-  Masjed
-  Houses (straw)
-  School



PRA in wadi Zabid:





- Time line at Al-Mawi area within the second group of wadi Zabid

Time	Spat water	Agriculture activities			Groundwater status			Des.	Imm.
		Area	C.T	Yield	Depth	W.L	W.Q		
1962	2- 3 flood per day enough and exceed the canal requirements	All agriculture lands	Corn, Mize, Millet, Sorghum	One maad of farming land gives 480kg	No wells	Springs and wet land	Fresh	No desertification or sand dunes movements	No immigration related to water and agriculture activities
1980	5-6 flood per 40 day	All agriculture lands	Corn, Mize, Millet, Sorghum	One maad of farming land gives 480kg	18	15	Fresh		
1990	The spate not exceed the requirements of the canal within the 40 days after that it flows downstream	All agriculture lands	Start of banana farming	Half of the crop productivity of 1980	22	20	Fresh		
2000	Drought (decrease in rainfall and spare water)	1 3 land was drought, 1 3 was banana farming, and 1 3 was cereals	Banana and Sorghum	Fourth of the crop productivity of 1980	33	30	Fresh		
2011	The worst drought	Only 1 2 of lands was farming	80% Banana	Fourth of the crop productivity of 1980	70	50	Fresh		

C.T= Crop type, W.L= water level, W.Q= water quality, Des.= Desertification, Imm.= Immigration
1 Maad= Is an area measurements unit used in Tihama and equal 3600m²

- Daily calendar at Al-Mawi area within the second group of wadi Zabid

Gender	Time (hr) and daily activities					
	5:00 AM-6:00 AM	6:00 AM-9:00 AM	9:00 AM-12:00 AM	1:00 PM -3:00 PM	3:00 PM-6:00 PM	6:00 PM-9:00 PM
Men (farmer)	Pray	Bring the requirements for breakfast and bring the animal feeding	Farm work	Lunch and chewing qat	Chewing qat	Pray and dinner and little qat after that go sleeping
Women*	Pray	Corral work and prepare the breakfast	House work	Lunch and corral clean	Sitting with women	Pray and dinner and after that go sleeping

* This is from the men point of view (the respondents is a men).

* The women do not have a role in agriculture activities except in seasonal crops harvesting season.

PRA in wadi Rima':

Time line at Al-Aukidah village, Al-Gafariah directorate, upstream of wadi Rima, near the weir

Time	Spat water	Agriculture activities			Groundwater status	
		Area	C.T	Yield	W.L	W.Q
<1982	The spate water flows and caused damage	Small area	Cereals, mango, banana	Small area	8-10	good
>1982	The weir and canal was constructed, it regulate spate water and leads to the benefit of the farmers	increased	Cereals, mango, banana	increased	18	good
2004- 2006	The spate water still flow	increased	Cereals, mango, banana with enhancement	increased	The drinking water project stopped and maintained by the community	
2009	The spate water still flow	increased	Cereals, mango, banana with enhancement	increased	Operate	
2012	The spate water still flow	increased	Cereals, mango, banana with enhancement	increased	The drinking water stopped by power people	

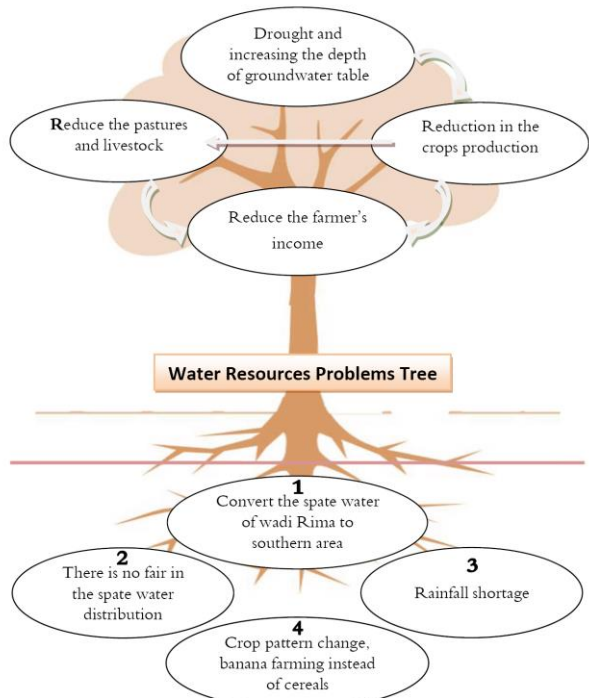
C.T= Crop type, W.L= water level, W.Q= water quality

The people in this area do not have any problems in the spate water. They have problem regarding to the drinking water project.

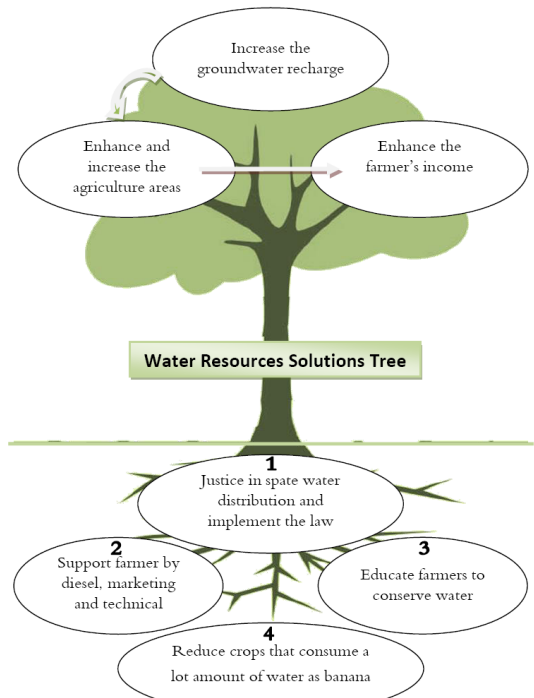
Resources map of upstream of wadi Rima':



	House (Ston)		Meas		Mango crop		Panana crop
	House (concrete brick)		Road		deviation construction		Main canal

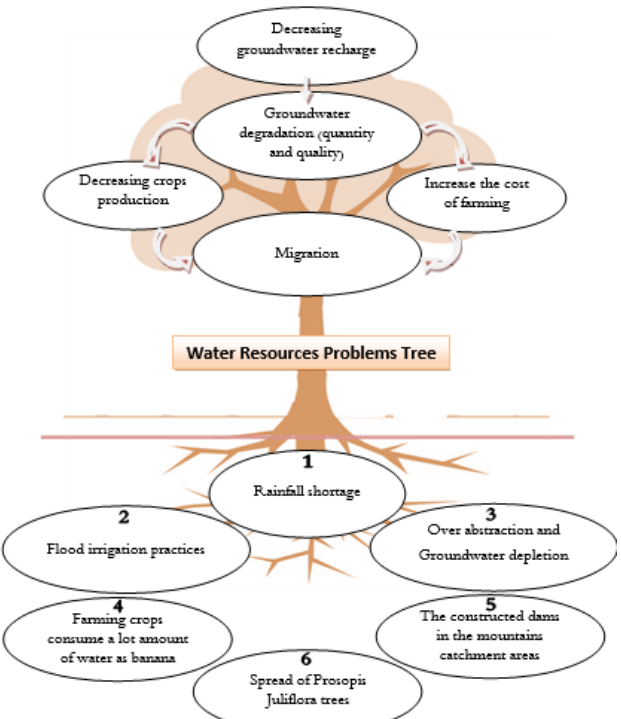


Water resources problems tree with problems causes ranking at Al-Jarubah area, wadi Rima.

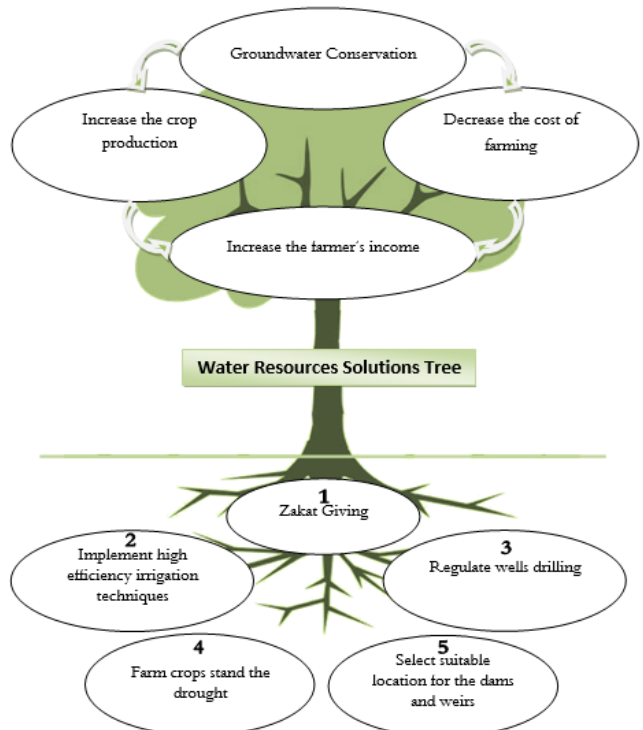


Water resources solutions tree with solutions ranking at Al-Jarubah area, wadi Rima.

- Al-Gah is located North of wadi Rima', eight km

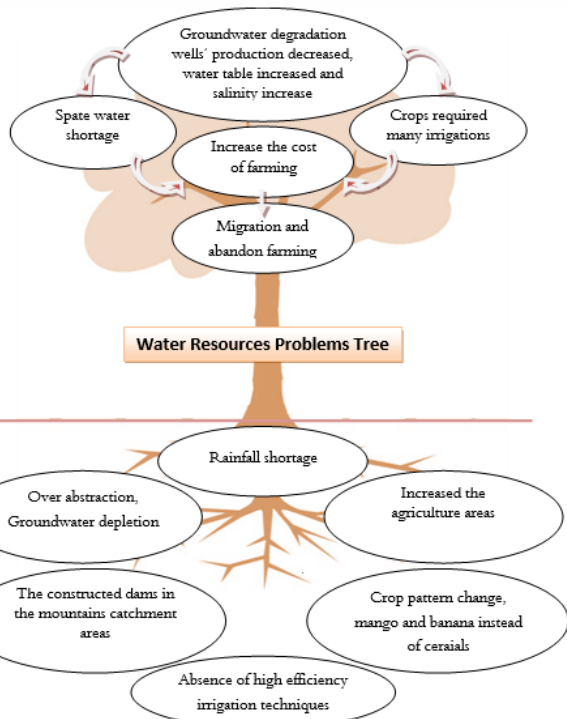


Water resources problems tree with problems causes ranking, at Al-Gah, wadi Rima, group 1

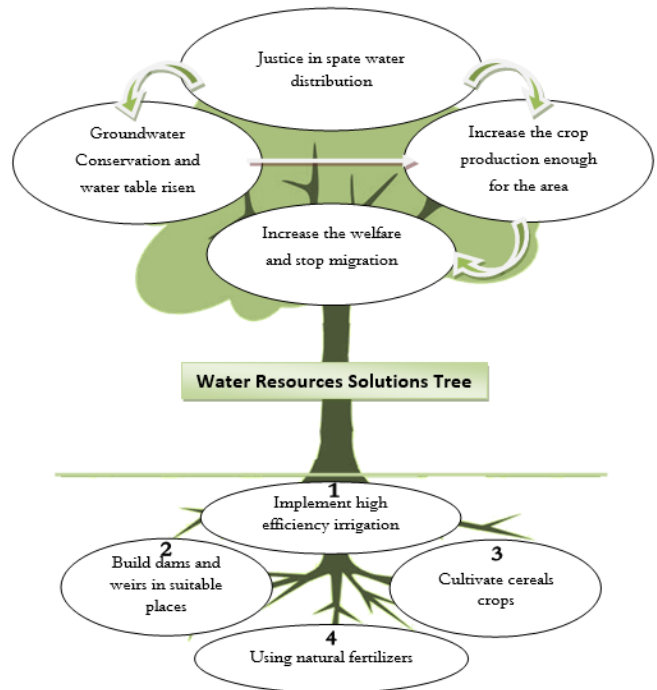


Water resources solutions tree with solutions ranking, at Al-Gah, wadi Rima, group 1

- Al-Gah is located North of wadi Rima', eight km



Water resources problems tree, at Al-Gah, wadi Rima, group2



Water resources solutions tree with solutions ranking, at Al-Gah, wadi Rima, group2

Appendix 7: PRA in Al-Mujaylis Rainfall: Monthly rainfall, 1975-7, at stations on the mountain plains, mm (Figures in brackets contain an element of uncertainty greater than normal) (LRD, 1980)

	1975												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Dhaf	-	-	-	-	7	2	89	175	39	0	0	0	(490)
Rizwa	-	-	-	-	15	34	110	114	39	0	0	13	(537)
Dawran	0	12	80	120	0	42	99	(367)	(155)	0	0	0	(875)
Ma'bar	0	4	62	112	2	9	61	192	13	0	0	0	(455)
Al-Darb	-	-	-	-	0	0	82	180	74	0	0	0	(514)
Dhamar	-	-	-	-	40	2	102	227	50	0	0	0	(599)
Maram	-	-	-	-	-	-	62	211	38	0	0	0	(439)
Samah-al-Ulya	-	-	-	-	7	6	52	183	118	0	0	2	(487)
Sanaban	-	-	-	-	-	-	106	178	31	0	0	0	(434)
Al-Shagab	-	-	-	-	6	18	53	237	90	0	0	11	(534)
Al-Husayn	-	-	-	-	3	9	105	244	42	0	0	0	(522)
Rabat	(0)	(0)	36	83	23	6	139	221	73	0	2	16	(599)
Shahsan	-	-	-	-	7	7	171	289	109	0	0	36	(738)

	1976												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Dhaf	0	15	93	43	40	2	27	52	-	-	-	-	(309)
Rizwa	0	14	111	38	79	9	45	83	0	0	70	0	449
Dawran	-	-	-	-	-	33	46	141	0	0	(104)	0	-
Ma'bar	0	16	90	62	36	3	46	66	0	0	37	0	356
Dhamar	0	3	57	140	48	6	50	106	0	5	53	0	468
Maram	0	3	53	70	47	0	23	49	0	0	32	0	277
Samah-al-Ulya	0	13	21	36	56	0	62	25	0	0	36	0	249
Sanaban	0	2	38	89	37	2	28	18	0	6	0	0	220
Al-Shagab	0	7	31	59	56	6	17	12	0	0	32	0	220
Rada	-	-	-	-	-	1	17	19	0	0	0	0	-
Rabat	0	7	60	106	108	5	46	127	25	0	45	0	529

	1977												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rizwa	13	0	72	71	197	30	0	59	14	114	0	0	570
Dawran	8	1	91	46	140	11	40	86	0	170	0	0	593
Ma'bar	8	0	13	9	78	0	13	33	6	116	0	0	276
Dhamar	15	9	39	45	170	0	25	138	0	116	0	0	557
Maram	11	0	24	26	114	9	15	105	0	88	0	0	392
Samah-al-Ulya	11	0	11	42	88	0	0	122	11	114	0	0	399
Sanaban	0	0	0	20	92	0	0	105	0	131	0	0	348
Al-Shagab	0	0	25	7	48	10	17	37	3	94	0	0	241
Rada	10	0	0	21	40	0	0	33	0	31	0	0	135
Rabat	18	29	42	137	80	59	26	149	33	106	2	25	706

Climatic data from Al-Jarubah (wadi Rima), 2 years means, 1975, 6 (LRD, 1977)

Parameter		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual mean	Annual total
Sunshine hr/day	Record n	7.4	7.0	6.6	7.7	8.5	7.5	5.6	6.1	6.9	8.5	8.6	7.8	7.4	
	Possible N	11.3	11.7	12.1	12.5	12.8	13.0	13.0	12.6	12.2	11.8	11.4	11.3		
	n/N	66	60	55	62	67	58	43	48	57	70	76	70	61	
Temperature C°	Mean max	32.0	32.5	35.0	37.0	38.2	39.7	39.2	37.1	36.9	35.8	34.0	22.8	35.9	
	Mean min	18.0	20.4	21.3	22.7	24.8	26.3	26.8	25.1	24.9	22.7	21.0	18.5	22.7	
	Mean= (max+min)/2	25.0	26.5	28.2	29.9	31.5	33.0	33.0	31.1	30.9	29.3	27.5	25.7	29.3	
Mean dew point C°	17.8	19.5	19.8	19.8	21.6	21.0	20.2	22.0	22.6	21.2	19.3	18.2	20.3		
Wind run, km/day	176	182	201	219	195	209	235	200	159	137	141	161	185		
Evaporation mm/month (Penmen Eo)	172	175	210	235	255	249	242	228	211	206	176	162	210		
Evaporation mm/month (Class A pan)	203	186	243	303	375	370	367	291	262	243	210	220	273		
Rainfall mm/month	10	5	6	42	42	22	47	182	92	49	21	0		518	

Rainfall station records in Zabid W.R.M.D (NERA, 2009)

Stations	UTM-East	UTM-North	Mean annual rainfall (mm)
Al Mahat	316625	1581596	199.9
Zabid	321929	1568649	209.3
Al khmah	330986	1577807	288.3
Yarim	433489	1581012	330.4
Basat	323844	1585232	359.9
Al Duminah	331061	1588870	361.2
Wadi Al har	417390	1605026	376.2
Najd Alhadad	415607	1608718	380.5
Al Sinam	420994	1608700	386.1
Al jarubah	330899	1564899	398.8
Al masna'ah	415645	1619780	416.4
Al Mishrafah	345441	1588777	417.6
Hamam Ali	408465	1619806	488.1
Al GhaWadir	338251	1588823	521.5
Gabal Alshark	388712	1618044	532.2
Al dalil	411846	1560801	711.1
Ibb	411795	1546053	909.3
Al Odien	400979	1542405	948.9

Wadi Rima Catchment Area

SI No	Name of Station	Station Code	Data Available	Average Annual Rainfall
1..	Basat	8.01	1982 -2002	392.0mm
2.	Dimnah	8.03	1982 – 2002	354.8mm
3.	Al Gawadir	8.04	1982 -2002	522.7mm
4.	Qirnah	8.05	1982 – 2002	332.4mm
5.	Hammam Ali	8.06	1982 – 2002	460.7mm
6.	Madinat As Shark	8.10	1982 – 2002	551.0mm
7.	Al Mahatt	8.11	1982 – 2002	186.6mm
8.	Al Masna'ah	8.12	1982 – 2002	393.1mm
9.	Al Mishrafh	8.13	1982 – 2002	392.3mm
10.	Nagd Al Hadad	8.14	1982 – 2002	397.2mm
11.	Al Qahmah	8.15	1982 – 2002	286.6mm
12.	Al Saman	8.17	1982 – 2002	407.7mm

Source: TDA Met. Dept

Appendix 8:

This letter is from TDA-SB to the TDA head quarter, on 1st September, 2012. Stated about the violations of Al-Jabarti Traditional water rights from Al-Abri and Al-Jrahzi and the continuous daily conflicts. It suggested raising these problems to governor of Hodeida.



الأخ الدكتور/ رئيس مجلس إدارة الهيئة
الأخ/ مدير إدارة الصيانة والتشغيل

تحية طيبة وبعد :-

الموضوع: الإشكاليات المتجددة يومياً بين مزارعي قناة الماوي الضفة الشمالية الحاجز رقم ٣ ومزارعي قناة العبري الجهرزي الضفة الجنوبية

إشارة إلى الموضوع أعلاه ونظراً لتجدد الخلاف وارتفاع حدة النزاع بين مزارعي القنوات المذكورة ورغم كل محاولاتنا في ضرورة التزام الجميع بالعرف والعادات المتوارثة والمنظمة لحقوق المائية في وادي زبيد على مدى ما يقارب شهر كامل إلا أنه وللأسف الشديد لاحظنا تمتع وعدم التزام مزارعي العبري والجهرزي بما كان معمولاً به منذ زمن بعيد في توزيع الحقوق المائية وكان آخر ما تم التوصل إليه خروج الأخوة مدير عام مديرية زبيد ومدير عام مديرية الجراحي صباح أمس الجمعة ٢٠١٢/٨/٢٦ بحيث حضر أثنان من المزارعين عن مزارعي العبري والجهرزي وأثنان عن مزارعي قناة الماوي بحضور مدير المنطقة ورئيس قسم الصيانة لعمل العمل المناسب وفي إطار العرف المنظم لذلك.

وتكثرت لاحظنا حضور مدراء المديرية وأثنان عن مزارعي قناة الماوي فقط بينما كان هناك جمع كبير من قبل مزارعي العبري والجهرزي الأمر الذي أعاق عمل ومهمة الأخوة مدراء المديرية بسبب الهرج والمرج الكثير من قبل أولئك الجمع من مزارعي العبري والجهرزي الغير مبرر.

الحقيقة أن هناك من يعمل على إثارة الفتنة بين المزارعين ومعاونة الخروج على العرف الذي كان ولا يزال سائداً في توزيع الحقوق المائية بوادي زبيد وهذه سابقة خطيرة وضير بأثمة ستكون عواقبها وخيمة على الجميع الأمر الذي يتطلب ضرورة سرعة طرح المشكلة على الأخ محافظ المحافظة لاتخاذ الإجراءات اللازمة بها يكفل ويضمن حق وحصول الجميع على المياه بحسب العرف والعادات والمنظم المنظمة للمياه في وادي زبيد منذ أكثر من سبعين عاماً قبل اتساع دائرة الشقوق والاعتداءات على حقوق الآخرين الذي سيؤدي بدوره إلى ردة فعل غير محبوبة النتائج والعواقب سيكثرت حينها من الصعب السيطرة على الأمور وسيفرق كل من في سفينة وادي زبيد الذي يقودها فضيلة الشيخ الصالح إسماعيل الجبرتي رحمه الله تعالى منذ أكثر من سبعة قرون مع العلم بأن جميع أراضي العبري قد استكمل ردها وتم إزال الماء إلى الجهرزي في غير مستحقة وهناك شرح هي المستحقة لتلك المياه حسب الأعراف والعادات المتبعة.

نرجو وضع حل عاجل وسريع وملزم للجميع بهذا العرف القائم أساساً على نظام الأعلى فالأعلى (الأعلى فالذي يليه).

هذا ما نلزم دفعه إليكم يرجى التكرم شاكرين بالاطلاع والتوجيه بها يلزم.

وتفضلوا بقبول فائق التحية والتقدير!!!

مدير المنطقة الجنوبية
عبدالباسط حسن الشميري


رئيس قسم الصيانة

م/ أحمد عبيد الله العنبري

Appendix 9:

This letter is from TDA head quarter to the Minister of Agriculture and Irrigation, on 2012. Titled "Reduce the expansion in constructing big storage dams in the catchment areas (drainage areas) for Tihama's wadies. The chairman of TDA mentioned that there were many complaints from the Tihama's farmers suffering from the continuous reduction of spate water because of the intersects of spate water in the catchment areas by the constructed dams. It was asked from MAI to stop the related authorities of building these storage dams.

REPUBLIC OF YEMEN
MINISTRY OF AGRICULTURE
AND IRRIGATION
TIHAMA DEVELOPMENT AUTHORITY
HODEIDAH



الجمهورية اليمنية
وزارة الزراعة والري
الهيئة العامة لتطوير تهامة
الحديدة

Our Ref : _____
Date : _____

إشارتنا : _____
التاريخ : _____

**معالي وزير الزراعة والري
الأخوة / أعضاء مجلس الإدارة**

بعد التحية،،،،،

**الموضوع : الحد من التوسع والانتشار في إنشاء العديد من السدود
التخزينية الكبيرة في مناطق المصبات والأحواض المائية
(الروافد الطبيعية الموسمية) لوديان تهامة الرئيسية**

إشارة إلى الموضوع أعلاه فإن الهيئة تلقت العديد من الشكاوي من المزارعين بهامة حول التناقص المتزايد في حجم وكمية مياه السيول الموسمية المتدفقة عبر الوديان الرئيسية والفرعية مقارنة بالمواسم للسنوات السابقة معللين ذلك إلى بناء العديد من السدود التخزينية الكبيرة وحجز المياه في مناطق أحواض الوديان والتي أخرها سد وادي الجنات الجاري تنفيذه في سائلة وادي الجنات شمال منطقة الدليل محافظة أب . كما يجري حالياً الإعداد لتنفيذ أعداد أخرى من تلك السدود في مناطق عديدة .

علماً بأن المنحدرات الجبلية القريبة وأجزاء في وسط وعمق الهضبة الجبلية الوسطى ومناطق الأحواض المائية تعتبر روافد مائية طبيعية ورئيسية لسهول تهامة وعلى مر التاريخ ، الأمر الذي يستوجب ضرورة إيجاد تنسيق دائم ومباشر مع الهيئة قبل الشروع في تنفيذ عمل أي سدود مائية تخزينية في المناطق الجبلية البعيدة والقريبة التي تنساب مياهها الموسمية إلى الأراضي الزراعية في سهل تهامة والتي توفر لليمن ما نسبته ٣٠-٤٠% من إجمالي المحاصيل الغذائية والثروة الحيوانية للجمهورية اليمنية .

هذا ما لزم الرفع به إليكم . وحتى يتم التنسيق برحى التكرم بالتوجيه إلى الجهات المختصة بإيقاف تنفيذ هذه الأعمال الأخيرة حتى يتبين عدم أضرارها بالحقوق المائية للمستفيدين في سهل تهامة .

يرجى التكرم بالاطلاع واتخاذ الإجراءات اللازمة لما فيه المصلحة العامة .

وتقبلوا وافر التحية والتقدير ،،،،،

رئيس مجلس الإدارة
د. عبدالسلام إبراهيم الطيب

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