Estimation of the Operation and Maintenance Expenditures for Spate Irrigation Systems

(Case Studies from Wadis Zabid, Rima, Abyan, and Tuban- Republic of Yemen)

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1.0) Introduction

During the past two decades, the Government of Yemen, represented by the Ministry of Agriculture & Irrigation (MAI), and with extensive donor support, has developed and improved spate irrigation systems including construction of diversion weirs, irrigation structures and canal headworks throughout the country and mainly in coastal plains of the northern and southern governorates. On the other hand, some 120 small dams have been constructed mainly in the northern and western governorates under the dam construction program executed by the General Directorate of Irrigation (GDI) of the MAI.

Now, the government, represented by MAI, does not have the resources to operate and maintain these schemes. This situation has led to deterioration of the spate irrigation systems with dwindling water distribution and hence agricultural production. Also the systems are increasingly vulnerable to damage by flash floods in the wadis. There are also problems regarding small dams whereby most of their designs were not based totally on technical and engineering considerations with no plans for O&M and with poor supervision by the GDI and/or the regional projects/ authorities, which were charged with the responsibility of construction of these dams.

Consequently the government has agreed with IDA to identify, prepare and then contribute in finance of a Participatory Irrigation Management (PIM) project which aims to gradually solve the above mentioned problems by rehabilitation of spate irrigation systems and establishment of Water Users Associations (WUA's) that will gradually bear the responsibility from the government with regard to O&M functions and expenditure for the spate irrigation systems to ensure long term sustainability and efficient utilization of Yemen's scariest resource; WATER.

As part of the preparation of the PIM project it was agreed with IDA that a seminar will be held sometime late in 1998 to highlight and discuss some of the aspects and components that are related to the said project. In this context this paper on O&M expenditures was prepared by the local consulting firm (Ghayth Aquatech, Ltd.) to be presented as one three background papers for the PIM seminar. The other two cover the social and organizational aspects and the legal aspects of spate irrigation systems.

2.0) Scope and Objectives of the Study

The scope of this study is to assess the feasibility of establishing water user associations (WUA's) in spate irrigated areas and small dam schemes.

An important element in WUA participation is the O&M burden that these associations would have to share with the government. Thus, the objective of this study is to answer questions from the various study areas regarding the O&M budgetary requirements, actual budget allocations made to the concerned irrigation departments (for 1998), the sources of finance including contributions by the government and by farmers (if any), and other questions relevant to the financial side of the O&M issue. The study had also to reflect the level of the current O&M services and to estimate the optimal O&M budget required per hectare at 1998 price. It also explores the possibility of reducing the O&M expenditures of irrigation systems as the WUAs take over the responsibilities for irrigation service.

For this purpose, four representative spate irrigation systems were selected. These are: Wadi Zabid and Wadi Rima' systems representing the Tihama region, and Wadi Tuban delta in Lahej and Wadi Bana in Abyan representing the systems of the southern coastal plains.

3.0) Methodology

A team of 5 local experts carried out the study: a water resources specialist an agro-economist, an irrigation engineer, a sociologist and a legal expert. The work was based on review of collected project documents and reports on the selected areas, including a study on PIM in Lahej and Abyan which was prepared for the WB by Saif *et. al*., (1998).

During the period 17-27 July 1998, the team made field visits to the four selected areas in Hodeidha, Lahej and Abyan governorates to collect data on the social, technical, financial and legal aspects of the O&M services, including data on the expenditure for spate irrigation systems. Questionnaires were administered and the study team held meetings and discussions with the Chairman of TDA; with senior staff of W. Zabid and W. Rima'; with the directors of the MAI offices in Aden, Lahej and Abyan; and with senior staff of irrigation in Wadi Tuban and Wadi Bana.

Discussions, interviews and questionnaires were also held/ administered to a number of O&M staff and to a number of farmers to get their response on the concept of establishing WUA's and their future role in contributing to the O&M costs. Data analysis and presentation of the results and recommendation are covered in the subsequent sections of this paper.

4.0) Operation and Maintenance of Spate Irrigation Systems

Obviously, after an irrigation project is completed, its benefits will be realized only if the operation and maintenance activities are satisfactory. These activities, depending on the nature and components of a project, are usually not easy to organize and implement since they require skilled and technical staff at all levels, adequate guidelines and standards, specialized machinery and equipment, proper information and monitoring, and comprehensive system management with the required financial resources.

In Yemen, like many other developing countries, most of the requirements for O&M are not adequately met and suffer from a number of problems and constraints. Consequently, under these conditions the spate irrigation systems do not-perform efficiently, and investments deteriorate to such an extent that water delivery and distribution can become unreliable and the farmers may revert to traditional methods. Also, in such cases major rehabilitation works become needed prematurely. Annex (A) describes in more detail the O&M status at the four spate systems covered in this study.

4.1) Operation and Maintenance Tasks

During the rainy seasons, the spates flow in sizable discharges ranging from low to very high floods, which last for relatively short periods of time, ranging from few hours to several days per spate. Hence, each spate flow has to be efficiently diverted in time with no or minimum damage to irrigation structures and canals networks while avoiding flow of water to the sea in the coastal regions. This is the first main objective of operation task. The second main objective is that after its diversion, the surface water (spate or base flow) has to be distributed to the agricultural lands within the command area of the Wadi in such a way as to maximize equity and benefits to the irrigators according to the approved water allocation plan which is usually based on the applicable water rights and its agreed-on modifications.

Similarly, maintenance of a spate irrigation system is another important management task for diversion weirs, irrigation structures and canal networks. To some extent there is an overlap between some of the operation tasks and maintenance tasks and it is important to coordinate

between them. There are three main types of maintenance: routine, periodic and emergency. Wadi Zabid project inspection and maintenance schedule is enclosed to illustrate the various O&M tasks required for the different components of the project with periodicity of carrying out such tasks (Annex B).

In general, the O&M tasks are entrusted to O&M sections under engineering departments of rural development authorities (RDA's) such as Tihama Development Authority (TDA) or to the irrigation sections of the MAI offices, as is the case in the southern governorates (e.g. MAI offices in Lahej and Abyan governorates). On the other hand, there are a number of foreign financed agricultural development projects which include spate irrigation development components and for which O&M manuals for the related spate system have been prepared to help and guide the concerned RDA's to establish the pertinent O&M units for the respective wadis.

4.2) Operation and Maintenance Expenditures:

The annual cost of O&M, including repair of the irrigation systems, will depend mainly on the following factors:

a) Number and type of diversion and control structures and other small irrigation structures and bank protection works.
b) Capacity length and type of main and branching canals with the related hydromechanical installations.
c) Nature and frequency of spate floods during the year.
d) Nature and degree of repair works being carried out according to the different types of maintenance.
e) River behavior during spate.
f) Extent of command areas to be irrigated under the system.
g) The extent to which the normal operation and maintenance practices are being followed and implemented, which depends to a large extent on extent of technical and financial support by the government.
h) Degree and nature of participation of farmers (beneficiaries of irrigation water).

Generally the annual cost of normal O&M services should not exceed 3% of the present worth of a system.

5.0) O&M Costs In the Studied Areas

As mentioned above the study covered four representative areas under spate irrigation systems: two in the Tihama region and two in the coastal plains of the southern governorates. Analysis of the O&M costs and the main findings of this study are briefly given subsequently.

5.1) Wadis of the Tihama Region

First, it must be pointed out that both of Wadis Zabid and Rima' are centrally managed and financed under the Southern Region Management (SRM) of TDA. Hence, each project will be reviewed separately but analysis of the O&M costs will be combined for the two projects.

5.1.1) Wadi Zabid Spate Irrigation System

Wadi Zabid project, which was completed in 1979, covered agricultural development for a total area of about 17,000 ha. The irrigation and infrastructure improvement works of the project, which cost about US$ 39.2 million, comprised the following:

- Five diversion structures each typically consisting of a concrete diversion weir, one or two canal head regulators, two sluiceways, an earth fuse plug and upstream and downstream earth guide bunds armored with riprap.
- Canal distribution network, totaling about 123 kms in length, of which about 41 kms are new or reconstructed canals in parts that are connected to pre-existing canals (82 kms) and all are along 16 irrigation canals with 178 structures serving a net area of about 15,200 ha.

The 16 canals and the two tail branches of Wadi Zabid are grouped into three canal groups each having separate turn of irrigation as shown in Table (1)

Table (1): The spate irrigation system of W. Zabid (source: Wadi Zabid Agricultural Project, Operation and Maintenance Manual, p. 2-5, March 1980.)

Canal Group	Served by Diversion No.	Name of Canal	Bank Side of the Wadi	Lengths of Main and Branch Canals in Kms	Net Irrigated Area (in ha.)	No. of Structures	Priority period for perennial & spate irrigation
I	1	Road	L	2.3	25		19 Oct-2 Aug. including base flow from 29 Mar. to 2 Aug.
	1	Bunay	R	9.8	855		
	1	Barry	R	2.2	270		
	2	Mansury	R	10.4	1080		
	1	Gerbeh	L	3.4	540		
	2	Rayyan	R	13.5	1125		
	2	Bagr	L	7.6	430		
	Sub-total			49.2	4325	110	
II	3	Mawi	R	14.7	2160		3 Aug. -13 Sept.
	3	Ebry	L	5.6	810		
	3	Yusif	R	10.1	1150		
	4	Gerhazi	L	9.8	1080		
	4	Gereb	Center	3.4	250		
	4	Bira	L	10.4	1330		
		Wadi Nasery	R	--	2385		
	Sub-total			54.0	9165	58	
III	5	Sharabi	R	7.3	560		14 Sept-18 Oct.
	5	Mahragi	L	6.6	270		
	5	Haram	L	5.8	225		
	5	Wadi Ain		---	250		
		Wadi Bed		---	420		
	Sub-total			19.7	1450	10	
		Total		122.9	15215	178	

The system also comprises a total of about 94 km of gravel surface roads; of which 21.9 kms are access roads to diversion structures and canal bifurcation structures, 10.9 km are canal roads (service or inspection roads) and 60.7 km are farm roads serving farm villages and farm lands in the project area.

The O&M section, for Wadi Zabid Project was established by TDA in 1979 within the Engineering and Irrigation Department (SRM) at the town of Zabid, as recommended by the O&M manual prepared by the consultant.

For more than 500 years, water rights in W. Zabid have been practiced according to old traditional customs based on Sharia'a principle "Al-ala- fal- ala"; i.e., the upstream field is given priority for irrigation before the downstream field. The priority dates of spate floods and

base- flow for each canal group are shown in Table (1). Under this strict system of traditional water rights, the downstream beneficiaries can irrigate their fields only during the above-specified periods and only if the flow is surplus to the upstream areas.

Earlier, the consultants proposed an alternative water allocation plan with dates slightly modified from those of the traditional water rights, to be implemented through a committee formed by the local authorities. Unfortunately both the plan and the committee failed to work or to be adopted by TDA. This is due to recurrent violations of the water allocation plan by some farmers who were not deterred by government authorities, and the fact that there was a conflict of interest with the large water users in the Wadi.

The O&M section is in charge of O&M services at the diversion structures, other hydraulic structures, and canal distribution network up to the gates off taking from the main and feeder canals up to the field turnouts. The farmers responsibility starts from field turnouts by delivering water through field ditches then irrigating their fields by pending spate water lavishly on their field basins. Irrigation tasks place from one field to the other in sequence according to water rights.

On the other hand, it was reported that, for some years, the farmers in Tihama region including Wadi Zabid used to pay 2% of their agricultural production income from spate irrigated lands as a sort of cost recovery fees to *wagibat* (Zakah) department. In any case, this "fee" contribution in to the O&M cost (which is no longer paid) together with the system of its levy doesn't seem to be an efficient way for sustaining the systems. Firstly, because it is mostly collected from the small farmers but not the big ones and, secondly, because it never reaches the TDA, and it has no official records of the collected amounts.

On the other hand the study team observed some technical problems, which negatively affect the system. These are:

1) Sediment load brought by the spate floods to W. Zabid is high. Model studies referred to by Camacho (1987) indicated that sediment concentration measured along Mansury-Rayyan-Boger canal (max. capacity 40 m^3/s) reached 18,600; 4,800 and 1,620 ppm at discharges of 40, 5 and 0.5 m^3/s respectively. This causes the following problems:

    a) Large deposits of coarse sediments with boulders accumulate heavily at the entrance of head regulator, especially at diversion structure No. 1, to the extent that when floods recede, the base flow flows over the weir crest instead of flowing through the head regulators. Consequently, every season the O&M section has to remove these huge sediments/ deposits to allow the Wadi flow to follow its normal course.

    b) Large amounts of sediment (mainly fine sands) are deposited with debris and trash along the main earth canals mainly due to inefficient functioning of weir sluiceway. Similarly, these deposits have to be removed by the O&M section, which does not have enough operating machinery or resources. Unfortunately, the sediments and deposits excavated from the main canals are not needed by nearby farms and it is not economic to haul it to the middle of the Wadi bed, which is too far from the canals. Consequently, the department dumps such deposits along the embankments of the main canals and inspection roads. This creates other problems whereby canal embankments get higher, and during rains the sediments fall-back to the canals. Also, there are difficulties in using the inspection roads that are covered with the fine sands excavated from the canals, especially during the rainy season.

    c) most of the silt and fine sediments of the spate water finally settle in the fields which are ponded with water to a depth of about 1.5m to get as much water and silt as

possible. With this traditional practice and the fact that most fields are not leveled, then due to accumulated siltation the level of the upstream fields which have priority for irrigation becomes higher than the level of the field outlets offtaking from the main canal. Then, to irrigate such fields adjacent to outlet, the farmers have to construct earth bunds (*Uqma*) just downstream of the outlet across the canal in order to raise the water level to enable them to irrigate their fields. This practice can lead to overtopping of water to the embankments of the canal and may cause breaching of the canal and depriving the farmers from irrigation till the canal is repaired. Also overflowing water may cause scouring around a small structure such as a drop, which will then need to be repaired too.

2- The concrete bodies of diversion structures 1 & 2 have been affected by abrasion by boulders and stones brought by floods.

3- Some of the turnouts are of small size compared to their respective areas to be irrigated. Such turnouts have to be replaced by ones with larger diameters.

4- Due to the practice of field-to-field irrigation, and especially in the upstream areas were farmers enjoy longer time priority of water rights, it has been reported that surplus water from excessive ponding in the field basins is diverted by farmers to the adjacent inspection roads thus damaging it by "man-made small floods" which sometimes even threaten small villages.

5- Cropping patterns in Wadi Zabid have shifted from cereals to banana, which is a better cash crop but with higher water requirements. This situation prevails mainly in the upstream areas where farmers enjoy priority of water rights (from both baseflow and spates) for about 10 months.

6- some farmers cultivate crops in land patches and strips along the Wadi bed (called *Gulal*). The problem is that these areas are expanding and are irrigated from spate water while traditionally they should be restricted to their original areas and be irrigated from baseflow only.

There is a report by the Director of SRM at Zabid covering the above-mentioned problems with some technical proposals to mitigate the damages. This matter needs further study and designs by consultants with the required funds for implementation.

5.1.2) Wadi Rima' Spate Irrigation System

The Wadi Rima' spate irrigation system serves a total command area of up to 8,000 ha. The irrigation works were constructed as one of the components of Tihama II and IV Projects. The system was designed to regulate and control irrigation during the perennial baseflow season with baseflow in the Wadi below 2 m^3/s and during the spate season for flows, which exceed 2 m^3/s. The irrigation works consist of the following components:

i) a weir with one offtake with a total delivery capacity of 15 m^3/s with the following structure sub-components:

* Dam wall across Wadi Rima',
* a flushing structure,
* an intake structure,
* a sand and gravel trap,
* an ejector structure for sand and gravel,
* an orifice to limit the discharge into the canal, and
* a side spillway to discharge excess water.

ii) main distribution structure bifurcating flow through a siphon (capacity 10 m^3/s, 350m long) to the south main supply canal which feeds 9 canals along the left bank of the Wadi and the other part of the flow is bifurcated to Hudayd canal along the right bank of the Wadi. Lengths of canals, number of irrigation structures and net irrigated areas are shown in Table (2).

Table (2): The spate irrigation system of W. Rima' (source: Wadi Rima' Irrigation System Water Allocation Plan, DHV, pp. 30-35, The Netherlands. March 1984)

No.	Name of Structure/Canal	Length of Main and Branch Canals in (Kms)	Number of irrigation structures	Irrigated Area in (ha)
1	Al-Mishrafah diversion weir			
2	Main supply canal	4.50	22	80
3	Main division structure & siphon	0.38	2	
4	North bank canals	9.00	5	2,520
	1. Al- Main			
	2. Al- Hudayd			
5	South bank canals	32.00	72	
	1. Ashraf			570
	2.Farii			490
	3. Malki & Nadal			530
	4. Zawran			1,200
	5. Yusfi			520
	6. Mussaffiyah			470
	7. Mawsfi			920
	8. Safwani			700
	Total	45.88	101	8,000

DHV consultant on the basis of available surface flow, water losses simulated a water allocation plan in the conveyance system and a gate operation schedule. Nine computer runs were made to investigate the performance of the traditional and the new Wadi Rima' irrigation system under various scenarios regarding the gate operation schedule and other parameters determining water allocation to the primary canals. Then it was agreed with TDA to adopt computer run # 9 which simulates the performance of the new system on the basis of a rotational schedule during baseflow and modular division of the flow at the siphon during spates.

The O&M is carried out by a unit under the O&M Section of the SRM in the town of Zabid. Irrigation from baseflow and spates in W. Rima' is carried out according to traditional customs based on the above-mentioned water allocation plan. The irrigation system of W. Rima' doesn't suffer from heavy sedimentation problems as in Wadi Zabid. This is because the irrigation works included an efficient flushing structure and ejector structures for sand and gravel. The command area of the Hudayd canal comprises the farm of the army's "Agricultural Supply Corporation" which insisted on TDA to allocate for them 50% more than the delivery capacity of the main supply canal (i.e., 7.5 m^3/s instead of 5 m^3/s as designed for the Hudayd canal). The corporation cultivates about 3,000ha of bananas upstream of the right bank of the Wadi while few big land lords cultivate another 2,000ha which is irrigated from the south main supply canal in upstream areas along the left bank of the Wadi. Bananas have high water requirements and, as in W. Zabid, strict application of traditional customs of water rights and unlimited cultivation of bananas upstream bring about problems of inequity in water allocation to the downstream farmers.

5.1.3) The O&M Expenditures for Wadi Zabid & Wadi Rima' Projects

At present, the government funds all O&M costs of the irrigation department which handles the O&M of w. Zabid and Rima' systems. The farmers in Zabid and Rima claim that they pay for the O&M by paying 2% of their crops' income on top of the Zakat. TDA officials envisage that levying water charges equivalent to 2% of gross value of agricultural produce would cover the O&M costs. However, TDA staff that many farmers were not paying and what has been collected never reached the TDA have confirmed it. Now, however, the above-mentioned tax levying system is not working. Thus, the government presently covers O&M costs only.

A) Allocated Staff Salaries

Table (3) shows that the total number of staff in the two wadis is 97 with total annual salaries amounting to about 8.5 million YR.

Table (3): The 1998 W. Zabid & Rima staff annual salaries (source: Irrigation Department, Zabid, TDA. July, 1998)

Position	No.	Annual Salary, '000 YR
1- Head O&M Section	1	180
2- Civil Engineers	3	432
3- Survey Technician	1	132
4- Maintenance Technician	2	216
5- Mechanics	13	1,092
6- Electrician Technician	1	84
7- Welder Technician	2	144
8- Maintenance supervisor	2	192
9- Electrician (vehicles)	1	84
10- Laboratory Technician	1	96
11- Laborer Supervisor	1	72
12- Cooling Technician	1	72
13- Tires Technician	1	72
14- Carpenter	1	60
15- Plumber	1	84
16- Driver Heavy Duty Machinery	25	3,000
17- Vehicles Drivers	1	72
18- Labor Chief	2	120
19- Maintenance Labor	26	1,560
20- Watchmen	12	720
Total	97	8,484*

* 5.090 Million YR for W. Zabid and 3.394 for W. Rima'.

B) Requested vs. Allocated Operation and Maintenance Budgets

Operation and maintenance budgets for wadis Zabid and Rima' irrigation systems for the year 1998 are presented in Table (4) which shows that the total allocation (YR 3.9 million) is only 30% of what was requested by the irrigation department (YR 13.53 million) for 1998.

Table (5) summarizes the data of Tables (3) & (4) and shows that the requested budget for the staffing plus O&M in Zabid and Rima is 948 YR per ha (1998 prices) while the allocated budget averages 533 YR per ha. Thus, what is budgeted is only 56% of what the irrigation department requested.

Table (4): Requested and allocated budgets for O&M of wadis Zabid & Rima' spate irrigation system for 1998 (source: Irrigation Department, Zabid, TDA. July, 1998).

Items	Unit	Qty.	Requested	Allocated
WADI ZABID				
a) Irrigation Structures				
1. Rehabilitation/ repair of sluiceways of Mansoury &Bunay canals	M3	8	69,120	
2. Earth fill around side of drop structure #2 in Al-Rayyan canal & raising bank wall along 100 m section	"	300	115,200	
3. Earth fill and compacting sides of drop str. #1 Mawi	"	60	262,800	
4. Earth fill around drop str. #4 for Bunay canal & raising its banks	"	180	288,000	
5. Greasing and oiling of gates of turnouts and outlets	Gates	179	112,800	
6. Painting of iron parts of gates & birdies of 1st & 2nd canal groups	M2	650	120,480	
7. Cleaning sediments from canal intake for the 3 canal groups	M3	9,100	1,515,000	
8. Repair gears of main gates	No.	7	350,000	
Subtotal			2,833,400	
b) Canal Network				
1. Desilting, reshaping & backfilling of banks of Al- Ryan canal (along 6 km)	M3	23,800	3,843,000	
2. Desilting & reshaping of Al-Mansouri canal (along 1.1 km)	"	9,720	1,647,000	
3. Desilting & reshaping of Mawi-Yusfi canal (along 24.5 km)	"	4,655	805,200	
4. Repair of pipe gears	No.	30	1,200,000	
Subtotal			7,495,200	
Total for W. Zabid			10,328,600	2,000,000*
WADI RIMA				
a) Irrigation Structures				
1. Repair of weir body	M3	4	29,160	
2. Greasing of gates.	Kg.	50	14,900	
3. Clearance of sediments and other deposits	--	lump sum	96,000	
4.Protection earthworks for lands downstream at the S. canal bank		2,000	252,000	
Subtotal			392,060	
b) Canal Network				
1. Repair of Al-Hnkh drainage structure	M3	75	190,800	
2. Repair of Al- Musafiah bridge	"	50	138,600	
3. Repair Al- Sanwani - Al- Yusufi canal	M3	10	36,840	
4. Desilting & Cleaning of canals	"	10,000	1,464,000	
5. Cleaning of Al-Aqum from the middle of south canal	Days	15	189,000	
6. Cutting trees	Km	8	151,800	
7. Repair of gear gates	No.	16	640,000	
Subtotal			2,811,040	
Total for W. Rima'			3,203,100	1,900,000*
GRAND TOTAL (for both wadis)			13,531,700	3,900,000*

* The O&M Section has no breakdown of the actual expenditures at that time.

Table (5): Requested and allocated staff plus O&M costs per ha. for wadis Zabid and Rima' (source: Irrigation Department, Zabid, and TDA. July, 1998).

Item	Amount (in YR)	%	Net Area (ha)
REQUESTED			
Staff salaries (1998)	8,484,000	38	
O&M costs (1998 prices)			
Wadi Zabid Irrigation System	10,328,600	47	15,215
Wadi Rima Irrigation System	3,203,100	15	8,000
Total	22,015,700	100	23,215
Total cost per ha	948		
ALLOCATED (actual)			
Staff salaries (1998)	8,484,000	69	
O&M costs (1998 prices)			
Wadi Zabid Irrigation System	2,000,000	16	15,215
Wadi Rima Irrigation System	1,900,000	15	8,000
The actual O&M budget allocated to the irrigation department for 1998	12,384,000		
Estimated O&M cost per ha made to the irrigation department for 1998	533		

A regression model analysis of the O&M cost of Wadis Zabid and Rima structures from 1988 to 1997, which was carried out using the data of Table (6), indicated that 65% of the O&M cost change for wadis Zabid and Rima' is related to time while 35% is related to other factors. The mean of the O&M costs is YR 2.36 million and the O&M cost has increased at an annual rate of about 20%, based on the data provided by Zabid Irrigation Department. Summary output of this regression analysis is shown in Annex (C).

It is realized that regression analysis requires at least 15 years of data, but the consultants had to settle for what was available. Notice also that the data used are for the *actual maintenance costs*. Moreover, it should be pointed out that salaries were not included in this analysis because of lack of data (time series) on this part of the cost.

Table (6): The O&M cost of Zabid and Rima from 1988 to 1997

Years	**Actual Cost of** Irrigation Structures Maintenance*	**Actual Cost of** Irrigation Canals Maintenance*	**Total** O & M
1988	308,972	1,133,437	1,442,409
1989	316,314	597,940	914,254
1990	234,338	1,078,342	1,312,680
1991	227,384	869,318	1,096,702
1992	498,246	1,161,823	1,660,069
1993	678,990	1,244,782	1,923,772
1994	855,888	1,299,348	2,155,236
1995	1,091,368	1,980,646	3,072,014
1996	1,212,631	1,980,646	3,193,277
1997	3,868,780	2,945,620	6,814,400

* Source: Irrigation Department, Zabid, and TDA. July 1998

5.2) Wadis of the Gulf of Aden Region

From this region, spate irrigation systems of Wadi Tuban and Wadi Bana in Lahej and Abyan governorates; respectively, were investigated as two case studies for O&M costs.

5.2.1) Wadi Tuban Spate Irrigation System

The Wadi Tuban spate irrigation system lies on a delta consisting of an alluvial fan with its apex at about 55 kms north of Aden. The average annual flow in the Wadi is about 125 MCM and the average total irrigation area is about 8,000 ha. The O&M services presently cover only 6,606 ha. The Wadi is partly irrigated by a modern system up to the field outlets, and partly irrigated by the traditional system.

As detailed in Table (7), the irrigation system comprises nine diversion weirs with typical head regulators and sluiceways and lined main and secondary canals for a total length of about 165.4 kms with 1,630 irrigation structures.

Table (7): The Spate Irrigation System of Wadi Tuban-Lahej

Name of Weir/*Uqma*	**Length of main & branch canals (Km)**	**Number of irrigation structures**	**Irrigated Area (ha)**
1- Al-Arais Weir	62.00	576	873
2- Ras Al- Wadi Weir	47.50	558	1,718
3- Beizag Weir	33.80	423	1,325
4- Faleg Weir	1.65	8	926
5- Hadaram Weir	15.40	42	543
6- Bustan Weir	4.00	16	747
7- Mugahed Weir	1.05	7	474
8- Al-Munasirah*	--	--	(2,100)*
9- Al- What *Uqma**	--	--	(1,233)*
Total	**165.40**	**1,630**	**6,606**

*Command areas under Al-Munasirah & Al-What *Uqma* are mostly groundwater irrigated & are not included in the total

Source: Irrigation Section. MAI Office, Lahej Governorate, July 1998

The Yemeni-Soviet Projects built these works during the period 1971-88. On the other hand a new weir called Al-Faqeeh and Lafiah located downstream from Falag weir is presently under construction with finance from LWCP. The Wadi Tuban proper passes through the most upstream diversion weir called Al-Arais then it flows 9 kms downstream to Ras Al-Wadi weir where it gets bifurcated into two wadis viz. Al-Wadi Al-Kabir and Al-Wadi Al-Saghir (which literally mean the large and small wadis, respectively) to wards the right and left bank of the Wadi respectively.

The status of the Wadi Tuban Spate Irrigation System is deteriorating and level of O&M is poor. This is particularly true with regard to maintenance of weirs and other structures and the canal network. Unfortunately maintenance has been neglected since the stoppage of the Yemen-Soviet projects in 1990 and due to the annual decrease of govt., funds allocated for O&M services. Therefore there was practically no maintenance for the system for the east 8 years. This is manifested by the fact that there is a program for replacing 26 old gates for 6 diversion weirs. The gates of the main and secondary lined canals are originally of bad quality with a stiff lifting mechanism and bad handles. However these gates were damaged and looted by people without any clattering measures by the local security authorities. Now there is an urgent need for replacement of 33 gates completely or in parts for the canal distribution system.

The maintenance for the 2 types of gates requires a budget of about mil. Y.R 37.5. Maintenance for concrete structures and for removal of heavy sediment and deposits (about 124000 m^3) requires a budget of about mill. Y.R 11.29. The govt. funds allocated for O&M within the 1998 budget for the Lahej MAI office is about mill. Y.R 65 of which about mill. Y.R 63.2 for salaries, which is too high, and only mill Y.R 1.8 mainly for operational services for

implementation of the seasonal water allocation plans according to traditional customs as explained above. Consequently the allocated O&M budget for the Lahej MAI office should at least be doubled on the short term. From the field visit the mission observed that these requirements would cover a total command area 6606 ha. However if rehabilitation and irrigation development works are implemented for Al-Munasirah weir and Al-What *Uqma* and few parts along the two wadis (will cost about Mill. Y.R 300 as a second phase for development) then the system will be equipped to irrigate a total command area of at least 8000 ha.

5.2.2) Wadi Bana Spate Irrigation System

The delta of Wadi Bana lies at a distance of about 60 kms NE of Aden. The average annual total flow is about 160 MCM and the average annual total irrigated area is about 19,000 ha. The Wadi Bana spate irrigation system consists of 5 diversion structures viz. Batis being the most upstream weir followed downstream by Hyja, Al-Diyyu, Al-Makhzan and Al-Graib weirs whereby the delta extends for a distance of about 43 kms to the Gulf of Aden. These weirs were initially built during the period 1953-1966. However they were seriously damaged a number of times during high flood years including the 1982 catastrophic floods which also affected other regions of the southern governorates. Consequently Batis and Hyja weirs were rebuilt in 1985 and 1987, respectively, through the Yemeni-Soviet Projects with modified designs based on new data of the high floods. The other weirs are presently destroyed and not functioning since 1982. Consulting firm (W.S. Atkins) which has studied flood damages in Wadi Bana has proposed and recommended implementation what they called "option B" which comprised: a new weir at Diyyu with 2 main canals supplying Diyyu, Nashera and Makhzan areas in addition to Wadi training and fieldwork for a total capital cost of 10.1 million Dinars in 1983 (about million Y.R 600 in 1983 prices). The estimated cost of the weir which is to be constructed at a new site slightly downstream of the present site was recently updated in a study by Saif et. al. (1998) at about US$1.63 million. Unfortunately none of these recommended works were implemented. Since 1983. However, presently the Diyyo weir command areas are served by the Diyyo canal, which is fed from a gated control regulator that was built in 1983 to act as a divide structure for the Diyyo and Nusheera main canals. The spate irrigation system with command areas, canals & structures are shown in Table (8).

Table (8): Wadi Bana (Abyan delta) spate irrigation system.

WEIR	**Main and branch c**anal lengths (Km)	**Irrigated Area** (ha)	**Number of** irrigation Structure
1. Bateis	3.2	10,000	10
2. Hayja	1	2,400	3
3. Diyyo	--	3,620*	
4. Makhzan	Non-functioning		
5. Gharaib	Non-functioning		
Total	4.2	16,020	13

Source: Irrigation section, MAI, Office, Abyan Governorate, July 1998
* although Diyyo weir is not functioning, this area is irrigated by Diyyo main canal, which is fed from the control regulator and diversion structure.

The Irrigation Section under the MAI office at Abyan is in charge of the O&M services for w. Bana spate irrigation system, which consists of two parts. The first part covers an area of about 4,510 ha along the west bank of the Wadi, with modern irrigation network consisting of main, secondary, tertiary and quaternary canals. The O&M section delivers water up to the secondary canals and the irrigation inspectors guide and help farmers to deliver water through tertiary and quaternary canals, which has outlets irrigating fields directly. The second part covers remaining areas under Wadi Bana, which are irrigated by traditional methods.

It must be stated that following the 1982 catastrophic flood, this section was re-organized and supported with a fleet of heavy earth moving machinery and staff through the "Traditional Irrigation Project" which was urgently established as an emergency project for rehabilitation of the seriously flood-damaged area which has almost paralyzed the irrigation systems of W. Bana and Hassan in Abyan governorate.
Subsequently, after completion of that project, most of the machinery, equipment and staff were left for the irrigation section, thus making it in a relatively better status with regard to provision of O&M services. For this reason the level of O&M services in this Wadi is moderately adequate under the functioning weirs and is certainly better than that of wadis Tuban and Zabid. Despite this fact, the irrigation section of Abyan, like other sections, suffers from the problem of the unwarranted annually diminishing funds allocated for O&M services, which cannot cover all of the areas under spate irrigation system. Also, this section needs relatively high capital investment (about 30 million US$ according to 1983 prices) to implement works proposed by Atkins Consultants. On visiting the Hayja weir, which was in operation, some technical problems were observed with regard to the curved weir crest which has to be modified to improve water delivery from Wadi flow over crest to the head regulator and upper intake of Ahboush canal.

5.2.3) Estimate of O&M Expenditures for Wadis Tuban & Bana Irrigation Systems

A) Allocated Staff Salaries

The allocated budgets for staff salaries in Lahej and Abyan are given in Table (9). The allocations (64 and 29.5 million YR, respectively) clearly reflect the overstaffing resulting from annexing almost all of the ex-Yemeni-Soviet Project staff at Lahej to the MAI office and those at Abyan to the irrigation section of the MAI office.

Table (9): Salaries of staff at Lahej and delta Abyan Irrigation Sections, 1998

Name of Post	No.	Yearly
Wadi Tuban		
1. Irrigation Engineer (Msc.)	4	665,460
2. Assistant Irrigation Engineer	15	2,467,971
3. Agricultural Economist	1	146,172
4. Admin. & Finance Staff	18	2,438,400
5. Technician	180	22,205,784
6. Carpenters and Masons	114	18,975,456
7. Watchmen	74	7,589,040
8. Extensionist of irrigation	30	3,419,592
9. Driver vehicles	40	4,697,460
10. Services labor	10	1,362,144
Total	**486**	**63,967,479**
Wadi Bana		
1. Head of O&M Department	1	180,000
2. Head Assistant	2	312,000
3. Head O&M Section	4	624,000
4. Civil Engineers	11	1,584,000
5. Assistant of Heads Section	3	396,000
6. Mechanic	2	168,000

Table (9): Continued

Name of Post	No.	Yearly
7. Technician	17	1,224,000
8. Welder Technician	17	1,224,000
9. Irrigation Labor	162	11,664,000
10. Communication Technician	2	168,000
11. Laborer Overseer	4	288,000
12. Driver Heavy Duty Machinery	22	2,640,000
13. Driver vehicles	10	720,000
14. Area Overseer	23	1,380,000
15. Maintenance	98	5,880,000
16. Watchmen	17	1,020,000
Total	395	29,472,000

Sources: Irrigation Section. MAI Offices, Lahej and Abyan Governorates, July 1998.

B) Requested vs. Allocated Operation and Maintenance Budgets

The Irrigation Section of the MAI Office in Lahej undertakes the O&M services for Wadi Tuban spate irrigation system. Unfortunately maintenance has been neglected since the termination of the Yemeni-Soviet Projects- and the annual government allocations for O&M have been decreasing. This has led to deterioration of the irrigation system with poor level of O&M services.

The spate irrigation system needs rehabilitation and maintenance on short- term and long-term basis. The most urgent maintenance works required for irrigation structures and canal network are shown in Table (10). Also budget lines allocated for operations (recurrent expenditures) are shown in Table (11) while the O&M cost per ha is shown in Table (12).

Table (10): Requested and allocated operation and maintenance cost for 1998 ('000 YR)- W. Tuban and Abyan delta spate irrigation systems.

Items	Unit	Quantity	Requested Budget	Allocated Budget
Wadi Tuban				
a) Irrigation Structures i) Provision & installation of 26 new fabricated gates for 6 weirs:				
1- Al-Arais Weir	gates	6	5,880	
2- Ras Al- Wadi Weir	gates	3	2,940	
3- Faleg Weir	gates	2	1,960	
4- Hadarem Weir	gates	6	5,880	
5- Bustan Weir	gates	6	5,880	
6- Mugahed Weir	gates	3	2,940	
Subtotal		**26**	**25,480***	
ii) Maintenance of small structures of irrigation systems under:				
1- Al-Arais Weir	Wadis		900	
2- Beizag Weir			700	
3- Faleg Weir			2,800	
Subtotal			**4,400**	
b) Canal network i) Provision & installation of gates new or in parts for canal turnouts as follows:				
• new gates for irrigation system of Al-Arais weirs	gates	33	6,600	
• gate lifting screw system with handles for Ras Al-Wadi irrigation network	misc.	25	2,000	
• gate lifting screw system with handles for Buzag irrigation network	misc.	18	1,620	
Subtotal			**10,220**	
ii) removal of sediments & other deposits from main & secondary canal				
1- Al-Arais Weir	M^3	30,000	1,160	
2- Ras Al- Wadi Weir		40,000	2,220	
3- Beizag Weir		20,000	960	
4- Hadaram Weir		20,000	1,500	
5- Faleg Weir		8,000	600	
6- Bustan Weir		6,000	450	
Subtotal		124,000	**6,890**	
TOTAL			**42,590**	**1,800 ****
Wadi Bana				
a) Irrigation Structures				
Provision & Installation of new gates to Weir and its main canal	gates	13	13,600	
b) Spare parts for Canal gates			225	
c) operation cost for earthwork maint. **			11,129	
d) Maint. of structures**			1,500	
TOTAL			26,454	3,600 ***

Sources: Irrigation Sections, MAI Offices Lahej and Abyan Governorates, July 1998

* The Land and Water Conservation Project (LWCP) cover finance

** Extracted from 1998 requested budget - Irrigation Section (Abyan)

*** This is the only allocation for maintenance and recurrent expenditures

Table (11): Allocated recurrent expenditures for the Agriculture & Irrigation Offices in Tuban (Lahej) and Abyan for 1998

		Annual allocation, '000 YR	
Item	**Budget line**	**Wadi Tuban**	**Abyan Delta**
1	Commodities, services and office expenses	36	216
2	Fuel, lubricants & maintenance	840	2,016
3	Drugs, food and commodity expenses	60	48
4	Rents for lands & buildings	0	0
5	Water, electricity and communication	384	108
6	Maintenance expenses	300	768
7	Transport and per diems	84	96
8	Training expenses	0	0
9	Other services expenses	96	348
	Total	**1,800**	3,600

Sources: Irrigation Section. MAI Offices, Lahej and Abyan Governorates, July 1998.

Table (12) shows that the requested O&M budget for w. Tuban is 16,403 YR per ha at 1998 prices while the allocated budget is only 9,956 YR per ha.

Table (12): Requested and allocated O&M costs per ha. for wadis Tuban and Bana spate irrigation systems (source: Irrigation Department, Lahej and Abyan governorates. July, 1998).

	Tuban (area 6,606 ha)		**Abyan (area 12,400 ha)**	
Item	**YR**	**%**	**YR**	**%**
REQUESTED				
Staff salaries (1998)	63,967,479	59	29,472,000	78
Operational expenditures (1998 prices)	1,800,000	1.6	3,600,000	9
Maintenance costs (1998 prices)	42,589,740	39.4	26,454,400	13
Total	108,357,219	100	59,526,400	100
Total cost per ha	16,403		**4,801**	
ALLOCATED (actual)				
Staff salaries (1998)	63,967470	97.3	29,472,000	94.2
Operational expenditures (1998 prices)	1,800,000	2.7	3600,000	5.8
Maintenance costs (1998 prices)				
Total	65,767,479	100	33,072,000	100
Total cost per ha	9,956		**2,522**	

Thus the allocated budgets for wadis Tuban and Bana are only 61% and 52% of the amounts requested by the respective Irrigation Sections. And most of the allocated budgets are salaries. However, these relatively more reasonable percentages, which are better than Zabid's and Rima, do not reflect a better status for O&M, but rather the abnormally high number of staff in these systems and the high allocations for salaries.

In essence, the government is financing part of the O&M costs of the irrigation department in delta Tuban-Lahej and delta Abyan. The farmers in Tuban were obliged to pay an irrigation fee of 100 YR/ Fadden/ season (225 YR/ ha. / season), for spate water and 500 YR/ year for each Fadden (1250 Y.R/ha/Y.R) that is irrigated from baseflow. According to the governor of Lahej decree no. 14/ 1996, the collected fees are to be deposited in a bank account in the name of Lahej Irrigation Section to be used later for O&M. This decree was enforced for one year only, and then the Ministry of Finance insisted that revenues should go to public treasury and the process ceased.

6.0) Analysis of Optimal Operation and Maintenance Budget

In order to compare and analyze the requested and allocated O&M budgets, optimal O&M budgets have been prepared for the four spate irrigation systems. These were based on proposals in the Operation and Maintenance Manuals which were available for two systems (Zabid and Rima) and as correlated with collected data and field visits for the four systems taking into consideration scope and type of O&M services as governed by the nature of the wadis, structures, irrigation systems, and total command areas.

6.1) Estimations of Optimal Budgets

A) Optimal Staffing

For the four systems, optimal staffing with annual salaries was prepared as shown in Table (13).

Table (13): Optimal staffing and costs for the four spate systems in wadis Zabid, Rima, Tuban and Bana (1998 prices).

Name of Post	Monthly Salary '000 YR	W. Zabid		W. Rima'		Wadi Tuban		Wadi Bana	
		No.	Annual Salary '000 YR	No.	Annual Salary '000 YR	No.	Annual Salary '000 YR	No.	Annual Salary '000 YR
1. Director of O&M Section	20	1	240	1	240	1	240	1	240
2. Administrative officer	15	1	180	1	180	1	180	1	180
3. Accountant	15	1	180	1	180	1	180	1	180
4. Storekeeper	10	1	120	1	120	1	120	1	120
5. Head of operation unit (irrig. / CE)	20	1	240	1	240	1	240	1	240
6.Head of Main. Unit. (mech. / CE)	20	1	240	1	240	1	240	1	240
7. Civil Engineer	20	1	240	1	240	1	240	1	240
8. Hydrologist \ Metreologist	20	1	240	--	--	1	240	1	240
9. Canal Water Master	10	15	1800	10	1200	10	1,200	12	1,440
10. Gate Operator	8	15	1440	10	960	10	960	12	1,152
11. Chief Mechanic	10	1	120	1	120	1	120	1	120
12. Assistant Mechanic	8	2	192	1	96	2	192	4	384
13. Forman - Structures & Gates	8	1	96	1	96	1	96	1	96
14. Forman - Earth works	8	1	96	1	96	1	96	1	96
15. Heavy Machinery Driver	10	7	840	6	720	7	840	16	1,920
16. Heavy Truck Driver	10	4	480	2	240	3	360	7	840
17. Vehicle Driver (4WD pick-up)	6	8	576	4	288	5	360	10	720
18. Surveyor	15	1	180	--	--	1	180	2	360
19. Laborer (O&M)	5	20	1200	12	720	15	900	30	1800
20. Watchman/ guard	2	10	240	4	96	18	432	10	240
21. Chairman	5	2	120	--	--	2	120	2	120
Total		95	9060	59	6072	84	7,536	116	10,968

* Driver for 2 bulldozers + 2 motor grader + 2 front end loader + 1 hydraulic excavator or drag line.
* The above list has been prepared based on experience and staffing proposed by consultant.

B) Optimal Operation Budgets (Fuel and Lubricants)

Optimal costs of fuel and lubricants for operation of the optimal number and type of heavy machinery and vehicles for earthwork maintenance and transport, on average year, were estimated for the four systems. The equipment requirements were assessed so as to undertake earthworks including clearance of sediments, trash and debris, maintenance of earthern flood protection works, service roads, ... etc. With the required transport including water distribution.

Table (14): Annual Cost Fuel and Lubricant for Operation of Various Units of Heavy Machinery and Vehicles for O&M Services of Spate Irrigation System (1998 Prices)

Item	Daily fuel consumption in liters	Cost in (YR) Monthly Operation			Total Annual cost of operation in Y.R
		Fuel	Lubricants	Total	
1. Bulldozer (D8 size)	288 diesel	86400	17,00	98100	784,800
2. Bulldozer (D6 size)	216 diesel	64800	8750	73550	588,400
3. Motor Grader	216 diesel	64800	8750	73550	588,400
4. Front-end loader	180 diesel	54800	7750	61550	492,400
5. Hydraulic Excavator	180 diesel	54000	7750	61550	492,400
6. Dump truck (15 tons)	40 diesel	12000	5650	17650	141,200
7. Water Tanker (15,000 l)	40 diesel	12000	5650	17650	141,200
8. Pick-up 4WD	**20** Petrol	21000	**1400**	**22400**	**179,200**

* Daily consumption is based one average 8 hours of operation per day.

** The year is estimated for 240 days after excluding Friday's public holidays and about 20% of this year for repair and maintenance and of season time for machinery & vehicles.

Table (15): Annual Cost of Operation of Machinery and Vehicles (Fuel & Lubricants) for O&M services of Spate Irrigation System for Wadi Zabid, Rima'a, Tuban and Bana in '000 Y.R (1998 Prices).

Item	Annual cost of operation per unit	Wadi Zabid		Wadi Rima		Wadi Tuban		Wadi Bana	
		Qty	Cost	Qty	Cost	Qty	Cost	Qty	Cost
1. Bulldozer (D8 size)	784.8	1	784.8	-	--	--	--	2	1569.6
2. Bulldozer (D6 size)	588.4	2	1176.8	2	1176.8	2	1176.8	4	2353.6
3. Motor Grader	588.4	2	1176.8	1	588.4	1	588.4	2	1176.8
4. Front-end loader	492.4	2	984.8	2	984.4	1	492.4	3	1477.2
5. Hydraulic Excavator	492.4	4	984.8	1	492.4	2	984.8	2	984.8
6. Dump truck (15 tons)	141.2	4	564.8	2	282.4	2	282.4	7	988.4
7. Water Tanker (15,000 l)	141.2	2	282.4	1	141.2	1	141.2	2	282.4
8. Pick-up 4WD	179.2	8	1433.6	4	716.8	4	716.8	8	1433.6
9. Grease for weir gates		LS	50.0	LS	25.0	LS	76.8	LS	40.0
Total			7438.8		4407.8		4459.6		10306.4

C) Optimal Maintenance Budgets

The third component of the optimal budget covers the costs involving no earth works e.g. repair of concrete for weirs & other irrigation structures, bridges and maintenance, painting. etc of hydromechanical installations. The cost was estimated according to the nature and field status of this component for the four irrigation systems. For wadis Tuban and Bana these costs are shown in Table (16).

Table (16): Estimated Optimal Maintenance costs for wadis Tuban and Bana systems in YR (1998 Prices)

Item	Wadi Zabid	Wadi Rima	Wadi Tuban	Wadi Bana
Maintenance and repair of concrete structures and mechanical installations	1,840,000	1,478,000	1,544,000	2,275,000
Average net command area	15,215	8,000	8,000	19,000
O&M costs/ha in YR	121	185	193	120

D) Cost of Annual Depreciation of Machinery, Equipment and Vehicles

A fourth component of the optimal budget is the depreciation cost of machinery & vehicles used in the maintenance activities in the various wadis. An attempt was made to estimate this component by calculating the cost of new equivalents (in 1998 prices) and depreciating them over 10 years (about 10% per year). These costs are shown in Table (17)

Table (17): Estimated Annual Cost of Depreciation of Heavy Equipment and Vehicles for Spate Irrigation System in Wadi Zabid, Rima'a, Tuban & Bana.

Item	Unit Price US$	Wadi Zabid		Wadi Rima		Wadi Tuban		Wadi Bana	
		Qty	Cost US$	Qty	Cost US$	Qty	Cost US$	Qty	Cost US$
1. Bulldozer (D8 size)	230,000	1	230,000	--		--		2	460,000
2. Bulldozer (D6 size)	165,000	2	330,000	2	330,000	2	330,000	4	660,000
3. Motor Grader	130,000	2	260,000	1	130,000	1	130,000	2	260,000
4. Front-end loader	170,000	2	340,000	2	340,000	1	170,000	3	510,000
5. Hydraulic Excavator	150,000	2	300,000	1	150,000	2	300,000	2	300,000
6. Dump truck (15 tons)	60,000	4	240,000	2	120,000	2	120,000	7	420,000
7. Water Tanker (15,000 l)	100,000	2	200,000	1	100,000	1	100,000	2	200,000
8. Pick-up 4WD	15,000	8	120,000	2	60,000	4	60,000	8	120,000
Subtotal			2020,000	4	1,230,000		1210,000		2,930,000
Misc-equip. (20%)			404,000		246,000		242,000		586,000
Total			2,424,000		1,476,000		1452,000		3,516,000
Annual depreciation cost at 10% in US$			242,400		147,600		145,200		351,600
Annual depreciation in Y.R ($ = 135 Y.R)			32,724,000		19,926,000		19,602,000		47,466,000

E) Summary O&M Optimal Budgets

Once the components of optimal budget were derived they were then summed and a 15% of the total was added to cover other miscellaneous O&M cost. Consequently summary O&M optimal budget for the 4 irrigation systems were prepared and presented in Table (18) below.

Table (18): Summary annual optimal budgets for costs O&M services for spate irrigation systems of Wadis Zabid, Rima, Tuban and Bana in 1998

Item of Expenditure	Cost in YR			
	Wadi Zabid	Wadi Rima'	Wadi Tuban	Wadi Bana
1. Staff Salaries	9060,000	6,072,000	7,476,000	11,208,000
2. Cost Operation of machinery and vehicles for earthwork maintenance, water allocation. etc	7,438,800	4,407,800	4,459,600	10,306,400
3. Cost Maintenance & repair mainly for concrete works on weirs, structures, bridges, and hydromech. installations, in canals.	1,840,000	1,478,000	1,544,000	2,275,000
4. Cost of depreciation of machinery & vehicles annual at 10%	32,724,000	19,926,000	19,602,000	47,466,000
6. Sub-total	51,062,800	31,883,800	33,081,600	71255400
7. Other miscell. O&M expense estimated at 15% of above.	7,659,420	4,782,570	4,962,240	106,883,710
Total	58,722,220	36,666,370	38,043,840	81,943,710
7. Average irrigated area (ha)	15,215	8,000	8000	19,000
8. O&M cost per (ha) in Y.R	3,859	4,583	4,764	4,313

Therefore according to above estimates the overall average optimal O&M cost per ha is about Y.R 4,432 (say $ 32.8) at ($ = 135 Y.R)

F) Estimated O&M Cost of W. Zabid & Rima Based on the Investment Costs

Table (19) shows that the investment costs for wadis Zabid and Rima' systems were US$ 39.2 and 26.59 millions, respectively. The present worth of these systems was then calculated using an annual depreciation of 3%.

Table (19): Estimated present worth's of wadis Zabid and Rima systems.

Component	**Cost in million US$ (1979 prices for w. Zabid & 1986 prices for w. Rima')**	**Present worth in million US$ (1998)***	**Net area served (ha.)**
Wadi Zabid **(completed 1979)**			
Diversion 1 & all of its equipment	8.30	4.73	1,700
Diversion 2	13.00	7.41	2,600
Diversion 3	11.30	6.44	5,200
Diversion 4	3.00	1.71	4,000
Diversion 5	3.60	2.05	1,300
Wadi Bed	39.20	22.34	415
Total			15215
Wadi Rima **(completed 1986)**			
Salaries and Technical Assistance	3.12	2.19	
Equipment	1.95	1.37	
Civil Works	21.17	14.84	
Operational Cost	0.35	0.25	
Total	26.59	18.65	8,000

* Based on an annual depreciation rate of 3%.

** Source: Basic data of cost benefit analysis, TDA Develop. Projects II & IV, W. Rima' Completion Report. '86.

Then, the O&M cost were estimated at as 2% and at 3% of the present worth, as shown in Table (20).

Table (20): Estimated O&M costs of Wadi Zabid and Rima systems, based on investment costs, at 1998 prices.

Spate Irrigation System	Present Worth, Million US$	Estimated optimal O&M per ha.	
		based on 2% of PW	based on 3% of PW
Zabid (15,215 ha)	22.34	29.36 US$ (YR 3,964)	43.95US$ (YR 5933)
Rima (8,000 ha)	18.65	46.6 US$ (YR 6,294)	69.92 US$ (YR 9,442)
For both wadis taken together (23,215 ha)	40.99	35.31 US$ (YR 4,767)	52.97 US$ (YR 7,151)
% requested to estimated (budget requested for both wadis = YR 948 / ha)	--	19.89	13.26
% allocated to estimated (budget allocated for both wadis = YR 533 / ha)	--	11.18	7.45

Thus, depending on whether one uses the 2 or 3 % of the present worth, the annual O&M cost at 1998 prices for Wadi Zabid ranges from about 30 to 44 US$ (YR 4,100 - 6,100) per ha. and for Wadi Rima from 47 to 70 US$ (YR 6,900 to 9,400) per ha.

For the two wadis taken together, the above 1998 estimated cost per hectare were estimated to range from about 43 to 53 US$ (4,700 to 7,200 YR). Compared to the requested budgets for 1998 (YR 948 per hectare), this represents only 13 to 20 % of the estimated, while the allocated budget (YR 533 per hectare) represents only 7 to 11 % of the estimated cost. While compared with the overall average optimal (4374 Y.R/ha mentioned on p.) it represents 89.3 to 59.9% of the above estimate at present worth of 2% and 3% respectively.

Unfortunately the consultant could not undertake similar exercises for Wadi Tuban and Wadi Bana due to non-availability of data concerning capital costs investment for these two spate irrigation systems.

G) Summary Optimal vs. Allocated Budgets

A summary of the total optimal annual O&M budget for the four systems is shown in Table (21), together with the allocated budgets for ease of comparison.

Table (21): Summary of the optimal vs. allocated O&M budgets for 1998 for the four spate irrigation systems (in '000 Y.R).

	Wadi Zabid		Wadi Rima'		Wadi Tuban		Wadi Bana	
Item of Expenditure	Optimal Annual Budget	1998 Allocated Budget	Optimal Annual Budget	1998 Allocated Budget	Optimal Annual Budget	1998 Allocated Budget	Optimal Annual Budget	1998 Allocated Budget
1. Staff Salaries	9,060	5,090	6,072	3,394	7,536	63,968	11,208	29,472
2. Operation of machinery and vehicles for earthwork maintenance *	74388	2,000	4407.8	1,900	4459.6	1,800	10306.4	3,600
3. Mainten. of weirs, structures, bridges, hydromech. installations, etc.	1,840		1,478		1,544		2,275	
Cost recovery of machinery	32724		19926.0		19602.0		47466.0	
Sub-total	510628		31883.8		33141.6		71255.4	
Other miscell. O&M costs (utilities, office rent, etc.) at 15% of the total	7659.42		4782.57		4971.24		10688.31	
Total O&M	58722.22	7,090	36666.37	5,294	38112.84	65,767	81943.71	33,072
Avrg. net command area (ha)	15.215		8,000		8,000		19,000	
O&M Cost / ha	3.859	0.466	4.583	0.662	4.764	8.22	4.313	1.74
Alloc. / Optimal %	12.1		14.4		172.5		40.36	
Alloc./Optimal % W/O Salaries	4.14		6.4		6.11		5.21	

* Optimal O&M budget values are taken from table (18).

b) on comparing the optimal vs. the allocated O&M budgets for each of the four wadis, one can easily see that the salaries component shows some abnormalities; namely:

- the wadis Zabid and Rima' have allocations of about 59% and 55% respectively lower than their optimal. On examining their staffing list it is noted that they are generally understaffed in total number and in some posts and unbalanced and overstaffed in others (e.g., drivers and mechanics).
- funds allocated for salaries of Wadi Tuban and Wadi Bana staff exceed the optimal budget by about 8.49 and 2.63 folds, respectively. This is due to overstaffing resulting from annexing almost all of the ex-Yemeni-Soviet Project staff at Lahej to the MAI office and those at Abyan to the irrigation section of the MAI office while this latter section has been already supported by staff and equipment under the ex-Traditional Irrigation Project (1982-89). Consequently this has led to a misleading percentage increase in the allocated over the optimal total O&M budget of 172.8% and 40.36. for Wadi Tuban and Wadi Bana, respectively. However, if comparison of the O&M budget is made without the salaries item, then the situation will be more realistic whereby the allocated funds of YR 1.8 & 3.6 million for wadis Tuban and Bana, respectively are only 6.11% and 5.21% of their respective optimal funds (W/O salaries) of YR 29446440 and Y.R 69054510 respectively.

c) the irrigation departments, which operate and manage the various spate irrigation systems in Yemen are facing serious problems of inadequate funding for their activities. If this issue is not solved then the sustainability of the spate systems will be undermined and their life will be drastically reduced.

7.0) O&M of Small Dams Irrigation Schemes

Before the field visit the study team reviewed various reports on the status of small dam irrigation schemes. It was found that such schemes do not generally include irrigation networks. They are rather used as storage lakes to recharge the groundwater aquifers. In the dry season, farmers are not prevented from tapping their water hoses into these reservoirs and pump the water by small submersible pumps for irrigation.

There has been no record of community organization to improve the use, desilt, or rehabilitate existing structures.

7.1) Visited Schemes

Field visits were made to three of these schemes in Taiz governorate. The findings are summarized below.

a) Al-Amirah Dam Scheme

Al-Amirah dam was built at the same location of the old dam (washed away some 45 years ago) situated north of Taiz at Wadi Arsoum near Sa'afan village. Water Power Consultancy Services (India) Ltd (WAPCOS) designed the new dam.

The small dam under this scheme is earth fill type with a clay core. The height of dam is 11 m and its width is 167 m. It has adjoining spate flow structures 116 m long and consisting of a small spillway weir and a breaching bund (fuse plug). The reservoir's total design capacity is 785,000 m^3 with a dead storage of 50,000 m^3. The dam has 2 irrigation conduit pipes with outlets with lengths of 75m and 50m situated at right and left side of the dam. Both are irrigating a total area of 176.4 ha downstream. The scheme has neither canal nor irrigation networks downstream and therefore there are no O&M services.

Presently this scheme comes under the responsibility of the Governor's Office at Taiz with adhoc technical supervision by the Southern Regional Agricultural Development Project (SRADP), Taiz.

It has been learnt that efforts are still underway to organize the water users roles in the process of equitable water allocation with the possibility for installation of modern irrigation network, which will then need O&M services.

On the other hand, garbage from the city of Taiz is disposed on the side of the Wadi course. This causes pollution of water flowing to the dam reservoir and deterioration of the water quality.

b) Damum Irrigation Scheme

This scheme lies at Al-Damum village, Mawiyah district (governorate of Taiz), at distance of about 17km NE of the city of Taiz. The structure, which was also designed by WAPCOS, is a stone face rubble masonry dike with a height of 17m from lowest Wadi bed level. The width and length of crest are 5.2 and 61m, respectively. The reservoir's total capacity is 160,000m^3 with live and dead storages of 140,000 and 20,000m^3, respectively.

The dam irrigates command area of 31 ha. of land through a conveyance system consisting of main supply pipes of 3174m total length and diameters ranging from 200 to 75mm, discharging design flows ranging from 29.1 to 3.84 l/s from head outlet to irrigate 6 irrigation sub-units

(shaks), through branch lines delivering water to stilling wells at the head of the distribution network.

The last stage of implementation was supervised by SRADP. However, during the field visit the team observed that there were technical defects in the installation of the irrigation network which were noted then by SRADP representatives in order to follow up with the supplier for repair. The beneficiaries of the scheme were observed to be in harmony and are in agreement regarding their participatory functions in irrigation by rotation and O&M services.

c) Al-Gunaid Small Dam

This small dam, which is located in Mesrakh district (governorate of Taiz), is privately owned. Al-Gunaid family built it in 1995 using their own funds with little support from the government. It is a masonry structure with a total reservoir capacity of 750,000m^3. It has 3 outlets with three main galvanized iron pipes of 8-inch diameter. This scheme was completed in 1996 and the owner of the scheme is still in the process of negotiating with the beneficiaries whereby he is proposing to irrigate for them against 25% of the cost of crop production.

7.2) Problems of Small Dam Schemes

The main problem with the small dams is that these schemes are commonly built without irrigation networks and without much community work to organize the beneficiaries for subsequent operation and maintenance of the reservoirs. Thus, in most cases the water stays in the reservoirs and the farmers are satisfied that it "recharges" their wells. Occasionally, the farmers would pump the water out of the lake using small portable "centrifugal" pumps.
Given that there is no formal community organization to operate and manage these systems once they are built, several difficulties arise:

a) Impact on spate-water rights: sometimes, when there are no irrigation networks, the beneficiaries are deprived of the spate water, which they used to get before the dam was built. Let alone the similar impact on the water rights of downstream riparian.

b) Reservoir silting: the life of the structures decreases since there is no organization to desilt the lakes. The lack of operation rules, and facilities to discharge the water and clean the lake bottom create obstacles for desalting.

c) Not enough studies of sites are carried out.

d) Fragmented planning for dams and water structures in general. The government should identify one department only; e.g., the Directorate of Irrigation of the MAI to be the only body in-charge of the program of small dam schemes.

8.0) Conclusions and Recommendations

8.1) Conclusions

1) *Status of the Water Sector as a Whole and Spate Irrigation:*

The scarcity of water in Yemen is a well known fact, which requires a well defined and proactive role on the part of the government to direct the development of this sector. It is envisaged that the government role should focus on:

a) Defining and implementing a strategy for managing water resources,

b) Providing an adequate legal, regulatory, and administrative framework for water management and development,

c) Guiding inter-sect oral allocations and

d) Developing water resources in the public domain.

Unfortunately, most of these functions have not been adequately addressed for the past three decades. It is only now, after the country has fallen into a water crisis, as evidenced by the falling water levels in many basins and water shortages in several cities, that an agenda for action is initiated (Towards a Water Strategy, September 1996), together with the establishment of the National Water Resources Authority (NWRA). Indeed, the developed Agenda for Action only lightly touches on the issue of spate irrigation and utilization of surface water. While, it remains to see what the current institutional framework for the planning of water resources can do to improve planning and coordination among the various key players in the sector.

2) *Status of the Spate Structures, Equipment and Machinery:* the existing systems are experiencing severe deterioration, as evidenced by: accumulation of sediments in the canals (especially in the Tihama systems), partial damages by floods (to the extent that some weirs went out of service, such as Diyyu and Al-Makhzan), erosion of parts of the systems, destruction and vandalism of gates and canal turn outs (especially in Ban and Tuban systems). Another problem is that many equipment and vehicles are not operating, simply because of lack of funds for maintenance, spare parts and repair.

3) *Status of the Operation and Maintenance Staff:* there is overstaffing in some O&M departments (Tuban and Bana) and un-balanced staffing in others (Zabid and Rima).

4) *Financial Resources (or Budget Allocations):*

- *Source of finance:* it is safe to say that the only finance for expenditure on the O&M of the spate irrigation systems is the public budget allocations. The entities in charge of the O&M of these systems do not receive any fees or charges from the farmers as contributions to the cost of O&M.
- *Sufficiency:* the technical and administrative departments in charge of the O&M are facing huge financial constraints due to the large deficit in the budget; i.e., large difference between what is allocated and what is required to adequately carry out the O&M and rehabilitation tasks for the existing structures. For instance, while the optimal O&M costs per ha in Zabid and Rima' were estimated at 3859 & 4583 YR, the budget allocations are only 12.1 & 14.4% of the optimal (4.14 & 6.4% without salaries).
- *Nature of allocations:* besides being limited, the financial allocations are largely to cover salaries (more than 90% of the budget in Abyan and Tuban). This is due to overstaffing in some departments. Additionally, in most systems, there are no funds (local or international) to rehabilitate and repair damaged or washed away components, or for flood protection works, or to construct the system structures which were not completed, despite the fact that studies and designs are ready for some.

5) *Sustainability of the Spate Structures:* the above-mentioned difficulties constitute a real threat to the sustainability of the existing systems. Undoubtedly, the expected service life of these structures is reduced.

6) *Role of the Local Authorities:* the local authorities realize the importance of farmers' contributions to the O&M costs. Upon a proposal by the Irrigation Office in Lahej, the Governor of Lahej issued a decree (No. 14 dated 14/4/1996) which, among other

regulations for irrigation, included an order to collect 100YR per Feddan per irrigation (about 250 YR per ha. per irrigation) of land irrigated from spates and 500YR per Feddan (1250 YR per ha.) of land irrigated from perennial baseflow. The revenues were to be deposited This decree was implemented for one year only (1997) then the Ministry of Finance objected, claiming that the revenues should go to the public treasury.

In Abyan, the office of the Ministry of Agriculture and Irrigation, after consultation with the Governor's Office, had proposed an internal regulation for irrigation in Abyan Delta, including the collection of irrigation fees. But the implementation of which was postponed.

7) *Farmers' Willingness to Contribute to the O&M Costs:* farmers in the four wadis are willing to contribute to the O&M costs, provided that equity in water allocation is ensured and that they receive their shares; even if it led to modification of part of the irrigation schedule which is based on the traditional system of water rights. This is to increase efficiency of use of the diversion structures and to take into account the changes in cropping patterns.

8) *Cost Recovery:* undoubtedly, the collection of irrigation fees proportional to the cost recovery requirement is a desirable issue to ensure sustainability of the systems. However, satisfying this goal remains difficult to achieve on the short term, particularly that it comes after the system of irrigation fees collection (which was enforced in Lahej and Abyan prior to independence and continued till the early nineties) has been abandoned, and when the recommendations by the consultants of Tihama systems, regarding the collection of irrigation fees have not been taken. In other words, the issue of collection of irrigation fees has not been taken seriously by the government except, perhaps, lately; and times of economic hardships to the farmers and consumers. Hence, we are led to conclude that the best that can be achieved at these times is to get the farmers to contribute to the O&M costs, but not full cost recovery.

9) *Enforcement:* there is not enough support from local enforcement authorities to enable TDA and the Irrigation Offices to implement the water allocation plans, deter offenders, and to protect the structures and their components.

10) *Structures Rehabilitation:* it is estimated that the capital cost required to rehabilitate the Wadi Tuban and Wadi Bana systems is about (900) million YR. It is also essential that funds be made available for wadis Zabid and Rima to solve the many technical problems, especially the sedimentation problem.

8.2) Recommendations

1) **With respect to water resources management:** a water strategy, which contains a clear policy on spate irrigation, should be adopted. It is also recommended to compose a coordination committee with members from the Ministry of Agriculture, NWRA and the necessary sub-committees at the governorates levels.

2) **With respect to the O&M costs:**

   a) It is necessary to adopt the principle of collection of irrigation fees from the farmers, as was the case in some wadis in the near past, in order to increase revenues and move the current systems to closer to sustainability. It is proposed that the fees become 500YR per ha. Per irrigation for spate irrigated lands and 1,000 YR per ha. For baseflow irrigated lands. The state would have to cover at least 50% of the optimal cost per ha.

b) It is necessary to commence, from now, social work to increase farmers' awareness with respect to necessity of contributing to the O&M costs. It is also necessary in any rehabilitation works to observe traditional water rights and to involve the farmers in the planning for the works/ structures.

3) **Role of local authorities:** it is absolutely important to capitalize on the two recent experiences with respect to involvement of Governor's offices in the over-seeing of needs of these systems.

4) **With respect to the cost of rehabilitation works:**

a) Farmer's role: it is not expected to succeed in convincing farmers to make financial contributions to the cost of such works. Nevertheless, they still have a vital role to participate in the planning of these systems/ structures and in organizing themselves to operate such systems.

b) Government role: to seek funding, reduce overstaffing (in order to reduce the costs of O&M born by the farmers), and activate the role of local law enforcement authorities to protect the structures and ensure implementation of water allocation plans.

c) Donor's role: to initiate an appropriate mechanism for financing, in such a way that allows involvement of O&M Departments and the nuclei of the WUA's which are to be formulated. An emergency project is needed quickly to make simple and necessary repairs/ rehabilitation works.

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Annex (A): Technical Aspects of the Operation and Maintenance of Spate Irrigation Systems

This annex examines the technical aspects of the O&M status of the spate irrigation systems, which were visited.

1) O&M Functions:

In developed spate irrigated areas, the O&M functions are undertaken for diversion and hydraulic structure, for water control and distribution, and for the canal network of the irrigation systems. In Yemen, generally, the O&M functions or tasks are entrusted to O&M departments of rural development authorities (RDA's) such as Tihama Development Authority (TDA), or to the irrigation sections of the Ministry of Agriculture & Irrigation (MAI) offices as is the case in the Southern Governorates (e.g. MAI office in Lahej and Abyan Governorates). On the other hand, there are a number of foreign financed agricultural development projects which have included spate irrigation development works and consultants have prepared O&M manuals for the related spate irrigation system which has helped and guided RDA's to establish the pertinent O&M units for the concerned wadis.

1.1) Operation:

During the flood seasons the spates flow in sizable discharges ranging from low to very high floods, which last for relatively short periods of time ranging from few hour to several days. Therefore each spate flow has to be efficiently utilized in time with minimum damage to the structures and canals, while avoiding flow of water to the sea in case of high floods. Also, another main objective of the spate operation services is to ensure equitable distribution of the available spate water from the most upstream point through the canal networks up to the fields downstream. To achieve this, the O&M Department has to prepare an annual spate water allocation plan based on irrigation schedules for the different crops within the command area of each diversion structure. In modern spate irrigation projects, some activities have to be done every season and prior to water actual operation and allocation. For diversion structures tasks to be done include flushing sediments through sluiceways and checking that the gates are operational. Also cleaning canals from sediments, weeds, debris, trash. etc and repairing any defects in the lined canals and maintaining and lubricating gates of turnouts and outlets to ensure its proper operation.

In the traditionally spate irrigated areas, the farmers (in anticipation of spates) have to build the required bunds "*Uqmas*" across the Wadi in order to direct the entire low stage flow of floods into their fields or by making temporary bunds or spurs (*obars*) projecting into the Wadi for deflecting a portion of the spate water to their adjacent fields.

1.2) Maintenance:

Maintenance of the spate irrigation system is an important management function. To some extent there is an overlap between some of the operation tasks and maintenance tasks and it is important to ensure a degree of coordination between them. There are three main types of maintenance: routine, periodic and emergency. They are defined and explained below.

a) Routine Maintenance: This is the simplest type. It shall be carried out daily based on regular inspection of structures and patrolling along canal distribution system. This will require carrying regular repair works including the following activities:

- Cleaning of silts, weeds, algae and debris from canal bed, gates and trash-screens.
- Removal of any blockage of flow in canals due to logs, accumulated debris. etc.
- Minor repairs of diversion structures and other small hydraulic structures e.g. canal drops, intake structures division and distribution boxes... etc.

- Cleaning of gates and greasing and oiling gate lifting mechanisms.
- Repair of leaks due to seepage in earth canals.
- Backfilling and compaction of eroded canal embankments caused by overflow or leakage of canals.

b) Periodic Maintenance: This type comprises the comprehensive cleaning and reshaping of canals and repair of structures and service roads. Some of the main related activities are:

- Clearance of heavy silt deposits especially in main structures and canals including removal of weeds and trimming of side slopes for earth canals.
- Painting of canal gates every year (every three years at most) with gauges if any.
- Minor repairs to concrete of headwork's and repainting exposed steelworks as for canal structures. It will be necessary to test the gates over their full range of travel.
- Pitching and riprap works at structures have to be regularly inspected and repaired as necessary.
- Reset boulders, mattresses, and gabions and replace where needed.
- repairing of service roads within the irrigation system to ensure continues good, access of O&M services with the required machinery.
- Maintain or reconstruct earth bunds "*Uqma*" across wadis and earth spurs diverting water "*Ubars*" required for traditionally spate-irrigated areas.

The timing of maintenance is important in that it should be affected with minimal disturbance to irrigation. Also, careful planning is a must in order to make best use of time. Wadi Zabid Project Inspection and Maintenance Schedule in enclosed to illustrate the various O&M required for (Annex B).

c) Emergency Maintenance: This type of maintenance covers repair of heavy damages such as breeches in structures or canals, which will require prompt action to prevent prolonged shortage of water or extensive damage. For this maintenance the required men, machines and materials have to the immediately provided for the work. Of course in the event of catastrophic floods more urgent actions will have to be taken.

A sample inspection and Maintenance schedule for Wadi Zabid project is enclosed to illustrate types of O&M tasks and periodicity of their implementation.

2) Field Visits to Selected Areas:

The Consultants team visited a number of selected representative areas to acquaint themselves and to collect data regarding the operation and maintenance (O&M) functions and expenditures. The visits covered 4 spate-irrigated wadis 2 in the Tihama Region and 2 in the southern coastal plains. The mission also visited 3 small dams in Taiz Governorate. A brief description of these visits with the main findings from irrigation and technical points of view are summarized below.

2.1) Visits to the Tihama Region:

The team traveled to Hodeidha (17/7/'98) where it met the Chairman of TDA and other senior officials on the next day. The mission was briefed on TDA project activities including O&M of spate irrigation of the wadis and available data and reports about wadis Zabid and Rima' were submitted to the team. A field visits to the two project areas (which are both under the southern region management unit, SRMU, of TDA whose headquarters is situated in Zabid.

The team arrived to SRMU in Zabid on 19/7/98. Further data on the activities and O&M expenditures of the unit, with special reference to wadis Zabid and Rima' projects, which were visited during the next 3 days. The results of visits to the two projects are as follows:

a) Wadi Zabid Spate Irrigation System:

Wadi Zabid project, which was completed in 1979, covered agricultural development for a total area of about-17000 ha. The irrigation and infrastructures improvement works of the project consist of the following:

- Five diversion structures each typically consists of a concrete diversion weir, one or two canal head regulators, two sluiceways, an earth fuse plug and upstream and down stream earth guide bunds armored with riprap.
- Canal distribution network with total length of about 122.9 kms, of which about 41.0 kms is new or reconstructed in parts that are connected to pre- existing canals (81.9) and all are along 16 irrigation canals serving a net area of about-15, 200 ha.

The 16 canals and the two tail branches of Wadi Zabid are grouped into three canal groups each having separate turn of irrigation as shown in Table (1).

Table (1): Irrigation structures and irrigated areas in the canal groups of w. Zabid spate irrigation system.

	Diversion Structure		**Weir**	**Canal Length (km)**			Area Served (Ha)			Priority Period for Perennial or Spate
Canal Groups	**No.**	**Over Flow Width (m)**	**Capacity (m^3/s)**	New or Recast	Existing	Total	No. of struct.	Groas	Net	Irrigation
I	1	140	1400	9.8	7.8	17.7	35	1860	1690	19th Oct.-2nd Aug.
	2	140	1400	14.1	17.4	31.5	75	2925	2635	
II	3	140	1400	12.8	27.5	40.3	57	5775	5200	3rd Aug.-13th Sept.
	4	129.1	900	1.7	12	13.7	1	4400	3965	
III	5	40	200	2.6	17.1	19.7	10	1450	1305	14th Sept. -18th Oct.
Wadi Bed	---	---	---	---	---	---	---	470	420	
Total		41.0		41.0	81.9	**122.9**	178	**16900**	15215	

The project has also constructed a total of about 94 km of gravel surfaced roads; of which 21.9 kms access roads to diversion structures and canal bifurcation structures and 10.9 km are canal roads (service or inspection roads) and 60.7 km are farm roads serving farm villages and farm lands in the project.

The water resources in the Tihama wadis including Wadi Zabid generally fall into three fairly clearly defined categories:

- Baseflows and minor spates those are generally sufficient to provide two crops (including bananas) per year on about 30% of the traditionally irrigated areas, which may increase to 40% with improved irrigation.
- Spate flows that may provide an average irrigation for just over one crop on about 60% of the traditionally irrigated areas but with a variable degree of probability.
- Groundwater is abstracted both in traditionally irrigated areas and rain fed areas of the Wadi with cropping intensity of about 2-3 crops per year.

In Wadi Zabid for more than 600 years the irrigation water rights have been practiced according to Sharia'a basic principle "Al-ala fal-ala' i.e. the upstream field is given priority for irrigation before the downstream field. In this regard the baseflow from 18 October to 29th March is allocated to the upper delta service area denoted as canal group-I in Table (1) above which also enjoys priority of spate irrigation during the period 29th March through 3rd August

with the middle and lower delta service areas i.e. canal groups II and III, respectively given priority on dates shown in Table (1). Under this traditional and strict regulation the beneficiaries of the lower areas can irrigate their fields only during the above specified periods and when the flow in the pertinent canals exceeds that of the upstream areas Unfortunately this situation does not fulfill the expected equity for the downstream irrigators and poses the need for flexible reconsideration of the regulations of the traditional "Al-a'al Fal-Ala'a" practice in order to attain better equity in water distribution and better utilization of the modern spate irrigation system which was not there countries ago.

The O&M department was established by the (SRMU) of TDA as guided by O&M manual prepared by the consultant which has also included an alternative water allocation plan with dates for irrigating the 3 canal groups slightly modified from the dates of the traditional water rights. However this alternative plan through a committee formed by local authorities have both failed to be adopted by TDA. This is due to recurrent violations of the water allocation plan by some farmers who were not deter by authorities and the fact that there was a conflict of interests with regard to some big water users in the Wadi. Consequently, this situation has resulted in a sort of disappointment to O&M Dept. and to the downstream farmers where all have felt hat they have no choice but to strictly adhere to the centuries old tradition of water rights practice.

The O&M department is in charge of O&M services at the diversion structures, other hydraulic structures, and canal distribution network up to the gates off taking from main and feeder canals to field turnouts. The farmers responsibility starts from field turnouts by delivering water through field ditches then irrigating their lands by pending spate water lavishly in their field basins. The O&M department can never undertake all the required tasks or even parts of it efficiently. This is due to the session problems facing the section of which is the very limited funds allocated by the govt. which also diminishes every year in addition to the problems of inadequate and depreciated machinery and lack of incentives to skilled staff. On the other hand, if was reported that the for some years the farmers in Tihama region including Wadi Zabid used to pay 2% of their agricultural production income from spate irrigated lands as a sort of cost recovery fees to *wagibat* (Zakah) Depts. Any way this procedure-which has stropped recently- is a poor and random method for levying tax from farmers. Also there are no official records of the collected amounts and nothing has been paid to TDA. Data on required allocations and actual expenditures of the O&M department has been collected by the agro-economist to be covered by the paper on "O&M expenditures".

Based on the field visits, collected reports, meeting and discussions with TDA and SRMU senior staff the following technical problems have been observed:

1) Sediment load in Wadi Zabid is high. In this paper Traditional Spate Irrigation and Wadi Development Schemes "Mr. Camacho referred to model studies whereby the concentration of sediment was measured for flow discharge ranging from $0.5m^3/s$ to the maximum of $40m^3/s$ along Mansury-Rayan-Bogr canal of Wadi Zabid. The sediment concentration reached 18600 ppm at 40 m^3/s and 4800 ppm and 1620 ppm at-discharges of 5 and 0.5 m3/s respectively. This high sediment concentration causes problems for the Wadi Zabid spate irrigation system at three levels as follows:
    i) Large deposits of course sediments with stones and pebbles accumulate at the entrance of head regulators to the extent that when floods recede, the baseflow of the Wadi flow over the weir crest instead of flowing through the head regulators. This is because the flow Wadi changes its courses due to the high accumulation of deposits. Consequently the O&M Dept. has to remove these large sediments and deposits every season to allow the Wadi flow to take its normal course to the head regulators.

ii) Large amounts of sediment (mainly fine sands) carrying debris and trash are deposited along the earth main canals due to inefficient functioning the sluice ways of the diversion structures. Also vegetation growth and weeds in the earth canals hinder their capacity and efficiency. Again the O&M Dept. has to clear the canals from sediments, debris, trash the vegetation and then reshape the cross section of the canals. This operation needs a lot of work and efforts by the O&M section which does not have enough machinery and resources unfortunately the sediment deposits excavated from the main canals are not required by nearby farm and is not particle and economic to dump it in the middle of the Wadi which is far away from the canals. Consequently the department dumps such deposits along the embankments of the main canals and inspection roads. This creates other problems whereby the canal embankments get higher and higher and during rains the sediments fall back to the canals; also there are difficulties in using the inspection roads that are covered with the fine sands of the despised sidemen's especially at time of rains.

iii) Most of the silt and fine sediments of the spate water finally settle in the farmer fields, which are pounded with water to a depth of about 1.5 to get as much as possible of water and silt. With this traditional practice and the fact that most farmers don't level their fields, then due to accumulated situation the level of the upstream fields which has first priority for irrigation becomes higher than the level of the field outlets off taking from the main canal. Then to irrigate such fields adjacent to outlet, the concerned farmers construct just downstream of the outlet an earth bund (*Uqma*) across the canal in order to raise the water in the canal to a level that will enable the farmers to irrigate their fields. This action may lead to over topping water to the embankment of the canal and may cause breaching of the canal and then depriving all farmers from irrigation till the canal is repaired. Also over flowing water may cause scouring around a small structure such as a drop, which will then need to be repaired.

2- Due to the practice of field to field irrigation and especially in the upstream areas were farmers enjoy longer time priority of water rights, sometimes and after excessive pending of water in the field basins it has been reported that farmers divert surplus flow to the adjacent inspection roads thus damaging it by man-made small floods which sometimes even threaten small villages.

3- Cropping pattern in Wadi Zabid has shifted from cereals to banana, which is a better cash crop, but with higher water requirements. This case mainly prevails in the upstream areas were farmers enjoy longer time priority of water right from base flow and spates for about 10 months.

4- Some farmers cultivate crops in land patches and strips along the Wadi bed (called *Gulul*). The problem is that these areas are expanding and are irrigated from spate water while traditionally these type of land should be restricted to their original areas and be irrigated from base flow only.

b) Wadi Rima' Irrigation System:

The Wadi Rima' irrigation system which serves command areas up to a total of 8,000 ha was visited on 22/7/98. The irrigation works were constructed as one of the components of Tihama IV Agricultural Development of Wadi Rima' phase-II. The irrigation system was designed to regulate and control irrigation during the perennial baseflow season with baseflow in the Wadi below 2 m3/s and during the spate season whereby flow in the Wadi exceeds 2 m3/s. The irrigation works consist of the following components:

i) a weir with one off takes with a total delivery capacity of 15 m3/s with the following structure sub-components:

- dam wall across Wadi Rima'
- a flushing structure
- an intake structure
- a sand and gravel trap
- an ejector structure for sand and gravel.
- an orifice to limit the discharge into the canal.
- aside spillway to discharge excess water.

ii) Main distribution structure and siphon (350 m long)
- a main supply canal (max. capacity 15 m^3/s) offtaking for the weir to the distribution structure.
- a distribution structure bifurcating flow through a siphon (capacity 10 m^3/s) 350 cm long to the south main supply canal which feeds 9 canal along the left bank of the Wadi and the other part of the flow is bifurcated to the Hudays canal along the right bank of the Wadi.

The O&M is carried out by a unit under the O&M section of SRMU at Zabid, irrigation from baseflow and spates is carried out according to traditional customs as in Wadi Zabid. The irrigation system of Wadi Rima' does not suffer from heavy sedimentation problems as in Zabid. This is becomes and ejector works included an efficient flushing structure areas of the Hydayed canal is irrigated by the military. Agricultural supply corporation which have insisted on TDA to allocate for them 50% of the delivery capacity of the main supply canal i.e. 7.5 m^3/s instead of 5 m^3/s as designed for the Hydayed canal. The corporation is cultivating about 300 ha of bananas upstream of the right bank of the Wadi while few big land lords cultivate another ha irrigated from the south main supply canal in upstream areas along the left bank) the Wadi. Banana case a high water requirements and as in Wadi Zabid strict application of traditional customs of water rights unlimited cultivation of bananas upstream bring about problems of equitable water allocations to downstream farmers.

The establishment of water users associations (WUA's) that will gradually take over the responsibility of O&M of spate irrigation systems is a subject that will recover by a separate paper. Hover the concept of establishing WUA's was discussed was discussed with govt. officials at TADA and its SRMU and also with a number of farmers.

2.2) Visits to the Southern Wadis Region

The team traveled from Taiz to Aden on Friday 24/7/98 and met with Dr. Abdul Aziz Saif who had previously headed a team, which has prepared a report on participatory spate irrigation management in Lahej and Abyan. The report was issued on March 1998. The mission has obtained from Dr. Saif clarifications regarding few points on the study and then he was briefed on the TORs of the mission and its field program for Lahej and Abyan. Dr. Saif also has lent the mission a copy of annexes I and II containing field questionnaire of the field survey that has been undertaken by his team in Lahej and Abyan. As Dr. Saif study contained a lot of technical information and data about Wadis Tuban and Bana, this section of the report will concentrate on technical matters regarding O&M.

As background information, it must be stated that two important "Agricultural Development Boards" were established, one in Abyan in 1948 and the other in Lahej in 1954, mainly to introduce cotton crop to be cultivated for the first time in Yemen and under spate irrigation system in each of Wadi Bana and Hassan in Abyan (under Al-Fadhli: Yafa'a Sahil Sultanates) and Wadi Tuban Delta in Lahej (under Al-Abdali sultanate). In general the board was in charge about the irrigation works and services and agricultural development (including cotton) and

extension services in the area. The water allocation of base flow spate was carried out in both Wadi Bana and Tuban according to traditional customs (Al-a'ala Fa Al-a'ala) as in Tihama Region further more in Lahej these was an agricultural council and a court that were established and organized by a sultanate decree.

In this respect, the O&M services were included among the irrigation services performed by the boards. The O&M functions of the board used to cover any existing weir or small hydraulic structures and concrete works. However, the cost of board services including that of the O&M used to be collected from the farmers as irrigation fees based on irrigated areas. The boards used to provide short-term cash loans to the farmers 3 times during the cotton season; the first loan is provided on sowing, the second on thinning and weeding and the third at harvest time. The farmers on installments during the season repay these loans and usually the last installment and irrigation fees are deducted from price of cotton produce, which the farmers were obliged to sell. Until independence of the southern Governorates from the British and the Sultans in 1967, the above mentioned system was operating successfully with built-in elements for its sustainability whereby cotton acreage has increased and the traditional cereal hope of sorghum continued to be the main food gain for the local population and the main source of fodder for livestock.

After independence land the new Republic called then People's Republic of South Yemeni issued Agrarian Reform laws of 1968 and 1970. Under the agrarian reform many agricultural lands in different governorates were confiscated including spate-irrigated areas in Delta Abyan and Wadi Tuban Delta. Most of the confiscated lands were redistributed to new farmers or ex-tenants called beneficiaries "with lease contracts for lands they don't originally own. Then these beneficiaries were organized in agricultural cooperatives under govt. and party control. These in about two decades (1970-90) a new land tenure system has been established in the southern Governorates. At the same time the above-mentioned boards have been dissolved and were replaced by two Public corporations for Agricultural development one fro Delta Tuban and the other for Delta Abyan. There two corporations in coordination with the MAI offices in Lahej and Abyan took over the responsibility of O&M services that used to be taken by the ex-boards but without recovering any costs from the beneficiary farmers to their cooperatives. Then by early eighties the responsibility of the O&M services for the spate irrigation systems was completed transfer used to the irrigation sections of the MAI offices.

In Wadi Tuban and Wadi Bana region the floods occur mainly in two seasons, which coincide with the rainfall season. The first floods season starts as early as the second half of February to the first-half of June (Seif Season). The second season occurs from July to first half of October (Kharif Season). There is base flow in the upstream parts of the two Wadis which at the end of the Kharif season starts generally decreasing till it ravishes completely before the beginning of the next season.

The system for planning and distribution of spate water and base flow is similar for both Wadis. An annual water allocation plan is prepared by an irrigation committee (IC) consisting representation of MAI office in the governorate, local authorities and farmers. The IC also prepares schedules of irrigation for each diversion structure (weir or traditional *Uqma*) with its command areas for each canal. The implementation of the water allocation plan of entrusted to the irrigation section of the MAI office allocated to irrigate field based on the traditional customs of water rights (ala'ala fala'ala). However the IC have established some rules to fulfill equity fro the downstream irrigation. These rules or procedures are based n the concept that at flood times, spate water will not be diverted to the fields that have received water either from base flow or from earlier floods. Also Kharif season spate water is exclusively allocated to

lands that have received no water during that year, and only when these requirements have been met, the previously irrigated lands will get additional amounts of water.

During the period 25-27 July, 1998 the mission has visited the spate irrigation "system in each of Wadi Tuban and Wadi Bana and have met with the directors and the respective engineers and staff of MAI office in Lahej and Abyan. The main findings of these visits are sum margined below.

a) Wadi Tuban Spate Irrigation system.

The Wadi Tuban irrigation system lies on a delta consisting of alluvium fan with its apex at about 55 kms north of the city of Aden. The catchments area of Wadi Tuban is about 5090 cm and the overage annual flow to the delta is about 125 million cubic meters (MCM). The total irrigated area in Delta Tuban ranges from 5300 to 15400 ha. Depending on the availability of water during the floods season. However the average annual irrigated area is about 8000 ha. The first modern spate irrigation structures vis-a-viz. Ras al-Wadi and Beizag diversion weirs were built across Wadi Tuban in 1958. Then these two weirs were rebuilt with another new diversion weir with lined main and secondary canals for a total length of about 165.4 kms by the Yemeni-Soviet projects during the period 1970-80. On the other hand, a new diversion weir called Al-Faqeeh and Al-Fiah located downstream from Faleg weir is presently under construction with finance from LWCP.

The Wadi Tuban proper passes through the most upstream diversion weir (Al-Arais) then flows downstream to Ras Al-Wadi weir where it gets bifurcated into two wadis: Wadi Al-Kabir and Wadi Al-Saghir. The largest of the Wadi Al-Kabir flows southwards from Ras Al-Wadi weir and through Faleg and Mujahid diversion weirs up to Al-Waht area where there *uqma* and very rarely reaches the sea at Hiswa village. The Wadi Al-Saghir flows southeast wards from Ras Al-Wadi weir passing through Beizag, Al-Hadarem. Al-Bustan and Al-Munasirah diversion weirs and then forwards Al-Munasirah village and increase of very high floods it may flow further east to desert areas. Wadi Tuban is partly irrigated by a modern system with lined main and branching canals up to field outlets. The remaining part of the Wadi is irrigated by traditional methods. Technical features and command areas of the above mentioned diversion weirs in Wadi Tuban spate irrigation systems are presented in Table (2).

Table (2): Technical features and command areas of Wadi Tuban spate irrigation system.

S.R	Diversion Weir	Over flow weir capacity m^3/s	Main canal Capacity m^3/s	No. of canals	Total length of canal (km)	No. of structures	length of services roads	Actual command Area (ha)	No. of farmers
1	Al-Arais	1970	30	16	62	873	67.8	873	601
2	RasAl-Wadi	2800	25	17	47.5	556	558	1718	1284
3	Beizag	1375	25	9	33.8	423	40.7	1325	681
4	Faleg	1260	32	9	(1.65)	8	3.5	926	683
5	Al-Hadarem	1100	50	2	15.4	42	17.5	543	633
6	Al-Bustan	1000	35	2	4.0	16	6.0	747	745
7	Al-Munasirah	560	35	1	--	--	--	(2100)*	--
8	Mugahed	1130	25	1	1.05	7	2.0	474	370
9	Al-Waht (*Uqma*)				16.54		--	(1233)*	--
	Total							**6606**	

***** Command areas under Al-Munasirah weir and Al-Waht *Uqma* are mostly irrigated by grou9ndwater and are not included in the total.

The status of the Wadi Tuban spate irrigation system is deteriorating and the level of O&M are poor. This is particularly true with regard to maintenance of weirs and other structures and the canal network. Unfortunately maintenance has been neglected since the stoppage of the

Yemen-Soviet projects in 1990 and due to the annual decrease of government funds for O&M services. Therefore there was practically no maintenance for the system for the east 8 years. This is manifested by the fact that there is a program for replacing 26 old gates for 6 diversion weirs. The gates of the main and secondary lined canals are originally of bad quality with a stiff lifting mechanism and bad handles. However these gates were damaged and looted by people without any clattering measures by the local security authorities. Now there is an urgent need for replacement of 33 gates completely on in parts fir the canal distribution system.

The maintenance for the 2 types of gates requires a budget of about mill Y.R 37.5. Maintenance for concrete structures and for removal of heavy sediment and deposits (about 124000 m^3) requires a budget of about mill. Y.R 11.29. The govt. funds allocated for O&M within the 1998 budget for the Lahej MAI office is about mill. Y.R 65 of which about mill. Y.R 63.2 for salaries, which is too high, and only mill Y.R 1.8 mainly for operational services for implementation of the seasonal water allocation plans according to traditional customs as explained above. Consequently the allocated O&M budget for the Lahej MAI office should at least the doubled on short term basis. From the field visit the mission observed these requirements would cover a total command area 6606 ha. However if rehabilitation and irrigation development works are implemented for Al-Munasirah weir Al-Waht *Uqma* and few parts along the two wadis will cost about Mill. Y.R 300 as a second phase for development, then the system will be equipped to irrigate a total command area of at least 8000 ha.

The governoror of Lahej issued a decree (4/ 1996) to organize the process of irrigation of agricultural lands in Lahej Governorate. The decree contained formulation of an irrigation council yet to the appointed-which will work with advisory capacity to the MAI office. Also based on this decree farmers have to pay irrigation fees of Y.R 100 for each feddan being irrigated by spate water per season (either "Seif" or "Kharif" season), while irrigators from base and spring flows have to pay a fee of Y.R 500 per year per feddan. The decree stated that collected fees has to the kept in a commercial bank in favor of irrigation section MAI office to the used for O&M of irrigation system in Delta Tuban. The mission was informed by MAI office that such irrigation fees were collected for one year only.

The irrigation engineer believes that now the participation of farmers any sort of cost recovery for O&M cannot be fulfilled. It is clear that adequate funds should he allocated by the govt. for an amount not less than mill Y.R. 100 per year to improve efficiency and to cover the required urgent maintenance. On the other board the MAI office should solve the problem of the present over staffing in the irrigation section especially in the posts which requires no skills (e.q watchmen, admin. & financial supporting staff) and this is a pre-requisite for any participatory approach to the farmers. Only then the farmers of Wadi Tuban may source paying the above mentioned fees and then they will gradually accept the idea of establishment of water users organization which will have to be carried out-under the recently formed multipurpose cooperatives for legal seasons as explained by the senior staff of the MAI office.

b) Wadi Bana Spate Irrigation System.

Delta Wadi Bana lies at about 50 kms NE of Aden. The catchment's area of Wadi Bana is about 7200 km^2 and the annual total flow in the Wadi is about 160 MCM. The total irrigated area in the Wadi ranges from 12000 to 24000 ha. Depending on the availability of the season's floods however the average annual irrigated area is about 19,000 ha. There are 5 diversion weirs: Batis, Al-Hayja, Al-Diyya, Al-Makhzan and Al-Graib weir serving Wadi Bana through canal distribution system with total length of about 800 km. These weirs are initially old and were severely damaged by the flood.

Consequently the Yemeni-Soviet Projects have rebuilt Batis weir on 1985 with a new design containing a fuse plug and with a capacity of flow over weir crest of about 5000 m^3/s. Most of Al-Hayja weir was rebuilt with a modified crest design. During the mission visit it was observed that Al-Diyyo and the most downstream weir Al-Graib are not operation being seriously damaged by the catastrophic floods of 1982 and latter by the high floods of 1989. In fact in 1984 consultant W.S. Atkins have recommended to rebuild Al-Diyyo weir at a new site slightly downstream from the old weir with a tonal cost of $ 1,631,404 as updated in the recent study by Saif's team. Table (3) shows command areas, number of farmers and other technical features related to the diversion weirs and irrigation system of Wadi Bana. The Wadi Bana spate system consists of to parts. The first parts cover an area of for 510 ha along the west bank of the Wadi and are equipped with a modern irrigation network up to quaternary canals. The other part covering the maiming areas of the Wadi irrigated by traditional methods.

Table (3): Technical features and command areas of W. Bana spate irrigation system.

S.R	Diversion Weir	Over flow weir capacity m^3/s	Main canal capacity m^3/s	No. of canals	Total length of canal (km)	No. of structures	length of services roads	Actual command area (ha)	No. of farmers
1	Batis	5000	50	1	3.2	10	3.2	10,000	2387
2	Hyja	5000	25	1	1.0	3	1.0	2400	728
3	Al-Dyyu							3620*	707
4	Al-Makhzan							--	671
5	Al-Graib							(3362)**	--
6	Total							16020	

Notes: * Although Diyyu weir is not functioning this area in irrigated by Diyyu canal from a gated control regulator built in 1993.
** This area is mainly irrigated by groundwater and therefore not including in the total.

As the case in Wadi Tuban, the irrigation department (ID) under the MAI office in Abyan is in charge of the O&M services for Wadi Bana spate irrigation system, which covers an average area about double that of Wadi Tuban. It must the stated that during the catastrophic flood of 1982 this (ID) was re-organized and supported with a fleet of heavy earth moving machinery and staff through the "Traditional Irrigation Project" which was urgently established as an emergency project for rehabilitation of the seriously flood-damaged areas. For this reason the level of O&M services is considered to be moderately adequate and is certainly better than that of wadis Tuban and Zabid. Despite this fact, the ID of Abyan, like other departments, suffers from the problem of the unwarranted annually diminishing O&M funds. Also, this department needs a relatively high capital investment to rebuild Al-Diyyu weir, which commands an area of about 3,620 ha. On visiting the Hayja weir, which was operational, some technical problems were observed with regard to the designed curved weir crest which has to be modified to improve water delivery from Wadi flow over crest to the head regulator and upper intake of A-Ahboush canal.

Preparation and implementation of water allocation plan for Wadi Bana is practically similar to that of Wadi Tuban and as explained at the beginning of this chapter. However, the main differences and comments are summarized as follows:

1) The ID of Abyan renders extra services beyond the field turnouts. This is exemplified by undertaking land leveling of farmers' fields using ID machinery while the farmers provide fuel and per diem to machinery driver through the cooperatives which, years back, also used to pay 1 dinar per feddan as part of a cost recovery.
2) In 1996 the MAI office of Abyan, in coordination with the Governor's office, prepared a draft ministerial decree organizing the spate irrigation in Abyan Delta (i.e. Wadi Bana + Wadi Hassan). The draft, which was to be signed by minister of agriculture and irrigation, was carefully prepared and it covered the main following points:
    a) Formation of an "irrigation council" to be appointed by the minister of agriculture and irrigation. The council is to be in charge of implementation of the decree after adopting spate irrigation seasonal plans prepared by ID and submitted to the MAI Abyan office. The council will also supervise field implementation of the water allocation plans and the required O&M services for the irrigation system.
    b) The decree has reconfirmed the well-known tasks of the irrigation department of MAI office with the required delegation of authority.
    c) It is understood that water allocation plan will be implemented according to traditional customs; however there is a clause in the decree which prohibits re-irrigation any crop for the second time in the same field basin during the same flood season unless it is decided by the irrigation dept.
    d) Beneficiary per season. This is considered to be a contribution to the O&M costs.

    Despite its positive aspects minister of MAI did not sign the above-mentioned decree up to now.
3) The director of MAI Abyan office promised to follow up with the minister to have the decree mentioned in (2) above issued, and will include payment of YR 500 fees/ feddan irrigated by the baseflow per year. He also expressed willingness and confidence to convince beneficiaries to pay the irrigation fees as an interim measure.
4) Two out of five planned new cooperatives have been established al Rowah and Al-Dagag according to the cooperative union law. The MAI Abyan office believes that the proposed WUAs can only be established through such new multipurpose cooperatives and this is mainly for legal seasons.

3) Optimal O&M Budget

In order to compare the requested and the allocated O&M budgets the irrigation engineer proposes to undertake this exercise against an annual optimal budget for O&M costs to be prepared for the spate irrigation systems. This will be based on consultant's O&M manuals that were available for Wadi Zabid and Wadi Rima and as correlated with field visits made for the four systems taking in to consideration scope and type of O&M services as governed by the nature of the wadis, structures, irrigation system and command areas. The optimal budget have been derived and estimated by the irrigation engineer as detailed below.

3.1) Estimations of Optimal Budgets

A) Optimal Staffing

For the four systems, optimal staffing with annual salaries was prepared as shown in Table (5).

Table (5): Optimal staffing and costs for the four spate systems in wadis Zabid, Rima, Tuban and Bana (1998 prices).

Name of Post	Monthly Salary '000 YR	W. Zabid		W. Rima'		Wadi Tuban		Wadi Bana	
		No.	Annual Salary '000 YR	No.	Annual Salary '000 YR	No.	Annual Salary '000 YR	No.	Annual Salary '000 YR
1. Director of O&M Section	20	1	240	1	240	1	240	1	240
2. Administrative officer	15	1	180	1	180	1	180	1	180
3. Accountant	15	1	180	1	180	1	180	1	180
4. Storekeeper	10	1	120	1	120	1	120	1	120
5. Head of operation unit (irrig. / CE)	20	1	240	1	240	1	240	1	240
6.Head of Maint. Unit. (mech. / CE)	20	1	240	1	240	1	240	1	240
7. Civil Engineer	20	1	240	1	240	1	240	2	480
8. Hydrologist \ Metreologist	20	1	240	--	--	1	240	1	240
9. Canal Water Master	10	15	1800	10	1200	10	1,200	12	1,440
10. Gate Operator	8	15	1440	10	960	10	960	12	1,152
11. Chief Mechanic	10	1	120	1	120	1	120	1	120
12. Assistant Mechanic	8	2	192	1	96	2	192	4	384
13. Forman - Structures & Gates	8	1	96	1	96	1	96	1	96
14. Forman - Earth works	8	1	96	1	96	1	96	1	96
15. Heavy Machinery Driver	10	7	840	6	720	7	840	16	1,920
16. Heavy Truck Driver	10	4	480	2	240	3	360	7	840
17. Vehicle Driver (4WD pick-up)	6	8	576	4	288	5	360	10	720
18. Surveyor	15	1	180	--	--	1	180	2	360
19. Laborer (O&M)	5	20	1200	12	720	15	900	30	1800
20. Watchman/ guard	2	10	240	4	96	18	432	10	240
21. Chairman	5	2	120	--	--	2	120	2	120
Total		95	9060	69	6072	87	7,536	117	11,2208

B) Optimal Operation Budgets (Fuel and Lubricants)

Optimal costs of fuel and lubricants for operation of the optimal number and type of heavy machinery and vehicles for earthwork maintenance and transport, on average year, were estimated for the four systems. The equipment requirements were assessed so as to undertake earthworks including clearance of sediments, trash and debris, maintenance of earthern flood protection works, service roads, ... etc. With the required transport including water distribution.

Table (6): Annual Cost Fuel and Lubricant for Operation of Various Units of Heavy Machinery and Vehicles for O&M Services of Spate Irrigation System (1998 Prices)

Item	Cost in (YR) Monthly Operation				Total Annual cost of operation in Y.R
	Daily fuel consumption in liters	Fuel	Lubricants	Total	
1. Bulldozer (D8 size)	288 diesel	86400	17,00	98100	784,800
2. Bulldozer (D6 size)	216 diesel	64800	8750	73550	588,400
3. Motor Grader	216 diesel	64800	8750	73550	588,400
4. Front-end loader	180 diesel	54800	7750	61550	492,400
5. Hydraulic Excavator	180 diesel	54000	7750	61550	492,400
6. Dump truck (15 tons)	40 diesel	54000	5650	17650	141,200
7. Water Tanker (15,000 l)	40 diesel	12000	5650	17650	141,200
8. Pick-up 4WD	**20** Petrol	21000	**1400**	**22400**	**179,200**

* Daily consumption is based one average 8 hours of operation per day.

** The year is estimated for 240 days after excluding Fridays public holidays and about 20% of this year for repair and maintenance and of season time for machinery & vehicles.

Table (7): Annual cost of operation of machinery and vehicles (fuel & lubricants) for O&M services of spate irrigation system for wadis Zabid, Rima'a, Tuban & Bana in '000 Y.R (1998 prices).

Item	Annual cost of operation per unit	Wadi Zabid		Wadi Rima		Wadi Tuban		Wadi Bana	
		Qty	Cost	Qty	Cost	Qty	Cost	Qty	Cost
1. Bulldozer (D8 size)	784.8	1	784.8	-	--	--	--	2	1569.6
2. Bulldozer (D6 size)	588.4	2	1176.8	2	1176.8	2	1176.8	4	2353.6
3. Motor Grader	588.4	2	1176.8	1	588.4	1	588.4	2	1176.8
4. Front-end loader	492.4	2	984.8	2	984.4	1	492.4	3	1477.2
5. Hydraulic Excavator	492.4	4	984.8	1	492.4	2	984.8	2	984.8
6. Dump truck (15 tons)	141.2	4	564.8	2	282.4	2	282.4	7	988.4
7. Water Tanker (15,000 l)	141.2	2	282.4	1	141.2	1	141.2	2	282.4
8. Pick-up 4WD	179.2	8	1433.6	4	716.8	4	716.8	8	1433.6
9. Grease for weir gates		LS	50.0	LS	25.0	LS	76.8	LS	40.0
Total			7438.6		4407.8		4459.6		10306.4

C) Optimal Maintenance Budgets

The third component of the optimal budget covers the cost no involving earth works e.g. repair of concrete for weirs & other irrigation structures, bridges and maintenance, painting. etc of hydromechanical installations> the cost was estimated according to the nature and field status of this component for the four irrigation systems. For wadis Tuban and Bana these costs are shown in Table (8). Table (8): Estimated optimal maintenance costs for wadis Tuban & Bana systems in YR (1998 prices)

Item	Wadi Zabid	Wadi Rima	Wadi Tuban	Wadi Bana
Maintenance and repair of concrete structures	1,840,000	1,478,000	1,544,000	2,275,000
Average net command area	15,215	8,000	8,000	19,000
O&M costs/ha in YR	121	185	193	120

D) Cost Of Annual Depreciation of Equipment of vehicles

A fourth component of the optimal budget is the cost of depreciation of equity machinery vehicles used in the maintenance activities in the various wadis. An attempt was made to estimate this component by calculating the cost of new equivalents (in 1998 prices) and depreciating the equipment already in use for maintenance of structures over 5 years (standard accounting practice to depreciate heavy equipment and vehicles by about 20% per year). These costs are shown in Table (9)

Table (9): Estimated annual cost of depreciation of heavy equipment and vehicles for spate irrigation system in wadis Zabid, Rima'a Tuban & Bana.

Item	Unit Price US$	Wadi Zabid		Wadi Rima		Wadi Tuban		Wadi Bana	
		Qty	Cost US$	Qty	Cost US$	Qty	Cost US$	Qty	Cost US$
1. Bulldozer (D8 size)	230,000	1	230,000	--		--		2	460,000
2. Bulldozer (D6 size)	16,500	2	330,000	2	330,000	2	330,000	4	660,000
3. Motor Grader	130,000	2	260,000	1	130,000	1	130,000	2	260,000
4. Front-end loader	170,000	2	340,000	2	340,000	1	170,000	3	510,000
5. Hydraulic Excavator	150,000	2	300,000	1	150,000	2	300,000	2	300,000
6. Dump truck (15 tons)	60,000	4	240,000	2	120,000	2	120,000	7	420,000
7. Water Tanker (15,000 l)	100,000	2	200,000	1	100,000	1	100,000	2	200,000
8. Pick-up 4WD	15,000	8	120,000	2	60,000	4	60,000	8	120,000
9. Grease for weir gates			2020,000	4	1,230,000		1210,000		2,930,000
Subtotal			404,000		246,000		242,000		586,000
Misc-equip. (20%)			2,424,000		1,476,000		1452,000		3,516,000
Annual depreciation cost at 10% in US$			242,400		147,600		145,200		351,600
Annual depreciation in Y.R ($ = 135 Y.R)			32,724,000		19,926,000		19,602,000		46466,000

E) Summary O&M Optimal Budgets

After the above derivation of components of optimal budget they were added together and then 15% of the subtotal was estimated to cover other miscellaneous O&M cost that was also added to obtain the total budget for each Wadi. Consequently summary O&M optimal budget for the 4 irrigation systems were prepared and presented in Table (8) below.

Table (10): Summary annual optimal budgets for O&M services for spate irrigation systems of Wadis Zabid, Rima, Tuban and Bana in 1998

Item of Expenditure	Wadi Zabid	Wadi Rima'	Wadi Tuban	Wadi Bana
	Cost in Y.R	Cost in Y.R	Cost in Y.R	Cost in Y.R
1. Staff Salaries (for details see table (3)	9060,000	6,072,000	7,536,000	11,208,000
2. Cost Operation of machinery and vehicles for earthwork maintenance, water allocation. etc	7,438,800	4,407,800	4,459,600	10,306,400
3. Cost of maintenance & repair: mainly for concrete works on weirs, structures, bridges, and hydromech. Installations, in canals.	1,840,000	1,478,000	1,544,000	2,275,000
4. Cost of depreciation of machinery & vehicles (at 10%)	32,724,000	19,926,000	19,602,000	47,466,000
6. Sub-total	510,62,800	31,883,800	331,41600	71255400
7. Other miscalls. O&M expense estimated at 15% of above	7,659,420	4,782,570	4971240	106883710
Total	58,722,220	36,666,370	38112840	81943710
8. Average irrigated area (ha)	15,215	8000	8000	19000
9. O&M cost per (ha) in Y.R	3859	4583	4764	4313

Therefore according to the above estimates the overall average optimal O&M cost per ha is about Y.R 4374 (say $ 32.4) at ($ = 135 Y.R)

F) Estimated O&M Cost of W. Zabid & Rima Based on the Investment Costs

Table (11) shows that the investment costs for wadis Zabid and Rima' systems were US$ 39.2 and 26.59 millions, respectively. The present worth of these systems was then calculated using an annual depreciation of 3%.

Table (11): Estimated present worth's of wadis Zabid and Rima systems.

Component	**Cost in million US$ (1979 prices for w. Zabid & 1986 prices for w. Rima')**	**Present worth in million US$ (1998)***	**Net area served (ha.)**
Wadi Zabid **(completed 1979)**			
Diversion 1 & all of its equipment	8.30	4.73	1,700
Diversion 2	13.00	7.41	2,600
Diversion 3	11.30	6.44	5,200
Diversion 4	3.00	1.71	4,000
Diversion 5	3.60	2.05	1,300
Total	39.20	22.34	14,800
Wadi Rima **(completed 1986)**			
Salaries and Technical Assistance	3.12	2.19	
Equipment	1.95	1.37	
Civil Works	21.17	14.84	
Operational Cost	0.35	0.25	
Total	26.59	18.65	8,000

* Based on an annual depreciation rate of 3%.
** Source: Basic data of cost benefit analysis, TDA Develop. Projects II & IV, W. Rima' Completion Report. '86.

Then, the O&M cost were estimated at as 2% and at 3% of the present worth, as shown in Table (12).

Table (12): Estimated O&M costs of Wadi Zabid and Rima systems, based on investment costs, at 1998 prices.

Spate Irrigation System	Present Worth, Million US$	Estimated optimal O&M per ha.	
		based on 2% of PW	based on 3% of PW
Zabid (15,215 ha)	22.34	29.36 US$ (YR 3,964)	43.54US$ (YR 5933)
Rima (8,000 ha)	18.65	46.6 US$ (YR 6,294)	69.92 US$ (YR 9,442)
For both wadis taken together (2,321 ha)	40.99	35.31 US$ (YR 4,767)	52.97 US$ (YR 7,151)
% requested to estimated (budget requested for both wadis = YR 948 / ha)	--	19.89	13.26
% allocated to estimated (budget allocated for both wadis = YR 533 / ha)	--	11.18	7.45

Thus, depending on whether one uses the 2 or 3 % of the present worth, the annual O&M cost at 1998 prices for Wadi Zabid ranges from about 30 to 45 US$ (YR 4,100 - 6,100) per ha. and for Wadi Rima from 47 to 70 US$ (YR 6,900 to 9,400) per ha.

For the two wadis taken together, the above 1998 estimated cost per hectare were estimated to range from about 53 to 54 US$ (4,700 to 7,200 YR). Compared to the requested budgets for 1998 (YR 948 per hectare), this represents only 13 to 20 % of the estimated, while the allocated budget (YR 533 per hectare) represents only 7 to 11 % of the estimated cost. While compared with the overall average optimal (4374 Y.R/ha mentioned on p.) it represents 89.3 to 59.9% of the above estimate at present worth of 2% and 3% respectively.

Unfortunately the consultant could not undertake similar exercises for Wadi Tuban and Bana for lack of data concerning capital costs investment for these two spate irrigation systems.

G) Summary Optimal vs. Allocated Budgets

a summary of the total optimal annual O&M budget for the four systems is shown in Table (13), together with the allocated budgets for ease of comparison.

Table (13): Summary of the optimal vs. allocated O&M budgets for 1998 for the four spate irrigation systems (in '000 Y.R).

Item of Expenditure	Wadi Zabid		Wadi Rima'		Wadi Tuban		Wadi Bana	
	Optimal Annual Budget	1998 Allocated Budget	Optimal Annual Budget	1998 Allocated Budget	Optimal Annual Budget	1998 Allocated Budget	Optimal Annual Budget	1998 Allocated Budget
1. Staff Salaries	9,060	5,090	6,072	3,394	7,536	63,968	11,208	29,472
2. Operation of machinery and vehicles for earthwork maintenance *	74388	2,000	4467.8	1,900	4459.6	1,800	10306.4	3,600
3. Mainten. of weirs, structures, bridges, hydromech. installations, etc.	1,840		1,478		1,544		2,275	
Cost recovery of machinery	32724		19926.0		19602.0		47466.0	
Sub-total	510628		31883.8		33141.6		71255.4	
Other miscell. O&M costs (utilities, office rent, etc.) at 15% of the total	7659.42		4782.57		4971.24		10688.31	
Total O&M	58722.22	7,090	36666.37	5,294	38112.84	65,767	81943.71	33,072
Avrg. net command area (ha)	15.215		8,000		8,000		19,000	
O&M Cost / ha	3.859	0.466	4.583	0.662	4.764	8.22	4.313	1.74
Alloc. / Optimal %	12.1		14.4		172.5		40.36	
Alloc./Optimal% W/O Salaries	4.14		6.4		6.11		5.21	

* Optimal O&M budget values are taken from table (9).

b) on comparing the optimal vs. the allocated O&M budgets for each of the four wadis, one can easily see that the salaries component shows some abnormalities; namely:

- the wadis Zabid and Rima' have allocations of about 59% and 55% respectively lower than their optimal. On examining their staffing list it is noted that they are generally understaffed in total number and in some posts and unbalanced and overstaffed in others (e.g., drivers and mechanics).
- funds allocated for salaries of Wadi Tuban and Wadi Bana staff exceed the optimal budget by about 8.49 and 2.63 folds, respectively. This is due to overstaffing resulting from annexing almost all of the ex-Yemeni-Soviet Project staff at Lahej to the MAI office and those at Abyan to the irrigation section of the MAI office while this latter section has been already supported by staff and equipment under the ex-Traditional Irrigation Project (1982-89). Consequently this has led to a misleading percentage increase in the allocated over the optimal total O&M budget of 172.8% and 40.36. for Wadi Tuban and Wadi Bana, respectively. However, if comparison of the O&M budget is made without the salaries item, then the situation will be more realistic whereby the allocated funds of YR 1.8 & 3.6 million for wadis Tuban and Bana, respectively are only 6.11% and 5.21% of their respective optimal funds (W/O salaries) of YR 29446440 and Y.R 69054510 respectively.

c) the irrigation departments, which operate and manage the various spate irrigation systems in Yemen are facing serious problems of inadequate funding for their activities. If this issue is not solved then the sustainability of the spate systems will be undermined and their life will be drastically reduced.

4.0 O&M of Small Dams Irrigation Schemes

Before the field visit the study team reviewed various reports on the status of small dam irrigation schemes. It was found that such schemes do not generally include irrigation networks. They are rather used as storage lakes to recharge the groundwater aquifers. In the dry

season, farmers are not prevented from tapping their water hoses into these reservoirs and pump the water by small submersible pumps for irrigation.

There has been no record of community organization to improve the use, desilt, or rehablitate existing structures.

4.1) Visited Schemes

Field visits were made to three of these schemes in Taiz governorate. The findings are summarized below.

a) Al-Amirah Dam Scheme

Al-Amirah dam was built at the same location of the old dam (washed away some 45 years ago) situated north of Taiz at Wadi Arsoum near Sa'afan village. Water Power Consultancy Services (India) Ltd (WAPCOS) designed the new dam.

The small dam under this scheme is earth fill type with a clay core. The height of dam is 11 m and its width is 167 m. It has adjoining spate flow structures 116 m long and consisting of a small spillway weir and a breaching bund (fuse plug). The reservoir's total design capacity is 785,000 m^3 with a dead storage of 50,000 m^3. The dam has 2 irrigation conduit pipes with outlets with lengths of 75m and 50m situated at right and left side of the dam. Both are irrigating a total area of 176.4 ha downstream. The scheme has neither canal nor irrigation networks downstream and therefore there are no O&M services.

Presently this scheme comes under the responsibility of the Governor's Office at Taiz with adhoc technical supervision by the Southern Regional Agricultural Development Project (SRADP), Taiz.

It has been learnt that efforts are still underway to organize the water users roles in the process of equitable water allocation with the possibility for installation of modern irrigation network, which will then need O&M services.

On the other hand, garbage from the city of Taiz is disposed on the side of the Wadi course. This causes pollution of water flowing to the dam reservoir and deterioration of the water quality.

b) Damum Irrigation Scheme

This scheme lies at Al-Damum village, Mawiyah district (governorate of Taiz), at distance of about 17km NE of the city of Taiz. The structure, which was also designed by WAPCOS, is a stone face rubble masonry dike with a height of 17m from lowest Wadi bed level. The width and length of crest are 5.2 and 61m, respectively. The reservoir's total capacity is 160,000m^3 with live and dead storages of 140,000 and 20,000m^3, respectively.

The dam irrigates command area of 31 ha. of land through a converyance system consisting of main supply pipes of 3174m total length and diameters ranging from 200 to 75mm, discharging design flows ranging from 29.1 to 3.84 l/s from head outlet to irrigate 6 irrigation sub-units (shakes), through branch lines delivering water to stilling wells at the head of the distribution network.

The last stage of implementation was supervised by SRADP. However, during the field visit the team observed that there were technical defects in the installation of the irrigation network which were noted then by SRADP representatives in order to follow up with the supplier for repair.

The beneficiaries of the scheme were observed to be in harmony and are in agreement regarding their participatory functions in irrigation by rotation and O&M services.

c) Al-Gunaid Small Dam

This small dam, which is located in Mesrakh district (governorate of Taiz), is privately owned. Al-Gunaid family built it in 1995 using their own funds with little support from the government. It is a masonry structure with a total reservoir capacity of 750,000m^3. It has 3 outlets with three main galvanized iron pipes of 8-inch diameter. This scheme was completed in 1996 and the owner of the scheme is still in the process of negotiating with the beneficiaries whereby he is proposing to irrigate for them against 25% of the cost of crop production.

7.2) Problems of Small Dam Schemes

The main problem with the small dams is that these schemes are commonly built without irrigation networks and without much community work to organize the beneficiaries for subsequent operation and maintenance of the reservoirs. Thus, in most cases the water stays in the reservoirs and the farmers are satisfied that it "recharges" their wells. Occasionally, the farmers would pump the water out of the lake using small portable "centrifugal" pumps.
Given that there is no formal community organization to operate and manage these systems once they are built, several difficulties arise:

a) Impact on spate-water rights: sometimes, when there are no irrigation networks, the beneficiaries are deprived of the spate water, which they used to get before the dam was built. Let alone the similar impact on the water rights of downstream riparian.
b) Reservoir silting: the life of the structures decreases since there is no organization to desilt the lakes. The lack of operation rules, and facilities to discharge the water and clean the lake bottom create obstacles for desalting.
c) Not enough studies of sites are carried out.
d) Fragmented planning for dams and water structures in general. The government should identify one department only; e.g., the Directorate of Irrigation of the MAI to be the only body in-charge of the program of small dam schemes.

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Annex B: Sample Inspection and Maintenance Schedule (Wadi Zabid Project)

Feature		Inspectionand/or Maintenance Tasks	After Storms	Daily	Monthly	Twice Yearly	Yearly*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DIV. STRUCTURES							
Concrete Structures	Overflow weirs	Repair glacis, block and sill concrete		•			•
	Sluiceways	Repair concrete and remove debris	•			•	•
	Head regulators	Repair concrete and remove debris	•				
	Hondroiling	Tighten bolts and nuts, repaint as required			•		
Earthworks	Channels	Operate sluiceway to keep channels open	•	•			
	Dikes	Repair erosion	•		•		
	Fuse plugs	Repair erosion	•			•	
	Riprap	Reshape and replace	•			•	
CANALS							
Concrete Structures	Bifurcations	Repair concrete, repair railings, remove debris	•				•
	Drop structures	Repair concrete, remove debris	•				•
	Tumults	Check gate functioning, repair eroded areas			•		
Earthworks	Canal section	Repair bank erosion, remove debris and blockages, inspect for piping seepage	•		•		
	Patrol roads	Regarded			•		
	Field channels	Clean, repair erosion			•		
ROADS							
Concrete Structures	Box culverts	Repair concrete					•
	Overflow sections	Repair concrete, reshope and replace riprap	•				•
	Pipe culverts	Repair headwalls, repair earth erosion, clean	•				•
Earthworks	Embankment	Regarded, repair bank erosion	•				
	Drainage ditches	Keep open, check erosion	•				
GATES							
Radial Gates	Hoists	Grease fittings and cables, flush and replace oil, fighten nuts				•	
	Gates	Grease fittings, adjust seals, repaint as necessary				•	
Slide Gates	Hand wheels	Grease hand wheel bearings & gate stems				•	
	Gates	Check adjustments of guides				•	
EQUIPMENT							
Heavy Equipment	Earthmoving	Operator maintenance					
	grading	shop maintenance		•			
	Equipment						
Transport	Trucks, light	Operator maintenance	•				
	Vehicles	Shop maintenance		•			

* Yearly or as required

Source: O&M Manual for Wadi Zabid Project

ANNEX (C): Summary output of the regression analysis of O&M costs for Wadi Zabid and Rima

SUMMARY OUTPUT	Y' = -192754 + 463861 Xa		235848.3
	(-0.257) (3.838)	463861	
		19.66778367	

Regression Analysis	
Multiple R	**0.805041632**
R Square	**0.64809203**
Adjusted	**0.604103533**
Standard	**1097655.342**
Observation	**10**

NOVA

	df	***SS***	***MS***	***F***
Regression	1	1.77513E+13	1.77513E+13	14.73321627
Residual	8	9.63878E+12	1.20485E+12	
Total	9	2.73901E+13		

	Coefficients	***Standard Error***	***t Stat***	***P-Value***
Intercept	-192753.8667	749841.35	-0.257059532	0.803620747
X Variable	463860.9394	120847.8758	3.838387197	0.004958524

Annex (D): The Operation and Maintenance Staff Opinions On The WUAs

Using a written questionnaire, 15 staff from the spate irrigation departments in Zabid, Rima, delta Tuban, and delta Abyan were asked about their opinion on establishing WUA's and their role in the O&M of the spate irrigation systems. The results are summarized below.

a) Staff opinion regarding the establishment of WUA's:

	Yes (for the WUA's)		**No (against the WUA's)**	
No of staff interviewed	**4**	**Freq.**	**11**	**Freq.**
Why	More secure for the structures	1	Capability is not adequate	2
	Guarantee the system continuation	1	Not organized and not homogeneous	4
	Feel the responsibility	2	Risk of deterioration of structures	3
			Cooperatives are week	1
			No law	1
%		27		73

b) Staff opinion regarding the current (1998) level of O&M.

Level	**Low**		**Medium**		**Good**		**Excellent**
Freq.	**6**		**8**		**1**		**Zero**
Why	Inadequate budget	4	Low staff salaries	1	No replacement of equipment	1	--
	Poor planning & monitoring	1	Inadequate finance	5			--
	Lack of equips.	1	Lack of equips.	3			--
	Centralized administration	1					

c) the main problems facing the O&M departments.

Description	**Freq.**	**%**
Big land owners ignore the water distribution plans	9	20.45
Lack of finance	9	20.45
Lack of equipment and their organization	7	15.90
Lack of experience	6	13.64
Lack of cooperation and government back-up of O&M dep.	4	9.09
Lack of regulation	4	9.09
Disputes between the farmers	2	4.55
Lack of cooperation among the staff	2	4.55
The sedimentation	1	2.27
Total	**44**	**100**

d): the best way to manage the irrigation system.

Description	**Freq.**	**%**
Managed by the official departments	7	50
Establish the water use associations (WUAs) with gradually participate in the management and the costs	4	29
The water users role should be limited to contributing to the O&M cost	3	21
Total	14	100

e): the best way to operate and maintain the systems.

Description	**Freq.**	**%**
Main structures & main canals to be operated and maintained by the department but secondary & tertiary canals to be operated and maintained by the beneficiaries	3	27
Independent administration and the cost to be paid by the beneficiaries	4	36.5
Supporting the existing department	4	36.5
Total	11	100

f): the bases for water distribution.

Description	Frequency
The customs	5
According to the irrigation regulations and the irrigation council instructions	5
The upper then the lower	5

g): the maintenance functions to be carried out by the beneficiaries.

Description	**Freq.**	**%**
Organize the beneficiaries in WUAs to maintain the branch canals to their fields	11	79
Nothing	2	14
Observe the flood distribution and inform about any misuse	1	7
Total	14	100

h): the operation function to be carried by the beneficiaries.

Description	**Freq.**	**%**
Operate the secondary canals	7	47
Nothing	5	33
Pay cost of operation only	3	20
Total	15	100

i): the works, which cannot be carried out by the beneficiaries.

Description	**Freq.**	**%**
Operation and maintenance of the irrigation structures	7	44
Operations	4	25
All works	3	19
Maintenance	2	12
Total	16	100

j): why the beneficiaries should not carry out works.

Description	**Freq.**	**%**
The beneficiaries have no experience	8	54
The beneficiaries have no equipments / budget	5	33
Conflicts between the beneficiaries	2	13
Total	15	100

k) The best way to organize the beneficiaries in WUA's 1998

Description	**Freq.**	**%**
Meetings to convince them	8	53
Water regulations	3	20
Don't know	2	13
Backup the societies	1	7
Canal irrigation masters	1	7
Total	15	100

l) Answer the following questions?

	Yes	**No**
Was there any attempt to organize the beneficiaries	6	7
Are there any regulations or instructions for WUA's	5	7
The possibility of making use of old customs of the operation and maintenance to organize the beneficiaries in WUA's.	10	2

m) How WUAs can be established?

How	Freq.	%
Through irrigation canal master and village heads and the irrigation councils	6	60
Through people who know the customs	3	30
Through societies	1	10
Total	10	100

n) The steps to start in your opinion 1998

Step	Number
No opinion	4
To add percentage to Zakah	1
Explain the idea and legalize the system	1
Total	6

The Farmers Opinion Regarding O&M Cost Sharing

Table (D-1) outlines the farmer's opinions on sharing the O&M costs in Delta Tuban, about 50% of the sample indicated their willingness to pay for O&M costs, 27% are unwilling to pay, and 23% are indifferent. Farmers in Lahej area are paying 100 YR per Feddan for spate irrigation; this will support the establishment of the WUAs.

Table (D-1) Farmers opinions in sharing the cost of O&M in Delta Tuban-Lahej 1998

Weir-Area	Owners	Beneficiaries	Total	Ave. hold, Fed.	Yes	No	Indifferent
Al-Arais	5	20	25	3.5	22	3	0
Ras Al-wadi	10	40	50	4	30	10	10
Beizag	10	15	25	3	12	7	6
Faleg	8	7	15	3	9	6	0
Al- Hadaram	7	8	15	3	6	5	4
Al-Bustan	20	5	25	5	10	3	12
Al-Munasirah	15	--	15	5	2	10	3
Mugahed	7	8	15	4	4	4	7
Al-What	10	5	15	5	5	5	5
Total	92	108	200	3.9	100	53	47
%	46	54	100	--	50	27	23

Source: Saif, 1998. Participatory Spate Irrigation Management Study in Lahej & Abyan, MAI. March 1998. P. 52

Also Table (D-2) outlines the farmers' opinions on sharing the O&M costs in delta Bana-Abyan. Some 68% of the sample indicated their willingness to pay for O&M costs, 17% are unwilling to pay, and 15 % are indifferent. Farmers in the area of delta Bana are more willing to pay for spate irrigation, often they have the spate water free of charge but they recognize that three of the delta weirs are out of order because of inadequate financing of the O&M costs and the need to rehablitate the system. This will help establish the WUAs.

Table (D-2): Farmers opinions on sharing the O&M costs in delta Bana-Abyan 1998

Weir-Area	Owners	Tenants	Total	Average	Yes	No	Indifferent
Bateis	25	10	35	7	25	5	5
Hayja	19	6	25	12	16	6	3
Diyyo	30		30	10	26	4	
Makhzan	25	5	30	15	15	5	10
Total	99	21	120	11	82	20	18
%	82	18	100		68	17	15

Source: Saif, 1998. Participatory Spate Irrigation Management Study in Lahej & Abyan, MAI. March, 1998. P. 52