Assessment of the Utilization of Water Dams and Reservoirs in the Highlands of Yemen

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Introduction

Yemen is considered a semi arid country. The annual rainfall ranges from 50 mm in the coastal area and eastern plateau to 500-800mm in the highlands. The per capita share from renewable water resources does not exceed 151m3 per annum, which correspond to 14% of the global average of the annual per capita consumption of water resources, which reaches 1100 m^3 per annum. Statistics show that the annual amount of renewable water is about 2500 Mm^3 out of which 1000 Mm^3 surface water and 1500 Mm^3 underground water. There is no balance between renewable water resources and annual water consumption. According to 2000 statistics the total water consumption reached 3400 Mm3 out of which 238 Mm3 was used for domestic purposes, 3094 Mm3 consumed by the agriculture sector and 68 Mm3 used by the industry and other sectors. The deficit is therefore about 900 Mm3. The deficit is compensated from underground water resources1. As a result the levels of underground water have dropped at an alarming rate.

The annual drop of water levels reached the following rate.

- Sana'a Basin 6-8 meters
- Sa'ada Basin 5-6 meters
- Amran Basin 3 meters
- Rada'a 5 meters
- Taez B asin 1.5- 2 meters
- Tuban- Abyan 0.2- 1 meter
- Tihama Basin 1-3 meters

The above rates explain the shortages of water in major cities such as Sana'a and Taiz. In these cities the water shortage reached critical stages and water is becoming available only once every three to four weeks.

To overcome this problem, the government rushed into the construction of dams and water diversions in different locations of the country to harvest rainwater and floods during the rainy season. The total number of dams and water reservoirs reached more than 222 units mainly in the highlands of Yemen.

The objective of this study is to evaluate the level of utilization of some of these c constructions in selected areas in the highlands.

Material and Methods

Data collection and field surveys were conducted in close collaboration with the General Directorate of Irrigation in the Ministry of Agriculture and Irrigation (MAI). Six dams and water reservoirs were visited (see map No. 1 for the locations of reservoirs).

Data collected covered parameters like location, dimensions, volume and capacity in addition to hydrological information such as description and characterization of the surrounding watershed, the average rainfall, the average water runoff in the valley plus other measurements (Annexes 1- 5).

For field data collection a special form was designed for individual interviews with farmers benefiting from the dam or water constructions. The irrigated area was measured and methods of irrigation were identified together with cropping systems applied and crops grown during the survey (Annex 6)

Samples of water from recently dug wells in the vicinity of dams and reservoirs were collected for analysis of water quality for irrigation.

Analysis of data collected was done and presented in tabulated forms showing the level of water recharge in open wells. The analysis covered the level of utilization of water for irrigation in the study area.

Results and Discussions

First Mikhtan Dam

Mikhtan dam is located in Al-Khirba area in Bani Hushaish District (Sana'a Governorate) at latitude N 15○ 22/ 53.5 // and longitude E 44○ 19/ 52.4// . The purpose of constructing the dam is to recharge underground water. The dam bed level is located at an elevation of 2400 meters above sea level (a.s.l.) and the top of dam level is at 2425 meters ASL. The capacity of the dam is 550.000 m3. The construction material of the dam is earth and stones (photo no. 1.A). The construction of the dam was completed in 1999 (Annex 1) and from that time the dam was not cleaned either from sediments or algae (photo no.1-B,D).

Mikhtan dam collects rainfall water from the surrounding watershed, which was estimated to be 194.8 mm/annum. Taking into account that the runoff coefficient is 0.20 the total amount of water reaching the dam is expected to be 199.000 m3 or 36.2 from the total capacity of the dam.

Water in the dam is used for irrigation of crops through pumping of water from open wells in the surrounding area of the dam. The wide spread of open wells in the area located at the lower part the dam was quite clear. The spread of open wells reached a distance 700 - 800 meters from the dam (photo no. 1-c). Farmers located further from the dam were not able to use water from the dam. Some of them were forced to purchase land located closer to the dam for drilling of open wells to be able to get water for irrigating their crops located further downstream. Water is conveyed by PVC pipes and cloth pipes which contributed to the increase of the cost depending on the distance from the dam.

The system of irrigation in the area surrounding the dam was drastically changed in comparison with the time before dam construction. Irrigation is mainly from open

wells after dam construction, while irrigation was from open wells and from floods before the dam construction. Water ownership and water rights was mainly sharing of

tube wells before the dam construction to the sharing of tube wells and private ownerships of open wells dug after the dam construction. This means that some farmers are using irrigation water from open wells for irrigation of their crops and in addition they use their share from the tube wells in the same. This happens irrespective of their actual demand for irrigation water. This situation significantly contributed to the low efficiency of water use in this area.

Accurate figures on the level of underground water change as a result of the dam construction were not available in the Irrigation Department simply because such data is not collected. However, discussions with farmers in the area revealed that the level of underground water changes positively and negatively at a rate of 2-3 meters during the dry season and the rainy season respectively. This is evident in the vicinity of the dam. However, in the case of areas located far from the dam open wells run dry of water if dry season was prolonged (table no. 1)

Results of water analysis in open wells around this dam indicated that water quality is high for irrigation purposes (table no. 6).

Second Noman Al-Aroosh Dam

The Noman Al-Aroosh dam is located Gahana center, Kholan District in Sana'a Governorate at longtitude N 15○ 14/ 37.4// and latitude E 44○ 39/ 52.4//. The purpose of the dam construction is irrigation and recharge of underground water. The bed level of the dam is 2086 m a.s.l. While the top of dam level is 2096 m a.s.l. The capacity of the dam is 89.000 m3. The construction of the dam is clods of rocky stone (photo no. 2A,B). The construction of the dam was completed in 2001, water sediments were observed in the dam bas in (photo 2 c).

Data on the change in underground water after the construction of the dam were not available. However, discussions with farmers indicated that underground water level ranged from 0-5 meters positively and negatively during rainy and dry seasons respectively. Interesting to note that underground water is recharged in cases when water spill of the dam. Therefore the recharge is from valley but not from the dam.(table no. 2)

Analysis of water collected from a well located 750 meters from the dam downstream indicated that salinity level in the sample reached 1.36 ms/cm. However, the level of sodium and bicarbonates were low. These levels make water suitable for irrigation provided that there is good management of water use (table no. 7)

Third Allujma Dam

Allujma dam is located in Khairan area, Bani Bahlool district in Sana'a Governorate at longitude N 15○ 19/ 14.5// and latitude E 44○ 23 / 21.3//.

The purpose of the dam construction is recharging underground water. The elevation at the base of the dam is 2600 meters a.s.l. and the elevation of the highest point in the dam is 2616 meters ASL. The capacity of the dam is estimated to be 28000 m3 .The construction material of the dam is earth and stones (photo no.3-A,B). The construction of the dam was completed in 1997.

The dam collects water from the watershed of Allujma valley. The water harvested is estimated to be 194.8 m3 per annum. On the basis of the assumption that the coefficient of water runoff in the valley is 0.35. Therefore the total amount of water reaching the dam was found to be 87.000 m3 annually,.

Water utilization from the dam is through the digging of open wells and pumping of water through the use of diesel water pumps. Open wells in the valley were found to be nearly empty as a result of water leakage from the left side of the dam. Farmers are, therefore, pumping water directly from the dam when it is full to capacity.

Information on the level of underground water after the dam construction was not available. However, it was possible to find out from farmers' interviews that the change in water level ranges between 0-1c meters positively and negatively in the dry and wet seasons respectively in wells located downstream in close distances from the dam. Open wells are nearly empty as a result of low recharge (table no. 3.)

Analysis of water samples collected from open wells indicated that the water quality is good for irrigation purposes (table no. 8)

Grape vines are the major crop grown in the valley where this dam is located (Photo no. 3C,D). Grapes require irrigation during February –March after the dormancy period in winter. In case there is no rainfall around this time of the year, farmers demand for irrigation becomes essential. Farmers with open wells are the most vulnerable segment of the farming community in this area as a result of non-availability of water in their wells. This segment of the farming community represents the majority of farmers in this area.

Fourth Al-Hayathem Dam

Al-Hayathem Dam is located in Al-Hayathem area in Nehm District Sana'a Governorate. At longitude N 15○ 39/ 36.7// and latitude E 44○ 25 / 13.8//. The purpose of dam construction is to recharge ground water. The elevation at the base of the dam is 1990 meters a.s.l. and the elevation at the highest point of the dam is 2007 meters ASL. The capacity of the dam is about 250.000 m3 . The construction material is earth and stones (photo no. 4-A). The construction of the dam was completed in 1996.

Water harvesting in the dam is from the watershed of Wadi Al-Wakar, which is estimated to be 191.4 mm per annum. If the runoff is 0.15 then the total amount arriving at the dam is about 924.000 m3 (annex 3).Water in the dam is used for irrigation of agricultural crops such as sorghum, wheat, barley, qat and peaches indirectly. Deep and shallow wells located around the dam are the major source of irrigation water. Water in these wells is pumped by means of diesel pumps. The dam has been constructed through community effort together with government support. The local community created its own local arrangements to ensure rational use of harvested water. These regulations restrict the direct pumping of water from the dam. However, direct pumping does exist. Water is pumped to a series of holes on the way to the targeted field. This practice was found to be wasting significant amounts of water as a result of leaching. (photo no. 4- C,D).

Sorghum, peaches, wheat, barley and qat are irrigated at 20,30, 10, 15 and 30 days intervals respectively. Surface irrigation is practiced in which significant amounts of water is wasted during conveyance and field application.

Data on the level of change in underground water before and after the construction of the dam were not available. However, farmers indicated that the level of surface under ground water changes positively and negatively at a rate of 2-4 meters during rainy and dry seasons respectively.(table no. 4)

Results of laboratory analysis of water samples taken from open wells indicated that salt concentrations in water samples were high ranging from 1.51 – 2.45 ms/cm. On the other hand it was observed that the percentage of sodium and bicarbonate in the residue of water samples was small thereby making it possible to use such water for irrigation provided irrigation is carried out under good management.(table no. 9).

Fifth Shahek Dam

The dam is located in Tane'm area Khawlan district in Sana'a Governorate. At longitude N 15○ 23/ 15.2// and latitude E 44○ 25 / 32.8//.. The purpose of dam construction is recharging underground water and irrigation. The elevation at the base of the dam is 2560 meters a.s.l. and the elevation at the top of the dam is 2592 meters a.s.l. The dam capacity is about 1,500,000 m3 The dam construction material is earth material and stones (photo no.5A).The construction was completed on 1986 (annex 4)

Shahek dam collects rainfall water from the surrounding watershed of Wadi Tanam. The amount of water collected was estimated to be 170 mm/annum. If the coefficient of water runoff is 0.035 then the total amount of water reaching the dam is about 280,000 m3 or 18.7% of the total capacity of the dam.

Despite the fact that water from the dam could be diverted through a pipe designed for this purpose during construction, this pipe was closed as a result of conflicts between two tribes sharing the water of the dam. Instead, water is used for irrigation from the surrounding open wells. Direct use of water from the dam through pumping by means of diesel engines is also practiced (photo no. 5 B, C). The overall condition of the dam is good. However there are significant amounts of debris in the dam. This indicates that there was no regular cleaning of water sediments since the completion of dam construction (photo no. 5 D).

Available statistics on the change of underground water before and after the construction of the dam are lacking. Nevertheless, discussions with farmers indicated that the level of surface underground water does not change except in cases there is overflow from the dam when it is full to capacity. The shallow underground water was found at a depth of 8-9 meters (table no.5). Results of laboratory analysis indicated that the quality of irrigation water taken directly from the dam and from the open wells is good and highly suitable for irrigation (table no. 10).

Grapes are widely cultivated in this area. The area under grapes reaches 50-90 % of the total cultivated area in the valley. Other crops grown are grains and qat.

Sixth Ghaiman Dam

Ghaiman dam is located in Ghaiman. Bani Bahlool district in Sana'a governorate at longitude N 15○ 15/ 59.2// and latitude E 44○ 20 / 35.7//. The purpose of the dam is to recharge underground water. The elevation at the bottom of the dam is 2390 meters a.s.l. and the elevation at the top of the dam is 2405meters a.s.l.. The dam capacity is 1.000.000 mln m3. The construction material is earth and stones (photo no.6- A, B). The dam was completed in 2000 (annex 5). Ghaiman dam receives rainfall water from wadi Ghaiman water shed. The amount of water from the watershed was estimated to be at an average of 194mm/annum. The coefficient of runoff is 0.035.Tertefore, the total amount of water reaching the dam is about 669.000 m3 or 66.9%of the dam capacity.

The dam was designed to extract water from it directly through a pipe system installed in the dam (photo. 6-C). The dam didn't receive any water since the completion of its construction (photo no. 6 - D). Agricultural lands surround the dam and there seems no water shed in the vicinity of the dam. It could be concluded that the location of the dam was not properly selected.

Conclusions

1. Clear systems for dam management and maintenance after completion of constructions are lacking. Similarly there are neither regular records on the amount of annual floods reaching dams nor records on the status of underground water before and after the construction of dams.
2. The is correlation between the capacity of some dams(Allujma and Al-hayatem) and the amount of runoff reaching the dams.
3. The production systems in areas where dams were constructed were replaced from spate irrigated to open well irrigated.
4. The sites of some dams were not properly selected.
5. Hydrological studies of some dams (Allujma) were not carried out in professional manner.
6. Areas located in close proximities of the dams are the most benefiting areas. However, areas located at a distance from the dams are not benefiting. Before dam construction. These areas used to benefit from floods during rainy seasons.
7. The low efficiency of irrigation methods applied at the field level and the high rate of water use from dams do not correspond with the capacity of the dams.

Recommendations

1. There is a need to identify authorities from the benefiting communities responsible for management and maintenance of dams. These authorities should also regularly keep records on amount of annual floods and status of underground water as well as methods of irrigation applied.
2. A similar study covering more dams and more locations should be launched without delay. This is essential to come to a clearer picture on the status of dams constructed all over the highlands of the country.
3. The Farmers' Union should actively participate in formulation of users cooperatives in areas where dams are constructed. These cooperatives should be responsible for management and maintenance of dams.
4. Enough geological and hydrological studies should be conducted by professional bodies are needed before deciding on the site of dam construction.
5. There is an urgent need for improving the efficiency of irrigation methods applied and the introduction of more efficient techniques in irrigation such as drip and or bubbler irrigation.

Table (1) shows the effect of Mukhtan dam on underground surface water storage

Name of farmer	Property character	Area, ha	Distance from dam meter	Water depth meter			Notes
				Rainy season	Dry season	Difference	
Ali Mohamed Gholyse	Owner	0.152	500	10	12	+ 2	Qat & peach
Mohamad Saleh Abdullah	Owner	1.74	700	13	16	+ 3	-
Quaid Saleh Jaber	Owner	0.871	1200	10	-	-	No water

Table (2) shows the effect of Nu'man dam on underground surface water storage

Name of farmer	Property character	Area, ha	Distance from dam meter	Water depth meter			Notes
				Rainy season	Dry season	Difference	
Ali Rashed Suns	Owner	0.375	100	-	-	-	
Saleh Alqanes Suns	Owner	2.0	750	5	10	5	-
Saleh M. Alqanes	Owner	7.5	1250	18	18	-	No water

Table (3) shows the effect of Allujmah dam on underground surface water storage

Name of farmer	Property character	Area, ha	Distance from dam meter	Water depth meter			Notes
				Rainy season	Dry season	Difference	
Ahmed A. Alfaqi	Owner	1.250	100	3	4	1	Corn, 25% Grape
Mohamed A. Shaker	Owner	0.750	700	3	4(Dry)	-	67% Grape, Qat
Ahmed D. Shaker	Owner	3.750	800	Drilling			100% Grape

Table (4) shows the effect of Al-Hayathem dam on underground surface water storage

Name of farmer	Property character	Area, ha	Distance from dam meter	Water depth meter			Notes
				Rainy season	Dry season	Difference	
Obad N. Shamilah	Owner	1.0	1500	6	10	4	
Saleh S. Al-Haythami	Owner	3.750	5	2	4	2	
Abdu Q. Al-mafa	Owner	1.0	1000	16	18	2	
Ahmed Almafa	Owner	2.0	1300				

Table (5) shows the effect of Shahik dam on underground surface water storage

Name of farmer	Property character	Area, ha	Distance from dam meter	Water depth meter			Notes
				Rainy season	Dry season	Difference	
Mohamed M. Galal	Partners	0.200	50	8	8	-	
Mohamed N. Al-Agam	Owner	1.0	500	8	8	-	
Mohamed A. Muqbel	Owner	1.0	600	9	9	-	

Table9 - Water Analyses of Al-Hayathem Dam

Sort of analyses		Abdu Q. Almafa	Ahmed Almafa
E.C.ms/cm		1.51	2.45
pH		8.0	7.9
Cations me/L	Na	2.8	6.9
	K	0.10	0.50
	Ca	7.5	8.9
	Mg	4.6	8.3
	B	-	-
	Total	15.0	24.6
Anions me/L	CO3	0.0	0.0
	HCO3	5.6	12.8
	Cl	3.2	1.2
	SO4	6.3	10.5
	NO3	-	-
	Total	15.10	24.5
SAR		1.14	2.35
RSC		- 6.5	- 4.4

Table 10 Water Analyses of Shahek Dam

Sort of analyses		Mohamed N. Al-aagam
E.C.ms/cm		0.77
pH		8.6
Cations me/L	Na	6.0
	K	0.20
	Ca	0.80
	Mg	0.40
	B	-
	Total	7.40
Anions me/L	CO3	1.20
	HCO3	1.20
	Cl	2.80
	SO4	2.50
	NO3	-
	Total	7.70
SAR		7.75
RSC		1.2

Table 6 - Water Analyses of Mukhtan Dam

Sort of analyses		DAM	Ali M.Qalees	Hussan H. Khamis
E.C.ms/cm		0.29	0.47	0.47
pH		8	8.2	8
Cations me/L	Na	1	2.1	2.1
	K	0.06	0.05	0.06
	Ca	1	1.3	2
	Mg	0.7	1.2	0.4
	B	-	-	-
	Total	2.76	4.65	4.56
Anions me/L	CO3	0	0	0
	HCO3	2	4	4
	Cl	0.4	0.6	0.4
	SO4	0.5	0.1	0.3
	NO3	-	-	-
	Total	2.9	4.7	4.7
SAR		1.08	1.88	1.92
RSC		0.3	1.5	1.6

Table 7 -Water Analyses of Al-Nu'man Dam

Sort of analyses		Saleh Al-Qanis
E.C.ms/cm		1.36
pH		8.0
Cations me/L	Na	4.8
	K	.14
	Ca	5.2
	Mg	3.2
	B	-
	Total	13.34
Anions me/L	CO3	0.0
	HCO3	6.0
	Cl	3.6
	SO4	4.0
	NO3	-
	Total	13.6
SAR		2.34
RSC		- 2.4

Table 8 -Water Analyses of Al-Lujmah Dam

Sort of analyses		Ahmed A. Al-faqi	Ahmed D. Shaker
E.C.ms/cm		0.73	0.44
pH		8.1	8.0
Cations me/L	Na	2.2	1.40
	K	0.80	0.30
	Ca	2.50	2.0
	Mg	2.40	1.2
	B	-	-
	Total	7.90	4.9
Anions me/L	CO3	0.0	0.0
	HCO3	5.2	3.6
	Cl	1.0	0.4
	SO4	1.10	0.4
	NO3	-	-
	Total	7.30	4.4
SAR		1.41	1.11
RSC		0.30	0.40

Annex – 1
General Directorate of Irrigation
ENGINEERING DATA SHEET

GENERAL **Dam No. 33**

Name of the Dam Mukhtan

Purpose of Dam: Ground water recharge

Location:

Governorate: Sana'a

District: Beni Husheish

Village: Al-Khirba

Wadi: Mukhtan

Sub-Wadi: ------

Longitude / Latitude: N 15° 22′ 53.5″ E 44° 19′ 52.4″

1000m UTM North / East: N 1700.65 E 428.3

Topographical Sheet no. (Scale 1:50.000): 1544 C2

Year of completion or status if not completed and Condition as at present

-The construction completed by GDI/MAI on 1999.

-The dam is in a good condition at present, except small leakage observed from the steel pipes outlet.

Improvement done and Year: Nil

Type of Dam: Earth fill

Height of Dam:

Deepest foundation level: DNA

Wadi bed level: 2400 m

Full Reservoir level: 2422 m

Max. Water Level 2424 m (estimated)

Top of Dam level 2425 m (actual)

Capacity and Area of Reservoir (1000 m^3):as estimated in the dam site

At Full Reservoir level: (FSL) 550

At Max. Reservoir level: 700

Surface Area at FSL 40,000 m^2

Nearest Downstream Village / Town: Mukhtan

Its Distance from Dam: 800 m

Its Population: 100

Describe economic development in downstream area and impact of Construction of the dam.

- Rise of the water table around 6-8 m in the wells of the nearby villages.

Name of officer / Community in charge responsible for operation and maintenance

Designation and office: MAI & Sa'awn Irrigation Association

Head – Quarter:

Phone / Fax Nos:

B. PROJECT FEATURES:

Salient features of Dam

Top Width: (m) 6.5 m

Maximum height of dam 25 m

Side Slope upstream and downstream: U/S is 2:1, D/S is 1.5:1

Berm location (level) and width: Nil

Upstream protection: Riprap works on the U/S face

Downstream toe: Nil

Drainage arrangements: Nil

Length of dam at top: 104 m (actual)

See attached typical cross-sections of the dam showing the above features.

C. HYDROLOGY

Catchment Area (km^2) : 5.1

Catchment area characteristics:

Shape of the catchment area: Fan shape

lowest contour at the dam site (m): 2400

highest contour u/s of the catchment area (m): 2904

difference between the highest & lowest contours (m): 504

Max. distance between the u/s & the d/s of the catchment (Km): 4.05

gradient: 12% (steep)

surface nature: Mountainous terrain

geological description: Cultivated terraces

Rainfall (mm): (by INGEMA CE &TAGDI)

Average annual rainfall: 194.8 mm

Average month wise rainfall (Jan-Dec): See table No. 4

Max. Rainfall (1-day / 2-day): 100 mm

Max. Intensity amount and Duration hours: DNA

Rain gauge stations: (Automatic / Manual): Addab'at (Manual)

Period of which record of rainfall available:

In catchment area: -----

Nearest out side catchment area: 1972-76, 1978-79

Runoff Coefficient:	0.2 (estimated according to the catchments characteristics)
Mean annual flow:	199 x 10^3 m^3

Spillway capacity and flood routing criteria:

Type of spillway:	Overflow provided by rock cutting
Spillway length: (m)	7.3 m
Crest level	2422 m
Spillway capacity (m^3/s) = $CBH^{1.5}$:	37.2 (C = 1.8, B = 7.3 m , H =2 m)
Whether with gates: (yes/no)	No
Type of gates (vertical/ radial / flash boards):	-----
Size of gates:	-----
Nos. of gates:	-----
Other outlet works details:	
Location:	At Wadi Center Line
Type:	Steel pipes
Nos:	2
Capacity	8//
Entrance level:	DNA
Exit level	At Wadi bed

Spillway downstream energy dissipation arrangements:
Nil, except the leakage of the steel pipes in the D/S.
Has any downstream retrogression observed (if yes – details): No

D. Commanded area and conveyance systems

Commanded area: (ha)

Gross commanded area:	95 ha (from topographic map)
Left	DNA
Right	DNA
Cultivable commanded area:	
Left	DNA
Right	DNA
Cropping Pattern:	Qat 75 %, Vegetables & fruits
Nos. of farmers:	350
Left	230
Right	120
Tube wells / open wells in commanded area:	open well
Left	30 - 35
Right	15 - 20
Data about working of open wells:	
Discharge	6 - 8 l/s
Depth	water table is at 10-20 m
Other details	50 participants in each well

Conveyance system:

Left:

Type: (pipe/open canal)	GI & PVC irrigation systems
Length: (m)	variable/random lengths
Discharge head: (L/s)	8
Size at head:	3//
Discharge at tail: (L/s)	6

Right

Type: (pipe/open canal)	GI & PVC irrigation systems
Length: (m)	variable/random lengths
Discharge head: (L/s)	8
Size at head:	3//
Discharge at tail: (L/s)	6

Outlet from conveyance system: Nil

E. Dam Performance

How many times has dam filled in last 5/10 years:	Twice since constructed
Any existing cultivation within reservoir area:	Nil

F. Remarks & Observations
This dam was visited on 2/4/2001.
The dam is located at a total distance of 15.6 Km;
8 Km on the asphalt road from Sana'a &
7.6 Km off road from the asphalt to the dam site.
Out of 150 wells, only 50 Nos. are presently working.
For each existing well there are around 50 participant.
Some of the wells are operated by local electricity.
Farmers are very satisfied of the dam performance & benefits.
The site was covered in two photographs.
The following farmer was interviewed:

Abdullah Yehya Ali Khamis farmer

Annex – 2
General Directorate of Irrigation
ENGINEERING DATA SHEET

GENERAL **Dam No. 10**

Name of the Dam Allujma
Purpose of Dam: Ground water recharge
Location:
Governorate: Sana'a
District: Beni Bahlul
Village: Kheiran
Wadi: Allujma
Sub-Wadi: ------
Longitude / Latitude: N 15° 19′ 14.5″ E 44° 23′ 21.3″
1000m UTM North / East: N 1693.95 E 433.5
Topographical Sheet no. (Scale 1:50.000): 1544 C2

Year of completion or status if not completed and Condition as at present
-The construction was completed by GDI/MAI on 30, Nov. 1997.
-The dam is presently leaking from the right abutment, below the spillway channel.

Improvement done and Year: On 2000, a concrete wall was inserted in the U/S Wadi bed as a remedy to stop the leakage.

Type of Dam: Earth fill with U/S reinforced concrete diaphragm

Height of Dam:
Deepest foundation level: DNA
Wadi bed level: 2600 m
Full Reservoir level: 2614.2 m
Max. Water Level 2615.2 m (estimated)
Top of Dam level 2616 m (actual)

Capacity and Area of Reservoir (1000 m^3): as estimated in the dam site
At Full Reservoir level: (FSL) 28
At Max. Reservoir level: 45
Surface Area at FSL 60,000 m^2

Nearest Downstream Village / Town: Kheiran
Its Distance from Dam: 1 Km
Its Population: 500-600

Describe economic development in downstream area and impact of Construction of the dam.
- Wells gets recharged during the rainy season only when the dam is recharged.

Name of officer / Community in charge responsible for operation and maintenance
Designation and office: Community, Mr. Mohammad Saleh Shaker
Head – Quarter:
Phone / Fax Nos:

B. PROJECT FEATURES:

Salient features of Dam
Top Width: (m) 4 m
Maximum height of dam 16 m
Side Slope upstream and downstream: U/S & D/S are 1-1.25:1
Berm location (level) and width: Nil
Upstream protection: RCC on the U/S face of the dam
Downstream toe: DNA
Drainage arrangements: Nil
Length of dam at top: 60 m (actual)

See attached typical cross-sections of the dam showing the above features.

C. HYDROLOGY

Catchment Area (km^2) : 1.275
Catchment area characteristics:
Shape of the catchment area: Fan shape
lowest contour at the dam site (m): 2600
highest contour u/s of the catchment area (m): 3000
difference between the highest & lowest contours (m): 400
max. distance between the u/s & the d/s of the catchment (Km): 1.35
gradient: 29% (steep)
surface nature: Hilly terraain
geological description: DNA
Rainfall (mm): (by INGEMA CE &TAGDI)
Average annual rainfall: 194.8 mm
Average month wise rainfall (Jan-Dec): See table No. 4
Max. Rainfall (1-day / 2-day): 100 mm
Max. Intensity amount and Duration hours: DNA
Rain gauge stations: (Automatic / Manual): Addab'at (Manual)
Period of which record of rainfall available:

In catchment area:	-----
Nearest out side catchment area:	1972-76, 1978-79
Runoff Coefficient:	0.35 (estimated according to the catchments characteristics)
Mean annual flow:	87 x 10^3 m^3

Spillway capacity and flood routing criteria:

Type of spillway:	RCC overflow channel
Spillway length: (m)	12 m
Crest level	2614.2 m
Spillway capacity (m^3/s) = $CBH^{1.5}$:	16.8 (C = 1.4, B = 12 m, H =1 m)
Whether with gates: (yes/no)	No
Type of gates (vertical/ radial / flash boards):	-----
Size of gates:	-----
Nos. of gates:	-----
Other outlet works details:	
Location:	At the Wadi centerline
Type:	Steel pipe
Nos:	1
Capacity	8//
Entrance level:	DNA
Exit level	At Wadi bed

Spillway downstream energy dissipation arrangements: Nil

Has any downstream retrogression observed (if yes – details): No

10-15 l/s is Leakage from the right abutment D/S the dam.

D. Commanded area and conveyance systems

Commanded area: (ha)

Gross commanded area:	90 ha (from topographic maps)
Left	DNA
Right	DNA
Cultivable commanded area:	(by inquiry from farmers)
Left	15-20 ha
Right	15-20 ha
Cropping Pattern:	Qat 1-2%, fruits (Grape 75%) & Grains
Nos. of farmers:	
Left	30
Right	30

Tube wells / open wells in commanded area:	tube well	open well
Left	1 expired	10-15
Right	-	10-15

Data about working of tube wells / open wells:

Discharge	3 - 4 l/s
Well depth	20-40 m
Other details water table from NGL -	almost dry

Conveyance system:

Left:

Type: (pipe/open canal)	Small earth trenches
Length: (m)	200-500 m
Discharge head: (L/s)	7
Size at head:	0.25 m^2
Discharge at tail: (L/s)	5.5

Right

Type: (pipe/open canal)	Small earth trenches
Length: (m)	200-500 m
Discharge head: (L/s)	7
Size at head:	0.25 m^2
Discharge at tail: (L/s)	5.5

Outlet from conveyance system: Nil

E. Dam Performance

How many times has dam filled in last 5/10 years:	Filled twice since constructed
Any existing cultivation within reservoir area:	Nil

F. Remarks & Observations

1- This dam was visited on 8/4/2001.

The dam is located at a total distance of 24 Km from Sana'a / Dar Salm square (Taiz street); 9 Km on the asphalt road from Sana'a / Dar Salm square to Raimat Humaid village & 15 Km off road from the asphalt road / Raimat Humaid village to the dam site.

The dam is presently leaking from the right abutment due to un-proper earth compaction during the construction of the dam.Some treatment in the Wadi bed was adopted to stop leakage in the D/S, but the remedy was insufficient.The farmers are suffering lack of ground water required for irrigation, their wells can provide water for only half hour.The Wadi is cultivated 75% with grape comprising all of it's varieties.The site was covered in three photographs. The following farmer was interviewed:

Nasser Homoud Sa'sa'a Farmer

Annex – 3
General Directorate of Irrigation
ENGINEERING DATA SHEET

GENERAL **Dam No. 4**

Name of the Dam Al-Hayathem

Purpose of Dam: Ground water recharge

Location:

3.1	Governorate:	Sana'a
3.2	District:	Nihem
3.3	Village:	Al-Hayathem
3.4	Wadi:	Al- Waker
3.5	Sub-Wadi:	------
3.6	Longitude / Latitude:	N 15° 39′ 36.7″ E 44° 25′ 13.8″
3.7	1000m UTM North / East:	N 1731.4 E 437.9
3.8	Topographical Sheet no. (Scale 1:50.000):	1544 A4

Year of completion or status if not completed and Condition as at present

-The construction was completed by farmers on 1996.

- seepage was observed at the D/S of the dam, when the water in the U/S was at 5 m of height.

Improvement done and Year: Nil, some amendments are proposed by MAI

Type of Dam: Earth fill

Height of Dam:

6.1	Deepest foundation level:	DNA	
6.2	Wadi bed level:	1990 m	
6.3	Full Reservoir level:	2004.7 m	
6.4	Max. Water Level	2006.5 m	(estimated)
6.5	Top of Dam level	2007.2 m	(actual)

7. Capacity and Area of Reservoir (1000 m^3): as estimated in the dam site

7.1	At Full Reservoir level: (FSL)	250
7.2	At Max. Reservoir level:	360
7.3	Surface Area at FSL	90,000 m^2

8. Nearest Downstream Village / Town: Al-Hayathem

8.1	Its Distance from Dam:	500 m
8.2	Its Population:	300-400 m

9. Describe economic development in downstream area and impact of Construction of the dam.

- Rise of the water table in the wells in the vicinity of the dam by 2-3 m.

10. Name of officer / Community in charge responsible for operation and maintenance

10.1	Designation and office:	MAI / Sana'a
10.2	Head – Quarter:	
10.3	Phone / Fax Nos:	

B. PROJECT FEATURES:

1. Salient features of Dam

1.1	Top Width: (m)	10.5 m
1.2	Maximum height of dam	17.2 m
1.3	Side Slope upstream and downstream:	U/S is 1:1, D/S is vertical
1.4	Berm location (level) and width:	Nil
1.5	Upstream protection:	Riprap works on the U/S face
1.6	Downstream toe:	DNA
1.7	Drainage arrangements:	Nil
1.8	Length of dam at top:	151 m (actual)

2. See attached typical cross-sections of the dam showing the above features.

C. HYDROLOGY

1. Catchment Area (km^2) : **Total** 32.195

Intersected catchment of Al-Khalaqa Dam No.7 5.525

Free 26.67

2. Catchment area characteristics:

2.1	**Shape of the catchment area:**	Fan shape
2.2	**lowest contour at the dam site (m):**	1990
2.3	**highest contour u/s of the catchment area (m):**	2620
2.4	**difference between the highest & lowest contours (m):**	630
2.5	**max. distance between the u/s & the d/s of the catchment (Km):**	8.35
2.6	**gradient:**	7.5% (steep)
2.7	**surface nature:**	Mountainous terrain
2.8	**geological description:**	Fractures limestone

3. Rainfall (mm): (by INGEMA CE & TAGDI)

3.1	Average annual rainfall:	191.4 mm
3.2	Average month wise rainfall (Jan-Dec):	See table No. 4
3.3	Max. Rainfall (1-day / 2-day):	96.5 mm
3.4	Max. Intensity amount and Duration hours:	DNA
3.5	Rain gauge stations: (Automatic / Manual):	Birbasa'l-a (Manual)

Period of which record of rainfall available:
3.5.1 In catchment area:
3.5.2 Nearest out side catchment area: 1991-97
3.6 Runoff Coefficient: 0.15 (estimated according to the catchments characteristics)
3.7 Mean annual flow: 924 x 10^3 m^3

4. Spillway capacity and flood routing criteria:

4.1 Type of spillway: Overflow provided by rock cutting
4.2 Spillway length: (m) 27 m
4.3 Crest level 2004.7 m
4.4 Spillway capacity (m^3/s) = $CBH^{1.5}$: 117 (C = 1.8, B = 27 m , H =1.8 m)
4.5 Whether with gates: (yes/no) No
4.6 Type of gates (vertical/ radial / flash boards):
4.7 Size of gates: -----
4.8 Nos. of gates: -----
4.9 Other outlet works details: Nil
4.10 Location: -----
4.11 Type: -----
4.12 Nos: -----
4.13 Capacity -----
4.14 Entrance level: -----
4.15 Exit level -----

5. Spillway downstream energy dissipation arrangements: Nil (firm rock of the Wadi bed D/S)

6. Has any downstream retrogression observed (if yes – details): Yes
About 5 l/s of water is seeping from the Wadi bed at the D/S

D. Commanded area and conveyance systems

1. Commanded area: (ha)

1.1 Gross commanded area:
1.1.1 Left DNA
1.1.2 Right DNA
1.2 Cultivable commanded area: (by inquiry from farmers)
1.2.1 Left 2,000
1.2.2 Right 3,000
1.3 Cropping Pattern: Qat 60 %, Grains, Maize & Berseem
1.4 Nos. of farmers:
1.4.1 Left 50
1.4.2 Right 70

1.5 Tube wells / open wells in commanded area:	tube well	open well
1.5.1 Left	3	---
1.5.2 Right	4	1

1.6 Data about working of tube wells / open wells:

1.6.1 Discharge	7 - 9 l/s	
1.6.2 Well depth	200-300m	10-15m
1.6.3 Other details: water table from NGL	100-150m	3m

2. Conveyance system: Nil
3. Outlet from conveyance system: Nil

E. Dam Performance

1.1 How many times has dam filled in last 5/10 years: Three times since constructed
1.2 Any existing cultivation within reservoir area: Nil

F. Remarks & Observations

1- This dam was visited on 26/3/2001.
The dam is located at a total distance of 40 Km from Sana'a check point to the dam site;
36 Km on the asphalt road from Sana'a check point to Beni Zitter &
4 Km off road from Beni Zitter to the dam site.
5 l/s seepage was observed at the D/S of the dam, when the water in the U/S was at 5 m of height.
The dam was storing water up to 5 m height.
The discharge in the wells increases whenever the dam gets filled.
Farmers are very satisfied of the dam performance & benefits.
The site was covered in one photograph.
The following farmers were interviewed:
Dhaif Allah Al-Zittery;Yahya Ali Gaeid Al-Haythemi;Dirhem Haythem Al-Haythemi

Annex – 4
General Directorate of Irrigation
ENGINEERING DATA SHEET

GENERAL **Dam No. 38**
Name of the Dam Shahek
Purpose of Dam: Ground water recharge + irrigation by pipes off-taking from the reservoir
Location:
3.1 Governorate: Sana'a
3.2 District: Khawlan
3.3 Village: Tane'm
3.4 Wadi: Tane'm
3.5 Sub-Wadi: ------
3.6 Longitude / Latitude: N 15° 23′ 15.2″ E 44° 25′ 32.8 ″
3.7 1000m UTM North / East: N 1701.275 E 438.4
3.8 Topographical Sheet no. (Scale 1:50.000): 1544 C2
Year of completion or status if not completed and Condition as at present
-The construction was completed by GDI/MAI on 1986.
-The dam is in good condition at present.
Improvement done and Year: Nil
Type of Dam: Rock fill with central earth core
Height of Dam:
6.1 Deepest foundation level: DNA
6.2 Wadi bed level: 2560 m
6.3 Full Reservoir level: 2584 m
6.4 Max. Water Level 2587 m (estimated)
6.5 Top of Dam level 2592 m (actual)
7. Capacity and Area of Reservoir (1000 m^3):
7.1 At Full Reservoir level: (FSL) 450 (by SELKHOPROMEXPORT study)1,500 (as estimated at the dam location)
7.2 At Max. Reservoir level: 600 as estimated in the dam site
7.3 Surface Area at FSL 1,065,000 m^2 as estimated in the dam site
8. Nearest Downstream Village / Town: Tane'm
8.1Its Distance from Dam: 500 m
8.2Its Population: 700-800
9. Describe economic development in downstream area and impact of Construction
- Rise of the water table in the wells in the wells of the nearby villages.
- Increase in the cultivated areas more than 15%.
10. Name of officer / Community in charge responsible for operation and maintenance
10.1 Designation and office: Community
10.2 Head – Quarter:

B. PROJECT FEATURES:
1. Salient features of Dam
1.1 Top Width: (m) 8 m
1.2 Maximum height of dam 30-32 m
1.3 Side Slope upstream and downstream: U/S & D/S are 1.25:1
1.4 Berm location (level) and width: Nil
1.5 Upstream protection: Riprap works on the U/S face
1.6 Downstream toe: Nil
1.7 Drainage arrangements: Nil
1.8 Length of dam at top: 85 m (actual)
3. See attached typical cross-sections of the dam showing the above features.

C. HYDROLOGY
1. Catchment Area (km^2) : 47.125 (by SELKHOPROMEXPORT study)
2. Catchment area characteristics:
2.1**Shape of the catchment area:** Fan shape
2.3 **lowest contour at the dam site (m):** 2560
2.3 **highest contour u/s of the catchment area (m):** 3344
2.4 **difference between the highest & lowest contours (m):** 794
2.5 **max. distance between the u/s & the d/s of the catchment (Km):** 6.7
2.6 **gradient:** 11% (steep)
2.7 **surface nature:** Mountainous terrain
2.8 **geological description:** Cultivated terraces
3. Rainfall (mm): (by INGEMA CE &TAGDI)
3.1 Average annual rainfall: 170 mm
3.2 Average month wise rainfall (Jan-Dec): See table No. 4
3.3 Max. Rainfall (1-day / 2-day): 54.2 mm
3.4 Max. Intensity amount and Duration hours: DNA
3.5 Rain gauge stations: (Automatic / Manual): Al-araqah (Manual)
Period of which record of rainfall available:
3.5.1 In catchment area: 1983-85

3.5.2 Nearest out side catchment area: -----
3.6 Runoff Coefficient: 0.035 (from SELKHOPROMEXPORT study)
3.7 Mean annual flow: 280 x 10^3 m^3

4. Spillway capacity and flood routing criteria:

4.1 Type of spillway: RCC overflow channel
4.2 Spillway length: (m) 14 m
4.3 Crest level 2584 m
4.4 Spillway capacity (m^3/s) = $CBH^{1.5}$: 109 (C = 1.4, B = 14 m , H =3 m)
4.5 Whether with gates: (yes/no) No
4.6 Other outlet works details:
4.10 Location: At the center line of the dam
4.11 Type: Steel pipe
4.12 Nos: 2
4.13 Capacity 8″
4.14 Entrance level: DNA
4.15 Exit level At Wadi bed level

5. Spillway downstream energy dissipation arrangements: Nil

6. Has any downstream retrogression observed (if yes – details): No

D. Commanded area and conveyance systems

1. Commanded area: (ha)

1.1 Gross commanded area: 140 ha (by SELKHOPROMEXPORT study)
1.1.1 Left DNA
1.1.2 Right DNA
1.2 Cultivable commanded area: 83 ha (by SELKHOPROMEXPORT study)
1.2.1 Left 35 %
1.2.2 Right 65 %
1.3 Cropping Pattern: Qat 50-60 %, Grapes & Grains
1.4 Nos. of farmers: 40 in Tane'm & 35 in Shahek
1.4.1 Left 28
1.4.2 Right 51

1.5 Tube wells / open wells in commanded area:	tube well	open well
1.5.1 Left	5	-
1.5.2 Right	45	4

1.6 Data about working of tube wells / open wells:

1.6.1 Discharge	4 - 6 l/s	
1.6.2 Well depth	250-300 m	40-50 m
1.6.3 Other details: water table from NGL	120-200 m	15-40 m

2. Conveyance system:

2.1 Left: Pipes off-taking directly from the reservoir
2.1.1 Type: (pipe/open canal) 4 Nos. Poly Ethylene (PE) & 8 Nos. GI pipes.
2.1.2 Length: (m) variable lengths to the farms
2.1.3 Discharge head: (L/s) 6
2.1.4 Size at head: 2″ - 2.5″
2.1.5 Discharge at tail: (L/s) 4
2.2 Right Pipes off-taking directly from the reservoir
2.2.1 Type: (pipe/open canal) PE pipes + GI pipes
2.2.2 Length: (m) 11 Nos. of variable lengths
2.2.3 Discharge head: (L/s) 6
2.2.4 Size at head: 2″ - 2.5″
2.2.5 Discharge at tail: (L/s) 4

3. Outlet from conveyance system: Nil

E. Dam Performance

1.3 How many times has dam filled in last 5/10 years: After 3 years of completion remained 5 years filled.
1.4 Any existing cultivation within reservoir area: Around 500,000 m^2 gets submerged

F. Remarks & Observations

This dam was visited on 2/4/2001.The dam is located at a total distance of 30 Km from Sana'a to the dam site. ;The Riprap works in the U/S were seen disturbed by the water stored U/S.The discharge in the wells increases whenever the dam gets filled.Farmers are very satisfied of the dam performance & benefits. A comparison between the documented pre-feasibility study of the dam prepared by SELKHOPROMEXPORT and the data encountered in this study is reflected in the following table:

S. No	Particulars	Pre-feasibility study	Data Sheet	Reasons of Differences
1	Catchment area (Km^2)	58.5	47.125	It's not known, although the figure of this study was checked and confirmed
2	Reservoir capacity (m^3)	450,000	1,500,000	The estimations in the site exceed 3 times the figure of the feasibility study.
3	Mean Annual Flow (m^3)	700 x 10^3	280 x 10^3	In this data study the catchment area is computed less than in the Pre-feasibility study, this led to different MAF value.

The following farmer was interviewed:Mohammad Saleh Taher Farmer

Annex – 5
General Directorate of Irrigation
ENGINEERING DATA SHEET

GENERAL **Dam No. 30**

Name of the Dam Ghayman

Purpose of Dam: Ground water recharge

Location:

3.1 Governorate: Sana'a
3.2 District: Beni Behlul
3.3 Village: Ghayman
3.4 Wadi: Ghayman
3.5 Sub-Wadi: ------
3.6 Longitude / Latitude: N 15° 15′ 59.1″ E 44° 20′ 35.7″
3.7 1000m UTM North / East: N 1687.9 E429.5
3.8 Topographical Sheet no. (Scale 1:50.000): 1544 C2

Year of completion or status if not completed and Condition as at present

-The scheme was constructed by GDI/MAI in 2000.

Improvement done and Year: Nil

Type of Dam: Rock fill with central earth core

Height of Dam:

6.1 Deepest foundation level: DNA
6.2 Wadi bed level: 2390 m
6.3 Full Reservoir level: 2402 m
6.4 Mxm. Water Level 2404 m (estimated)
6.5 Top of Dam level 2405 m (actual)

7. Capacity and Area of Reservoir (1000 m^3):

7.1 At Full Reservoir level: (FSL) 700 (by SELKHOPROMEXPORT)
7.2 At Maxm. Reservoir level: 1,000 as estimated in the dam site
Surface Area at FSL 600,000 m^2 as estimated in the dam site

8. Nearest Downstream Village / Town: Ghayman

8.1 Its Distance from Dam: 1 Km
8.2 Its Population: 3000

9. Describe economic development in downstream area and impact of Construction

- Not observed yet.

10. Name of officer / Community in charge responsible for operation and maintenance

10.1 Designation and office: MAI
10.2 Head – Quarter:
10.3 Phone / Fax Nos:

B. PROJECT FEATURES:

1. Salient features of Dam

1.1 Top Width: (m) 11 m
1.2 Maximum height of dam 15 m
1.3 Side Slope upstream and downstream: U/S is 3H:1V, & D/S is 2.5H:1V
1.4 Berm location (level) and width: 5 m wide each, as shown in the drawings.
1.5 Upstream protection: Riprap works on the U/S face
1.6 Downstream toe: Nil
1.7 Drainage arrangements: Nil
1.8 Length of dam at top: 250 m

4. See attached typical cross-sections of the dam showing the above features.

C. HYDROLOGY

1. Catchment Area (km^2) :

Total 102 (by SELKHOPROMEXPORT) 98.175 as per this study
Intersected catchment of Allujma Dam No.10 1.275
Free 96.9

2. Catchment area characteristics:

2.1 **Shape of the catchment area:** Elongated shape
2.4 **lowest contour at the dam site (m):** 2390
2.3 **highest contour u/s of the catchment area (m):** 2820
2.4 **difference between the highest & lowest contours (m):** 430
2.5 **max. distance between the u/s & the d/s of the catchment (Km):** 19.1
2.6 **gradient:** 2.3% (Average)
2.7 **surface nature:** Mountainous terrain
2.8 **geological description:** Cultivated terraces

3. Rainfall (mm): (by INGEMA CE &TAGDI)

3.1 Average annual rainfall: 194.8 mm
3.2 Average month wise rainfall (Jan-Dec): See table No. 4
3.3 Max. Rainfall (1-day / 2-day): 100 mm
3.4 Max. Intensity amount and Duration hours: DNA
3.5 Rain gauge stations: (Automatic / Manual):Addab'at (Manual) Period of which record of rainfall available:
3.5.1 In catchment area: -----

3.5.2 Nearest out side catchment area: 1972-76, 1978-79
3.6 Runoff Coefficient: 0.035 (similar to Dhahek Dam No.38 from SELKHOPROMEXPORT study)
3.7 Mean annual flow: 669 x 10^3 m^3

4. Spillway capacity and flood routing criteria:

4.1 Type of spillway: Clear overflow RCC weir
4.2 Spillway length: (m) 48 m
4.3 Crest level 2402 m
4.4 Spillway capacity (m^3/s) = $CBH^{1.5}$: 190 (C = 1.4, B = 48 m , H =2 m)
4.5 Whether with gates: (yes/no) No
4.6 Type of gates (vertical/ radial / flash boards): -----
4.7 Size of gates: -----
4.8 Nos. of gates: -----
4.9 Other outlet works details:
4.10 Location: At the center line of the dam
4.11 Type: Steel pipe
4.12 Nos: 1
4.13 Capacity 12//
4.14 Entrance level: 1.5 m above Wadi bed
4.15 Exit level Wadi bed level

5. Spillway downstream energy dissipation arrangements: Nil
6. Has any downstream retrogression observed (if yes – details): No

D. Commanded area and conveyance systems

1. Commanded area: (ha)

1.5 Gross commanded area: 158 ha (by SELKHOPROMEXPORT study)
1.5.1 Left DNA
1.5.2 Right DNA
1.6 Cultivable commanded area: 66-70 ha (by inquiry from farmers)
1.6.1 Left 28 ha
1.6.2 Right 42 ha
1.7 Cropping Pattern: Qat 35%, Fruits & Grains
1.8 Nos. of farmers:
1.8.1 Left 40
1.8.2 Right 60

1.5 Tube wells / open wells in commanded area:	tube well	open well
1.5.1 Left	5	2
1.5.2 Right	8	3

1.6 Data about working of tube wells / open wells:

1.6.1 Discharge	4 – 5.5 l/s		
1.6.2 Well depth	250-350 m	30-50 m	
1.6.3 Other details: water table from NGL	150-200 m	15-30 m	

2. Conveyance system:

2.1 Left:

2.1.1 Type: (pipe/open canal) Only Flexible pipes are used
2.1.2 Length: (m) variable / random lengths
2.1.3 Discharge head: (L/s) 5.5
2.1.4 Size at head: 2.5//
2.1.5 Discharge at tail: (L/s) 4

2.2 Right

2.2.1 Type: (pipe/open canal) Only Flexible pipes are used
2.2.2 Length: (m) variable / random lengths
2.2.3 Discharge head: (L/s) 5.5
2.2.4 Size at head: 2.5//
2.2.5 Discharge at tail: (L/s) 4

3. Outlet from conveyance system: Nil

E. Dam Performance

1.1 How many times has dam filled in last 5/10 years: Not yet
1.2 Any existing cultivation within reservoir area: All the reservoir is cultivated with grains.

F. Remarks & Observations

This dam was visited on 2/4/2001.The dam is located at a total distance of 15.5 Km; Km on the asphalt road from Sana'a / Bir Obaid & 4.5 Km off road from the asphalt road to the dam site.The un-grouted Rip Rap on the U/S & D/S faces is not placed properly, the stone size & quality is not properly selected as well.Few houses are located within the FSL, they will be submerged if the stored water level is within FSL & over.Farmers in the U/S do not seem to be so keen to have the dam constructed due to their concern about their crops covering the entire reservoir area.The site was covered in two photographs. The following farmer was interviewed:Ali Ahmad Saleh Aqaba,Farmer

المركز الدولي للبحوث الزراعية في المناطق الجافة
البرنامج الاقليمي لشبه الجزيرة العربية

وزارة الزراعة والري
الهيئة العامة للبحوث والأرشاد الزراعي

دراسة تقييمية لاستخدامات المياه من السدود المائية في المرتفعات اليمنية

أستبيان جمع البيانات

رقم الأستمارة:.....

1 **القرية:**..... **الناحية:**.....

المديرية:..... **المحافظة:**.....

2 **أسم السد:**..... **الأحداثيات:**.....

نوع السد **تاريخ بناء السد**

جهة التمويل

الأرتفاع عن سطح البحر:.....

أرتفاع جسم السد:..... **حجم السد:**.....متر مكعب

3 **المعدل السنوي للأمطار:**

الموسم	خلال ال 12 شهر الماضية (مم)	المعدل السنوي (مم)
الشتاء		
الصيف		
المواسم الاخرى		
اقصى منسوب للمياه في السد		

4 **أقصى كمية من المياه في السد يكون خلال شهر:**.....

5 **المساحة الزراعية التي تروى من السد:**.....هكتار

عدد المزارعين:.....

6 موقع المزرعة بالنسبة للسد:

أ- رداعة ب- وسط ج-منتهى

7 بيانات عن المزارع:

اسم المزارع:.....

عمر المزارع:..... سنة

الخبرة في الزراعة:..... سنة

الخبرة بأستخدام الري:..... سنة

نوع المزارع: أ- يعمل جزئياً في المزرعة ب-يعمل كلياً في المزرعة

عدد أفراد الأسرة الساكنين في المزرعة:.....شخص

مصادر الدخل من خارج المزرعة:..... %

الدخل المزرعي: ..... %

مساهمة الأنتاج النباتي: ..... %

مساهمة الأنتاج الحيواني: ..... %

8 **مساحة المزرعة:**.....

أ- **المساحة المزروعة:**.....هكتار ، ب- **المساحة المروية:** .....هكتار

9 نوع ملكية الأرض:

أ- ملك .....%

ب- مؤجرة ..... %

ج- شراكة ..... %

د- أخرى(تذكر) ..... %

10مصادر المياه المتوفرة في المزرعة:

أ- مياه السد

ب- مياه جوفية آبار

ج- أخرى (تذكر)

11مالذي يحدد التركيبة المحصولية الحالية في مزرعتك؟

أ- ظروف التسويق ب- السياسات الزراعية

ج- الأثنان د-ولا واحد منهما

12كيف تتخذ قراراتك بشأن المحاصيل المزروعة؟

أ- طول موسم النمو ، ب-متطلبات العمل ، أخرى(تذكر).....

13**هل ان استخدام الأرض محدد لمحاصيل معينة فقط؟**

أ-نعم ب- لا

- اذا كان الجواب نعم، ماهي المحاصيل المحدد زراعتها ونسبة الأرض المزروعة بكل منها؟

المحصول	نسبة الأرض %
قمح	
شعير	
ذرة شامية حبوب	
ذرة شامية أعلاف	
ذرة رفيعة حبوب	
ذرة رفيعة أعلاف	
طماطم	
بطاطس	
خضروات أخرى	
فواكة	
قات	

مستوى الأستفادة من مياه السد:

أسئلة موجهة للمزارع:

أ- كيف تحصل على حاجتك من مياه السد للري؟

- من قناه ري ترابية موصلة بالسد
- من قناة ري أسمنتية موصلة بالسد
- من أرض مزارع قبلك
- بالسحب مباشرة من السد بواسطة ماكينات الضخ.

ب- هل تحصل على مايكفي من المياه لري كل المساحة؟.

ج- هل تعاني من نقص توفر المياه؟

د- اذا كان الجواب نعم كيف تغطي نقص المياه؟

- عن طريق السحب من المياه الجوفية.
- شراء مياه من الوايتات.
- من مصادر أخرى (تذكر)

ه- كيف تقيم تأثير السد على المياه الجوفية؟.

- أرتفع منسوب المياه الجوفية بعد انشاء السد.
- أنخفض منسوب المياه الجوفية بعد انشاء السد.
- لآيوجد أثر يذكر.

دور الأرشاد الزراعي في منطقة السد:

أ- أسئلة موجهة للمرشد الزراعي:

- **كيف تحسب أحتياجات المحاصيل الزراعية من المياه؟**
- هل لديكم برامج توعية لأدارة المياه على مستوى الحقل؟
- اذا الجواب نعم : أذكر نوع تلك البرامج وكيف تنفذ:

.....
.....
.....
.....

ب- أسئلة موجهة للمزارع:

- **كيف تقدر أحتياجات المحاصيل الزراعية من المياه؟**

بالمشاهدة: حالة النبات ..... ، رطوبة التربة .....

ت- تشغيل وصيانة السد:

أ- أسئلة لأدارة الري:

ماهي أسس تصريف المياه من السد:

حسب رغبة المزارع :..... ، حسب حاجة المحاصيل المزروعة:..... حسب حجم المياه في السد:..... ، ظروف أخرى(تذكر):.....

كيف يتم صيانة السد (من الترسبات والشقوق ..الخ):

بمشاركة المزارع:..... ، مسؤلية الدولة:..... ، مسؤلية المزارعين

وضح ذلك:

.....
.....
...

Assessment of impact of utilization of Treated Waste water on Soil and Environment at Al-Sha'ab Treatment facility in Aden

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Introduction

The republic of Yemen is distinguished by scarce water resources due to absence of natural rivers, low average rainfall and limited groundwater reserve accompanied with high salinity. The agricultural sector consumes around 92% of the total water used in the country, while the domestic and industrial consumption are about 26 and 2% respectively (World Bank 1996, AOAD 1995). Therefore, all the views are focused towards the adoption of appropriate use of the water policy and minimize its wastage in application which is due to increase in population (3.7% annually) agriculture and expansion urban construction and consequently arises demand for water.

Under such circumstances, there is an urgent need for search of water resources in order to meet the growing demand for overall development. These resources are the treated sanitation water, which are suitable alternatives for municipal water in cultivation of industrial crops, such as cotton, forage and the green belts, which safeguards the coastal cities from seasonal winds, and ornamental plants. The reuse of such water after its treatment deserves all the scientific and financial efforts to promote it to applicable stages, considering the importance of this resource in the water resource wealth in irrigation of extensive areas of green belts in Aden City and in desertification control program.

The use of anthropogenic input from human and animal in agriculture is an old practice in Yemen. After modernization and urban expansion, sewage water is being disposed off into subsoil. In large towns, sewage water is treated and then recycled in agriculture. There is no exact record about its volume and use, but some studies estimated that the annual volume of sewage water in Yemen is in the range of 45-75 million cubic meters and is expected to reach 150 million m3 / year by the year 2010 (AOAD 2000).

The average water production for the Aden city reaches nearly 100,000 m3/day (38.5 million m3 /year) (NWASA). Of this amount about 25-30% is lost in the conveyance system. The average raw wastewater production rate is estimated at 55,000 m3 /day (about 20 million m3 /year). Of this raw wastewater, 15,000 m3 /day (5.5 million m3 / year) is currently treated to the secondary level at Al-Sha'ab plant, which was established in 1986 and serves the areas of Al-Mansoora, Sheikh Othman and Al-Sha'ab. The remaining volume of raw sewage production (40,000 m3 /day, 15.0 million m3 /year) is collected from areas of Crater, Maalla, Tawahi and Khormaksar and delivered into another secondary treatment facility recently constructed adjacent to the sea shore at Al-Areesh.

Oxidation lagoons are the only method used in sewage treatment in the Al-Shaab treatment plant. There is, thus no monitoring of quality and quantity measurements of the treated wastewater (TWW), whether it is utilized or discharged to the sea. Nevertheless, the laboratory of sanitation at Al-Areesh

treatment facility recently established to conduct analysis for raw and TWW in order to establish an on-going program of water quality and quantity measurements of TWW.

At present, part of the discharge of TWW from the Al-Sha'ab treatment facility is being used in agriculture. However, most of the TWW is dumped into the sea. There is currently a plantation of shrubs and trees around the facility irrigated by using TWW. Downstream farmers grow crops such as cotton and forages that are grazed by cattle.The source of this water is from the sewage treatment facility. It must be stressed that Expanded use and application of this wastewater needs conducting detailed studies on the quality of the TWW at different times of the year before refuse in order to determine the suitability of the TWW for irrigation. The suitability of the TWW at Al-Sha'ab treatment plant for irrigation depends on several factors that have a direct relation with soil and plant. The most important element in the quality of TWW is the total salinity expressed as electrical conductivity (EC MS/cm) and total dissolved salts (TDS mg/L). The second main factor in water quality is alkalinity expressed in the term of SAR (sodium absorption ratio), which is calculated by the following equation:

$$\text{Adj SAR} = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+} + mg^{2+}}{2}}} \{1 + (8{,}4 - phc)\}$$

The value of adj SAR takes into consideration several factors such as carbonate and bicarbonate, which tends to dissolve calcium and magnesium carbonate and so increase the rate of the soluble calcium and magnesium or tends to precipitate the calcium and magnesium and therefore decrease the solubility of these two cations.

The third factor is the toxic ions such as CI, HCO3 , B and NA that affect the humans, animals, plants and environment at large.

The fourth important factor in water quality is the heavy metals. Some of these elements affect the animals and human health; other affect agricultural productions rate other affect the quality of products.

The general standards for wastewater reuse adopted from different resources (FAO 1985, WHO 1989, EPC 1993) is presented in table 1.

Apart from monitoring program of TWW, it is also necessary to carry out studies on residual effect for such water application in soil and its impact on the environment.

The objectives of this study were:

1) To determine the quantity and quality of TWW regarding total salinity, specific toxic elements, heavy metals and presence of different microorganisms, their identification and quantification.
2) To determine the impact of utilization of TWW on soil and environment.
3) To determine the suitability of secondary treatment of wastewater for irrigation.

Al-Sha'ab Treatment Facility:

Al-Sha'ab treatment facility has been constructed in 1986; it receives raw wastewater from Al-mansoura, Shekh Othman and Al'Sha'ab localities as the amount of raw wastewater delivered into this plant is estimated as 20,000 m3/day, at present time. This quantity is more than 40% of the previous estimation done during construction. The increase in pumped raw wastewater into treatment plant is mainly due to the urban expansion due to internal migration during the last ten years.

The process of the Al-Sha'ab treatment plant consists of stabilization bonds system. Figure 1 shows the layout of the plant. Al-Sha'ab treatment facility consists of machine building at which screens are installed. Then raw wastewater is distributed into three lines of bonds. Anaerobic bond serves the two systems, while the old system contains four facultative bonds1.3 and 2. 4. The other new system (Kabuta) consists beside the anaerobic bonds four facultative bonds 5.7 and 6.8. Table 2 explains the dimensions.

Methodology:

In coordination with National Water and Sewage Sanitation Authority (MWASA) the assessment of TWW and its impact of utilization on soil and environment where evaluated at Al-Sha'ab treatment plant by taking samples from raw and treated wastewater, soil at different depth (up to 100cm) and

plants (shoots and roots). Ten water samples were collected in 1.5 liters polyethylene bottles from the inlet of flowing wastewater.

Table 1. General standards for wastewater reuse.

Parameters	Units	Degree of restriction		
Salinity		None	Slight to moderate	Severe
ECW	Ds/m	0,70	0.7-3.0	>3.0
TDS	Mg/L	450	450-2000	>2000
BOD	Mg/L	20	30	>30
COD	Mg/L	60	90	>90
TSS	Mg/L	30	45	>45
PH	Mg/L	6.0-8.4	6.0-8.4	<6.0 or>8.4
Permeability				
Adj SAR		ECW=		
0-3		0.7	0.7-0.2	<0.2
3-6	AND	1.2	1.2-0.3	<0.3
6-12		1.9	1.9-0.5	<0.5
12-20		2.9	2.9-1.3	<1.3
20-40		5.0	5.0-2.9	<2.9
TOXIC IONS				
Na	Me/L	<3.0	3-9	>9.0
Cl	Me/L	3.0	3.0-10	>10.0
HCO_3	Me/L	<1.5	1.5-8.5	>8.5
FC	Colony/100m	1000	5000	>5000
Intestinal nematode	/egg/liter	<1	1	>1
TOXIC Elements				
Total N	Mg/L	<5	5-30	>30
No_3	Mg/L	<5.0	5-30	>30
Pb	Mg/L	<5.0	5.0	>5.0
Cu	Mg/L	<0.2	0.2	>0.2
Zn	Mg/L	<2.0	2.0	>2.0
Fe	Mg/L	<5.0	5.0	>5.0

Table 2. Characteristics of the old and new system.

Old System

Anaerobic	Facultative			
	Pond 1	Pond 2	Pond 3	Pond 4
Length (m)	204	170	200	175
Width (m)	100	102	90	90
Depth (m)	2.0	2.0	2.0	2.0
Volume(m^3)	40800	34640	36000	31500

New System (kabota)

Anaerobic	Facultative			
	Pond 5	Pond 6	Pond 7	Pond 8
Length (m)	267	245	240	250
Width (m)	110	100	100	100
Depth (m)	1.5	1.5	1.5	1.5
Volume(m^3)	44055	36750	43920	38625

Each sample represents a single pond. The water samples were transferred immediately to the laboratory of soil and irrigation section in Al-kod Agricultural Station. total salinity and sodium and potassium concentration in raw and TWW were determined by electrical conductivity and flame photometry. Calcium and magnesium and carbonate and bicarbonate concentrations were detection by titration of EDTA and HCL in the presence of erichrome black, and phenolphthalein, methyl orange indicators. Chloride was determined by silver nitrate method, while sulphate was determined by the precipitation of barium chloride. In the other hand for the detection of concentration of heavy metals in the TWW, 10 ml was taken from the water samples and diluted to100ml by distilled water. These samples were transferred to Geological Laboratory of the Board of Geological Survey and Minerals (Aden Branch) for the analysis of the heavy metals such as Zn, Cu, Pb and Fe by atomic absorption.

For the presence of microorganisms their identification and quantification, each sample of wastewater was diluted in sterilized distilled water. Thus, a series of dilution led to final dilution of 1 x 109 One ml of aliquot from the final dilution was aseptically transferred utilizing sterilized pipette to dilution plate agar and spread evenly on the agar surface for identification of different bacteria and colony counts.

Complex soil samples at depth of 0-25, 26-50, 51-75 and 76-100 cm were taken from the farm irrigated by TWW by auger. The soil samples were air-dried and passed through a 2mm sieve. Suspensions (1:1 w/w) of these air-drie0d soil samples were made and filtered through a Whitman filter paper No: 2. Total salinity cations and anions concentration in the filtrates were determined by the same methods mentioned in the samples of wastewater. Whereas the heavy metals such as Cu, Zn, Pb and Fe in soil irrigated from TWW were extracted by diethylenetriaminpenta acetic acid (DTPA).

Then the suspensions were filtered through a Whitman filter paper No: 2 then the heavy metals in the filtrates were determined by atomic absorption. While for the isolation of microorganisms from the soil irrigated from treated wastewater, the soil samples were crushed by hand to break the colds, mixed thoroughly to ensure homogeneity of samples. Ten grams of soil was transferred to 100ml of sterilized distilled water.

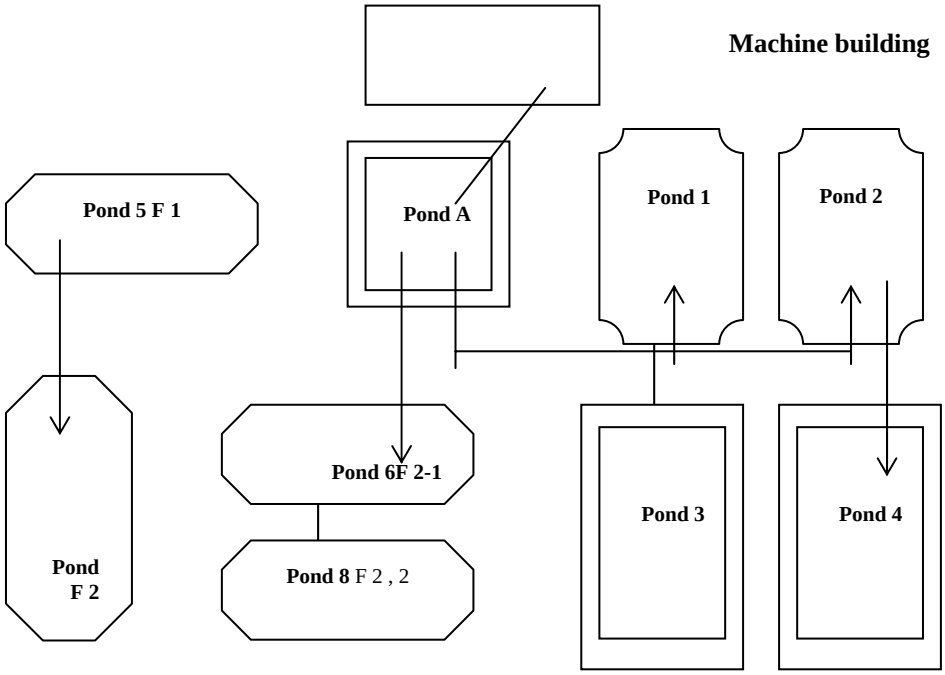

Figure 1 Al-Sha'ab sewage treatment plant at Aden

Table 3. Chemical Composition of Wastewater and Treated Wastewater at Al-Sha'ab Plant

Stabilization Ponds	PH	EC Ms/cm	Cations Me/Liter					Anions Me/liter				Rate of Soluble Sodium %
			T.D.S. Mg/L	Ca	Mg	Na	K	CO_3	NCO_3	Cl	SO_4	
Raw wastewater	7.2	3000	1920	7.0	6.0	16.0	0.8	2.5	6.5	14.0	7.0	123
Anaerobic	8.0	3000	1856	6.5	7.0	16.0	0.75	3.0	5.0	13.0	9.0	119
Pond 5	8.0	2900	1856	6.5	5.0	17.0	0.80	2.5	5.0	10.0	11.5	148
Pond 6	8.0	2900	1856	6.0	6.0	16.0	0.80	2.0	5.0	12.0	10.0	133
Pond 7	8.0	3100	1984	6.5	6.0	17.5	0.80	2.5	6.0	12.0	10.5	140
Pond 8	8.0	3100	1984	4.5	8.0	17.5	0.80	2.0	5.0	12.0	12.0	140
Pond 1	8.0	3200	2084	5.0	8.0	18.0	0.90	3.0	5.0	14.0	10.0	138
Pond 2	8.0	3200	2084	5.0	7.0	19.0	0.85	3.0	5.4	14.0	9.5	158
Pond 3	8.0	3300	2112	5.0	7.0	20.0	1.00	3.0	6.0	14.0	10.0	167
Pond 4	8.0	3300	2112	5.0	7.0	20.0	1.00	3.0	6.0	14.0	10.0	167
Effluent WW		3100	1984	5.5	6.5	18.0	0.90	2.5	5.5	13.0	10.0	150

A dilution of 1x109 was used for plating.Random shoots and roots samples of sorghum (sorghum vulgare L.) and elephant grass (pennisetum purpureum schumach) were collected from ratoon crop and transported to soil and irrigation laboratory. The samples were washed under running tap water. For detection of heavy metals the plant samples were chopped, dried in an oven at 70C for 24 hours and grinded in electrical blender. 5 grams of each sample were taken and put in crucibles. These crucibles were put in furnace for ignition, the ashes of these samples were dissolved by aqua regia and diluted up 100 ml by distilled water, the heavy metals such as Cu, Zn, Pb, and Fe were determined by atomic absorption.For identification and quantification of bacteria in plant samples of forage crops, 250 gram of fresh shoot samples were shopped, grinded in sterilized pestle and mortar with 100 ml of sterilized distilled water. A series of dilution led to final dilution of 1 x 109. The method described earlier was applied for platting and colony counts. Similar technique was applied for the roots.

Results and Discussion

The chemical characteristics of raw and treated wastewater at different stabilization ponds are show in tables 3 & 4 the electrical conductivity (EC) and total dissolved salts (TDS) range between 2900-3200 µS/cm and 1850-2050mg/l, with lowest values appeared in oxidation ponds of 5&6 the other chemical constituents in table 3 exhibit a mild variations from pond to pond, where they are almost similar. The heavy metals such as Cu, Pb,Zn and Fe presented in table 4 are in negligible quantities except Zn, which varies between 1 to 1.3 p.p.m.According to the standards for wastewater reuse presented in table 1 (adopted from FAO 1985), WHO (1989) and EPC, technical secretariat, Republic of Yemen (1993) , the treated wastewater are in the acceptable range of suitability. Whereas this water contains considerable amounts of Na and Cl ions, the percentage of increase these elements from the maximum allowable limit were 200 and 30% respectively, the chloride contents in these treated wastewater injuries the plant leaves by appearing necrotic spots when it is applied by sprinkler irrigation. Although soluble sodium occupied more than 55% of the total soluble cations in the wastewater, the pH is likely to be below 8.0 as a result of the repressive influence of the neutral soluble salts, the electrical conductivity of wastewater is more than 3.0 µS/cm. Due to a considerable amount of Cl in the TWW, it is recommended to apply TWW by surface irrigation in order to avoid the injury of plant leaves.To eliminate the accumulation of soluble salts such as chloride on the soil surface, and to avoid damaging the root zone of crops grown under irrigation from TWW, it is necessary to apply additional amount of water with each irrigation frequency for periodical leaching . After 3 to 4 years of using this water it is recommended to apply a capital leaching with fresh water. Secondly it is recommended to grow crops that are highly tolerant to Cl. For reducing the effect of sodium on the soil permeability when irrigating with treated wastewater, it is prerequisite to add gypsum into the soil. This material is rich in calcium, which balance Na in the soil solution and replaces it on the soil exchangeable complex. Consequently, this will reduce the severity of increased Na in the soil.

Apart from its use in irrigation, the treated wastewater (TWW) is a source of ammonia, ammonium and nitrate, phosphorus, and potassium (table 5). At an irrigation of 500mm per year, TWW would provide 595, 10 and 180 kg/ha of N,P, and K respectively. These amounts are of economic value. However, these nutrients, particularly nitrogen, are pollutant rather than desirable input when this TWW is pumped to the sea or reaches the groundwater reservoir.The influx of raw wastewater is collected in anaerobic ponds and thereafter, flown to aerobic or facultative ponds allowing oxidation of raw materials in wastewater. Table 6 clarifies the types of bacteria detected in wastewater from different ponds.

Table 4. Content of Heavy metal in Wastewater at Al-Sha'ab Treatment Plant

Type of Wastewater	Content of Some Heavy Metal (ppm)			
	Zn	Pb	Cu	Fe
Raw Wastewater	1.30	Nil	Nil	Nil
Anaerobic pond	1.25	Nil	Nil	Nil
Pond 5	1.00	0.01	0.01	Nil
Pond 6	1.00	Nil	Nil	0.015
Pond 7	1.25	Nil	Nil	Nil
Pond 8	1.00	0.01	Nil	Nil
Pond 1	1.20	Nil	Nil	Nil
Pond 2	1.30	Nil	0.015	0.01
Pond 3	1.25	0.015	Nil	Nil
Pond 4	1.30	Nil	Nil	Nil

During the treatment process, certain types of bacteria such as Pseudmonas Spp., E. coli, survived, whereas others were perhaps eliminated. These bacteria were found in infinite population under the dilution 1x105 and therefore impossible to quantify the colony forming units. All the bacteria shown in table 6 are pathogenic and are of major concern in regard to human health and marine habitats, since the wastewater from the final fermentation pond is dumped into the Arabian Sea, Gulf of Aden. Causing serious marine population.'

TWW is suitable for irrigation purposes regarding the total salinity and heavy metal such as Cu, Pb, Zn and Fe, but it is harmful to animal and human health in relation to its high content of nitrogen and pathogenic microorganisms. Among the entire pathogenic organism, total coliform and faucal coliform are the main criteria for microbiological pollution in wastewater (Dart and Stretton 1997, American public Health, 1975, Mara 1976, Loeh et al, 1979). In this study, comparison of total coliform and faecal coliform revealed high population of colony forming units per 100 ml. Of wastewater (table 7).

The above data exceeds the international stranded described by EU, WHO, 1989. The initial count of total coliform from the inlet of raw material till the outlet from the final fermentation pond showed a slight decline in the population of the coliform, whereas, in the case of faecal coliform, there was a two-fold decline. The high population is beyond the range of sanitary limit and warrants immediate

action to reduce the population of pathogenic bacteria in wastewater in order to render it suitable for various safe applications. This is confirmed by Parsons et al 1975.

Table 5. The concentration of Nutrient elements in treated wastewater

Wastewater	Nutrient Substances (Mg/L)							Total Suspended Solid (mg/L)
	SO4	NH4	NO2	NO3	NH3	PO4	K	
Influent	280	84	0.1386	Nil	79	13.2	32.0	450
Effluent	260	57.75	0.0099	8.48	54.5	1.95	36.0	98

Table 6. Microorganisms isolated from the existing ponds at Al-Sha'ab wastewater treatment plant.

Treatment	Bacteria Isolated*
Pond 1	Pseudomonos *Spp. Shigella spp.; coliform spp.;* E.coli
Pond 2	Pseudomonos *Spp.*
Pond 3	*Pseudomonos* Spp.
Pond 4	*E. coli : coliform Pseudomonos*
Pond 5	*E. coli : coliform Pseudomonos* Spp
Pond 6	Pseudomonos Spp E. coli citrobacter
Pond 7	*Pseudomonos*
Pond 8	*Pseudomonos*
Pond 9	*Pseudomonos* spp. *Citrobacter*
Pond 10	*E. coli : coliform Pseudomonos* spp.

* Bacteria colonies shown above were detected in infinite numbers from dilution $1x10^5$ and therefore impossible to quantify.

Table 7. Population of two dominating bacteria found in wastewater at Al-Sha'ab study site.

Source of waste water	Date of Sampling	Total Coliform	Faecal Coliform
		CFU/100 ml	
Inlet	July 15, 2003	56×10^6	40×10^6
Outlet	July 15, 2003	37×10^4	9×10^4
Pond 1	July 29, 2003	1×10^6	Zero
Pond 2	July 27, 2003	2×10^6	1×10^6
Pond 3	July 29, 2003	7×10^4	2×10^6
Inlet	August 5, 2003	55×10^6	15×10^6
Pond 1	August 5, 2003	1×10^6	Zero
Pond 2	August 5, 2003	3.2×10^5	5×10^6
Pond 3	August 5, 2003	6×10^3	Zero
Pond 4	August 5, 2003	3×10^3	Zero
Pond 5	August 5, 2003	5×10^6	5×10^6
Pond 6	August 5, 2003	6×10^6	1.84×10^6
Pond 7	August 5, 2003	3.3×10^5	9×10^4
Pond 8	August 5, 2003	2.6×10^5	7×10^4
Outlet	August 5, 2003	6.2×10^5	2.8×10^3

International standard for a tolerant level of pathogenic bacteria in WW according to EU is 1×10^3 CFU/100 ml wastewater

Table 8. Biological oxygen demand (BOD) in the different ponds at Al-Sha'ab study site.

Source of wastewater	BOD (mg/Liter)
Influent	520
Anaerobic	370
Pond 1	115
Pond 2	150
Pond 3	85
Pond 4	85
Pond 5	130
Pond 6	140
Pond 7	160
Pond 8	65
Effluent	160

* Tolerant Level according to EU is 30 mg/L

Biological oxygen demand (BOD) from the influent to effluent showed approximately a three-fold decline (Table 8). Considering the BOD in the treatment process of wastewater, there was a gradual decline in (BOD) and fluctuation due to variation in multiplication of bacteria in the ponds. This indicates that there was no total climination of bacteria or perhaps the presence of organic matter during the process of treatment of wastewater or at least to maintain the permissible level of bacterial population. This could be attributed to the presence of suspended organic matter particles, which might have supported the survival of bacteria and their multiplication.The total efficiency to remove carbonic particles and biological contamination in the Al-Sha'ab treatment plant was moderate, where the residual rates of the BOD total suspended solid (TSS) , total and faucal coliform in the effluent wastewater used for irrigation or pumped into the sea water were 65, 98 mg/l and 3.7 x 105 and 9x104/100 ml. This situation clearly indicates that the treatment facility suffers from high hydraulic and organic load above its designed capacity, the designed influent flow rate to the plant was 15000 m3 /day which results in total retention time of 22.1 days, this retention time is reasonable to achieve high removal efficiency of BOD and pathogens which may approach the guideline recommended by WHO (1989). However due to urban expansion and increasing population as the result of local immigration during the last ten years, the influent flow rate to the plant is 20000m3 /day (measured pumping station NWASA 2003). The performance of the present conditions could be evaluated by calculation of hydraulic retention time in an anaerobic and facultative ponds, the retention time in the anaerobic pond was calculated by dividing the volume of the pond over the influent flow rate and was

0.5 day. This value was to shorten and was 4 to 8 times less than the WHO guideline. While, the retention time in the facultative ponds was 15.3 days, which is less the designed retention time by 5 days. So it was clear from the data of BOD, TSS total and faecal coliform that the treated wastewater of the Al-Sha'ab treatment plant cannot be used for irrigation purposes or other reuse without restrictions. This is due to feature of this water, which does not coincide with the standards fort wastewater reuse. Therefore, for producing effluent treated wastewater from this plant acceptable to international standards described by EU, and WHO 1989, it is required to increase the retention time in the treatment plant. Increasing the retention time can be achieved by constructing three additional ponds for anaerobic stabilization and three additional ponds for purification and fermentation.Treated wastewater is currently used in agriculture at small scale. Diverting TWW to irrigate some forage crops does this. It must be mentioned that this practice is applied without any attention given to the contents of the TWW used. To determine the magnitude of this problem, the residual effect of using TWW on soil was studied. The soil treated along the downstream was sandy loam throughout soil profile up to 100 cm. (table 9).

Table 9. Percentage of soil fraction and soil texture.

Soil depth	Soil Fraction Percentage				Soil Texture
	Coarse sand	Fine sand	Silt	Clay	
0-25	82	4.0	4.0	10	Sandy Loam
26-50	90	0.0	0.0	10	Sandy Loam
51-75	90	0.0	0.0	10	Sandy Loam
76-100	77	4.0	4.0	14	Sandy Loam

The salts content of 1:1 extracts of the soil is presented in table 10, the salinity expressed in US/cm was very little and does not exceed 759 US/cm. The soil is non-saline; the ph of the soil was slightly to moderately alkaline reaction. Soluble Ca 2+ and Mg2+ were very low. Thus, it is prerequisite to apply gypsum from time to time in order to prevent accumulation of Na+ in the soil and consequently reduce the formation of alkali hazard. The contents of these elements were very low for all heavy metals except Fe. Its content varies between 2.25 to 7.00 ppm with a highest value in the surface of the soil, the contents of heavy metals in the soil irrigated with TWW to a certain extent coincided with their contents in TWW except Fe. The high amount of Fe when compared to other heavy metals may be due to accumulation of municipal refuse. This is understandable given the fact that the land currently cultivated by forage crops(sorghum and elephant grass) was a place for sanitary land fills from the town during the past twenty years. However, the sewage sludge is considered a source of inorganic compounds, it is a good soil amendment. It was found that the physical and chemical properties of the soil irrigated by TWW were improved when compared with the neighboring uncultivated land.

Table 10. Chemical feature of 1:1 extract of the soil Irrigated with Treated Wastewater.

Soil Depth	PH	EC/MS /cm	Soluble cationsmeg/L				SAR	Soluble anions meg/L			
0-25	8.4	0.73	0.8	0.9	5.4	0.23	5.87	0.2	3.6	3.2	0.35
26-50	8.4	0.66	0.8	0.8	4.8	0.18	5.39	0.2	2.6	3.2	0.58
51-75	8.3	0.7o	0.8	0.8	5.2	0.2o	5.84	0.2	2.8	3.2	0.8o
76-100	8.4	0.75	0.8	0.9	5.6	0.23	6.o9	0.2	2.7	4.o	0.43

Table11. Content of some heavy metals in the soil irrigated with treated wastewater

Soil depth	Cu	Zn	Pb	FE
0-25	0.56	0.17	0.06	7.00
26-50	0.50	Nil	0.12	5.50
51-75	0.53	Nil	0.04	3.00
76-100	0.50	0.12	0.12	2.25

The concentration of heavy metals such as Cu, Zn, Pb, and Fe in soil irrigated from TWW is shown in table 11.

The most important factor for utilizing wastewater in agriculture is the contamination of environment. Table 12 shows the concentration of heavy metals in different parts of forage crops.

The concentration of heavy metals such as Cu, Zn, Pb and Fe were relatively high and located in the contaminated stage according to Allaway's finding (1970) (quoted by Brady 1974). The source of lead (Pb) for contamination is airborne lead from automobile exhausts. The airborne particles are moved far from the point of exhaust and are an important factor in determining the lead content in food. Just how much lead is deposited directly on the leaf surface and how much is deposited on the soil surface and how much is deposited on the soil and then taken up by the plants is not known. However, behavior of this element in soil would suggest that much of the lead in food crops comes from atmospheric contamination. Whereas, the concentration of Cu and Zn in different parts of forage crops are not known whether it comes from atmospheric contamination either from the sewage sludge. Table 13 shows the existence of bacteria in soil at different depth and its translocation in plant parts.

Pseudomonos Spp and Yerseia Spp were dominating in all the soil and plant samples and survived in a viable form. Ongerth and Jopling, 1977 emphasized the treatment of wastewater intended for irrigation of crops, so as to eliminate the pathogenic and avoid environmental hazard.

Table 12.Concentration of some heavy metal in forage crops (ppm)

Forage Crops	Cu	Zn	Pb	FE
Elephantgrass (shoot)	10.00	9.25	1.50	240
Sorghum (soot)	6.00	11.0	1.25	220
Sorghum (shoot)	7.00	8.50	1.25	925.0

Table 13. Microorganisms isolated from soil and parts irrigated from treated wastewater.

Soil Depth	Bacteria Isolated*
0-25	*Pseudomonas* spp
26-50	*Yersenia spp.; Pseudomonas* spp.;
51-75	*Yersenia spp.; Pseudomonas spp .*
76-100	*Yersenia spp.; Pseudomonus* spp.*; shigella; y.*
Leaves	*Yersenia spp.; Pseudomonas* spp.; *Coliform*
Roots	*Yersenia spp.; Pseudomonas* spp.;*coliform;*

Conclusions

- The treated wastewater from the Al-Sha'ab treatment plant is in the acceptable range of suitability for irrigation purpose in regard of salinity and heavy metal concentrations.
- The treated wastewater is considered as a source of concentration, if it is pumped into the sea or reached the ground water, due to its high contents of nitrogen and pathogenic microorganism and it is harmful to human and animal health.
- The overall efficiency of the Al-Sha'ab treatment plant in removed carbonic particles and biological contamination is moderate.
- The Al-Sha'ab treatment facility at such circumstances mainly suffers from high hydraulic and organic load above its designed capacity.

Recommendations

- The farmers or agricultural workers must be subjected to periodic medical monitoring and immigration against typhoid and cholera.
- Stop the application of the treated wastewater at least two weeks before cutting fodder or cattle are allowed to graze.
- Forage crops should be harvested at the maturity stage at which the concentration of toxins is lowest.
- Animals must be slaughtered only in recognized abattoirs where all carcasses are inspected and all infected carcasses are rejected and properly disposed off.
- The Boiling of milk produced from cows fed on grasses and fodder irrigated by treated wastewater is essential.
- To produce effluent treated wastewater at the level of international standards, it is recommended to prolong the retention period of treatment of wastewater in order to minimize or eliminate the pathogenic microorganisms and BOD. This can be achieved by constructing additional 3 ponds for each of the anaerobic and facultative stabilization.

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- المنظمة العربية للتنمية الزراعية 2000 : دراسة استخدام مياه الصرف الصحي في الإنتاج الزراعي في الدول العربية

Study Evaluation of Seed Multiplication of Important Forage Grasses in Coastal Zone

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Abstract

This study has been carried out based on results of the previous season 2002-2003 and also according to the recommendations related to the selection of most suitable time for collection and planting of seeds of grasses under this study. The collection and planting of forage seeds continued to ensure accumulation of sufficient seeds for further replanting in their natural habitat. Seeds were collected at full maturity stage. The results of these efforts were accumulation of good amount of seeds of the three forages.

Introduction

Growth of range grasses in the South Coastal Zone of Yemen depends on rainfall. The amount of rain in this region was very limited in the last season. The collection of seeds of the three forages from their natural habitat was practically impossible. This is mainly because under drought conditions whatever seeds formed are likely to be weak and with low % germination. During field visits it was observed that several forage species do exist in addition to the previously selected ones. Discussion among the team led the conclusion that it might advisable to increase the number of forages under investigation. This is important under the unreliable rainfall conditions in the coastal agro-ecological zone of Yemen. It was also observed during the field trip, the presence of significant number of forage shrubs species, which are highly palatable and highly valued by herd owners in that area. The team decide to launch field investigation to identify these species and plan for further multiplication of the most promising ones.

Material &Methods

Some modifications were made to the process of land preparation to plant forage in the research station as well as seed collection and storage. These modifications can be summarized as follows

1-Land preparation: Land was ploughed by chisel plow and followed by disc harrow.;Land leveling was done by a leveler; Crushing of soil clods was achieved by the disc harrow; Canals were dug and land was divided into equal plots with an area of 150M^2 each.; The plots were given a false irrigation to encourage seed germination of weed seeds; The germinated seeds were pulled put 10 days after irrigation. 2-Planting of seeds and transplanting of seedlings: Planting was done manually in straight lines 50 cm apart. Holes 30 cm in depth were made to transplant seedlings from the station's nursery and from the field.3- Harvest and seed collection: Seeds at physiological maturity were collected manually from lower levels to the higher levels of the inflorescence. Seed collection was done in stages, which lasted for a whole month. Seeds were collected into separate paper bags.4- Seed drying and seed storage: Seed were dried in the store after spreading them separately on the floor in a shaded place. The drying of seeds did not last long, because seeds were already dry and mature in shape when collected. The paper bags were necessary to prevent moisture accumulation in the plastic bags.;After seeds were collected they were cleaned and the husk of some species was removed manually at the same time small and defected seeds were discarded.;Collected and cleaned seeds were put in a refrigerator for storage until they are redistributed.

Amounts of seeds collected

The amount of collected seeds reached about 4 kilograms for Cenchrus Ciliaris, 3Kilograms for Dichanthum spp and one kilogram for Panicum torgidum.

Results & Discussion

The results indicated that the growth of Cenchrus Ciliaris species gave more seeds from Dichuntum spp species. The second species next to the first was panicum turgidum . Also. It was noticed that the Panicum torgidum plants grown from seeds ere no superior to plants of the same species grown from seedlings. The Cenchrus Ciliarus species was successesful when grown from both seeds and seedlings. The Dichunthum spp species was successfully grown from seedlings only. Attempts to germinate Dichunthum seeds were not successful so far.

Recommendations

It could be concded that further efforts of seed multiplication of forage species should be on opther forages outyielding the selected ones especially Dichunthum and Panicum torgidum. These two species proved difficult to propogate by seeds. Cenchrus Ciliaris is better with regard to its palatability followed by Dichunthum spp. Panicum Turgidum appeared less palatable by animalsTherefore it is recommended to replace Panicum torgidum by another more acceptable forage species.

Technical Report on Ombahara Protected Area in Abyan

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Abstract

After the establishment of the protected area and the land work a study was conducted to record the vegetative cover in the whole protected area in general and in every site. The total number of plants recorded and collected after two years of the establishment of the protected site was 50 plant types related to 38 genus from 20 families (Bazara). In this season and after 17 years since establishment the study was conducted once again to determine development, which took place in the protected area in terms of number and types of plants. Results of survey indicated that 62-plant type belonging to 42 genus and 22 families were recorded. It was observed that the increase was in the plant types. The number of genus was slightly increased. The number of families was not changed. In addition to the above mentioned information and in order to assess changes which took place in the protected area with respect to the increase of plant density and occurrence of plants in the five embankments, the plant density and the land cover during the season 1999/2000 . The plant cover was 69% ,61 and 61% in the three directions respectively. During the 2003 season the land cover was increased on the expense of plant density as a result of soil erosion from lack of maintenance of embankments before the rainy season. The plant density for the three directions in the first site was 36%, 24%, and 26%. The % land cover for the three directions in the same site was 70%, 79% and 79%.

Introduction

When the protected site was established in the early eighties of the last century it was not expected that this protected site would have significant effect on the lifestyle of the nomads in that area. At the beginning several nomads living in the vicinity of the protected area started changing their minds about migrating to new areas, as was the case in their lifestyle. This was a result of improvement of vegetative cover as a result of conserved moisture and accumulated soil in the embankments constructed as part of the protected area. Instead of the traditional wool tents nomads started constructing stone houses for permanent settlement. Water for drinking purposes for both nomad families and their animals was secured by diverting water from a spring located up the hill overlooking the protected site. The number of household families has also been increased to nearly 30 households. A new school for children was recently constructed, thus providing education to the young children in the area. By doing this the nomads change their lifestyle and become new settlers in the area. Similar developments on the same line as in this protected area starting taking place in the nearby valleys.

Objectives

The main objective of this study is to compare changes that took place during 17 years in the vegetative cover of the protected area of Om-Bahara in Abyan.

Material and methods

This study was conducted in the year 2003. An inventory field survey was conducted to record all plant species available in every embankment of the protected area. The plant species were grouped as per their plant classification. This inventory was compared to the same exercise carried out two years after the establishment of the protected area. The plant density and the land cover were recorded as per approach of Mr. Parker method (Parker Circle) to identify the above-mentioned parameters.

A point previously identified called the center. From this point three directions were selected at a length of 30 meters towards the North the second towards the South East (120 0 from the first). The third direction was towards the South West. (120 0 from the second direction.)100 readings were taken in each direction (30 meters long). The distance between readings were 30 cm. A stick plotted the Parker Circle. Readings were made on whatever was in the circle. This includes plants, gravel, and plant residues in all three directions.

Results and Discussions

At the time of establishment of the protected area in Om-bahara, a survey was made in which all plants in the protected area were recorded. The number of plants was limited to 20 types belonging to 14 families. Most of these families were not edible by animals (Bazar'a) . Two years later a similar survey was conducted in every embankment constructed in the protected area. In this survey the number of plant types was increased. 28 new plants were recorded. As a result of preventive measures

adopted in the protected area as well as the result of soil sedimentation which took place in the newly constructed embankments which led to the formation of soil and silt carried out by seasonal floods behind the embankments thus creating a suitable environment for germination and plant growth. The soil and silt accumulated contained significant number of annual edible forage seeds such as : Heliotropium rariflorum (Stocks) ،Aristida mutabilis (L.) ، Fagonia schweinfurthii (Hadidi) سيواق ، Boerhivia diffussa (L.) ، حمـه Tephrosia puria (L.)زغانـة ، Cleom scaposa DC حمـض،Salsola rebescens Franch and other species and types. This is an example of the increase of pant species in the protected area. During the year 2003 several field trips to the protected area were made. During these visits field inventories were conducted in every embankment separately. As a result it was possible to assess plant types in the site. Summery of this inventory is presented in the following tables.

The data presented in the tables clearly demonstrates the increase of plant types in every embankment as compared to similar inventory carried out two years after the establishment of the protected area. The total number of plant types reached 62 types. The number of genus was only 26 two years after the establishment of the protected area and reached 42 genus 17 years later.

Despite the increase of number of types it was observed that the embankments were eroded as a result of lack of maintenance and flood destruction. This flood erosion and the absence of regular maintenance mostly affected annual plants and shrubs. On the other hand the lack of maintenance of the fence has led animals to enter the protected area without any control. This affected the carrying capacity of the protected area .As a result of lack of funds the site was left unattended for several years. During the 1999/2000 seasons the plant cover and the land cover in the protected area was studied once again. Data collected was compared with previous data collected earlier. The comparison revealed that several plant species were absent as a result of overgrazing and or drought.

Conclusions

The Om-bahara protected area is the only site remaining of protected areas in Abyan Governorate. The location of the site and the limited funds available create problems in sustaining data collection and proper maintenance of this site. Several proposals were submitted to AREA and the Regional Station management in order to ensure required funds for sustaining these activities from Government budget. The efforts of APRP are acknowledged in supporting data collection and maintenance of this protected area.

Previous Studies

Bazara and Others: Study of the natural plant cover in Om-Bahara protected area.

Mughram A.K. and Mohamed Hasan: Study of the natural plant cover in 1999/2000 in Om-Bahara protected area.

Table (1) List of plants recorded in Om-Bahara Protected area

Family name	Scientific name	Local name	After Two Years					After 17 Years				
			1*	2	3	4	5	1	2	3	4	5
Acanthaceae	*Anisotes trisculus(Forsskal)Nees*	مضاض	_	_	_	_	_	_	_	_	_	_
	Rulia spp.		_	_	_			_	_	_		_
Aizoaceae	*Aizoon canariens L.*	حدق						_		_		_
Amaranthceae	*Aerva lanata (L) juss ex*	راء	_			_	_		_	_	_	_
	A. tomentosa	راء				_	_	_	_	_		_
	A. javanica (Burf)	راء	_			_	_		_			_
Asclipdaceae	*Glassonema varians (Stock) Benth*	كابش	_	_		_	_	_		_		
	Pergularya daemia (Forssk.) chyov.	كابش	_	_		_				_	-	_
Boraginaceae	*Heliotropium bottae Delf*	رمرام	_	_	_	_	_		_		_	
	H. fartakens O, Schwartz	كحلي	_		_			_		_		_
	H. rariflorum Stock	رمرام	_	_	_-	_	_	_		_	-	
Buseraceae	*Commiphora gileadensis (L.) Christ*	قيطام	_	_	_	_	_		_		_	
	C. faricea	بشام قفل						_		_	_	
Comparaceae	*Cleome scaposa DC*	زقاق	_	_				-		_		_
	Cadaba glandulosa (Forsskal)	كلو			_	_	_		_	_		
	C. rotundifolia	عم تكوك			_	_			_		_	
	Maerua crassifolia (Forsskal)	صرح		_	_	_	_		_	_	_	
Chenopodaceae	*Halyxlon recurum*	سواد						_	_			
	Salsola foetida Defl	حمض			_	_	_	_		_	_	
	Anbasis articulata (Forsskal)	صباغ	_	_	_	_	_	_				_
Cucurbitaceae	*Citrulus colocyrthis (L.) Schrader*	حدج	_			_	_		_		_	
	Momordica balsamina (L.)	حدق							_			_
	Zehnaria anomala C. Jeffrey	رفارف	_	_	_	_	_	_		_	_	
Comparaceae	*Cleome scaposa DC*	زقاق	_	_				-		_		_
	Cadaba glandulosa (Forsskal)	كلو			_	_	_		_	_		
	C. rotundifolia	عم تكوك			_	_			_		_	
	Maerua crassifolia (Forsskal)	صرح		_	_	_	_		_	_	_	
Chenopodaceae	*Halyxlon recurum*	سواد						_	_			
	Salsola foetida Defl	حمض			_	_	_	_		_	_	
	Anbasis articulata (Forsskal)	صباغ	_	_	_	_	_	_				
Cucurbitaceae	*Citrulus colocyrthis (L.) Schrader*	حدج	_			_	_		_		_	

	Momordica balsamina (L.)	حدق							_			
	Zehnaria anomala C. Jeffrey	رفارف	_	_	_	_	_	_		_	_	
Euphorbiaceae	*Choz0phora oblongifolia (Del)Juss.*	تنوم	_	_		_	_	_	_			
	Euphorbia cuneata Vahl	بكا	_	_			_	-		_		
	E. herta (L.)	لبينة	_		_	_						
	E. serpens Kunth	لبينة	_	_	_	_	_	_			_	
	Jatropha glandulosa Vahl	دميع	_	_	_	_	_		_		_	
	Jatropha spinosa (Forsskal)	دمع مع	_	_		_	_	_		-		
Graminacea	*Arisrida mutabilis (L.)Trim..)Rupr.*	خليس	_	_	_				_		-	
	Cenchrus ciliaris (L.)	خضر						_	_	-	_	
	Dactylottenium sindcum (Forsskal) عريجة							_	_	_	_	
	Panicum turigidum (Forsskal)	ثمام						_	_	_	_	
	Arisrida spp.	دفن	_	_	_	_	_	_		_		
Copositheae	*Launaca massenensis*	مرار			_	_	_		_	_	_	
Leguminaceae	*Acacia ehrenpergiana Hayne*	السلم	-						_		+	
	A. herella	حرلة								_		
	A. senegal (L.) Willd.	قتاد		-	_			_	_	_		_
	A. spp.	قلقل		-	_			_	_		_	_
	A. tortilis (Forsskl)	سمر بلدى	-		_	_	_	_	_	_	_	-
	Cassia italica (Miller) Lam.ex.F.	عشرق	-			_		_	_	_		
	C. obovata Collad	عشرق	-			_			_			_
	C. senna	سناء										
	Indigofera oblongifolia Forssk,	حسار	-		_	_	_	_		_	_	
	I. spinosa Forssk.	حل شبرم	-			_			_	_	_	
Nyctaginaceae	*Boerhavia elegans Choisy*	خيم	-		_	_		_	_	_		
	Commicarpus gradiflora	صدح			_		_	_		_		
Papilionaceae	*Tephrosia nubica*	ياروط			_	_		_		_		
	T. purpuria (L.) Pwrs.	حمة	-				_		_			_
Resedaceae	*Ocgradenus arabicus Chaud, Hillcoat &Mhller*	حرشفة			_		_	_		_	_	
	Reseda sphenoleoides Defl.					_	_	_	_		_	
Scrophulariaceae	*Campylanthus pungens O.Schwartz*	سيواق	-		_	_			_	_	_	
	Linaria spinifolia Schwartz	لوالو	-		_	_			_	_	_	
Tiliaceae	*Corchorus depressus (L.)Stocks*	لجن	-	- -	_	_	_	_	_		_	
	Grewia tenase (Forsskal) Flori	شوحط	-		_	-		_		_		
Vitaceae	*Cissus quadrangularis (L.)*											
	C. rotundifolia											
Zygophyllaceae	*Balanites aegyptiaca Del.*	صر			_	_	_					
	Fagonia isotricha Murb	حل			_	_	_	_				
	F. schweinfurthii (Hadidi)	حلاوة			_	_	_		_	_		
	F. spinosa	حل				_		_	_		_	
	Zygophyllum simplex (L.)	قرمل							_		_	

* Numbers reflect the number of throws for counting of plant cover. Plants after each throw were listed in a special row after two years and after 17 years.

Table (2) Plant Density, Plant Cover in Om-Bahara Protected area

Direction No. 1

Local Name	Scientific Name	No Touches
عروق	Dactylottenium sidicum	16
ويكة	Corchorus olitorius	2
ثمام	Panicum turigidum	15
ياروط	Tephrosia purpuria	3
مخلفات نباتية	Plant litter	20
تربة	Soil	12
حجر	Stones	4
رمل	Sand	28
الكثافة النباتية 36% , التغطية الرضية 72% , التعرية 28%		

Direction No. 2

Local Name	Scientific Name	No Touches
ثمام	Panicum Turigidum	18
عروق	Dactylottinium sindicum	7
صر	Balanites aegyptiaca	1
حمطى		3
حصار شوكي	Indigofera spinosa	5
مخلفات نباتية	Plant litter	10
صخر	Stones	8
حصي	Grevels	12
تربة	Soil	14
رمل	Sand	21
الكثافة النباتية 30% , التغطية الارضية 79% , التعرية 21%		

Direction No. 3

Local Name	Scientific name	No Touches
رمرام	Heliotropium rariflorum	3
لبينة	Euphorbia serpens	1
عروق	Dactylottenium sidicum	3
عشرق	Cassia italica	1
نمينم		1
بكاء	Euphorbia cuneata	3
مضاض	Anisotes trisculus	1
ثمام	Panicum turigidum	15
حصار شوكى	Indigofera spinosa	6
حصي	Grevels	19
تربة	Soil	20
مخلفات نباتية	Plant litter	6
رمل	Sand	21
الكثافة النباتية 34% , التغطية الارضية 79% , النعرية 21%		

Survey of Plant Cover in Al-Khon Protected Area in Wadi Hadramout

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Abstract

El-Khon protected area contains huge diversity of plant cover containing around 16 plant family under which there are 32 genus and 37 plant types. The plant cover is distributed over the protected area in lower sites as well as high sites. The lower sites are characterized by more plant diversity and high plant intensity as compared with the higher sites in the protected area.

The most common plants in the protected area are those belonging to the grfaminae family such as: Cenchrus ciliaris, Panicum turgidum and Pennisetum divisum. There are also plants belonging to the family such as: tortilis Acacia and Indigofera spinosa. Several other plants belonging to other families also exist.

Introduction

Natural rangelands are the source for animal feed. These rangelands are often subjected to deterioration or overgrazing resulting in the drain of valuable plants and subsequent desertification.

The establishment of El-Khon protected area is the first attempt in Wadi Hadrramout aimed at studying the level of deterioration of range lands and the possibility of conducting interventions in water harvesting for possible improvement of these valuable feed resources for animal grazing.

Material and Methods

A preliminary survey of the selected site was conducted. During this survey, the topography of the site was identified and measured. High areas and low areas were marked in the map representing the site. Plant species available in the site were identified in a representative total area of 25 M x 25M = 625 M2. The criteria for identification of plants were based on available references. In these sites plant density and plant intensity of each family and each genus as well as types and species were measured.

A measuring tape was used for taking distances and a simple counter was used for counting plants.

Results

Plant Diversity in the protected area:

Several types of trees and shrubs were identified in the protected area. The number of these types differs between types. The survey revealed that the number of plant families reached 16 . Under these families there are approximately 32 genus and 37-plant type. Eight plant types were not identified so far.The plant collection in the protected area contains weeds from the graminae family and from the family. (Table 1)

Plant Distribution in the protected area:.

The topography of the protected area is divided into twp parts:

1. Low sites with a coarse surface penetrated by plants and receive dew moisture and floods during the season.
2. Higher spots with coarse sand penetrated with plants and receive rain drops only.

As a result of the differences between sites there is big difference between plant cover as represented in table (2).

Discussions

It is obvious that the protected area is characterized by a big diversity of plants. This diversity differs in the number of plants (plant intensity) in different sites of the protected area. In general it can be said that the number of palatable plants is less than unpalatable plants in the whole protected area.

The types belonging to the Graminae and Leguminosae families are the most palatable plants and are most affected by overgrazing. These plant types are supposed to be on the priority list in terms of seed collection and seed multiplication for possible replanting in the protected area in the future.

It was also observed that the plant density and plant diversity is much better in the lower sites as compared to the higher sites. This could be attributed to the comparative advantage of the lower sites in collecting more moisture and floods during the annual rainy season

Table (1) The plant Cover in the Protected area (Al-Khawn)

No. Types	No. Genus	Scientific Name	Family	Local name
1	1	***Acacia tortilis***	**Leguminosae**	سمر
1	1	***Ziziphus leucodermis***	Rhamnaceae	حبض
1	1	*Dipterygium glucum*	**Capparaceae**	علقه
1	1	*Rhazya stricta*	Apocynaceae	حرمل
1	1	*Blepharis ciliaris*	Acanthaceae	باشويكوك
1	1	*Indigofera spinosa*	Leguminosae	شكيكوك
1	1	*Cassia italica*	Leguminosae	عشرق
1	1	*Boerhavia sp*	Nyctaginaceae	حيدوان
3	1	*Tribulus longipetalus*	Zygophyllaceae	زهر
1	1	*Tephrosia spp*	Leguminosae	خضيراء
1	1	*Indigofera sp*	Leguminosae	حوير
	1	*Aerva javanica*	Amaranthaceae	راء
1	1			حدج
1	1	*Citrullus colocynthis*	Cucurbitaceae	**متكه**
1	1	*Convolvulus sp*	Convolvulaceae	سرو
3	1	*Heliotropium bacciferum*	Boraginaceae	خويمه
1	1	*Cleome spp*	Cleomaceae	دريمه
1	1	*Fagonia indica*	Zygophyllaceae	خله
1	1	*Ammi sp*	Umbelliferae	ثمام
1	1	*Panicum turgidum*	**Gramineae**	حليام
1	1	*Pennisetum divisum*	Gramineae	ابيد
1	1	*Cenchrus ciliaris*	Gramineae	لحية التيس
1	1	*Chrysopogon sp*	Gramineae	شنان
1	1	*Cymbopogon parkeri*	Gramineae	تنون
1	1	*Abutilon sp*	Malvaceae	نقاوه
1	1	**Zygophyllum simplex**	Zygophyllaceae	سعده
8			Cyperaceae	انواع غير معروف

Table (2) Plants in two different locations in the protected area

Frequency of types	Plant Density/M^2	Location (2)			Plant Density / M	Location (1)			**Scientific Name**
		Source Water	Surface	Location		Source Water	Surface	Location	
100					0.003				A.tortilis
100					0.01				Convolvulus sp
100					0.11				T.longipetalus
100					0.02				Boerhavia sp
100					0.05				Indigofera spinosa
100					0.25	ماء	حصوي		Blepharis ciliaris
100					0.01	المطر	%80		H.bacciferum
100					0.04			مرتفع	Tephrosia spp
100					0.003				A. javanica
100									Cleome spp
100					0.70				Unknown spp
					0.07				
50	0.03								D.glucum
50	0.006								R.stricta
50	0.02								Cassia italica
50	0.01								
50	0.05								*Indigofera sp*
50	0.01								Ammi sp
50	0.01								C.colocynthis
50	0.12			منخفض					C.parkeri
50	0.08								C.ciliaris
50	0.03								P.turgidum
50	0.01								Chrysopogon sp
100	0.30	ماء	حصوي						A.tortilis T.
100	0.70	المطر+	%75						longipetalus
100	0.03	ماء							Boerhavia sp I.
100	0.13	السيل							spinosa
100	0.02								Tephrosia spp
100	0.04								A.javanica
100	1.50								Blepharis ciliaris
100	0.006								Cleome spp
100	0.006								Convolvulus sp H.
100	0.355								bacciferum
100									Unknown spp

Evaluation and Multiplication Seed of Three Rang Grasses in North Highland

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Abstract

Three range and forage arid grasses species have been seeded by hand in September 2002 in Al-Erreh regional research station of northern high land. These are cane Bluestem (Andropogon barbanoides lag)Buffel grass(Cenchrus ciliaris 1), and Pennisetum thunbergii .The length of growth for these species were from 190-200 days until the flowering stage reach 50% in winter season. The germination seed rate after harvesting directly were reached the three species respectively Adropogon barbanoides, Cenchrus ciliaris and Pennisetum thunbergii 3,4-6%. The seed of three species have been collected from range & forage plant under trial in two stage of growth(stage of (early growth and mature stage).The results indicated the germination percentage rate was low 20,26% for two species respectively; Cenchrus ciliaris L, Andropgon barbanoides .The other species of Pennisetum thunbergii seeds has ability for germination where it was reached about 63%.That was after three month from storage in a room temperature degree 23-25. The production of seed for species Pennisetum thunbergii was reached about 7 kilogram, and 5 kilogram and 3 kilogram for two species second and third Cenchrus ciliaris and Andropogon barbanoides .The seed production for first species in average 8,25 ton /hectare. Air dry forage while the forage production for second and third species were 4,25 ton /hectare and 4,2 ton/hectare air-dry forage.

Introduction

The annual and perennial long and short stemmed graminae family is important source of forage for cattle and sheep(Digestany, 2000).In addition to that, the annual and perennial legumes and grasses forages are considered the best fodder for sheep(Chaudhary 1989). The seed have been collected during early full mature stage. That was during three months (April, May, and June) by hand. The process was accomplished during three days, and then the seeds were dried and purred and stored at room temperature. The forage production was cut by hand from the surface of land at 3 cm height after seed maturity. The forage was dried in an open and ventilated shaded area and was weighed and turned over every day for ten days.

Results & Discussion

The results indicated that seed of Pennisetum thmbergii have the ability for germination and renew forage plant production if the seeds were collected during early mature stage(the stage before the test from full mature seed). The germination percentage of seeds of Pennisetum thmbergii was 63% while the germination percentage of the seeds of the other two other species Cenchrus ciliaris and Andropogon barbanoides was 16 and 20 % respectively. That was after storage for five months under room temperature conditions. (Table 1) Justice and Bass (1978) indicated that Alister in 1943 concluded from an evaluation trial of forage seeds collected at very early mature stage and stored for 4 – 5 months showed weak germination when compared with seeds collected in early maturity and full maturity stages. There was exception, however in two species namely Bromus marginatas and polyantus.

Table 1 Germination percentage of seeds of three range local grasses Collected at an early maturity and full maturity stages

Germination percentage		Species
Full maturity	**Early Maturity**	
52	**20**	***Andropogon Barbanoides Lag***
55	**26**	***Cenchrus ciliaris L***
71	**63**	***Pennisetum thunbergii kunth***

The results indicated that Germination percentages of mature seeds after harvesting directly for three species Andropogon barbanoides, Cenchrus ciliaris Pennisetum thunbergii were 3-4-6 % respectively (Table. 2). Usually the dormancy of grasses is longer in comparison with seeds of crop fields. The germination percentage of grass Cenchrus ciliaris L ranged from 3-79 % during 13 month after harvest (Winchster 1954). The results indicated that 1000 seed weight was 0.8 , 0.8 and 8.7 gram for Andropogon barbanoides Cenchrus ciliaris and Pennisetum thunbergii respectively. These species are important for farmers due to their high ability to germinate after the first rainfall in the season and also for their high palatability for animals all the year around.

Seeds from the three species were replanted for much needed seed multiplication and further evaluation of forage seed dormancy. In spite of doubts about the regeneration ability of the seeds of wild grasses when harvested before the Full mature stage (Justic and Bass 1978). The early shattering of seeds at the maturity stage remains a challenge to seed producers. (Turnerr 1998). This problem was partially overcome under Yemeni local conditions in the case of Pennisetum thunbergii. This could have been attributed to the fact that the above species might have the ability to develop its regeneration organs at an early stage of maturity as a result of physiological factors or might not have germination inhibitors at the early maturity stage of seeds. The dormancy of forage seeds differs from one species to another. It must be noted that the dormancy stage of the wild forage seed is more common and complicated than in the case of field crops (justice and Bass 1978)

The properties of Pennisetum thunbergii in stage of dormancy could have formed early in order to achieve high % germination during three months in comparison with of the other two species .This was attributed to the suitable storage conditions reflected in ideal temperatures and humidity which proved close to the natural conditions where the species is naturally growing as well the other characteristics related to the early formation of regeneration organs and the absence of germination inhibitors .

Conclusion & Recommendation

The desirable achievements in forage seed production of Pennisetum thunbergii kunth which resulted in collwcting sufficient seeds. On the other hand, presence of sufficient seeds for limited multiplication of the Andropogon spp which has been selected in the past stresses the need to continue seed multiplication of the three species for research and development in the coming few sesons.

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Integrated Production and Protection Management in Cucumber Cultivation Under Plastic Houses In The Terraces In Winter Season

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Abstract

The on-farm trial was conducted in wadi Al-Naeem – Shibam District – Al-Mahweet Governorate. The dimensions of the plastic house were 267.5 m long and 8.5 m width with a total area 225.25 M2. Cucumber variety "Julia" was used in this trial. The average number of plants per M2 The IPPM approach was adopted in this trial as early as land preparation, the use of green mesh to prevent influx of insects and improve ventilation, the use of plastic mulch on the ground to prevent weed infestation, management of irrigation water, fertilizer application and mechanical control of insect / pests.

Results obtained indicated that the water used efficiency reached 73.8 kg/M3. No control measures were used to control downy mildew except dusting with agriculture soleplate twice throughout the season. The control of insects was limited to two applications only and was restricted to hot spots only. The yield of this trial reached 8.72 kg/M2 with a total yield 225.25 kg/ M2. It must be noted that this yield was relatively low as a result of the effect of frost which affected the trial towards the end of the growing season.

Economic assessment of this on-farm trial revealed that the experiment secured economic return totaling 81.6% despite the effect of frost. The social assessment of the on-farm trial among participating farmers in the field days indicated that many farmers expressed willingness to invest in protected agriculture under the local conditions of Al-Mahweet.

It was concluded that protected agriculture in Al-Mahweet has big potential. There is evidence that further expansion of protected agriculture cultivation of cash crop in terraces is likely to expand in the near future.

Introduction

Production Systems in Yemeni Terraces depend mainly on seasonal rainfall as major source of irrigation. Under these conditions rain is utilized directly or indirectly through water harvesting techniques as additional source of irrigation or through diversion of runoff for conservation in water cisterns or water reservoirs and small dams. Potential for improvement of rainfed production systems of subsistence crops in terraces is not high. On the other hand expansion of land by means of rehabilitation and construction of new terraces is very limited due to the rigid topography of the terrain and steep slopes.

Terraces are small in size and fragmented in location and landownership. Careful assessment of socioeconomic of these production systems revealed that the only way to increase productivity in these production systems is to diversify income of farmers in these areas by introduction of high value crops with the help of modern techniques for rational use of limited resources in these rigid conditions.

Experiments carried out in pilot areas under similar conditions revealed that growing cash crops under protected agriculture proved rewarding and promising. Results also indicated that there is a need to test more cash crops and test different seasons in growing of cash crops in order to provide farmers with alternatives to broaden their selection capacity and multiple choices.

This on farm trial was aimed at testing cucumber cultivation under plastic house conditions in Al-Mahweet during winter conditions.

Material and Methods

The trial was conducted in the plastic house of the farmer Abu- Alregal Husain in Wadi Al-Naeem Shibam District Kawkaban. The elevation of the site was 2400 Meters Above Sea Level (ASL). In a plastic house 26.5 m long and 8.5 m wide. The height of the plastic house was 3.5 m (total area of the plastic house was 225.25M2)

The front and rare doors of the plastic house were covered with agricultural mesh (90 holes / Cm2) to prevent insects' attacks. The mesh was permanently fixed in the rare door while kept as a moveable curtain in the front door to allow free entry when necessary to the plastic house. Side ventilation windows were made and covered with the same mesh four meters long and 1.2 meters wide to improve ventilation and prevent influx of insects.

Cucumber hybrid seeds variety " Julia" was sown in a nursery bed made up of peat moss on 21/8/2002. First germination was recorded on 24/8/2002. The % germination reached 98 one week after sowing. Seedlings were transplanted to the plastic house after treating the holes in the plastic house with "Radivam" solution at a rate of 4ml/liter water to promote root growth. Planting of seedlings was on both sides of the three middle beds. Spacing between seedlings in the bed was 50 cm.

Spacing between lines was 40-50 cm. The total number of plants was 410/plastic house and thye plant density was 1.8 plant / M2 . Replanting of empty holes was carried out three days later. The plastic mulch was spread on beds before transplanting to prevent weed growth and conserve moisture in the soil. The two rare beds on the sides were planted with cucumber in single lines The remaining space ion the sides was planted with lettuce for domestic purposes.

Irrigation

Water applied during land preparation was not calculated. The irrigation scheduling which took place afterwards was as follows

- From the 4Th September till the 3rd October 10 irrigations were applied at a rate of 400 liters/irrigation or a total of 4000 liters were applied at a rate of 1 liter/plant
- From 5th October till 3rd November 10 irrigations were applied at a rate of 600 liters/irrigation or a total of 6000 liters at a rate of 1.5 liters /plant.
- From 5th November till 8th January 21 irrigations were applied at a rate of 800 liters/irrigation or a total of 16800 liters were applied at a rate of 2 liters/plant.
- The total amount of irrigation water applied throughout the season (4 months and 10 days) was 26800 liters = 26.8M3

Fertilizer Application

Well-cured organic manure was applied at a rate of 1 ton/ plastic house and 30 kg TSP during land preparation.During the growing season Compound mineral fertilizers were applied as per the following details

Table (1) Details of fertilizer application to cucumber crop in the on-farm trial in Al-Mahweet under plastic house conditions

Type of Fertilizers NPK	Total Amount (KG)	Number of applications	Time of application
13-40-13	4	4	Elongation 3-17/10
20-20-20*	19	14	20/10 – 6/01 Flowering and Fruiting
15-15-30*	18.5	7	26/10- 22/12/2002 Fruiting and Harvesting

*These types of fertilizers were used at an alternative manner as of fruiting stage until two weeks before the last crop was harvested.

Foliar spray with micro nutrient fertilizers was carried out twice at a rate of 1.5 gm/liter water.

Insect/Pest Control

During the month of January the crop was affected with frost as a result of not closing the doors at the end of the day and lack of any heating measures.

Table (2) Details of the insect/pest control measures in cucumber cultivation during the winter season 2002/2003

Decease	Stage of Growth	Method of Control
Downy Mildew	Elongation and flowering	Removal of infected and dry leaves and burn them. Dusting with sulphate at rate of 0.5 kg/plastic house
Leaf miner	Flowering	Removal of infected leaves and disposal outside the house
Aphids	Fruit initiation	Mechanical control of aphids. If infection persist spray infected plants. When infection spread over most plants spraying was done on 22/11/2002 with Dimothwaite 40% at a rate of 1ml/ liter water

Results and Discussions

Calculation of amounts of irrigation water applied throughout the season revealed that this amount reached 26.8 M3 at a rate 0.12M3 /M2 of the plastic house. The efficiency of water used appeared to be 73.8-kg/M3 irrigation water compared to 6kg/M3 when growing cucumber in the open fields.

The adoption of IPPM in cucumber cultivation in plastic houses has drastically reduced favorable conditions of pest decease spread in the plastic house. This is evident in the limited sprays of the crop to control decease/ pest infestation. Only one spray was applied to control of downy mildew. This is an example of improved ventilation. The spray against insects' was restricted to only two sprays thanks to the use of agricultural mesh.

Productivity

The total production of the plastic house during the season reached 1964Kg from 26 pickings at a rate of 8.72 kg /M2 or 4.8 kg/plant. This yield is considered low when compared to the yield of previous year which reached 12.9 kg/M2 . This reduction in yield was attributed to the incidence of frost, which affected the crop in January 2003.

The details of harvests of cucumber from the on-farm trial during the winter season of 2002 /2002 are illustrated in the following table

Table (3) details of harvesting of cucumber under plastic house conditions in winter season 2002/2003

No	Date	Yield/pick	Sale Price (YR)	Total Price (YR)
1	12/10	21	50	1050
2	17/10	31	50	1550
3	19/10	38	50	1900
4	22/10	41	50	2050
5	25/10	42	50	2000
6	28/10	54	50	2700
7	02/11	75	50	3750
8	06/11	81	70	5670
9	10/11	72	70	5040
10	14/11	102	70	7140
11	18/11	111	70	7770
12	22/11	110	70	8400
13	26/11	120	70	4060
14	29/11	58	70	4970
15	31/11	71	70	7700
16	04/12	110	70	7420
17	08/12	106	70	7420
18	13/12	106	70	6020
19	15/12	86	70	5600
20	18/12	80	70	5950
21	22/12	85	70	6860
22	26/12	98	70	6020
23	30/12	86	70	4900
24	04/01	70	70	4900
25	08/01	70	70	2800
26	11/01	40	70	2800
	Total	**1964**		**131440**
	Average	**75.5**	**64.62**	

The summery of production of cucumber from the on-farm trial in Wadi Al-Naeem is summarized in the following table

Table (4) Details of yield and productivity from cucumber on-farm trial under plastic house conditions in winter season 2002/2003

Area	No of Pickings	Productivity			Yield (Ton/ha)
		Kg/house	Kg/M^2	Kg/plant	
8.5 x 26.5 m ($225.25M^2$)	26	1964	8.72	4.8	87.2

Economic Assessment

The following table (5) illustrates costs and revenues from growing cucumber in winter season (2002/2003) in plastic house (area 225.25M2) in wadi Al-Naeem / Al-Mahweet.

Items	Cost (YR)
Seeds	8000
Fertilizers	10700
Marketing	10480
Irrigation	8100
Labor	16790
Packages	400
Chemical Control	150
Seasonal Depreciation	17750
Total Costs	72370
Total revenue (Return)	131440
Net Return	59070
Average Return %	81.6

Feed Back from Field days

Data and feedback collected from the participating farmers in field days and from communication with farmer himself revealed the following

- The farmer was impressed from the economic return of the on-farm trial. He expressed willingness to repeat the cultivation of cucumber on his own arrangements.
- Several requests from farmers participating in field days were received by the extension agency in the Governorate to have access to donor agencies to help purchase plastic houses and erect them in different parts of the Govedrnorate.
- Several farmers expressed their willingness to purchase plastic houses from their own resources to grow cash crops under similar conditions in Al-Mahweet.

Growing of Cash Crops in Green Houses in Mild Winters Conditions of the Southern Uplands of Yemen

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Abstract

The green house was cultivated for the second time with cucumber in winter season. The variety Burum was used. Seeds were sown on 4th September 2002. Drip irrigation was used. Soluble fertilizers were applied at the recommended rates and timing.

Chemical control was restricted to only four sprays with fungicides to control downy and powdery mildew. Fruit picking started on the 19th October 2002 and lasted till the 16th of December 2002. A total of 18 harvests were recorded. The total yield was 1655 kg despite symptoms of infection with nematodes that appeared on the 66 days after planting. This infection affected the length of the growing season and led to premature death of the plants.

Results indicated that there is improvement in utilization of irrigation water in growing cucumber under the green house. The M3 of irrigation water gave 17.8 kg of cucumber. The total amount of water applied to the crop throughout the season (105 days) was 93M3.

Introduction

Protected agriculture is considered an advance approach for rational use of natural resources. This is mainly because it offers maximum yield from limited land area and limited water resources when compared to the cultivation of crops in open field and the use of surface irrigation. Because of this advantage, farmers having limited land as in the case of terrace production systems in the southern uplands of Yemen can benefit from this technology in better utilization of their land resources under terrace conditions.

Research on protected agriculture in terraces located at an elevation of 1600-1700 Meters Above Sea Level (MSL) started in the late nineties with support from ICARDA/APRP. Under this program a plastic house was constructed in Al-Turba Taez Govedrnorate for research and extension purposes. Cucumber is grown in this plastic house in winter for the second time to assess the possibility of growing two crops per year under the conditions of Al-Turba.

Materials and Methods

Land preparation started on the August 2002.. The preparation included preparation of five furrows in a form of beds 60-cm. width for planting. The space between beds was 90 cm. Plastic mulch was installed over the beds. Planting of cucumber seeds took place on the 4th of September. The variety Burum was used. Planting took place after applying of 7M3 of irrigation water to the furrows. Planting took place on both sides of the furrow in the middle furrows and on one side on the rare furrows. The rate of planting was one seed per hole. Spacing was 50 cm between holes in the furrow. Green beans (Tima variety) were planted at the rare furrows on the 2nd of September for observation. After planting, all the ventilation sites were closed for five days before the door opposite wind direction was opened for ventilation. One week after planting germination was over and irrigation was applied at a rate of one M3 at the same time missing holes were replanted. The front and rare doors were gradually opened for ventilation.The program of fertilizer application was as follows

- During the second and third weeks after planting NPK fertilizers (N13- P40-K13) was applied at a rate of 1.5 kg twice weekly.
- During the third and fourth weeks NPK (N20- P20- K20)was used at arate of 1.5 kg twice weekly.
- During the sixth and seventh weeks NPK (N30 –P15-K15) was applied at a rate of 1.5kg twice weekly. N20 –P20-K20 was also applied at a rate of one kg twice weekly
- During the remaining period NPK 30-15-15 and NPK 20-20-20 were applied at a rate of one kg twice weekly.

Pruning of branches and removal of infected leaves as well as some spraying against fungicides for prevention or control when necessary were carried out. The chemical control. Was restricted to four sprays against powdery and downy mildew. Nemafal and Fifa were applied to reduce the severity of nematode infection which became apparent 66 days after planting.

Results and Discussions

Harvesting

.Fruit picking started on 19th September 2002 and lasted till 16th December 2002. A total of 18 harvests were made. Green beans harvesting started on 6th November and lasted till 24th December 2002. A total of five harvests were recorded. The details of harvests of cucumber and green beans are illustrated in table 1 and 2 respectively.

Table (1) Fruit picking intervals and yield per harvest of cucumber during winter in Al-Turba

No	Date	Yield (kg)	Duration between harvests
1	19/10/2002	20	3
2	22/10	100	3
3	25/10	100	3
4	28/10	118	3
5	31.10	132	3
6	3/11	165	3
7	6/11	160	3
8	10/11	150	4
9	13/11	122	3
10	17/11	110	4
11	20/11	100	3
12	23/11	55	3
13	27/11	64	4
14	30/11	54	3
15	3/12	50	3
16	7/12	55	4
17	11/12	60	4
18	16/12	40	5
Total		1655	

Table (2) Fruit picking intervals and yield per harvest of green beans in Al-Turba Taez

No	Date	Yield (kg)	Interval between pickings
1	6/11	8	4
2	10/11	6	4
3	14/11	12	4
4	19/11	15	5
5	24/11	9	5
Total		50	

Table (3) Total yield of cucumber and green beans in Al-Turba plastic house (252 M2)

Crop	Yield (Kg)			Yield (Ton/ha)
	252 M2	Kg/M2	Kg/plant	
Cucumber Main Crop	1655	6.6	3.7	5.6
Green BeansSecondary Crop	50	1	-	10

The total yield of cucumber and green beans per the area of the plastic house (252 M2

In the winter season is mentioned in the following table.

Results in the above table (2) demonstrate that the yield of cucumber under plastic house cultivation reached 65.6 Ton/ha despite the incidence of infection with nematodes after 66 days of planting. The yield of green beans grown as secondary crop reached 10 tons /ha under plastic house cultivation.

Irrigation Water Application

The amount of irrigation water applied by means of drip irrigation is recorded in the following table No (4).

Table (4) Amount of irrigation water applied during the different growth stages of cucumber in the winter season

Stages	Duration and Time From Planting ,Stage of Growth	Duration	Amount of water (M3)
First	Two days before planting, Germination period	7 days	7
Second	One week after planting till 25 days after planting, Seedlings Growth and elongation	17 days	9
Third	After the second stage till 51 days after planting, Growth flowering and fruit setting	26 days	23
Fourth	After the third stage till the end of the season	57 days	54
Total		107	93

Results in the above table indicate that the total amount of irrigation water applied by drip reached 93 M3. The plants used this amount during four major stages of growth. The maximum stage of water use was the last stage which was associated with fruiting and harvesting. During this stage approximately 58% of the total amount of water was used. This is mainly because of the intensive vegetative growth and fruit elongation and harvesting. Results also indicate that one M3 of drip irrigation produces 17.8 kg cucumbrer.

Chemical Control

The program of chemical control was kept to the minimum as part of the Integrated Plant Production and Protection strategy maintained in this type of cucumber cultivation under plastic house conditions. Details of the chemical control program applied are provided in table (5)

The Total Production of Cucumber in Al-Turba Plastic House

Compilation of production of cucumber in the plastic house throughout 2002 year

Table (5) Infection of cucumber crop and chemical Control applied throughout the growing season in winter.

Type of Chemical	Time of application	Amount applied	Type of infection	Degree of infection
Semolex M (72.5%)	29/9/ 2002	2gram/liter water	Downy Mildew	Medium
Semolex M (72.5%)	3/10	Same	Downy Mildew	Medium
Semolex M (72.5%)	28/10	Same	Powdery Mildew	Medium
Mankozeb	15/11	same	Nematodes	High
Nemafal*	17/11	4grams/ M^2	Nematodes	High
Fifa	17/11	2ml/M^2		

* Nemafal anf Fifa were applied to help plants develop secondary root systems for overcoming the severity of nematode infection.

(Summer and winter planting) is recorded in table (6)

Analysis of the above table suggests that that the total yield of cucumber per annum in a plastic house in Al-Turba reached 3428 Kg in two seasons. The yield of susmber in the summer season reached 1768 kg from an area of 140 M2 and the yield of winter season reached 1655 kg from an area of 252 M2 . It must be noted that the difference of calculated areas in summer and winter was a result of missing holes of cucumber in the summer season as a result of rodent attacks of seeds and the limited reserve seeds remained for gap filling. The average yield per M2 was 17.5 kg.

Table (6) Total yield of cucumber grown in the plastic house of Al-Turba during summer and winter seasons in 2002.

Yield in Summer (kg)	Yield in winter (kg)	Total yield 2002	Yield per M^2 (kg)	Yield /ha Ton/ha	Water use/M^3	Total No sprays against fungus
1768	1655	428	17.5	189.6	231	6 sprays

The total amount of irrigation water applied during the two seasons reached 231 M3. The productivity of drip irrigation water applied reached 18.9kg cucumber fruits for one M3 water applied.

Economic Assessments

The objectives of the economic assessments of on-farm trials are

1. Identify the investment components of the plastic house and their costs
2. Calcultae running costs related to cucumber cultivation under plastic house cultivation.
3. Calculate yield per unit area under plastic house cultivation
4. Analysis of inputs and outputs to calculate economic return of growing cucumber under plastic house conditions.
5. Prepare recommendations for promotion of this type of cultivation on the basis of economic parameters.

The project

The project is a plastic house with an area of 252M2 grown with cucumber for two seasons(summer and winter) in the year 2002.

Location

The location of the plastic house is Shamatein Province Taez Governorate (55km from Taez) in the property of farmer Abdul wasea Abdulla who was selected as a participating farmer in the testing of this technique.

Project Components and Investments Costs

The project components and investment costs are illustrated in table (7)

Running Costs

Running costs are those costs related to the running of the project and includes different production costs.

Running costs are summarized in table No. (8)

Total Revenue of cucumber growing

The yield of cucumber for the two seasons from an area 142 M2 and 252M2 was found to be a786 and 1655 kg respectively.

The average cost of one kg cucumber was 70 and 80 Yemeni Rials for summer and winter respectively. Therefore, the total revenue from cucumber was 240170 Rials for both seasons.

Table(7) Project components and Investment Costs.

No	Components	Cost(Rial)
1	Plastic Cover	40000
2	Galvonized structure	140000
3	Internal irrigation network	6320
4	External Irrigation network	40000
5	Water Tank	15000
6	Agriculture Mesh & mulch	15000
7	Land preparation	15000
8	Construction and transport	35000
Total		306320

Table (8) Components of running costs of growing cucumber in a plastic house with an area of 252 M2 For two seasons (summer and winter 2003)

No	Cost of Component	Total cost (Rials)/142M^2	Total Cost (Rials)/252M^2	Total Cost
1	Seeds	6000	10000	16000
2	Chemicals pesticides	2000	2000	4000
3	Manure	5500	-	5500
4	Chemical fertilizers	10000	10000	20000
5	Irrigation	9500	6000	15500
6	Harvesting & Marketing	3000	2000	5000
7	Annual depreciation	7500	7500	15000
8	Cost of Capital	7500	7500	1500
9	family labor	27000	15000	42000
10	Cost of supervision	5000	-	5000
Total		78050	60000	138050

Economic analysis

The net economic return from cucumber growing in an area of 252M2 is summarized in table No 9

Table (9) The net economic return from growing cucumber in an area of 252M2.

No	Component	unit	Total cost
1	Cost of produce	Rials	240170
2	Total cost of production	Rials	138050
3	Net Return	Rials	102120
4	% Net return to capital	%	74

Economic Assessment

The following parameters were used for the economic assessment of the project.

- Net production value (NPV) or Net Current Cost
- Rate of Internal Economic Return
- Duration of Capital Recovery

The net Current Cost of the Project is summarized inn table (10)

Table (10) Net current cost of the project.

Year	Total Revenues	Total Costs	Cost of Deduction	Current Cost of revenues at (10%)	Current value of total cost at (10%)
1	240170	444370	0.909	218315	403932
2	240170	138050	0.826	198380	114029
3	240170	138050	0.751	180368	103676
4	240170	138050	0.683	164036	94288
5	240170	138050	0.621	149146	85729
6	240170	138050	0.564	135456	77860
7	240170	138050	0.513	123207	70820
8	240170	138050	0.466	111919	64331
9	240170	138050	0.424	101832	58533
10	240170	138050	0.385	92465	53149
Total				1475124	1212076

Net Current Cost = Total current cost for revenues – Total current value for total cost

1475124 - 1212076 = 263048 Rials

% Return/Cost = Current net Cost / Cost of Investment

1475124/1212076 = 1.2

The analysis of return and economic Costs of the project are illustrated in table (11)

Conclusions

Results obtained suggest the following conclusions

1. There was an increase in yield of cucumber in the second season despite the incidence of infection with nematodes which was observed 66 days after planting.
2. The quality of the produce was high due to limited if not negligible use of chemical sparys.
3. There was high water use efficiency when drip irrigation method was adopted in green house cultivation in Taez. One M3 of water was used to produce 18.9 kg of cucumber.
4. The climatic conditions of Al-Turba proved suitable to produce cucumber under plastic house conditions in both summer and winter seasons.

5. The number of sprays to control fungicides was minimum in both seasons and did not exceed 6 sprays.
6. Economic analysis of the project proved that investment in plastic house cultivation in Al-Turba is rewarding. This was evident by
   a. The Current net value is 263048 YR and is positive.
   b. Return / Cost is 1.2% and this figure is more than ONE
   c. Internal Net Return = 36% and this figure is higher than the Minimum Deduction Cost.

All the above figures clearly demonstrate that despite the high cost of investment of construction of plastic houses the economic return was found to be positive when cucumber was grown in two seasons under the prevailing conditions in Al-Turba.

Table (11) Analysis of return and economic Costs of the project

Year	Total Return (Rials)	Total Costs	Net Cash Flow	Cost Deduction 10%	Current cost at minimum price	Cost Deduction (15%)	Current Cost at maximum Price
1	240170	444380	204210				
2	240170	138050	102120				
3	240170	138050	102120				
4	240170	138050	102120				
5	240170	138050	102120				
6	240170	138050	102120				
7	240170	138050	102120				
8	240170	138050	102120				
9	240170	138050	102120				
10	240170	138050	102120				

Cost of Minimum Deduction (C min D)
Cost of Maximum Deduction (C Mx D)
Current Value at Minimum Price (CVMin P)
Current Value at Maximum Price (CVMax P)
From the above table the following calculations can be made
Percentage of Internal Economic Return =

$$\frac{(C\ Min\ D) + (CVMin\ P) \times (CMx\ D - Cmin\ D)}{CVMin\ P - CVMax\ P} = 10 + \frac{299682 \times (15-10)}{299682 - 26136} = 38\%$$

Recommendations

1. It was found possible to grow cucumber under plastic house conditions in Al-Turba in places at an elevation of 1600-1700 MSL under reliable source of irrigation.
2. It is essential that more than one crop is grown annually.
3. There is a need to rely on local resources for some inputs of this promising approach. This is essential to minimize the cost of inputs and capital investment.
4. There is a need to study local markets for marketing of cucumber. This will be prerequisite if more plastic houses are constructed in the area.
5. The control of nematodes is essential. There is a need to develop cheap and environment friendly techniques for this control. Nematodes can be a limiting factor in any further expansion of plastic house cultivation in Al-Turba.

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Dissemination of Integrated Production and Protection Management Technique of Cucumber Pests in Protected Agriculture Under Farmer's Conditions in Dhamar

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Abstract:

The study was conducted as on farm trail in Al-ragihi farm in Dhamar Plain at 1st of august ,2003 using cucumber crop, variety (nour) grown under to plastic houses with an area of 500 m2 ; one of them used for implementation of integrated production and protection management (IPPM) measures and the second used as control. In order to transferred the (IPPM) package to the farmers with the objectives of producing an economical cucumber crop in addition to eliminate and reduce the hazard chemical used. The results indicated that adoption of (IPPM) program in the plastic house led to limitation and reducing the pest infestation in the crop. Where the percentage of infection on the plant were (10%, 20% and 20%) by Downy Mildew, Aphids and Leaf Miners respectively. While the infestation in control plastic house where 30%, 40%, 60% and 15% for Downy Mildew, Aphids and Leaf Miners and Spiders respectively. Therefore the number of sprays with pesticides in IPPM plastic house limited to only one spry for controlling Downy Mildew and Aphids. Where as Leaf Miners controlled only by using the hot spots control. Compared with control plastic house, where the number of sprays recorded were 9, 6, 3 and 1 for controlling Downy Mildew, Aphids, Leaf Miners and Spiders respectively. This contributed in reducing the chemical control costs and increasing the productivity in IPPM plastic house, which led to higher net return reaching 326.98%. On the basis of these positive results , it is highly recommended that the IPPM approach in green houses management should be followed by green house owners.

Introduction

Implementation of integrated production and protection management (IPPM) program, which is based on several interventions aimed at reducing the reliance on chemical control by implementing proper agricultural practices and preventive measures such as proper ventilation, solariztion, control of humidity and the mechanical control of insect/pests as well as control of hot spots proved to be effective in the production of high quality cash crops under plastic houses. In Yemen Adopting of IPPM concept on cucumber in the green houses (1999 - 2001) at the Central Highlands Research Station farm and under green houses belonging to some farmers gave significant results in reducing the number of sprays with fungicides used for controlling Downy mildew to 3 sprays /season and insecticides to 2 sprays / season (Abdullah Muharrm et al, 2003).Therefore, in this season the IPPM package was transferred to the farmer's fields with the objective of producing an economical cucumber crop by reducing the use of chemical pesticides.

Materials and Methods

Two plastic houses with an area of 500m2 belonging to AL Ragihi for Agriculture Corporation in Dhamar plain were selected and cultivated with cucumber variety Nour at 1st of August 2003. One of the plastic houses used for implementing the IPPM measures as followed,

- Cleaned the land from plant debris of the previous crop.
- Watered the soil to 40 cm depth.
- Ploughing the land up to 30-40cm.
- Smoothened and leveled the land.
- Determining the planting rows (5 rows) with 80cm wide, making an earth tunnels along the row.
- Applying of fresh manure in each row at rate of 2 ton/house with Micronics sulphate
- Rising up the rows with 40 cm height.
- Fixed the irrigation pipes one pipe/row.
- Covering the soil with white plastic mulch for two month, (May - June).
- Application of 50 kg P2 O5 48%.
- Using of black plastic mulch.
- Doors upper and side walls ventilation openings were covered with insect proof netting .

- Planting wad done directly in double lines plant density of 2 plant/m according to the dimension shown in the following table:

Treatments

No	Treatments	# of Plants	Plant density	# of Lines	Plants Per line	In-line spacing	Line spacing
1	IPPM management program	1050	2 p/m^2	10	105	0.5m	1 m
2	Control	1050	2 p/m^2	10	105	0.5	1 m

Protection measures were as follows:

Dusting with Micronics sulphate on vegetate growth, hot spots, through stripping of infected leaves, However in some cases there was a need to spray the infected plants or may be whole greenhouse. The following table summarizes the plant-protection program applied in comparison with the control.

Pests	Chemicals	IPPM		Sprays	Control		# of sprays
		Quantity			Quantity		
		gm	ml		gm	ml	
Downy Mildew	Fungicides	250	-	1	2500	-	9
wilting	-Foliar sprays - with irrigation water	- 500	300 -	3 1	- 1000	700 300	5 3
Total		750	300	5	3500	1000	17
Aphids*	Insecticides	-	80	1	-	690	6
Leaf miner*	=	-	-	-	100	50	3
Spiders	=	-	-	-	100	100	1
	-	-	80	1	100	150	10

* Aphids and leaf miners in IPPM were controlled by using the mechanical and hot spots control.

In the conventional plastic house (Control) .

The soil solarization also done during summer by covering the soil with while plastic sheet , using of chemical substance namely moucad at a rate of 2 kg / house.

No insect proof netting had been used.

Irrigation scheduling:

Water applied during land preparation was not calculated. The Irrigation scheduling after wards was as per the following table:

Stage of plant growth	# Quantity of water/ irrigation	Quantity of water/stage
First growing and Elongation period 1/8 – 15/9/2003	0.7 m^3 (0.6 Liter/ Plant)	31.5 m^2
Fruiting and picking stage 16/9-1/12/2003	2 m^3(1.9 Liter/Plant)	150m^3
Total Quantity of water /growing period,	-	181.5 m^3

- Water was applied daily through out the season.

Fertigation

During the growing season compound mineral fertilizers were applied as per the following, Table

Details of fertilizers application to cucumber crop in the on – farm trial in AL-Ragihi farm (Dhamar plain) under IPPM and Control plant/house.

Type of Fertilizers (NPK)	Total amount (kg)		Number of applications		Time of application
	IPPM	Control	IPPM	Control	
1) 15-30-15	10	15	7	10	First stage of growth
2) 20-20-20*	40	50	50	40	Flowering and fruiting stage
3) 12-12-36*	50	50	30	30	Fruiting and picking
4) 15-15-30*	10	10	5	5	Fruiting and picking

*These types of fertilizers were used at an alternative manner as of fruiting and picking stage.

-Foliar sprays with micro nutrients fertilizers and Bio stimulants substances was carried out for two to 4 times at rate of 1 ml / 1 – 1.5 gram per liter of water in IPPM plastic house and the same rate of same substances were applied two to five times in the control house

Results and Discussions

Adoption of IPPM measures on cucumber crop grown under green house led to limitation and reduction of pests spread. This evident in the limited of chemical sprays used for controlling the pests. Results indicated that the percentage and the degree of infection with Downy Mildew were 10% and

3% respectively as compared to control house (30% and 10%). There – fore only one spray was applied to control this disease in addition to mechanical and hot spots control. Using of insect proof netting and hotspots control in IPPM house led to limitation of Aphids and leaf mines and spiders spreading so that only one spray was applied to control Aphids as compared to control house which reached to 10 spray during the season table (1). Using proper soil colorization technique in IPPM minimized the infestation with soil borne diseases (wilting) to 50% as compared to control. In table (2) calculation of amount of irrigation water applied through out the season revealed that this amount was same in the two plastics house with 181.5 m3 , however the water use efficiency (WUE) in terms of yield per unit of water consumed was higher in IPPM house with 30.7 kg/m3 than control which was 25.1 kg/m3.

Productivity

Results in table (3) showed that the total production in IPPM plastic house was 5600 kg/500m2 from 29 pickings at the rate of 11.2 kg/m2 of the unit area of the plastic house where as the yield from the same area and same pickings in control plastic house was less with amount of 1039 kg than IPPM and the production from the unit area in this house was 9.1 kg/m2.

Economical analysis

Tables 4, 5 and 6 illustrates the details of total partial Budget total variable cost , revenues and marginal analysis for IPPM technology on cucumber crops grown under plastic house as compared to control house.

Table (1) Average of percentage and degree of pests and disease infestation , number of sprays for IPPM and control plastic houses under farmer's conditions (on – farm trail) winter 2003.

Pests	Treatments	Time of assessment	% of infection	Degree. Infection	Of sprays
Downy Mildew	-IPPM plastic house	45 days after planting	10%	3%	1+ hot spots control measures
	- Control		30%	10%	9
Soil borne diseases (wilting)	-IPPM	60 and 90 days	-	-	4
	- Control	60 and 90 days	20%	5%	1 plus hot spots controlling measures
Leaf miners	-IPPM	110 days	10	10	Hot spots controlling measures
	- Control		60	30	3
Spiders	-IPPM	85 days	0%	0%	-
	- Control		15%	8%	1

Table (2) Total amount at irrigation water throughout the season (m3) and WUE (kg/m3)

Total amount of water	Total Yield kg/ plastic house		WUE kg/m^3	
	IPPM	Control	IPPM	Control
181.5 m^3	5600	4560	30.9	25.1

Table (3) Total yield per plastic house and per unit area (m2) for cucumber crop (On-farm trail) Dhamar plain 2003

Treatments	# of pickings	Total yield per plastic house (500 m2)	Yield per m2
- IPPM technique	29	5600 kg	11.2 kg/m2
- Control	29	4561 kg	9.1 kg/m2