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LIFE Integrated Water Resources Management
Task Order No. 802
EPIQ II: Contract No. EPP-T-802-03-00013-00

Task 6: Improved Waste Water Reuse Practices

IRRIGATION AND CROP MANAGEMENT PLAN

Report No. 25

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Prepared by ECODIT, Inc.

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ACRONYMS & ABBREVIATIONS

APRP	Agricultural Policy Reform Program
BCWUA	Branch Canal Water User Association
BOD	Biological Oxygen Demand
CDA	Community Development Association
CLAC	Central Lab for Agricultural Climate
CLEQM	Central Laboratory for Environmental Quality Monitoring (MWRI)
COD	Chemical oxygen demand
CTO	Cognizant Technical Officer (the USAID person responsible for supervising a technical assistance contractor)
CY	Calendar Year
ECODIT	ECODIT, Inc (a US based international consulting firm specializing in Environmental Management)
EEAA	Egyptian Environmental Affairs Agency
EEPP	Egyptian Environmental Policy Program (a USAID-funded program aimed at achieving environmental policy reform)
EMP	Environmental Monitoring Plan
EPADP	Egyptian Public Authority for Drainage Projects (MWRI)
EPIQ	Environmental Policy and Institutional Strengthening Indefinite Quantity Contract
ET	Evapo-transpiration
ETmax	Maximum Evapotranspiration
ETO	Reference Crop Evapo-transpiration (potential)
EWr	Effective Water Requirement
FC	Field Capacity
GIS	Geographic Information System
GOE	Government of Egypt
GPS	Global Positioning System
GW	Groundwater
GWS	Groundwater Sector
IRG	International Resources Group (a Washington DC-based consulting firm that is prime contractor for the IWRMP)
IWMD	Integrated Water Management District
IWRM	Integrated Water Resources Management
Kc	Crop Coefficients
LIFE	Livelihood Income from the Environment
LOE	Level of Effort
M&E	Monitoring and Evaluation
MALR	Ministry of Agriculture and Land Reclamation
mg/l	milligrams per liter
MISD	Matching Irrigation Supply and Demand

MOE	Ministry of Education
MOH	Ministry of Health
MOU	Memorandum of Understanding
MSEA	Ministry of Sate for Environmental Affairs
MWRI	Ministry of Water Resources and Irrigation
NetWr	Net Water Requirement
NGO	Non-governmental Organization
NWRC	(MWRI) National Water Research Center
O&M	Operation and Maintenance
OJT	On-the-Job Training
pH	Potential of Hydrogen ions (measure of acidity or alkalinity)
PM&E	Performance Monitoring and Evaluation
ppm	Parts per Million
PWP	Permanent Wilting Point
RWS	Relative Water Supply
SS	Suspended Solids
STTA	Short-term Technical Assistance
SWERI	Soils, Water, and Environment Research Institute (MALR)
TA	Technical assistance
TOR	Terms of Reference
TS	Transition State (chemical)
TSS	Total Suspended Solids
TWW	Treated Wastewater
USAID	United States Agency for International Development
WQU	MWRI Water Quality Unit
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

Egypt has been using treated wastewater to produce wood and other industrial products since the early 1990s. The Ministry of Agriculture and Land Reclamation (MALR) has established 23 water-reuse projects across the country including one in Luxor where African mahogany, mulberry, and physic nut (*Jatropha curcas*) are being grown. So far, these projects have been exclusively government-driven and private sector participation is absent. An inter-ministerial committee recently approved an Egyptian Water Reuse Code and the Ministerial Decree was issued in April 2005. Task #6 under the LIFE Integrated Water Resources Management Project (LIFE–IWRM) will demonstrate the technical feasibility of wastewater reuse in a manner that is environmentally safe and compliant with safety considerations and Egyptian law. In particular, the Project will manage a water reuse site in Luxor (10 feddan), near the new Luxor wastewater treatment plant. The site will receive treated wastewater from the nearest maturation pond and grow a number of commercial crops including Jojoba, *Jatropha*, sorghum, flax, cut flowers, and ornamental plants.

This report presents an Irrigation and Crop Management Plan to guide the project team during crop planting activities and irrigation practices. It provides information about how to prepare the soil before crop planting, crop monitoring, and crop irrigation. The proposed crop irrigation plan is based on the irrigation design prepared by the LIFE–IWRM irrigation design specialist, Dr. Ahmad Beheiry. The irrigation system consists of a pumping station with a design outflow of 60 m^3/hour, a filtration unit, and a distribution network. The irrigation network is composed of a 125-mm main line, 75-mm sub-mains, 18-mm laterals, and different sizes of drippers. Spaghetti drippers have been installed. Although they offer some advantages over pressure-regulated drippers, they usually result in non-uniform distribution of water because of pressure loss with distance. This can be adjusted by preparing a good irrigation schedule and refining this schedule based on performance.

This irrigation plan presents water requirements for each of the proposed crops for each month of the year. Crop coefficient (Kc), percent wetted zones, and irrigation efficiency have been considered in the calculations to produce the net water requirements. The climate in Luxor is notoriously hot during summer resulting in evapo-transpiration rates in excess of 10-mm per day. The irrigation system therefore must supply sufficient water to keep the crops comfortable and minimize the occurrence of water stress. Over-irrigation will result in unnecessary losses through evaporation and percolation. Irrigation scheduling is the process of deciding how much water to apply and when. The period of time to irrigate the crops and in which sequence and/or combination of plots should be developed and tested on site through trial and error. It is important to recognize that some plots must be irrigated simultaneously. To prevent water-logging and water stress, it is recommended to monitor soil moisture using tensiometers installed in several locations. To monitor and record water supply at the plot level the project has installed water meters near each valve.

1. INTRODUCTION

BACKGROUND

Egypt has been using treated wastewater to produce wood and other industrial products since the mid 1990s. The Ministry of Agriculture and Land Reclamation (MALR) has established 13 water-reuse projects across the country. The most common crops include African mahogany (*Khaya senegalensis*), mulberry (*Morus spp*), and physic nut (*Jatropha curcas*). So far, these projects have been exclusively government-driven, and private sector participation is absent or negligible.

The objectives of Task 6 under LIFE–IWRM are to provide technical assistance, guidelines, and commodity support for the design, installation, operation, and monitoring of a demonstration wastewater use site producing a variety of approved commercial plant species in accordance with the recently prepared "Egyptian Manual as Guidelines for Treated Wastewater Reuse in Agriculture."

The Ministry of Housing released The Egyptian Code for the Reuse of Treated Municipal Wastewater in Agriculture (Ministerial Decree No. 171/2005) in April 2005. This water reuse code provides the legal framework for implementing wastewater reuse activities in Egypt. The Code can now serve as a solid platform to enhance and formalize the water reuse sector in the country. The water reuse demonstration site in Luxor is intended to comply with and demonstrate relevant sections of this Code.

PURPOSE

The purpose of this report is to describe specific crop and irrigation management requirements in support of the wastewater reuse demonstration site in Luxor. These management requirements aim to optimize the irrigation system design from an agronomic, hydraulic, and environmental point of view.

METHODOLOGY

The LIFE–IWRM project team recruited the services of a local agricultural engineer, Eng. Ahmad El Beheiry, to prepare the irrigation system design. Crop selection for the demo site was selected by the project team in July 2005 and the irrigation system design was approved in September 2005. These decisions form the basis for this Irrigation and Crop Management Plan.

REPORT ORGANIZATION

This report is organized into four chapters:

1. Introduction
2. Design considerations
3. Crop management plan
4. Irrigation management plan

and four appendices:

Task 6: Irrigation and Crop Management Plan

1. Technical specifications of selected crops
2. Egyptian Waste Water Code
3. Crop Cash Flow
4. Crop Monitoring Datasheets

2. DESIGN CONSIDERATIONS

SITE DESCRIPTION

The project identified a site east of the Luxor Wastewater Treatment Plant (WWTP), at N 25°37.774' and E 032°40.773'. A location map is shown in figure 1. The demonstration site is located adjacent to the lagoon ponds (I and II), covers 10 feddans (4.2 ha), with dimensions of 237m × 187m, and is located on Ministry of Housing (MOH) property, which is responsible for the operation of the WWTP. The Governor of Luxor, through MSEA, approved use of the land to serve as a water reuse demonstration site under the LIFE project. A schematic of the site location is shown in figure 2. The site is level—the elevation difference between the highest and lowest point is 1.8m. It is easily accessible from the main road. The demonstration site receives treated wastewater from the nearest maturation pond, 15 meters away. The pond is protected by an earth dike and, according to the site engineer, is about 1.5m deep including 0.5m freeboard. The project has received clear instructions not to carry out any activity that could impact the physical integrity of the lagoon or the dike.

Figure 1 **Location Map**

QUALITY OF TREATED WASTEWATER

The quality of the treated wastewater in these lagoons is reportedly very high in comparison to the water in other units of the treatment plant. The WWTP environmental laboratory conducts routine sampling and analysis of the influent and effluent water, including effluent from the aeration and maturation ponds in the new plant. Standard tests include pH, alkalinity, BOD, COD, DO, TDS, TSS, and coliform count. Table 1 presents test results for a 5-day sampling campaign of effluent in the maturation pond. The campaign was conducted by the local laboratory for the project from September 14 to 19, 2005.

Figure 2 **Demonstration Site Schematic**

SOIL QUALITY

The Project Team collected 24 soil samples from eight locations inside the demo site and from three different depths (0–30, 30–60, and 60–90). The samples were analyzed at the Ministry of Agriculture/Agricultural Research Centre/Soils, Water & Environment Resources Institute (SWERI)/Unit of Analysis & Studies, Giza, Cairo. Physical tests were conducted on all 24 samples (8 locations) and chemical tests were conducted on 9 samples (3 locations). Physical tests include particle size distribution (to determine texture), and chemical tests includeing: pH, electrical conductivity, anions and cations, $CaCO_3$, organic matter, and macro- and micro-nutrients. The test results were included in the Environmental Monitoring Plan (EMP) Report No. 21, and are summarized below:

- Alkalinity high, pH ranges from 8.05 to 8.45
- Electrical conductivity moderate, EC ranges from 3.5 to 7.4 dS/m
- Organic matter very low (expected), OM ranges from 0.03 to 0.53 percent
- Texture ranges from loamy sand to sandy (>90 percent sand)

Table 1 Sample Lagoon Effluent Test Results

	Temp (˚C)	pH	BOD (mg/l)	COD (mg/l)	DO (mg/l)	TDS (mg/l)	TSS (mg/l)	Coliform Count (1000)
Sept 14	30	7.8	25	31	7.5	454	30	2,400
Sept 15	31	8.05	28	40	8.3	486	32	3,000
Sept 17	30	8	25	31	6.2	476	28	3,000
Sept 18	30	8.5	28	31	8	450	25	3,400
Sept 19	30	8.5	23	31	7.9	466	30	3,500
Average	30.2	8.17	25.8	32.8	7.58	466.4	29	3,060
Standard*	35	6-9	60	80	>4	2000	50	5,000

* Egyptian Water Reuse Code (Grade B)/Law 48/1982 (Egyptian Code, Table No. 4-1)

GROUNDWATER

Based on observations from nearby production wells, the depth to the water table is about 18–20 meters. Nitrate (NO_3) tests conducted on-site using a nitrate meter showed very low nitrate values in the range of 5–15 parts per million (ppm).

IRRIGATION SYSTEM LAYOUT

The irrigation system consists of a pump station, a filtration unit, a fertigation unit, and an irrigation distribution network with mains, sub-mains, and laterals.

DESIGN ASSUMPTIONS

- System allowable discharge tolerance = ± 10%
- Operating Pressure Variation = ± 5-40%
- In-line emitter operating pressure = 1.0 bar
- Emitter design tolerance = 3.0 m
- Maximum lateral net friction head loss = 1.5 m
- Maximum flow velocity = 1.2 m/s

PUMP STATION

The pump installed on the site was designed to deliver 60m^3 per hour with a pressure head of 40m. The capacity was based on a 5-hour workday, a maximum crop water requirement of 30 m^3/feddan/day, equivalent to 300m^3 for the whole site. The peak crop water requirement (peak WR) occurs during June (peak month) at full maturity (5-year old plantation). The selection of a suction pump mounted inside a pump house on a concrete floor was the best option from a technical and environmental viewpoint. The Project opted for a diesel pump because electric power could not be provided at the demo site without incurring costly infrastructure including 400 meters of power lines and a transformer, or a stand-alone diesel pump that would generate electricity to run the pump.

FILTRATION UNIT

The project installed a dual filtration unit of gravel/sand and disc filters. The sand/gravel filter consists of three filter tanks, 36 inches in diameter, with a nominal flow of 60m^3/hour. The epoxy-coated tanks are equipped with pressure gauges and air vacuum relief valves, as well as a back-flush system.

The disc filter has a nominal flow rate of 60m^3/hr. The maximum allowable pressure drop between the inlet and outlet should be less than 0.2 bar. The discs should be cleaned manually once per week. The filtration system is shown in figure 3 and the media for the sand filter in figure 4.

FERTIGATION UNIT

The Project will not install a fertigation unit. However, should future test results indicate the need to fertilize the crops, it is recommended to install the Venturi Injection Unit (1”1/2) because it is simple to operate and accurate. This fertigation system can inject accurate dosages of liquid or soluble fertilizers (before the filtration unit) at a constant rate. It will inject the liquid or soluble fertilizer into the irrigation system via the pressure differential created by the control valve upstream of the disc filter.

Figure 3 **Filtration system (sand and disc)**

Figure 4 **Inert media for sand filter**

IRRIGATION DISTRIBUTION NETWORK

The irrigation distribution network includes main, sub-main, and lateral lines. The main line measures 125mm in diameter and delivers water from the pump to the sub-mains, an approximate distance of 200 meters. Sub-mains (75mm in diameter) deliver water from the mains to the laterals. The laterals (18mm in diameter) extend from the sub-mains and deliver water to the crops. Table 2 summarizes the spacing between lateral tubes and individual emitters along lateral tubes for a selection of crops.

Table 2 **Spacing between Laterals and Emitters**

Crop	Area (Fd)	Laterals		Distance between Emitters Along Lateral (M)	Irrigation Method
		Length (m)	Distance btw laterals (m)		
Flowers	2	45	1.0	0.5	Drip & furrow
Flax	2	45	1.0	0.5	Drip (flood later)
Jojoba	2	45	4.0	2.0	Drip
Jatropha	1	45	3.0	3.0	Drip
Sorghum	2				Flood

SYSTEM MAINTENANCE

System maintenance should include:

- Laterals and filters should be checked weekly and flushed monthly
- Emitters should be cleaned when necessary

- Weed growth should be kept away from emitters
- Tubing should be checked for leaks and kinking
- Flow meter should be checked for correct flow rate at the plot level.

SYSTEM FLUSHING

The entire system irrigation network should be flushed before installing the drip lines. The main lines, sub-mains, and laterals should be flushed in sequence for best results. The flushing process shall be maintained until the water is completely clean. This could take a several minutes. The filtration unit should be carefully monitored and routinely flushed to produce clean water and minimize clogging.

PERFORMANCE TESTING

The irrigation system should be tested to determine the uniformity of distribution in case of using spaghetti lines to evaluate how much water is delivered at the end of the line compared to the beginning. Spaghetti lines recommended by the Irrigation Design Specialist tend to discharge more water at the beginning of the lines because they are not pressure-regulated. This can lead to insufficient pressure to operate the last emitters in a plot. During installation the field team and project team installed drippers with different diameters according to the crop. This change reduced the non-uniformity. For flax and sorghum it is recommended to use flood instead of drip irrigation.

3. CROP MANAGEMENT PLAN

CROP SELECTION AND LAYOUT

The Project Committee selected five demonstration crops for the demo site:

- flowers and ornamentals
- flax
- Jojoba
- sorghum
- *Jatropha*

Crop selection was based on a number of factors:

- Water quality of the treated waste water (see Annex B: Egyptian Waste Water Code)
- Climate and soil conditions
- EEAA and MALR interests
- Marketing and economic considerations (Annex C: Crop Cash Flow).

The demonstration site is divided into 18 plots of equal size about 0.5 feddan each.

As well as the selected commercial crops, the Project planted a green fence to mark the perimeter and to serve as windbreak. Figure 5 shows the distribution of the crops in the demo site. Details on crop spacing, estimated area, and estimated quantities are presented in Table 3.

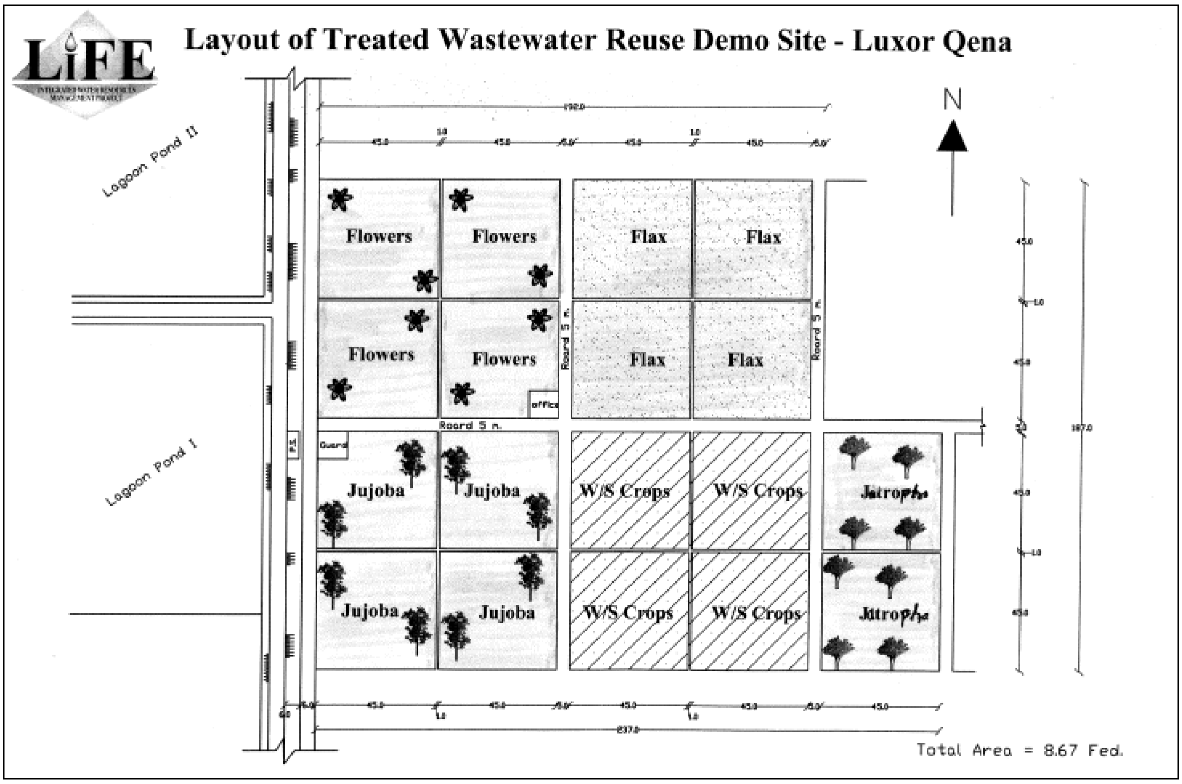

Figure 5 Crop Layout

Table 3 Luxor Demo Crop Density

Crop	Spacing between Rows (M)	Spacing along Rows (M)	Area (Feddan)	Number of Crops per Feddans	Total Number of Crops
Flowers	1	N/A	2	16,000	32,000
Flax	N/A		2	N/A	N/A
Jojoba	4	2	2	506	1012
Jatropha	3	3	1	450	450
Sorghum	N/A	N/A	2	N/A	N/A

GROWTH PERIODS, CROP CALENDAR, AND EXPECTED YIELDS

Table 4 presents growth periods, suggested planting dates, and potential yields for each crop type.

Table 4 Luxor Demo Cropping Pattern and Yields

Crop	Growth Period (days)	Plant Date	Potential Yield (t/fd)
Flowers	All year	January - February	N/A
Flax	155 days	November 15	0.56
Jojoba	Permanent		0.80 (after 4-5 years)
Jatropha	Permanent		1.43 (after 4-5 years)
Sorghum	140 days	April 15	1.6

PLANT AGRONOMIC MONITORING

Dr. Mustapha El Hakeem, Reforestation Consultant at the Egyptian Environmental Affairs Agency (EEAA), requested the LIFE Project Team to monitor the agronomic performance of *Jatropha* and Jojoba during the growing season to assess plant response to treated wastewater by taking regular measurements (e.g., height, biomass) and making pertinent observations (e.g., germination, date of flowering and date of shedding). Table 5 lists suggested agronomic measuring parameters for these crops. Simple field forms to record observations in a tabular and systematic fashion for this purpose are provided in Appendix D. The field team will receive training on how to make and record these observations.

Table 5 Agronomic Measurement Parameters

Crop	Weekly	Seasonal	Harvest
Jatropha	Plant height	Date plant started to shed its leaves and date of last	Average weight of capsules in grams per

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	Number of lateral (base) stems Maximum stem thickness Node height	shedding Date plant started to generate new leaves (and date of leaf maturity) Date of flowering Date of seed formation Date of harvesting	tree Average number of seeds per tree Average weight of seeds (and shell) per tree
Jojoba	Plant height Thickness of the main stem at the crown Number of main branches emerged on the crown Number of leaves Number of internodes		

4. IRRIGATION MANAGEMENT PLAN

CROP WATER REQUIREMENT

Crop water requirement is equivalent to the rate of Evapo-transpiration necessary to sustain optimum plant growth. Net crop water requirement (NetWr) is a function of the actual Evapo-transpiration and the crop coefficient. It is calculated as follows:

$$NetWr = ETact - R - r = Kc*ETo - R - r$$

Kc = Crop Coefficient

ETo = Reference Evapotranspiration

ETact = Actual Crop Evapotranspiration

Kc = Crop Coefficient

R = Rainfall

r = Soil water reserve

In Luxor, rainfall (R) and soil water reserve (r) are nil. Therefore, NetWr is equal to ETact.

Total water requirement is calculated by adding leaching requirements and applying application efficiency.

REFERENCE CROP EVAPO-TRANSPIRATION (ETo)

ETo is calculated using the FAO Penman-Monteith model. ETo is a function of climatic conditions including maximum and minimum temperature, relative humidity, number of sunshine hours, and wind speed. ETo values in Luxor are presented in Table 6**.** They range from 3.39 mm/day in December to 10.12 mm/day in June.

Table 6 Reference Crop Evapo-transpiration (Luxor)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tmax	23.0	25.5	29.5	34.8	38.7	41.1	40.6	40.7	38.6	35.3	29.6	24.6
Tmin	5.4	7.0	10.6	15.7	20.0	23.0	23.6	23.4	21.5	17.5	12.1	7.2
RHmean	52	42	34	26	22	23	26	27	32	40	47	53
RHmin	25	20	16	13	11	12	14	15	17	21	24	26
Wind (km/d)	216	264	288	288	264	264	264	264	264	168	216	168
Sunhours	9.10	9.70	10.10	10.80	11.60	13.10	13.00	12.20	11.80	10.80	9.60	9.00
ET fao	3.68	5.03	6.67	8.43	9.33	10.12	10.01	9.66	8.66	5.79	4.85	3.39

CROP COEFFICIENTS (Kc)

Crop coefficients are specific to (i) each crop and (ii) growth stage. Crop coefficients are not affected by climatic conditions. The coefficients include both transpiration from plant stomata and evaporation from wet soil and foliar surfaces, with the assumption that the availability of water is not limiting to plant growth and development. The most commonly used Kc values come from the FAO "Irrigation and Drainage Paper #56: Crop Evapo-transpiration: Guidelines for Computing Crop Water Requirements." Unfortunately, the FAO database does not provide Kc value for all possible crops. Kc values for special crops such as *Jatropha* should be based on the nearest crop category (e.g., seed oil crops or fruit trees), as presented in Table 7.

ACTUAL WATER REQUIREMENTS

ETo is multiplied by Kc to obtain estimates of crop water demand or actual Evapo-transpiration (ETact), which is equal to net crop water requirement (NetWr). To keep the crops healthy, it is not enough to irrigate them based on the NetWr because the irrigation plan must also account for water loss linked to irrigation efficiency. Irrigation efficiency is never 100 percent. For drip irrigation efficiency can reach 90 percent. For spaghetti emitters, it can drop to 80 percent. Irrigation efficiencies are lower for other irrigation methods: 70-80 percent for sprinkler irrigation and 50-70 percent for surface irrigation. Therefore, actual water requirement (AWr) is calculated as follows:

AWr = 100 * NetWr / 80 (drip irrigation)

AWr = 100 * NetWr / 60 (flood irrigation)

Table 7 presents the actual Wr for all the crops in the demo site assuming an irrigation efficiency of 80 percent for drip-irrigated crops (*Jatropha*, Jojoba, flax, and flowers) and 60 percent for flood irrigated crops (sorghum). In the case of *Jatropha* and Jojoba, which are planted in rows and therefore achieve only partial groundcover (canopy closure), the adjusted water requirement was calculated using a wetted soil area of 75 percent.

ANNUAL WATER REQUIREMENT

For purposes of water scheduling, it is important to estimate daily and monthly actual water requirement (AWr) to guarantee supply. AWr in Luxor will range from about 10m^3/day/feddan in December (100m^3 for the entire demo site) to 32m^3/day/feddan in June (320m^3 for the entire demo site).

IRRIGATION SYSTEM DESIGN CONSIDERATIONS

The proposed irrigation management plan is based on the following assumptions and criteria:

Total irrigated surface area is 10 feddans (including 1 feddan as fallow)

Peak water requirement is 30m^3/day/feddan

Total number of irrigation hours during peak water demand is 5 hours/day, but could be increased to 7 hours (from 6:00 AM to 10:00 AM and from 5:00 PM to 8:00 PM)

Pump discharge is 60m^3/hour

Table 7 Crop Water Requirements for Luxor Demo Site

	Crop	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Eto		mm/d	3.68	5.03	6.67	8.43	9.33	10.1	10	9.66	8.66	5.79	4.85	3.39
Kc	Flowers		0.5	0.5	0.5	0.73	0.95	0.95	0.95	0.95	0.95	0.95	0.62	0.3
	Flax		0.75	1.1	1.1	0.85	0.6						0.35	0.75
	Sorghum					0.3	0.75	1.2	1.2	1.05	1.05			
	Jojoba		0.65	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.65
	Jatropha		0.65	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.65
Growing days	Flowers	days	31	29	31	30	31	30	31	31	30	31	30	31
	Flax	days	31	29	31	30	15						15	31
	Sorghum	days				15	31	30	31	31	5			
	Jojoba	days	31	29	31	30	31	30	31	31	30	31	30	31
	Jatropha	days	31	29	31	30	31	30	31	31	30	31	30	31
Eta	Flowers	mm/mo	57	73	103	185	275	288	295	284	247	171	90	32
	Flax	mm/mo	86	160	227	215	84	0	0	0	0	0	25	79
	Sorghum	mm/mo	0	0	0	38	217	364	372	314	45	0	0	0
	Jojoba	mm/mo	74	102	145	177	202	213	217	210	182	126	102	68
	Jatropha	mm/mo	74	102	145	177	202	213	217	210	182	126	102	68
Net WR	Flowers	m3/fed/mo	240	306	434	775	1154	1211	1238	1195	1037	716	379	132
	Flax	m3/fed/mo	359	674	955	903	353	0	0	0	0	0	107	331
	Sorghum	m3/fed/mo	0	0	0	159	911	1530	1564	1321	191	0	0	0
	Jojoba	m3/fed/mo	311	429	608	744	850	893	912	880	764	528	428	287
	Jatropha	m3/fed/mo	311	429	608	744	850	893	912	880	764	528	428	287
Irrigation Eff.	Flowers		0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Flax		0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Sorghum		0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Jojoba		0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Jatropha		0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
WR	Flowers		399	511	724	1292	1923	2019	2064	1991	1728	1194	631	221
	Flax		599	1123	1592	1505	588	0	0	0	0	0	178	552
	Sorghum		0	0	0	266	1518	2550	2607	2201	318	0	0	0
	Jojoba		389	536	760	929	1063	1116	1140	1101	955	660	535	359
	Jatropha		389	536	760	929	1063	1116	1140	1101	955	660	535	359
WRadj.	Flowers	m3/fed/mo	319	408	579	1034	1539	1615	1651	1593	1382	955	505	177
	Flax	m3/fed/mo	599	1123	1592	1505	588	0	0	0	0	0	178	552
	Sorghum	m3/fed/mo	0	0	0	212	1215	2040	2085	1761	255	0	0	0
	Jojoba	m3/fed/mo	234	322	456	558	638	669	684	660	573	396	321	215
	Jatropha	m3/fed/mo	234	322	456	558	638	669	684	660	573	396	321	215
Water Application	Flowers	m3/fed/day	10	14	19	34	50	54	53	51	46	31	17	6
	Flax	m3/fed/day	19	39	51	50	39						12	18
	Sorghum	m3/fed/day				14	39	68	67	57	51			
	Jojoba	m3/fed/day	8	11	15	19	21	22	22	21	19	13	11	7
	Jatropha	m3/fed/day	8	11	15	19	21	22	22	21	19	13	11	7
Area	Flowers	Feddan	2	2	2	2	2	2	2	2	2	2	2	2
	Flax	Feddan	2	2	2	2	2	2	2	2	2	2	2	2
	Sorghum	Feddan	2	2	2	2	2	2	2	2	2	2	2	2
	Jojoba	Feddan	1	1	1	1	1	1	1	1	1	1	1	1
	Jatropha	Feddan	2	2	2	2	2	2	2	2	2	2	2	2
WR for the area	Flowers	m3/day	21	28	37	69	99	108	107	103	92	62	34	11
	Flax	m3/day	39	77	103	100	78	0	0	0	0	0	24	36
	Sorghum	m3/day	0	0	0	28	78	136	135	114	102	0	0	0
	Jojoba	m3/day	8	11	15	19	21	22	22	21	19	13	11	7
	Jatropha	m3/day	15	22	29	37	41	45	44	43	38	26	21	14
	TOTAL	m3/day	82	139	184	253	318	311	307	280	251	100	90	68

In Luxor, the farm manager may need to increase the number of irrigation hours in summer to accommodate exceptional heat conditions. Irrigation should preferably be done in the early morning hours (6 AM) or late evening (after 5 PM).

IRRIGATION APPLICATION

The maximum amount of water that can be applied per irrigation to meet crop water requirements is called irrigation application (IA). The irrigation application depends on soil characteristics and is a function of the soil's field capacity (FC) and permanent wilting point (PWP). Soil water in excess of PWP but up to FC is the water available for plant growth. To determine IA, this plan assumes a rooting depth of 0.5–1.0 meter and an allowable soil water depletion of 50 percent and an annual mean ETo of 7.1 mm/day. The irrigation application is calculated as follows:

$$IA = (FC - PWP)\ d_m\ Z\ P\ /\ 100$$

IA = Maximum net amount of water that can be applied (linear)

FC = Field Capacity (volumetric)

PWP = Permanent Wilting Point (volumetric)

d_m = Allowable moisture depletion (percent)

Z = Depth of soil to be irrigated (root zone) (linear)

P = volume of wetted soil area (percent)

Table 8 presents the design assumptions used to calculate the irrigation application for each crop including irrigation efficiency and the wetted area in percent. The maximum design flow rate was calculated based on the irrigation design and considers the total number of laterals and emitters per 1 feddan plot.

Table 8 Design Assumptions for Estimating the Irrigation Application

Crop	Irrigation Method	Irrigation Efficiency (%)	Wetted Area (%)
Flowers	Drip / furrow	80	100
Flax	Drip	80	100
Jojoba	Drip	80	75
Jatropha	Drip	80	75
Sorghum	Flood	60	100

IRRIGATION SCHEDULING

Irrigation scheduling is the single most critical management practice in the demo site. Too much water will percolate into the groundwater and too little water will stress the plants. In agricultural terms, irrigation scheduling should satisfy crop water requirement by maintaining soil moisture between field capacity (FC) and permanent wilting point (PWP).

Irrigation frequency will be based on FC, PWP, and crop water requirements. The soil is sandy, therefore frequent irrigation is required to meet crop requirements and avoid plant stress. The proposed schedule irrigates multiple plots each day with a frequency of 4 days in winter and 2–3 days in summer.

The recommended irrigation management plan requires the total flow rate (60m^3/hour) be delivered to more than one plot by opening several valves at the same time. This will reduce pressure buildup and extend irrigation times. This option offers several advantages but it is more complex to operate. For example, only crops with similar water requirements can be irrigated at the same time. *Jatropha* and jojoba can be irrigated simultaneously but jojoba and sorghum cannot, because sorghum has much higher water needs.

The Project team will monitor the capability of the field team to manage irrigation. The uniformity of distribution can be investigated using the bucket system by collecting water from several emitters at various distances from the main and sub-main lines for a certain period, say 5 minutes or more. The Uniformity Coefficient (CU) can be calculated as follows:

$$CU = \frac{\text{minimum rate of discharge per emmiter}}{\text{average rate of discharge per emmitter}} \times 100$$

Table 9 shows the daily water requirement, irrigation frequency, and recommended water application for each crop by month, assuming a plot is about half a feddan or 45m x 45m. It gives a guide to the field team for preparing monthly irrigation schedules. It also allows selection of the groups of plots that should be irrigated at the same time.

Table 9 Irrigation Scheduling Guidelines

	Crop	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daily Water Reuirement per feddan	Flowers	m3/fed/day	10	14	19	34	50	54	53	51	46	31	17	6
	Flax	m3/fed/day	19	39	51	50	19						6	18
	Sorghum	m3/fed/day				7	39	68	67	57	8			
	Jojoba	m3/fed/day	8	11	15	19	21	22	22	21	19	13	11	7
	Jatropha	m3/fed/day	8	11	15	19	21	22	22	21	19	13	11	7
Irrigation Frequency	Flowers	days	4	3	2	2	2	1	1	1	2	2	3	4
	Flax	days	4	4	3	3	3						2	3
	Sorghum	days				2	2	2	2	2	3	3		
	Jojoba	days	4	4	3	3	2	2	2	2	2	3	4	4
	Jatropha	days	4	4	3	3	2	2	2	2	2	3	4	4
Water Application per Plot per irrigation	Flowers	m3/plot/irrig.	21	21	19	34	50	27	27	26	46	31	25	11
	Flax	m3/plot/irrig.	39	77	77	75	28						6	27
	Sorghum	m3/plot/irrig.				7	39	68	67	57	13			
	Jojoba	m3/plot/irrig.	15	22	22	28	21	22	22	21	19	19	21	14
	Jatropha	m3/plot/irrig.	15	22	22	28	21	22	22	21	19	19	21	14

Assumption: Pump discharge is 60 cubic meters per hour. Volume should be measured at the existing meters at the head of plots.

IRRIGATION MONITORING

It is recommended that the Project installs half a dozen tensiometers to monitor soil moisture during the growth season. Collection of soil moisture data will help refine irrigation schedules and prevent excessive percolation losses. The Project has provided the site with one central and five plot-level water meters to measure flow rates.

APPENDIX A: TECHNICAL SPECIFICATIONS FOR SELECTED CROPS

JOJOBA

Genus species	*Simmondsia chinensis*
Description	Woody perennial bushes native to the deserts of Arizona, northern Mexico, and California. Jojoba is an evergreen, dioecious plant; pollination usually occurs in February and March.
Spacing between rows	3.5 meters
In-line spacing	1.5 meters
Cropping density	800 seedlings per feddan
Male-to-Female ratio	1:7 (100 male to 700 female) Male seedlings should be planted upwind to wind-pollinate female seedlings downwind.
Agronomic requirements	Jojoba is a drought-resistant plant but extreme heat will significantly reduce yields. Prepare holes 75-90 cm deep and 50 cm wide and mix with organic supplements (sun-cured manure, compost), 250 grams super phosphate and 0.5 kg sulfur. Jojoba flowers under cultivation are highly sensitive to frost. If frost does occur in Luxor, then induced dormancy should be practiced prior to the frost season.
Water requirements	To maintain a stable yield, Jojoba plants grown commercially require a consistent and a plentiful supply of water. Irrigate Jojoba seedlings using 8-liter/hour drippers.
Economic interest	Jojoba plants can produce high-quality oil. The seeds contain alpha, delta, and gamma tocopherols (all forms of vitamin E) and the extractable liquid content of matured jojoba seeds can range between 50 and 54 percent. Jojoba seeds are also known to contain an appetite suppressant (simmondsins) that may be used by pharmaceutical companies as a form of dietary supplement. Jojoba plants reach harvest maturity after three years.

JATROPHA

Genus species	*Jatropha curcas* (Physic nut)
Description	Physic nut is a shrub with toxic seeds that contain a high percentage of oil used for candles, soap, and biodiesel production. It is a drought resistant shrub that grows up to 20' tall under favorable condition with spreading branches. There are male and female plants of *Jatropha curcas*. Fruits contain 2–3 large, black, oily seeds. These black, thin shelled seeds are toxic; they contain the toxalbumin curcin making them fatally toxic.
Spacing between rows	3 meters
In-line spacing	3 meters
Cropping density	450 trees/feddan
Agronomic requirements	*Jatropha* grows well in low-rainfall conditions (it can survive with less than 200 mm per year). The plant is undemanding in soil type and does not require tillage. All parts of the plant are reported to be poisonous if ingested.
Water requirements	Does not need much water; is resistant to long periods of drought and can withstand short, light frost.
Economic interest	Physic nut can produce oil for manufacturing candles and soap, or to be used as biodiesel. Yields of up to 318 g/shrub have been reported (wider spacing produces higher yields).

FLAX

Genus species	*Linum*
Description	Flax has been grown since the beginnings of civilization, and people all over the world have celebrated its usefulness throughout the ages. Cultivated flax, *Linum usitatissimum*, is of two types: one is grown for the seed and the other for fiber production. The genus *Linum* is the source of both flax fibers and linseed oil.
Cropping density	7500 plants/fd; seeds 70 kg/fd
Agronomic requirements	Land preparation is required; planting is in November with harvesting in April/May.
Water requirements	Irrigation should be applied every 2–4 days to avoid water stress that will cause reduced yield.
Economic interest	Flax is the source of flax fibers (used as stubble) and linseed oil.

SORGHUM

Genus species	*Sorghum sp.*
Description	Sorghum is a genus of about 20 species of grasses native to tropical and subtropical regions of Eastern Africa. The plant is cultivated in Southern Europe, Central America, and Southern Asia. Sorghum is used for food, fodder. It has many common names including Egyptian Millet.
Agronomic requirements	Sorghum requires an average temperature of at least 25°C to produce maximum grain yields in a given year. Sorghum is a high nitrogen feeding crop. It is drought- and heat-tolerant and is especially important in arid regions.
Water requirements	450– 650 mm/growing period
Economic interest	Sorghum is an important source of food and fodder.

ORNAMENTAL PLANTS

Common English Name	Genus species	Common Arabic Name	Type	Spacing (m)	Quantity
Cut Flowers					
Rose	*Rosa spp.*	الورد البلدى	Seedling	1×1	2,100
Bird of Paradise	*Sterlitzia reginae*	عصفور الجنه	Seedling	1×1	2,100
Gladiolus	*Gladiolus spp.*	الجلاديولس	Bulb	0.20×0.20	13,125
Outdoor Ornamental Plants					
Indian fig	*Opentia vulgario*	الصبار المستورد	Seedling	0.50×0.50	1,400
Golden Dewdrop	*Duranta repens*	الدورنتا	Seedling	0.50×0.50	700
Winter Plants					
Sweet Acacia	*Acacia farnesiana*	عنبر كشمير	Seedling	0.20×0.20	8,750

APPENDIX B: EGYPTIAN WASTEWATER CODE CLASSIFICATION OF PLANTS AND CROPS IRRIGATED WITH TREATED WASTEWATER

Grade	Agricultural Group	Recommendations
A	G1-1: Plants and trees grown for greenery at tourist villages and hotels	Grass, Saint Augustine grass, cactus plants, ornamental palm trees, climbing plants, fencing bushes and trees, wood trees and shade trees
	G1-2: Plants and trees grown for greenery inside residential areas at the new cities	Grass, Saint Augustine grass, cactus plants, ornamental palm trees, climbing plants, fencing bushes and trees, wood trees and shade trees
B	G2-1: Fodder/Feed Crops	*Sorghum sp*
	G2-2: Trees producing fruits with epicarp	On condition that they are produced for processing purposes, such as lemons, mangoes, date palms and almonds
	G2-3: Trees used for green belts around cities and afforestation of highways or roads	*Casuarina, camphor, Athel tamarix* (salt tree), oleander, fruit-producing trees, date palms, and olive trees
	G2-4: Nursery plants	Nursery plants of wood trees, ornamental plants, and fruit trees
	G2-5: Roses and cut flowers	Local roses, eagle roses, onions (e.g. *gladiolus*)
	G2-6: Fiber crops	Flax, jute, hibiscus, sisal
	G2-7: Mulberry for the production of silk	Japanese mulberry
C	G3-1: Industrial oil crops	Jojoba and *Jatropha*
	G3-2: Wood trees	Caya, camphor, and other wood trees

Source: Egyptian Water Reuse Code (Ministerial Decree No. 171/2005), unofficial translation.

APPENDIX C: MARKETING AND CROP CASH FLOW

Source: "Use of Wastewater in Egypt," Ross E. Hagan and Nadine El Hakim, USAID Internal study, 2003

PURPOSE

In this study the feasibility of three agricultural crops using treated wastewater was evaluated.

This analysis relied on existing market data and prior research. It estimated nominal profits, net present value, and internal rate of return for a 60-feddan project irrigated with primary treated wastewater. Alternative crops studied were Jojoba, cut flowers, and trees (intercropping of African mahogany, *poinciana*, and *cupressus*).

ASSUMPTIONS

This study assumed the investment cost for all three alternatives would be based on a 1:1 debt: equity ratio. Loans would be available from a commercial bank at 15 percent interest rate to finance 50 percent of the investment costs. Replacement costs for portions of the irrigation system would be needed for the trees alternative and would be financed through equity.

The cost of land was assumed to be zero up to a 20-year grace period offered by the GOE for utilization of marginal lands. After 20 years, an annual utilization fee was charged per feddan. An average price for water was set at 0.05 L.E. per cubic meter. Because of health safety concerns, all irrigation water was applied through a localized (drip) irrigation system.

FINDINGS

All three illustrative crop varieties—trees, jojoba, and cut flowers—were found to be financially viable alternatives in the sense that they show a positive net present value and an acceptable internal rate of return over the life of the project (see tables below).

Indicator	Flowers	Jojoba	Trees
Net present value at 18% discount rate (LE)	23,120,546	2,033,418	459,423
Internal rate of return	159%	43%	27%
Simple payback period	1 year	4 years	2 years

Task 6: Irrigation and Crop Management Plan

Flowers Cashflow

Cashflows in LE / Year	1	2	3	4	5	6	7	8	9	10	Total
Plus: Project Revenues (1)	8,715,180	8,933,060	9,385,296	10,106,937	11,156,167	12,622,179	14,637,858	17,399,813	21,199,983	26,475,874	140,632,347
Less: Project Operating Expenses(2)	7,028,400	7,012,722	7,197,937	7,388,482	7,584,652	7,786,555	7,994,509	8,208,636	8,429,204	8,656,494	77,287,590
Less: Project Debt Repayment (3)	0	240,322	240,322	240,322	240,322	240,322	240,322	240,322	0	0	1,682,255
Less: Project Equity	2,925,660	0	0	0	0	0	0	0	0	0	2,925,660
Net Profit	-1,238,880	1,680,015	1,947,037	2,478,133	3,331,194	4,595,302	6,403,027	8,950,855	12,770,779	17,819,380	58,736,843
Net Present Value(2)	-1,238,880	1,680,015	1,649,140	1,778,795	2,026,372	2,368,926	2,797,311	3,313,889	4,006,902	4,738,075	23,120,546

NPV at 18% Discount Rate over 10 years	**23,120,546**
IRR	**159%**
Simple Payback Period	**one year**

Assumptions:
(1) Revenues are based on yield of one farm, not on overall market demand, i.e. this does not indicate that everything produced will be sold.
It is reasonable to assume that such abnormal profits will dissipate if supply exceeds demand.
(2) Assumes discount rate of 18 percent.
(4) Operating expenses per feddan are detailed below. Figures included in above analysis are aggregates for a 60-feddan project.
(3) Assumes a 1:1 Debt:Equity ratio and 15 percent interest rate. Loan term is 7 years.
(*) Project revenues and operating expenses are subjected to annual inflation rates of 2.5 percent.
This rate has been the most common in Egypt over the past few years as per the Economist Intelligence Unit Report.

Running Cost/Year	1	2	3	4	5	6	7	8	9	10	Total
Planting	13,366	13,366	13,366	13,366	13,366	13,366	13,366	13,366	13,366	13,366	133,660
Seeds and seedlings	6,764	6,764	6,764	6,764	6,764	6,764	6,764	6,764	6,764	6,764	67,640
Permanent Labors	5,971	3,135	3,292	3,456	3,629	3,810	4,001	4,201	4,411	4,632	40,538
Land prep + fertilizer	2,704	2,704	2,704	2,704	2,704	2,704	2,704	2,704	2,704	2,704	27,040
Irrigation water	542	407	407	407	407	407	407	407	407	407	4,205
Harvesting	12,944	12,803	12,803	12,803	12,803	12,803	12,803	12,803	12,803	12,803	128,171
Marketing	31,956	31,956	31,956	31,956	31,956	31,956	31,956	31,956	31,956	31,956	319,560
Ground + Air Freight	42,893	42,893	42,893	42,893	42,893	42,893	42,893	42,893	42,893	42,893	428,930
Sub-Total Running cost/feddan	117,140	114,028	114,185	114,349	114,522	114,703	114,894	115,094	115,304	115,525	1,149,744
Subtotal running cost	7,028,400	6,841,680	6,851,100	6,860,940	6,871,320	6,882,180	6,893,640	6,905,640	6,918,240	6,931,500	68,984,640

Jojoba Cashflow

Cashflows in LE/Year	1	2	3	4	5	6	7	8	9	10	11
Plus: Project Revenues	0	0	0	309,369	419,029	557,196	749,603	951,281	1,200,078	1,281,333	1,313,367
Less: Project Operating Expenses(3)	59,100	64,575	79,112	98,923	110,602	120,563	132,553	146,208	161,706	170,844	175,116
Less: Project Debt Repayment (1)	0	48,694	48,694	48,694	48,694	48,694	48,694	48,694	0	0	0
Less: Project Equity	296,400	0	0	0	0	0	0	0	0	0	0
Net Profit	-355,500	-113,269	-127,806	161,752	259,733	387,939	568,355	756,379	1,038,372	1,110,489	1,138,251
Net Present Value(2)	-355,500	-113,269	-108,252	116,105	157,996	199,986	248,299	280,035	325,795	295,273	256,487

Cashflows in LE/Year	12	13	14	15	Total
Plus: Project Revenues	1,346,201	1,379,856	1,414,352	1,449,711	12,371,377
Less: Project Operating Expenses(3)	179,493	183,981	188,580	193,295	2,064,652
Less: Project Debt Repayment (1)	0	0	0	0	340,860
Less: Project Equity	0	0	0	0	296,400
Net Profit	1,166,707	1,195,875	1,225,772	1,256,416	9,669,465
Net Present Value(2)	222,796	193,530	168,109	146,027	2,033,418

NPV at 18% Discount Rate over 15 years	**2,033,418**
IRR	**43%**
Simple Payback Period	**4 years**

Assumptions:
(1) Assumes a 1:1 Debt:Equity ratio and 15 percent interest rate. Loan term is 7 years.
(2) Assumes discount rate of 18 percent.
(3) Operating expenses per feddan are detailed below. Figures included in above analysis are aggregates for a 60-feddan project.

Running Cost/Year	1	2	3	4	5	6	7	8	9	10	11
Permanent Labors	360	380	420	441	463	486	510	535	562	600	600
Operation	360	360	480	480	530	530	530	530	530	530	530
Maintenance	240	260	280	300	300	300	300	300	300	300	300
Irrigation water*	25	50	75	100	100	100	100	100	100	100	100
Harvesting	0	0	0	210	277	360	465	585	720	750	750
Sub-Total running cost/feddan	985	1,050	1,255	1,531	1,670	1,776	1,905	2,050	2,212	2,280	2,280
Sub-total running cost	59,100	63,000	75,300	91,860	100,200	106,560	114,300	123,000	132,720	136,800	136,800

Running Cost/Year	12	13	14	15	Total
Permanent Labors	600	600	600	600	7,757
Operation	530	530	530	530	7,510
Maintenance	300	300	300	300	4,380
Irrigation water*	100	100	100	100	1,350
Harvesting	750	750	750	750	7,117
Sub-Total running cost/feddan	2,280	2,280	2,280	2,280	28,114
Sub-total running cost	136,800	136,800	136,800	136,800	1,686,840

Timber Trees

Cashflows in LE/Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Plus: Project Revenues(4)	0	738,000	0	0	0	0	0	0	0	0	0	1,258,094	0	0	0
Less: Project Operating Expenses(5)	51,000	52,200	53,400	54,600	55,800	58,800	60,000	61,200	63,600	64,800	67,200	69,000	71,400	73,800	76,800
Less: Project Debt Repayment (2)	0	50,518	50,518	50,518	50,518	50,518	50,518	50,518	0	0	0	0	0	0	0
Less: Project Equity	307,500	0	0	0	0	0	0	0	0	37,466	0	0	0	0	0
Net Profit	-358,500	635,282	-103,918	-105,118	-106,318	-109,318	-110,518	-111,718	-63,600	-102,266	-67,200	1,189,094	-71,400	-73,800	-76,800
Net Present Value(3)	-358,500	635,282	-88,018	-75,453	-64,673	-56,354	-48,282	-41,361	-19,955	-27,192	-15,142	227,071	-11,555	-10,121	-8,926

Cashflows in LE/Year	16	17	18	19	20	21	22	23	24	25	26	27	28	Total
Plus: Project Revenues	0	0	0	0	0	0	0	0	0	0	0	0	35,060,400	37,056,495
Less: Project Operating Expenses	54,960	56,820	69,480	72,540	103,800	109,080	113,857	118,137	123,727	128,832	134,660	140,618	146,114	2,306,226
Less: Project Debt Repayment (1)	0	0	0	0	0	0	0	0	0	0	0	0	0	353,625
Less: Project Equity	0	0	0	0	0	0	0	0	0	54,262	0	0	0	399,228
Net Profit	-54,960	-56,820	-69,480	-72,540	-103,800	-109,080	-113,857	-118,137	-123,727	-183,094	-134,660	-140,618	34,914,286	33,997,416
Net Present Value(3)	-5,413	-4,743	-4,915	-4,349	-5,273	-4,696	-4,154	-3,653	-3,242	-4,066	-2,534	-2,243	471,885	459,423

NPV at 18% Discount Rate over 28 years	**459,423**
IRR	**27%**
Simple Payback Period	**2 years**

Notes:
(1) This assumes a 60-feddan project intercropped with African Mahogany, poinciana, and cupressus.
(2) Assumes a 1:1 Debt:Equity ratio and 15 percent interest rate. Loan term is 7 years.
(3) Assumes discount rate at 18 percent
(4) Project revenues were computed as follows: (a) Poinciana seedlings: LE12 x 1000 seedlings/feddan x 60 feddans= LE 720,000.
(b) Cupressus yields 400 trees/feddan x 0.5 m3 of wood x LE800/m3 x 60 feddans = LE 958,850.
(c) African mahogany yields LE600,000 per feddan x compouneded inflation rate of 95% x 60 feddans = LE34,915,966
(5) Operating costs are detailed in table below.
(*) Project revenues and operating expenses are subjected to annual inflation rates of 2.5 percent.
This rate has been the most common in Egypt over the past few years as per the Economist Intelligence Unit Report.

Running Cost / year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Permanent Labors	200	210	220	230	240	260	270	280	300	310	330	340	360	380	400
Operation	200	210	220	230	240	260	270	280	300	310	330	340	360	380	400
Maintenance	100	100	100	100	100	110	110	110	110	110	110	120	120	120	130
Irrigation Water	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350
Cost of land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Running cost per feddan	850	870	890	910	930	980	1,000	1,020	1,060	1,080	1,120	1,150	1,190	1,230	1,280
Subtotal running costs	51,000	52,200	53,400	54,600	55,800	58,800	60,000	61,200	63,600	64,800	67,200	69,000	71,400	73,800	76,800

Running Cost / year	16	17	18	19	20	21	22	23	24	25	26	27	28	Total
Operation	420	440	650	700	760	820	860	900	950	1,000	1,050	1,110	1,150	15,140
Maintenance	130	140	140	140	150	150	160	160	170	170	180	180	190	6,390
Irrigation Water	350	350	350	350	350	350	350	350	350	350	350	350	350	6,200
Utilization cost of land	0	0	0	0	450	477	506	536	568	602	638	677	717	10,421
Subtotal running cost	54,960	56,820	69,480	72,540	102,600	107,820	112,537	116,757	122,287	127,332	133,100	138,998	144,434	2,293,266

APPENDIX D: CROP MONITORING DATASHEETS

Name of person filling out the datasheet:	
Date of entry:	
Plot number:	
Name of crop:	
Readings and Measurements:	
Plant height (cm)	
Number of lateral (base) stems at crown	
Stem thickness at the crown	
Node height	
Seasonal Observations:	
Date plant started to shed its leaves	
Date plant started to generate new leaves	
Date of flowering	
Date of seed formation	
Date of harvesting	
Harvest readings and measurements:	
Average weight of capsules in grams per tree	
Average number of seeds per tree	
Average weight of seeds (and shell) per tree	