Chapter 2: improved water and land productivities in the saline areas of the Nile Delta

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2.1 Characteristics of the saline areas

The study was conducted in El-Serw (New Alexandria) located about 32 km south of Damietta, Damietta Governorate as shown in Figure 2.1. El-Manzala Lake is to the east, Dakahlia Governorate lies to the south, and to the west are El-Sharqawia canal and the Nile River.

The selected site has the general characteristics of marginal lands:

- Drainage system problems
- High water table
- Increased soil salinity
- Seawater intrusion
- Pollution due to extensive use of chemicals; low water quality
- Available water increases relatively in winter
- Tail-end canal problems become less acute, especially in summer
- All farmers use surface irrigation systems.

The area under study is about 8000 ha, which represents about 15% of the total cultivated area. According to the Agricultural Census of 2000, the area of El-Talamza is about 342 feddan, El-Sibakhat is about 871 feddan and the 'Out of area served' region is about 498 feddan

2.1.1 Soil characteristics

Marginal lands (salt affected soils) are irrigated with fresh water, drainage water, and a mix of the two. Such soils are generally of high salinity and/or have a high exchangeable sodium percentage (ESP) in the case of alkalinity problems. Soils exhibiting both problems are termed as saline alkali soil (Table 2.1).

Figure 2.1. The marginal lands site location at El-Serw.

Table 2.1. Fertility and the physical and chemical analyses of the soils of the marginal lands, El-Serw.

Farm	N (ppm)	P (ppm)	K (ppm)	Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	pH (1:2.5)	EC (dS/m)	ESP
1	36	11.2	570	5.48	18.51	26.43	49.58	8.1	1.9	3.5
2	35	10.1	600	5.75	13.15	32.28	48.22	8.3	2.2	3.4
3	40	12.0	620	4.27	13.49	37.95	44.29	8.2	1.8	1.8
4	33	9.8	680	5.29	16.86	32.41	45.44	8.4	2.8	18.6
5	34	10.6	510	4.28	12.6	28.02	55.46	8.0	9.5	16.2
6	50	11.8	520	6.48	25.16	25.58	42.42	8.0	6.8	16.8

Note: EC – electrical conductivity

Considering the marginal soil analysis (Table 2.1), it is quite clear that El-Serw site is, in general, characterized by a high clay content (between 48% and 55%) and high pH values – ranging between 8.0 and 8.4 with an average value of 8.16. The soils from the six farms in the investigation were tested and found to vary from one farm to the other. The soils of Farms 1, 2, 3, and 4 were slightly affected by salinity, with an EC value ranging between 1.8 and 2.8 dS/m (average 2.17 dS/m) while those of Farms 5 and 6 had high EC readings (6.8 – 9.5 dS/m) as well as high ESP values (16.2 to 18.6) indicating that both farms are located on saline-alkaline soils.

2.1.2 Soil and soil fertility improvement practices

The three groups of farmers called: El-Talamza, El-Sebakhat and Out of area served. use manure and chemical fertilizers to improve the soil and soil fertility as illustrated in Table 2.2. Applications of manure and fertilizer are the most common methods, while gypsum ranks second, and drainage and sub-soiling rank third among the fertility management practices in the three groups.

All farmers in the three groups have salinity problems on their lands. However, there are many treatments to maintain the soil in a good quality. In general, most farmers apply the Mole method for drainage in addition to main and branches drains. In the case of soil fertility, most farmers, except the 'Out of area served' group, add manure and chemical fertilizers.

2.1.3 Farmers selection procedures

A sample of 30 farmers was interviewed. The farmers were selected from 3 different groups located across El-Shoka canal, Khodry canal, Anber drain and El-Serw main drain, and they are spatially distributed as follows:

- The first group, referred to as El-Talamza group, consists of farms where fresh water is the main source for irrigation;
- The second group, referred to as El-Sebakhat group, consists of farms where fresh water and drainage water from the

Table 2.2. Quantity applied of fertilizer per feddan in the three groups.

Item	El-Talamza	El-Sebakhat	Out of area served
Manure:			
Availability	No	Yes	Yes
Application	Yes	Yes	Yes
Quantity (m^3)	8	8	12
Cost (EGP/m^3)	10	10	10
Leaf fertilizer:			
Application	No	Yes	No
Chemical fertilizer (50 kg bag):			
Urea 46.5%	3	3	3
Ammonium nitrate 33.5%			
Ammonium sulfate 20%			
Mono Superphosphate 15.5%	3	4	3
Potassium 48%			

Source: Checklist of the Participatory Rural Appraisal report.

Anber drain and El-Serw main drain are the main sources for irrigation;

- The third group, referred to as 'Out of area served' (Kharerg El-Zemam) group, consists of farms where the drainage water of the El-Serw main drain is the main source for irrigation.

Farmers were selected from three different groups located across the El-Shoka canal and El-Serw main drain. Three basins were selected, referred to as groups El-Talamza, El-Sebakhat and 'Out of area served.

A sample of 16 farmers was selected to monitor the biophysical and socioeconomic parameters – 6 farmers in El-Talamza group, and 5 farmers each for El-Sebakhat group and the 'Out of area served' group. The selected farmers were interviewed twice a year to collect socioeconomic information.

2.2 Characteristics of the community

2.2.1 Farm size

There are not too many variations in farm size among the farmers in the 3 groups. For example, in El-Talamza group, the average farm size is estimated at 3.5 feddan. The average farm size in El-Sebakhat group is estimated at 4.2 feddan, while that for the 'Out of area served' group is estimated at 2.6 feddan.

2.2.2 Family size and workforce

In El-Talamza group, the family size ranges between 0.8-6.2 HCU, with an average of 3.8. However, the family size in El-Sebakhat group ranges between 1.8 and 8.6 HCU, with an average of 4.6. For the 'Out of area served' group, family size ranges between 2.6 and 14.8 HCU, with an average of 7.0. The 'Out of area served' group has the largest labor families in terms of Human Labor Units.

2.2.3 Structural ratios

The average land size available per family member (the feddan of cultivated area per human consumption unit, or CA/HCU) in El-Talamza group is 0.9 feddan. For El-Sebakhat group this ratio is estimated at 0.9 feddan and for the 'Out of area served' group it is estimated at 0.4 feddan. In contrast, the average family labor unit available per feddan of cultivated area (HLU/CA) is 0.26 for El-Talamza group and 0.29 for El-Sebakhat group. The HLU/CA values for the groups is less than that for the 'Out of area served' group, consequently they have higher needs for hired labor. The structural ratios are summarized in Table 2.3

2.2.4 Livestock holding

Most farmers (82%) have animals. The herd size is illustrated in Table 2.3.

2.2.5 Farmer's income

Tables 2.4 and 2.5 show that farmers in El Serw area consider field crops and livestock as the main sources of agricultural income for both winter and summer.

2.2.6 Cropping patterns

Table 2.6 shows that rice and cotton are the main summer crops while wheat and berseem are the main winter crops for the three groups.

Most farmers practice two-year crop rotations. There are four main crop rotations for the three groups:

- Berseem/rice
- Berseem/cotton
- Wheat/cotton
- Wheat/rice
- Area under production

Table 2.7 shows some economic indicators of the winter crops for the three groups, while Table 2.8 illustrates those of the summer crops for the three groups.

2.2.7 Crop varieties

In addition to cotton, the wheat varieties planted by the three groups were Sakha 103, Sakha 104 and Sakha 93 and the rice varieties were Hybrid 1 and Hybrid 31.

2.2.8 Water management and supply

There are variations in El-Serw water supply and quality among farmers, depending on the distances of their fields from the source. Water problems differ according to whether the farm is located on the canal or the mesqa.

Table 2.3. Structural ratios of the three groups.

Group	Average farm size (feddan)	HCU	CA/HCU	LU	HLU	HLU/CA
El-Talamza	3.5	3.8	0.9	2.9	0.9	0.26
El-Sebakhat	4.2	4.6	0.9	4.9	1.2	0.29
Out of area served	2.6	7	0.4	4.6	2.7	1.04

Note: HCU – Human Consumption Unit; HLU – Human Labor Unit; LU – Livestock Unit.
Source: Collected and calculated from the multidisciplinary survey.

Table 2.4. Income earned (EGP) from different activities for the three groups in the winter seasons 2005 and 2006.

Group	Farmer code no.	Season 2005				Season 2006			
		Field crops	Livestock	Off-farm income	Total income	Field crops	Livestock	Off-farm income	Total income
El-Talamza	1	12,000	4,800	7,000	23,800	31,865	21,243		53,108
	2	2,500	4,500		7,000	7,570	7,570	6,000	13,570
	3	1,800	3,600		5,400	2,300	300		2,600
	4	22,000			22,000	23,800	2,644		13,076
	5	4,000	4,000		8,000	6,538	6,538		13,076
	6	4,500		5,000	9,500	3,645			3,645
	Av.	7,800	2,817	2,000	12,617	12,620	6,383	1,000	16,513
El-Sebakhat	1	22,000	5,000		27,000	22,176	2,772		24,948
	2	6,000	1,500		7,500	12,110	3,027	7,000	22,137
	3	5,000	1,000	4,000	10,000	6,74	1,593	7,000	14,967
	4	15,000	5,000	6,000	26,000	16,415	4,103	6,000	26,518
	5	24,000	6,000		30,000	30,290	12,981		43,271
	Av.	14,400	3,700	2,000	20,100	17,473	4,895	4,000	26,368
Out of area served	1	6,000	2,400	5,000	13,400	7,175	1,793	4,000	12,968
	2	3,500		1,000	4,500	8,720			8,720
	3	6,000			6,000	6,000			6,000
	4	5,000			5,000	5,100		7,000	12,100
	5	1,700	600	2,000	4,300	1,830	457	2,000	4,287
	Av.	4,440	600	1,600	6,640	5,765	1,125	2,600	8,815

Source: Data survey.

Table 2.5. Income earned (EGP) from different activities for the three groups in the summer seasons 2005 and 2006.

Group	Season 2005				Season 2006			
	Field crops	Livestock	Off-farm income	Total income	Field crops	Livestock	Off-farm income	Total income
El-Talamza	7,800	2,817	2,000	12,617	12,620	6,383	1,000	16,513
El-Sebakhat	14,400	3,700	2,000	20,100	17,473	4,895	4,000	26,368
Out of area served	4,440	600	1,600	6,640	5,765	1,125	2,600	8,815

Source: Data survey.

Table 2.6. Cropping patterns for the three groups.

Group	Summer 2004-2005	Winter 2004-2005	Summer 2006	Winter 2006-2007
El-Talamza	Rice, cotton	Wheat, berseem	Rice, cotton	Wheat, berseem, faba bean
El-Sebakhat	Rice, cotton	Wheat, berseem	Rice, cotton	Wheat, berseem
Out of area served	Rice, cotton	Wheat, berseem, Sugar beet	Rice	Wheat, berseem

Source: Collected and calculated from the multidisciplinary survey.

El-Talamza group and El-Sebakhat group receive fresh, good quality irrigation water in the winter season, but there is a shortage of water in summer, especially in May, June, and July. At this time the farmers use drainage water from El-Serw and Anber drains. Even though the water quality of the latter is very bad they do not have any other source. Farmers in the 'Out of area served' group depend on El-Serw drain for irrigation.

Farmers in the three groups do not have any water table problems except in May, June, and July. They solve any water problems by allocating irrigation time among themselves.

2.2.9 Pests and weeds control

Weeds are found in the fields of the three groups. The manure and the water used on the fields are the main reasons for this infestation. Farmers of El-Talamza group apply herbicides to control weeds. El-Sebakhat group farmers weed by hand while the 'Out of area served' group farmers use both herbicides and hand weeding. Cotton leaf worm and red worm are the main plant pests for the three groups and they apply chemicals to control these pests.

Farmers in the three groups have difficulties in getting technical information. El-Talamza group and El-Sebakhat group rely on their own experiences. The 'Out of area served' group gets information from the agricultural station.

2.2.10 Land productivity

Total production was recorded to evaluate the impacts of the project. Tables 2.9 and 2.10 show the total winter and summer production for the three groups.

Table 2.11 shows that the productivity of the second and third groups is higher than that of the first group for all crops, except for berseem.

2.3 Objectives and methodologies

2.3.1 Winter crops

Wheat

- Farmers' irrigation practices
- Full irrigation (ET+0.2ET for leaching or more according to salinity), basin irrigation
- 70% of full irrigation, basin irrigation
- Wide furrow after broadcasting.

Berseem (dry and wet planting)

The traditional method for planting berseem is to broadcast wet seed on flooded land. This method increases

Table 2.7. Area under production for the three groups in winter.

Group	Farmer code No.	Crops	Area in 2005 (feddan)	Area in 2006 (feddan)
El-Talamza	1	Wheat	2.52	2.1
		Berseem	2.39	2.38
		Faba bean		0.42
	2	Wheat	0.35	0.42
		Berseem	0.35	0.4
		Faba bean	0.12	
	3	Wheat		0.13
		Berseem	3.7	
	4	Berseem	2.1	0.24
		Wheat	2.35	2.1
	5	Sugar beet		2.35
		Wheat	0.42	
	6	Wheat	0.42	0.84
		Berseem	0.42	0.42
El-Sebakhat	1	Wheat		0.42
		Berseem	0.42	1.79
	2	Wheat	0.84	1.68
		Berseem	0.42	0.84
	3	Wheat	0.95	0.84
		Berseem		0.42
	4	Wheat	1.26	0.56
		Berseem	1.63	1.68
	5	Wheat	1.26	1.68
		Berseem	2.1	1.68
		Sugar bee	0.42	
Out of area served	1	Berseem	1.05	1.68
		Wheat	0.42	
	2	Berseem	0.84	1.47
	3	Wheat		1.68
		Berseem	0.84	
	4	Wheat	0.84	0.84
	5	Wheat	0.21	0.84
		Berseem	1.05	

Source: Monitoring and Evaluation (M&E) Survey Report.

Table 2.8. Area under production for the three groups in summer.

Group	Farmer code no.	Area for rice (feddan)			Area for cotton (feddan)		
		2004	2005	2006	2004	2005	2006
El-Talamza	1	6	10	11	6	2	1
	2	1.96	1.3	0.96	0	0.63	1
	3	0.88	0.88	0.88	0	0	0
	4	11	11	11	0	0	0
	5	2	2	1	0	0	1
	6	2	2	1.5	0	0	0
El-Sebakhat	1	5	5.2	6.25	3.4	4	2
	2	2	2	2	2	2	2
	3	0	1.2	1.2	2.3	1.2	1.2
	4	3	5	5.5	3.88	2	1.5
	5	6.5	6	5	3	3.5	4.5
Out of area served	1	3.5	3.5	3.5	0	0	0
	2	2	2	4	0	0	0
	3	2	2	2.5	0	0	0
	4	2	2	2	0	0	0
	5	1	1	1	0	0	0

Source: Monitoring and Evaluation (M&E) Survey Report.

water losses through evaporation and percolation. A new planting approach was applied – dry seeds were planted on dry soil with the same plant density as in the traditional method. This method insured uniformity of water distribution in the field and led to increased productivity. In addition, it saved an application of water and decreased the irrigation costs.

- Farmers' irrigation practices
- Full irrigation (ET+0.2ET for leaching requirements)
- 70% of full irrigation.

2.3.2 Summer crops

Rice

- Farmers' practices
- Irrigation every four days with 7 cm depth
- Irrigation every eight days with 7 cm depth

Cotton

- Farmers' practices
- Full irrigation
- 70% of full irrigation

Table 2.9. Total winter production for the three groups.

Group	Farm code	Crops	Production 2004-2005 (t/ha)	Production 2005-2006 (t/ha)
EL-Talmza	1	Wheat	37.5	30
		Berseem	213.75	250
		Faba bean		3.5
	2	Wheat	4.675	7
		Berseem	62.25	62.5
		Faba bean	0.35	
	3	Wheat		3
		Berseem	34.8	
	4	Berseem	30.8	50
		Wheat	312.5	30
	5	Sugar beet		450
		Wheat	5.25	
	6	Wheat	60	80
		Berseem	3	3
EL-Sebakhat	1	Wheat	25	30
		Berseem	5	22.5
		Onion		
	2	Wheat	8.75	350
		Berseem	50	12
	3	Wheat	10.125	125
		Berseem		5.625
	4	Wheat	15.75	112.5
		Berseem	290.25	22.5
	5	Wheat	18.75	160
		Berseem	500	4.5
		Sugar beet	37.5	
Out of area served	1	Berseem		280
		Wheat	4.5	
	2	Berseem	218.75	162.5
	3	Wheat		187.5
		Berseem	110	
	4	Wheat	8.5	10.5
	5	Wheat	1.325	9.375
		Berseem	75	1.25

Source: Collected and calculated from the multidisciplinary survey.

Table 2.10. Total summer production for the three groups.

Group	Production of rice (t/ha)			Production of cotton (t/ha)		
	2004	2005	2006	2004	2005	2006
El Talamza						
1	20	35	40	0.89	2.2	1.5
2	6	6.5	4.5		0.94	1.3
3	3	3	4.3			
4	30	32	33			
5	6.5	7	3.5			1.2
6	6	6.5	5.5			
El Sebakhat						
1	15	20.5	25	3.14	5.7	1.9
2	7	8	8	0.9	0.9	1.2
3		15	4	2.8	1.9	1.3
4	18	20	22	2.4	2.9	1.6
5	16	20	20	2	2.8	4.9
Out of area served						
1	10	10.5	10.5			
2	6.5	7	16			
3	6.5	7.5	10			
4	7	7	8			
5	2.5	2.5	3			

Source: Collected and calculated from the multidisciplinary survey.

2.4 Results

2.4.1 Wheat

Results in Tables 2.12 and 2.13 indicate that deficit irrigation reduced the amounts of irrigation water by between 145mm and 58 mm (between 25% and 19%) in 2005-2006 and between 174 mm and 92 mm (between 21% and 29%) in 2006-2007. Over all, the average amounts of water saved were 107 mm (22%) in 2005-2006 and 137 mm, (24%) in 2006-2007.

At four of the six farms, deficit irrigation under basin conditions resulted in a significant reduction in the wheat yield in 2006-2007 as shown in Tables 2.12, 2.13, and 2.14. However, the yield reductions were much less than the amounts of water saved in the two seasons. Yield reductions ranged from 2% to 8% in 2005-2006 and from 2% to11% in 2006-2007 while the amounts of water saved ranged from 19% to 25% in 2005-2006 and from 21% to 27% in 2006-2007. The reductions in the yields depended on the farmers' management practices. Deficit irrigation resulted in a lower grain yield than the farmers' irrigation practices. In 2005-2006 the yields were less by between 100 kg/ha (2%) and 152 kg/ha (8%) and in 2006-2007 they were down by between 117 kg/ha (2%) and 790 kg/ha (11%) for the farms on these marginal lands.

Table 2.11. Productivity of main crops in El-Serw area.

Crop	El-Talamza	El-Sebakhat	Out of area served
Winter season crops			
Wheat (t/ha)	5.8	7.0	7.0
Berseem (t/ha)	37.5	32.5	37.5
Sugar beet (t/ha)			50
Summer season crops			
Cotton (t/ha)	2.0	3.2	2.8
Rice (t/ha)	7.5	10	8.8

Source: Collected and calculated from the multidisciplinary survey.

Table 2.12. Effect of different water regimes on the yield of wheat on marginal lands at El-Serw, 2005-2006 and 2006-2007 seasons.

	Talamza		Sebakhat		Out of area served	
Farm	1	2	3	4	5	6
2005-2006 Amount of water applied (mm)						
Farmer practice	595	587	590	592	297	304
Req	558	547	539	534	282	291
0.7 req	463	455	449	447	233	246
2006-2007 Amount of water applied (mm)						
Farmer practice	646	643	723	607	450	345
Req	613	605	679	505	430	311
0.7 req	512	504	554	433	336	253
$W.F_b$	536	533	584	450	368	275
2005-2006 Yield (t/ha)						
Farmer practice	5.60	5.25	4.55	6.20	4.52	3.35
Req	5.56	5.30	4.60	6.25	4.53	3.40
0.7 req	5.50	5.15	4.40	5.70	4.15	3.30
Aver	5.55	5.23	4.52	6.05	4.40	3.35
2006-2007 Yield)t/ha)						
Farmer practice	$6.02^{(a)}$	6.70^{a}	6.25^{b}	7.19^{b}	5.60^{b}	5.45^{b}
Req	6.62^{b}	7.12^{b}	6.79^{c}	8.38^{c}	6.18^{c}	6.24^{c}
0.7 req	5.90^{a}	6.40^{a}	5.81^{a}	6.40^{a}	5.05^{a}	4.85^{a}
$W.F_b$	6.61^{b}	7.20^{b}	7.27^{d}	8.03^{c}	5.93^{bc}	5.99^{c}

Note: + $^{(a,b,cd)}$: Numbers followed by the same letter are not statistically different at a < 5%.

Table 2.13. Effect of interventions on WP for wheat in kg/m³ at El-Serw in the 2005-2006 and 2006-2007 seasons.

	El-Talmza		Sebakhat		Out of area served	
	Hassan	Hamdy	El-Bon	Mohamdein	El-Sayed	El-Morsy
2005-2006						
Farmer practice	0.94	0.89	0.77	1.05	1.52	1.1
Req	1.00	0.97	0.85	1.17	1.61	1.17
0.7 req	1.19	1.13	0.98	1.28	1.78	1.34
2006-2007						
Farmer practice	0.93	1.04	0.87	1.19	1.24	1.58
Req	1.08	1.18	1.00	1.66	1.44	2.01
0.7 req	1.15	1.27	1.05	1.48	1.50	1.92
Water productivity (kg/m³)	1.23	1.35	1.25	1.78	1.61	2.18

Note: Req – irrigation water requirements.

Table 2.14. Average amount of water applied, yield, and WP for wheat at El-Serw for the 2005-2006 and 2006-2007 seasons.

	Farmer practice	Req	0.7 req	$W.F_h$
Water applied (mm)	558	503.4	394	438.8
Yield (t/ha)	5.556	5.915	5.217	6.839
WP (kg/m^3)	1.091	1.261	1.364	1.567
Relative amount of water applied	1	0.90	0.71	0.79
Relative yield	1	1.06	0.94	1.23
Relative WP	1	1.16	1.16	1.44

Note: Req – irrigation water requirements.

In the experiment, deficit irrigation resulted in an increase in WP by between 0.22 kg/m^3 (17%) and 0.24 kg/m^3 (25 %) in 2005-2006. They were also up by between 0.221 kg/m^3 (21%) and 0.339 kg/m^3 (25%) as compared to the yields recorded for the farmers' irrigation practices in 2006-2007. Generally, the WP was 1.115 kg/m^3 for the farmers' irrigation practices and 1.333 kg/m^3 for deficit irrigation practices in 2005-2006 and between 1.141 kg/m^3 for the farmers' irrigation practices and 1.395 kg/m^3 for the deficit irrigation practices in 2006.

The irrigation water requirement saved 55 mm (10%), increased the yield by 6 %, and the WP by 0.170 kg/m^3 (16%) over the comparable results using the farmers' usual irrigation practices. The deficit irrigation practice increased WP by 25%.

In conclusion, deficit irrigation yield of 239 kg/ha represented a yield reduction of about 6%. This was achieved with a 29% (162 mm) saving in irrigation water and resulted in improving WP by 0.273kg/m^3 as compared to farmers' irrigation practices.

Traditionally, at El-Serw site, wheat is not grown in narrow raised seed beds, but is cultivated as a broadcast crop in the basin. Tables 2.12 and 2.14 and Figure 2.2 show the effects (RBb) of the irrigation water interventions used on grain yield and water productivity (WP). The amount of water saved compared to the farmers' traditional management practices (growing wheat in the basin as a broadcast crop) ranged from 72 mm to 157mm. The amount of irrigation water saved varied between 157 mm (26%) and 72 mm (17%) as compared to amount used in the farmers' traditional practices. Overall, the amount of irrigation water saved was 111 mm, which represents a saving on the amount used in the farmers' traditional practices of about 20%.

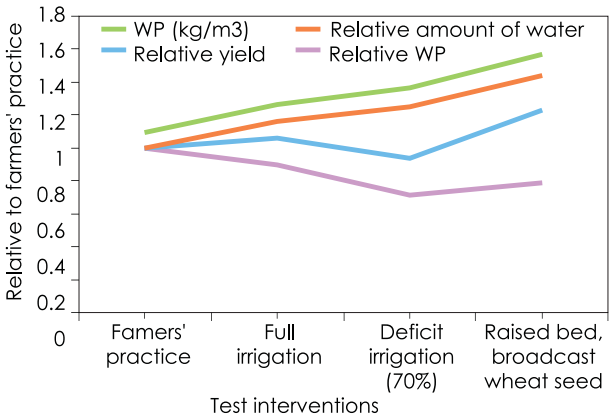

Figure 2.2. Average WP, relative amount of water, relative yield and relative WP of wheat at El-Serw site for the 2005-2006 and 2006-2007 seasons.

Besides reducing the amount of water that needs to be applied by the farmers, the broadcasting seed on a raised-seed bed method significantly increased wheat grain yield – by between about 8% and

16% (between 509 kg/ha and 1018 kg/ha) – over that produced by the farmers' irrigation practices. The average increase in wheat grain yield over the farmers' irrigation practices was 639 kg/ha (10%). See Table 2.12.

The use of wide raised seed beds reduced the amount of water that needed to be applied by the farmer and increased the yield, leading to higher water productivity. In the 2006-2007 season, the water productivities for wheat grown by broadcasting seed on wide raised beds was as shown in Table 2.14. These results can be compared with the WPs achieved using the farmers' traditional irrigation practices which are available above. Over all the farms, the water productivity for the farmers' practices was 1.146 kg/m^3, while that for the wide raised beds was 1.585 kg/m^3 – this represents a nearly 38% increase.

Generally, under salt-affected conditions, planting wheat on wide furrows by broadcasting the seed seems a simple way to save water and increase wheat grain yield. This was reflected in higher water productivity. The raised seed bed saved 119 mm (21%) of the water and increased the yield by 1283 kg/ha (23%), and the water productivity 0.476 kg/m^3 (44%).

2.4.2 Berseem

The data in Table 2.15 illustrate the effects of the interventions on water applied, yield, and water productivity of berseem at El-Serw for 2005-06 and 2006-07.

By comparing deficit irrigation (70% of full irrigation) with the farmers' practices in 2005-2006, it was found that this technique saved at least 52% of the water applied under the farmers' practices. The corresponding reduction in yield ranged from 9% to 19%. The water productivity for the deficit irrigation practice followed by that for the full irrigation treatment showed higher values than that achieved following the farmers' usual practices.

In 2006-2007, deficit irrigation reduced the seasonal amount of water applied by the farmers by 371 mm (a 44% reduction). Figure 2.3 shows that deficit irrigation significantly reduced dry yield by 2.95 t/ha (12%) compared to the yield from the farmers' usual irrigation practices under basin irrigation. However, the reduction in fodder yield is much less than the amount of water saved. Thus, the water productivity of the deficit irrigation was higher by 0.724 kg/m^3 (33%) than that obtained by traditional practices. In comparison to the water requirement of berseem, the farmers applied on average 119 mm (15%) more than was necessary. This increased supply of water resulted in a decrease in yield of between 0.5 t/ha and 2.9 t/ha in 2005-2006 and 2.3 t/ha in 2006-2007. These figures represent an average decrease in 2005-2006 of 6.5% and a decrease of 8 % for the second season. A higher WP was obtained following the deficit irrigation regime, followed by supplying the actual irrigation water requirements.

2.4.3 Cotton

The data for the cotton yield, given in Table 2.16 indicates that the farmers' irrigation practices gave the lowest seed yields. The yield obtained using wide furrow was 173 kg/ha higher than farmers' practices in 2006 and 906 kg/ha more in 2007. The amount of

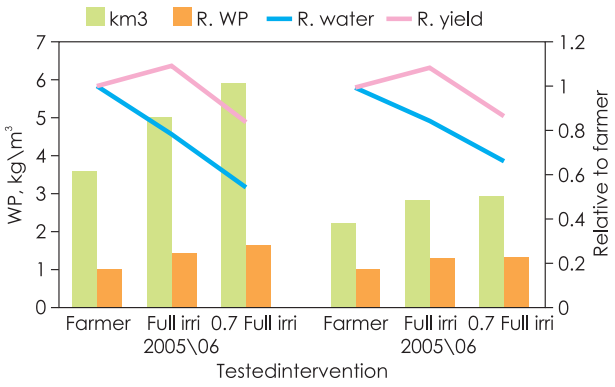

Figure 2.3. Average WP, relative yield, relative amount of water applied, and relative WP of berseem at El-Serw in the 2006 and 2007 seasons.

Table 2.15. Effects of different water treatments on the yield, and WP for berseem at El-Serw for the 2005-2006 and 2006-2007 seasons

Farmer	Treatment	2005-2006			2006-2007		
		Water applied (mm)	Yield (t/ha)	WP (kg/m³)	Water applied (mm)	Yield (t/ha)	WP (kg/m³)
Hamdy	Farmer practice	510	23.42	4.592	1,100	24.4[b]	2.218
	Req	385	24.11	6.262	929	26.69[c]	2.873
	0.7 req	271	21.85	8.062	729	21.45[a]	2.942
El-Bon	Farmer practice	540	14.40	2.667			
	Req	375	17.33	4.620			
	0.7 req	263	12.00	4.561			
Khafagy	Farmer practice	450	15.83	3.517			
	Req	384	16.35	4.258			
	0.7 req	268	13.95	5.204			
		Relative					
Hamdy	Farmer practice	100	100	100	100	100	100
	Req	75.49	102.95	136.37	84	109	129
	0.7 req	53.14	93.30	175.57	66	88	133
El-Bon	Farmer practice	100	100	100			
	Req	69.44	120.35	173.23			
	0.7 req	48.70	83.33	171.02			
Khafagy	Farmer practice	100	100	100			
	Req	85.33	103.28	121.07			
	0.7 req	59.56	88.12	147.97			

Table 2.16. Effects of different water management interventions on the yield and WP of cotton on marginal land at El Serw in the 2006 and 2007 seasons.

	2006				2007			
	Farmer practice	Full	0.7 full	WF_h	Farmer practice	Full	0.7 full	WF_h
Yield (t/ha)	2.365	3.193	2.71	2.538	2.730	3.702	3.825	3.636
Amount of water (mm)	1133	1016	855	854	995	919	745	781
WP (kg/m³)	0.209	0.314	0.317	0.297	0.274	0.403	0.513	0.466
Relative								
Yield	1	1.350	1.146	1.073	1	1.356	1.4	1.33
Amount of water	1	0.897	0.755	0.754	1	0.92	0.75	0.78
WP	1	1.505	1.518	1.423	1	1.47	1.87	1.70

irrigation water waved by the wide furrow method amounted to 25% (279 mm) in 2006 and 22 % (214 mm) for 2007. For water productivity, the relative increases were from 50 to 58%, being 0.105, 0.207 and 0.088 kg/m for full irrigation, 0.75 of required irrigation and wide irrigation furrow, respectively.

2.4.4 Rice

The effects of different irrigation regimes on the yield of rice grown on marginal lands at El-Serw are shown in Tables 2.17 and 2.18. The data show that using a saturation regime resulted in a lower rice yield as compared to the farmers' usual regime of watering at four or eight day intervals to a 7cm depth. The best results were obtained using irrigation every four days in the two seasons 2006 and 2007.

The relative increases in yield over the farmers' practices ranged from 168 kg/ha (2%) to 855 kg/ha (11%) in 2006 2 and from 325kg/ha (1%) to 1055 kg/ha (7%) in 2007. Also, the four day intervals saved between

Table 2.17 Effects of different water treatments on the yield and WP of rice on marginal lands at El-Serw in the 2006 season.

	Farmer practice	4 day	8 day	Saturation	Aver	Farmer practice	4 day	8 day	Saturation
	Yield (t/ha)					Relative yield			
Farm 2 Hassan	6.913	7.688^{i}	6.178^{m}	5.8^{n}	6.645^{e}	1	1.11	0.89	0.84
Farm 3 El Bon	9.08^{cde}	9.388^{b}	8.925^{e}	7.245^{k}	8.66^{b}	1	1.03	0.98	0.8
Farm 4 Mohamde	9.22^{bc}	10.075^{a}	9.235^{bc}	7.79^{hi}	9.08^{a}	1	1.09	1.00	0.84
Farm 5 Sayed	7.893^{h}	8.63^{f}	8.213^{g}	7.25^{k}	7.997^{d}	1	1.09	1.04	0.92
Farm 6 Morsy	8.96^{de}	9.128^{cd}	8.72^{f}	7.443^{j}	8.563^{c}	1	1.02	0.97	0.83
Aver	8.413^{b}	8.982^{a}	8.254^{c}	7.106^{d}	8.189	1	1.07	0.98	0.84
	Amount of water applied (mm)					Relative amount of water applied			
Farm 2 Hassan	1500	1350	1100	920	1218	1	0.9	0.73	0.61
Farm 3 El Bon	1400	1300	1150	1000	1213	1	0.93	0.82	0.71
Farm4 Mohamde	1350	1250	1050	910	1140	1	0.93	0.78	0.67
Farm 5 Sayed	1050	950	800	700	875	1	0.9	0.76	0.67
Farm 6 Morsy	1150	1050	900	740	960	1	0.91	0.78	0.64
Aver	1290	1180	1000	854	1081	1	0.91	0.78	0.66
	Water productivity (kg/m^3)					Relative water productivity			
Farm 2 Hassan	0.461	0.569	0.562	0.63	0.556	1	1.23	1.22	1.37
Farm 3 El Bon	0.649	0.722	0.776	0.725	0.718	1	1.11	1.20	1.12
Farm 4 Mohamde	0.683	0.806	0.88	0.856	0.806	1	1.18	1.29	1.25
Farm 5 Sayed	0.752	0.908	1.027	1.036	0.931	1	1.21	1.37	1.38
Farm 6 Morsy	0.779	0.869	0.969	1.006	0.906	1	1.12	1.24	1.29
Aver	0.665	0.775	0.843	0.851	0.783	1	1.17	1.27	1.28

Note: + $^{(a,b,cd)}$: Numbers followed by the same letter are not statistically different at a < 5%.

Table 2.18. Effects of different water treatments on the yield and WP of rice on marginal land at El-Serw in the 2007 season.

	Farmer practice	4 day	8 day	Satur	Raised bed method	Farmer practice	4 day	8 day	Satur	Raised bed method
	Yield (t/ha)					Relative yield				
1	8.5[b]	9.09[bc]	8.223[b]	6.338[a]	8.214[b]	1	1.07	0.97	0.75	0.97
2	8.958[b]	9.228[b]	8.768[b]	6.768[a]	9.105[b]	1	1.03	0.98	0.76	1.02
3	8.958[b]	9.588[c]	8.525[b]	7.175[a]	8.703[b]	1	1.07	0.95	0.80	0.97
4	8.933[c]	8.988[c]	8.26[b]	7.393[a]	8.956[c]	1	1.01	0.92	0.83	1.00
5	8.913[c]	9.238[c]	8.705[b]	8.178[b]	9.331[c]	1	1.04	0.98	0.92	1.05
Aver	8.852	9.226	8.496	7.170	8.862	1	1.04	0.96	0.81	1.00
	Amount of water applied (mm)					Relative amount of water applied				
1	1200	1130	1030	760	725	1	0.94	0.86	0.63	0.60
2	1280	1180	1040	780	720	1	0.92	0.81	0.61	0.56
3	1320	1180	1020	840	800	1	0.89	0.77	0.64	0.61
4	1330	1190	1030	840	810	1	0.89	0.77	0.63	0.61
5	1160	1000	850	760	690	1	0.86	0.73	0.66	0.59
Aver	1258	1136	994	796	749	1	0.90	0.79	0.63	0.60
	Water productivity (kg/m^3)					Relative water productivity				
1	0.708	0.804	0.798	0.834	1.133	1	1.14	1.13	1.18	1.60
2	0.7	0.782	0.843	0.868	1.265	1	1.12	1.20	1.24	1.81
3	0.679	0.813	0.836	0.854	1.088	1	1.20	1.23	1.26	1.60
4	0.672	0.755	0.802	0.88	1.106	1	1.12	1.19	1.31	1.65
5	0.768	0.924	1.024	1.076	1.352	1	1.20	1.33	1.40	1.76
Aver	0.705	0.816	0.861	0.902	1.189	1	1.16	1.22	1.28	1.68

Note: + [(a,b,cd)] : Numbers followed by the same letter are not statistically different at a < 5%.

100 mm (18%) and 150 mm (27%) of the irrigation water in 2006 and between 70 mm (6%) and 140 mm (14%) in 2007, in comparison to the farmers' practices.

In 2006, irrigation at eight day intervals reduced the rice yield by between 155 kg/ha (2%) and 735 kg/ha (11%). The amount of water saved compared to the farmers' irrigation practices ranged from 250 mm (18%) and 400 mm (27%). In the 2007 season, irrigating at eight day intervals reduced the yield by between 190 kg/ha (2%) and 673 kg/ha (8%) while the amount of water saved ranged from 170 mm (14%) to 310 mm (27%). The advantage of the water saturation regime is that it saves the most irrigation water. The amount of water saved was not less than 350 mm (27%) and was as high as 580 mm (39%) in 2006 and varied between 442 mm and 500 mm in 2007. In 2006 the reduction in yield ranged from 643 kg/ha (8%) to not more than 1835 kg/ha (20%) while in 2007 the variation was from 735 kg/ha (8%) to2162 kg/ha (25%).

To introduce another simple water saving practice, rice grown on raised seed beds was tested in the second season, 2007 (Table 2.18). When calculated over the actual area sown on the raised bed, this treatment had total grain yields in g/m^2 of 821, 910, 870, 895 and 933 on Farms 1, 2, 3, 4, and 5. These results can be compared to the yields resulting from the farmers' usual irrigation practices of 850, 896, 896, 893 and 891 g/m^2. The amounts of water saved were 475, 560, 520, 470 and 509 mm which are not less than 39% as compared to farmers' practices (Table 2.18).

Tables 2.17 and 2.18 show that the average water productivity values for all the farms were, in ascending order, in 2006, 0.665 kg/m^3 (farmers' usual practices), 0.775 kg/m^3 (four day irrigation cycle), 0.843 kg/m^3 (eight day irrigation cycle), and 0.851 kg/m^3 (saturation treatment). The comparable values in 2007 were 0.705 kg/m^3 (farmers' practices), 0.816 kg/m^3 (four day irrigation cycle), 0.861 kg/m^3 (eight day irrigation cycle), 0.902 kg/m^3 (saturation treatment), and 0.923 kg/m^3 (raised bed method).

It can be seen, that the saturation treatment produced higher water productivity compared to the four and eight day irrigation cycles and the farmers' treatments. However, it is practically difficult for the farmers to adopt this finding. This raised seed bed method for rice cultivation was tested in the 2007 season as a modified cultural practice. The results pointed out that it is a promising practice if it is well implemented, for increasing rice water productivity, while maintaining acceptable yield levels. Consequently, growing rice on raised seed beds was carried out during the 2008 season in marginal land sites with certain modifications to improve the technology.

2.5 Conclusions

- The results of the on-farm trials showed that recommended irrigation techniques are simple techniques that can be easily implemented by the farmers. They can lead to a significant increase in the yield, crop water productivity, and in the amounts of water saved as compared with those obtained following the farmers' traditional practices.
- Deficit irrigation is a technique that has shown a beneficial effect in maximizing crop water productivity. The results of the trials carried showed that the implementation of such a technique, where a relatively high proportion of the irrigation water is saved, did not result in any significant losses in yield for the major crops.
- The raised bed technique showed very satisfactory results on the different sites investigated (old lands and marginal lands) with the main winter (wheat and berseem) and summer (corn and cotton) crops. This technique, besides saving around 30% of the amount of water applied, increased crop production by nearly 10% over the farmers' traditional irrigation practices. Furthermore, the implementation of such a simple technique resulted in average water saving amounting to between 20% and 25% of that corresponding to the basin irrigation practice of the farmers.
- When the crop was irrigated with 70% of the required amount of water, the reduction in wheat yield compared to that obtained under full irrigation was only 8%. This, again, confirms that we can produce nearly the same yield, while saving up to 30% of the water traditionally applied by farmers.
- Cotton could be produced successfully by reducing the volume of irrigation water applied. Irrigation of cotton with volumes of water corresponding to 70% of the required amount resulted in a yield reduction corresponding to 10% of the yield obtained under the farmer's irrigation practices.