Chapter 5: Socioeconomic assessment of improved water management practices in Egypt's irrigated agriculture

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5.1 Introduction and justification

Egypt has a cultivated area of 3.3 million ha, of which 2.6 million ha is the old lands of the Nile Valley and Delta, and the rest (0.7 million ha) is new land (including the salt-affected area in the north of Delta). The cropped area is 5.8 million ha with a cropping intensity of 1.8.

Egypt has limited its share of the Nile River to 55.5 billion m^3. Meanwhile, water demand is continuously increasing due to population growth, industrial development, and increasing living standards. With limited renewable fresh water resources and a continuous increase in water demand, the issue of future water planning for Egypt becomes very serious. If the present management practices and cropping patterns prevail, this could mean that up to 60% of the agricultural land will not be irrigated, (Resource Management (RM), Nile Valley and Red Sea Project (NVRSP).

A review and analysis of a relevant set of previous projects' activities (e.g., RM., Long-term Trial (LTT)/Long-term Monitoring (LTM), NVRSP, Agricultural Policy Reform Project (APRP-RDI)) provided a base line for this project and revealed that there are three major eco-systems in Egypt:

1. Old lands that include all cultivated areas in the Delta
2. Newly reclaimed lands that include El-Bustan area (sandy calcareous land)
3. Salt-affected lands that are threatened by sea-water intrusion and a shallow water-table.

The objectives of this report are to evaluate and test, with community participation; the benchmark water management options which sustainably improve water productivity, net return per water unit, and optimize water use. The strategies evaluated have to be economically viable, socially acceptable, and environmentally sound in the three different agricultural eco-systems. These eco-systems are located on three selected canals, the Alatf canal (improved versus not-improved misqa community in the Menofia Governorate), the El-Bustan canal (a water users association (WUA) versus a no water users association community in the Nubaria Area), and El-Shoka canal (a fresh water using versus a drain water using community in Damietta Governorate).

This report assesses and evaluates the Egyptian Irrigated Benchmarks site. Given the limitations of the data obtained from the trials conducted, the results presented are preliminary and subject to further verification through wide-scale experimentation and in demonstration trials on farmers' fields.

5.2 Site Selection and portability study

5.2.1 Site and community selection (Figure 3.1)

Three representative sites (old lands in the middle of Delta, new lands in Nubaria, and salt affected lands in north Delta) have been purposely selected across three chosen canals – the Alatf (in Menofia Governorate), El-Bustan (in Nubaria Area) and El-Shoka (in Damietta Governorate). With the participation of local agricultural cooperative members and leaders, who are involved in the planning and implementation of research, each selected site was classified into 2 or 3 communities based on water use, water quality, or the existence of a Water Users Association (WUA).

5.2.2 Preparatory studies

Three types of preparatory studies have been carried out since January 2005 to collect data that would help the multi-disciplinary team (MDT) to define the site characterization and sample design.

5.2.3 Review studies

Participatory Rural Appraisal (PRA)

Based on the information gap identified through the review of secondary information, additional data was collected using the participatory diagnosis (PD) methodology to get a deep understanding of the targeted communities. The volume and type of data collected depended on the information gaps and the degrees of precision and depth of analysis required for the diagnosis. A community based approach, ensuring community participation was adopted. A participatory rural appraisal (PRA) and its associated tools were applied to collect information to facilitate characterization of the selected sites.

Multidisciplinary surveys (MDS)

Multidisciplinary surveys were carried out to assess general feelings and values and to identify issues for in-depth investigation. Accordingly, after completing MDS for the selected sites, the MDS team randomly selected between 10 and 15 farmers from each selected community and interviewed them. The MDS questionnaire sought information on the following topics: farm system, farm income, crop rotation and pattern, water and soil management, productivity, farmers' preferences for different practices, farmers' awareness (knowledge), and the impact of new technology.

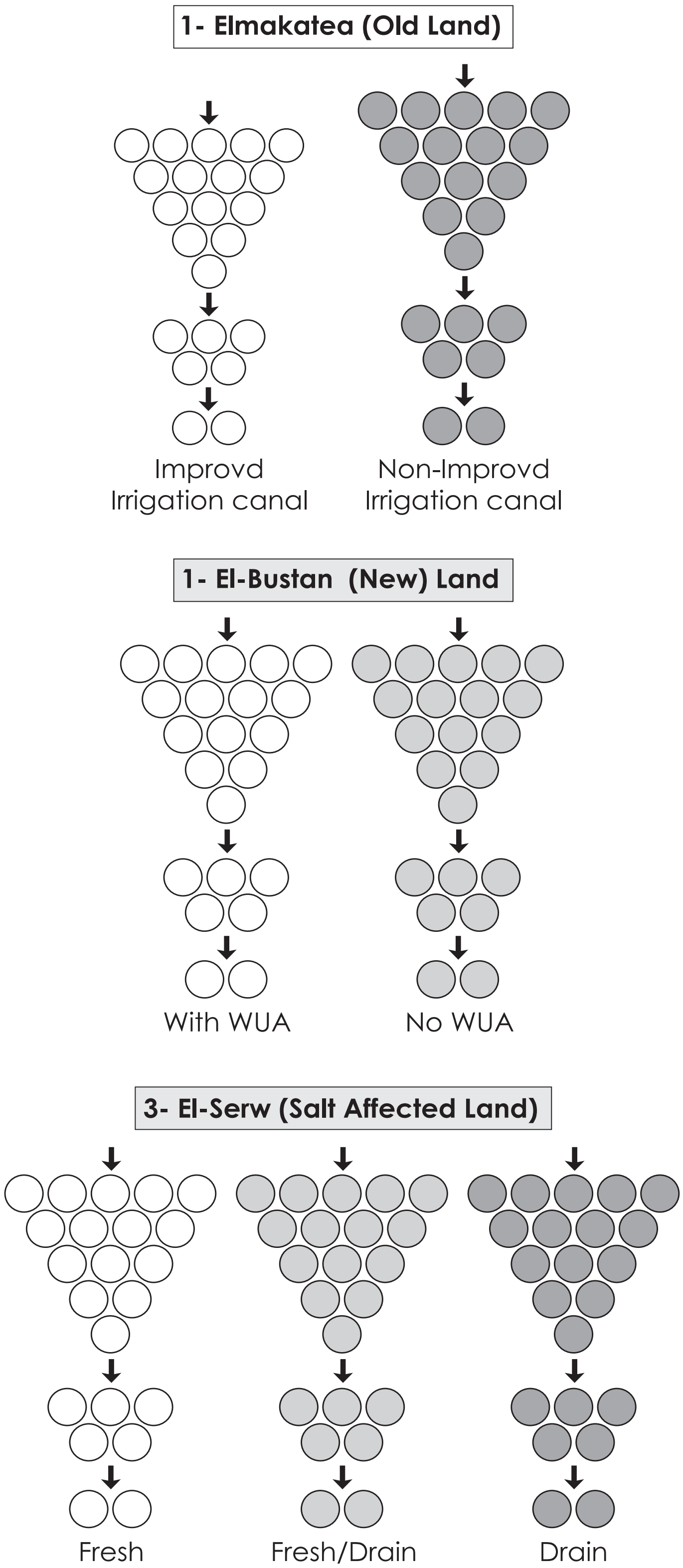
Monitoring and evaluation (M&E) surveys

A sample, of size five, farms/farmers was selected from each community to monitor the change in the farms' resources over time as a result of the farmers' practices. Finally, two of the farms/farmers being monitored were selected for water trials, sound agronomic practices, and farmers' perception. The socioeconomic team carried out two monitoring and evaluation (M&E) surveys annually, one in November to monitor the farming practices of the summer season and the other in June to cover the winter season. The team interviewed 10 farmers from the old lands, 10 from the new lands, and 15 from the salt-affected lands, using the participatory approach. The M&E questionnaires were completed and the data were processed into the database.

With the information from previous studies, PRA and MDS farmers/farms were selected for M&E and modeling activities from each site. Two-stage cluster sampling was used to select five farms from each community in the first stage for M&E activities. In the second stage, two farms were selected from these five for field trials and modeling. In a few instances some of the farmers selected for the trials in the first year were replaced in the second year with new ones. The clusters in each site are shown in Figure 5.1. These clusters are as follows.

Old lands

El-Makataa was the site selected in the old lands. The selected area was divided into two communities based on the construction of the irrigation system. The first one was an improved system misqa community and the other was as unimproved misqa community. The water flow is continuous in the improved system, while in the unimproved system it is based on a seven day irrigation cycle.



1 – Two communities across a misqa

15 farms: MDS, Sept/Oct 2005

5 farms: M&E 2005, 2006, 2007

2 farms: field interventions (modeling and field trials)

2 – Two communities across WUAs

15 farms: MDS, Sept/Oct 2005

5 farms: M&E 2005, 2006, 2007

2 farms: field interventions (modeling and field trials)

3 – Three communities across sources of water

10 farms: MDS, Sept/Oct 2005

5 farms: M&E 2005, 2006, 2007

2 farms: Field interventions (modeling and field trials)

Figure 5.1. Site and community selection

New lands

The village of El-Hussein in El-Bustan was selected as the representative site of the new lands. Two communities were selected in El-Hussein area, one which had established a water users association (WUA) and the other without one (No WUA).

The marginal lands

These are salt-affected soils located in the north of the Delta. This area is threatened by sea water intrusion and a shallow water table. El-Serw was selected as the representative site for this type of land. Three communities were selected based on their source of water and the water quality; El-Talamza as the representative community for a fresh water source, El-Sebakhat as the representative community for fresh and drain water sources, and Khareg El-Zimam as the representative community for a drain water source.

5.3 Simple methodology for economic evaluation of the tested options

Enterprise budgets analysis is used to compare the profitability of the alternative options. These budgets help ensure that all costs and receipts for crop budgets under the irrigation benchmark (IB) options are included. Often receipts and costs are difficult to estimate in budget preparation because they are numerous and variable. Net returns are calculated as the difference between total revenue (price * yield) per hectare and total variable costs which include land preparation, weeding, irrigation, and harvesting, and input costs, such as seed, fertilizer, manure, and chemicals. Fixed costs, such as land rent, were excluded as these are irrelevant to the farmers' decisions regarding their technology choices since crop yields are independent of these costs.

Because of the emphasis of the benchmarks project, returns to water application, (measured in EGP/m^3) are used as a measure of water productivity. This is obtained by dividing net returns per hectare by the amount of water applied per hectare. The results of both net returns and water productivity are presented as the average value for the two seasons for each crop. The results for each site are also disaggregated for the communities involved.

5.4 Results and discussion

5.4.1 Old land site

On the old lands, the major constraints to sustainability include poor water management and land fragmentation. The options tested include crop-specific irrigation regimes (full, deficit and raised bed options), full irrigation, and traditional farmers' practice on winter wheat and maize crops on the improved and unimproved misqa. Full irrigation is meant to meet the full crop water use and leaching requirement, while deficit irrigation represents 70% of the amount of water for full irrigation.

The results of the enterprise budget analysis for 2005-2006 and 2006-2007 (data not shown) indicate the superiority of wide furrow compared to the farmers' irrigation practice for wheat. The productivity and total returns increased by between 5% and 6%. Total variable costs decreased by between 7% and 8%, and returns over variable costs increased by between 12.5% and 13%. Net returns increased by between 5% and 10%. Accordingly, the new irrigation option, the raised bed (wide furrow) system, is expected to save between 20% and 30% of the irrigation water and be more profitable, accepted, and adopted by farmers either for winter or summer crops in the old lands.

Table 5.1 compares the profitability per unit area and water productivity (WP), in terms of the return per unit of water, in the old lands. Wheat farmers who applied wide furrow and deficit (70% of full) irrigation options had, on average, the highest returns per unit of water – wide furrow irrigation, EGP 3.24/m³ and deficit irrigation, EGP 3.31/m³. Wide furrow irrigation had the highest profit value (EGP 12,296/ha) compared to that from the farmers' practice (EGP 11,630/ha), full water requirement (EGP 11,557/ha) and 70% of the full requirement (EGP 11,976/ha). Wheat profitability under the alternative options is almost the same. However, the deficit irrigation and wide furrow options yielded much higher water productivity (returns per unit of water). Thus, the full requirement used in this experiment may have been overestimated. Future trials need to estimate this value more accurately.

Maize growers had a slightly higher returns to water application, EGP 0.77/m³ (for the wide furrow option) and EGP 0.73/m³ (for the deficit irrigation option), as compared to that for the farmers' usual practice and the full irrigation requirement options. However, these differences between the different options for maize are very small. In terms of net returns, the farmers' usual practice and full requirement have almost the same level of returns, while returns under deficit irrigation and wide furrow are slightly higher.

Wheat farmers following the raised bed (wide furrow) and deficit (70% of requirement) options obtained higher water productivity that amounted to 2.83 EGP/m³ and 2.97 EGP/m³, as compared to farmers' practice and the full requirement options in all systems (Figure 5.2). However, there was a higher potential for improving water productivity on unimproved misqa than on farms on improved misqa. This reflects the possibility of higher water losses and the tendency of farmers to over-irrigate their wheat crops in the unimproved systems. This may also be because the farmers using the improved misqa have continuous water access while those on the unimproved misqa do not.

Maize farmers using the raised bed (wide furrow) and deficit (70% of full) options obtained higher water productivity – 0.74 EGP/m³ for the former and 0.70 EGP/m³, for the latter – during the 2006-2007 season as compared to farmers' practice (0.65 EGP/m³) and full requirement irrigation options (0.65 EGP/m³), as shown in Figure 5.3. Unlike the wheat farmers, the maize farmers at the improved misqa community were less efficient in managing water resources under all the options tested except the farmers' option. In contrast to wheat,

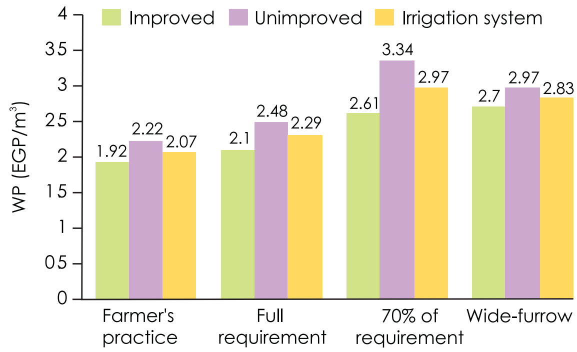


Figure 5.2. Average WP (EGP/m³) for wheat crop grown under different IB options over the two seasons 2005-2006 and 2006-2007.

Table 5.1. Average net returns and WP of wheat and maize in the old lands (2005-2007).

Options	Wheat (2005-2006 and 2006-2007)		Maize (2006-2007)	
	Net returns (EGP/ha)	Water productivity (EGP/m³)	Net returns (EGP/ha)	Water productivity (EGP/m³)
Farmer	11,730	2.28	4,419	0.72
Full requirement	11,557	2.56	3,938	0.68
70% of full req.	11,976	3.31	4,745	0.73
Wide furrow	12,296	3.24	4,285	0.77

Figure 5.3. Average WP (EGP/m³) for maize crop grown under different IB options, over the seasons 2005-2006 and 2006-2007.

the WP of maize is much lower given the relatively higher prices and yield of wheat as compared to maize.

5.4.2 New land sites

On the new lands, the sandy soil and over and/or inadequate irrigation represent the major constraints to the sustainability of improving water productivity in this system. The options tested included full crop requirement, deficit irrigation management representing 80% of the full crop requirements, and the farmers' usual practices. These options are applied to sample farms from both the WUA and No WUA groups for wheat and groundnuts, the two major winter and summer crops grown on this system.

Using enterprise budget analysis, the total returns, costs, and net return are estimated under the alternative irrigation systems. The results of the enterprise budget analysis for wheat for the 2005-2006 and 2006-2007 seasons and groundnut for the 2006 and 2007 seasons suggests that the total return was increased by between 3% and 7%. Deficit irrigation also reduced costs by between 5% and 7%, energy by between 17% and 30%, labor by 20%, and increased water saving by 25% as compared to the farmers' irrigation practice. Accordingly, using deficit irrigation in the new lands is a promising option.

The net returns and WP of wheat and groundnut grown on the new lands using the farmers' practice, full irrigation requirement, and deficit irrigation at 80% of the full requirement are compared in Table 5.2. The wheat yields are much lower on the new lands as compared to those on the old lands because of the known differences in soil quality. Consequently, both net returns and water productivity in the new lands are much lower.

Wheat returns per unit area on the new lands showed only limited variability under the different options, with highest returns being obtained with the deficit option (EGP 4874/ha). Also, this option resulted in the highest water productivity (EGP 1.59/m-3). This arose because of the relatively small reduction in yield (5%) as compared with that obtained under the full requirement and the yield being almost the same as that obtained using the farmers' practice.

Table 5.2. Average net returns and WP for wheat and groundnut in the new lands in the period 2005 to 2007.

IB options	Wheat (2005-2006 and 2006-2007)		Groundnut (2006 and 2007)	
	Net returns (EGP/ha)	Water productivity (EGP/m³)	Net returns (EGP/ha)	Water productivity (EGP/m³)
Farmer	4,591	1.10	5,642	1.03
Full requirement	4,586	1.15	6,063	1.09
Deficit (80% of full)	4,874	1.59	5,596	1.18

This appears to be a promising option for improving WP without affecting profitability and wheat yields.

The returns and WP for groundnut in the new lands have shown limited responses to the alternative irrigation options. The net returns from groundnuts ranged from EGP 5596/ha to EGP 6063/ha, while water productivity increased from EGP 1.03/m^3 with the farmers' practice to EGP 1.09/m^3 under full irrigation, and EGP 1.18/m^3 under deficit irrigation, as shown in Table 5.2. The deficit irrigation option appears to be a promising one for groundnuts on the sandy soils of the new lands.

Wheat growers in the 2005-2006 and 2006-20078 seasons who followed the deficit irrigation option had, on average, the highest net return per unit of water used (EGP 1.57/m^3) as compared to the other options – farmers' practice, EGP/m^3 1.1, and full irrigation requirement EGP 1.15/m^3 (Figure 5.4). The management of irrigation water resources practices of those farmers who are members of the WUA are, apparently, less efficient than those of the farmers who are not members. This is a surprising result, particularly when compared to the relatively high productivity of the members using the full requirement and deficit irrigation options. This may suggest that combining the water saving techniques (the technology options) with institutional reforms may increase the efficiency of water use.

The aggregated results of the two summer seasons for groundnut do not show a clear advantage for any of the options and between the two institutional settings (Figure 5.5). The difference in water productivity is very small, although deficit irrigation does show a slight advantage compared to the farmer's practice and full irrigation options. These results are inconclusive and should be interpreted with caution given the limited sample size in these trials.

5.4.3 Salt-affected land sites

Poor water management and water quality represent the major constraints to productivity for this system. Under this system, the options tested with wheat included crop-specific irrigation regimes (full, deficit and raised bed options) and compared these to farmers' traditional practice. These options were tested under three sources of irrigation water – fresh water, fresh and drainage water mixed, and drainage water only.

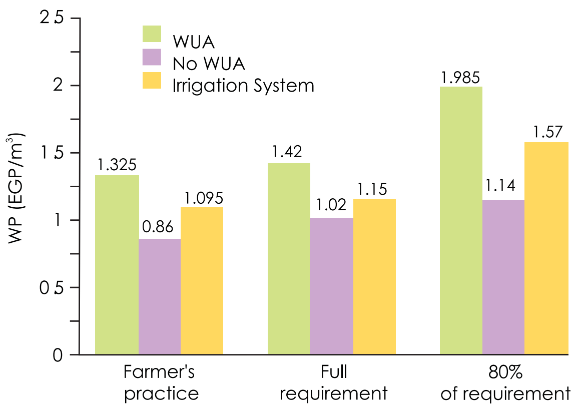


Figure 5.4. Average WP (EGP/m^3) for wheat crop under different irrigation options over two seasons (2005-2006 and 2006-2007) in the new lands.

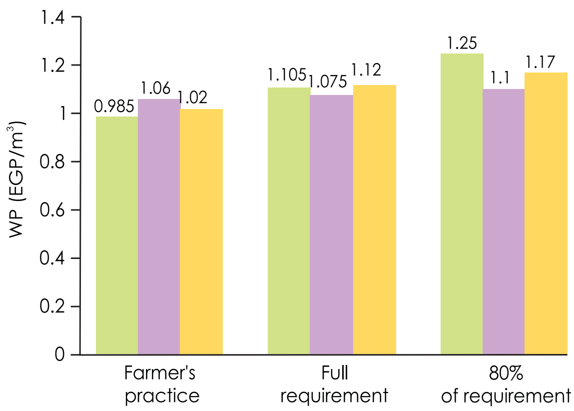


Figure 5.5. Average WP (EGP/m^3) for groundnut grown under different irrigation options in the 2006 and 2007 seasons in the new lands.

Using enterprise budget analysis, the total returns, costs and net return were estimated for alternative irrigation systems, including full irrigation, deficit irrigation (80% of the full requirement), and farmers' practices. The changes in net benefit over time were monitored. The results of the enterprise budget analysis for wheat, for the 2005-2006 and 2006-2007 seasons, and rice, for the summer seasons of 2006 and 2007, revealed that total returns and total productivity were decreased by between 6% and 10%, but wheat productivity was increased by 6%. Under deficit irrigation, total productivity and total returns were decreased by between 15% and 18%. Compared with the results from the farmers' irrigation practice, deficit irrigation reduced costs by between 8% and 16%, energy by between 5% and 24%, labor by between 20% and 30%, and increased water saving by between 20% and 25% percent. Accordingly, applying deficit irrigation in the marginal lands is questionable and needs further demonstrations and experimental work to prove any potential. This is especially so in the salt-affected soils in the northern Delta at El-Serw where the experimental work was carried out.

For rice, the alternative irrigation options to the farmers' traditional practices on marginal land involved reducing irrigation frequency to four and eight days or reducing the amount applied to the field capacity level. Of these, the saturation option involves applying the smallest amount of water. Under these options, the profitability of rice increases from EGP 4369/ha for saturation to EGP 5773/ha for the farmers' practice (see Table 5.3). The reduction in frequency of rice irrigation to every eight days increased the water productivity by 20% compared to farmer's practice.

For rice, the farmers' practice was compared to three levels of irrigation frequency, every four days, every four to eight days, and at saturation. In the marginal lands in the summer seasons of 2006 and 2007, irrigation every four days had, on average, a net return for WP for farmers who applied the saturation option of EGP 0.52/m^3 while that for farmers who irrigated every four days was EGP 0.51/m^3. Both of these were higher than the net return for WP for the other irrigation system options (Figure 5.6). However, rice has a much lower productivity than wheat in this system. For returns based on the quality of the water used, farmers using drainage water obtained the highest water productivity.

The wheat experiment involved two alternative options to the farmers' practice – full requirement and deficit irrigation (70% of full requirement). For wheat grown on this marginal land, the levels of return are very similar with the highest returns occurring for the full irrigation requirement option. However, the deficit irrigation option showed substantial gains in WP (35%) and thus appears to be a promising option for wheat. So, deficit irrigation appears to be a promising option for improving water productivity in wheat production under the conditions of the three ecosystems. For the

Table 5.3. Average net returns and WP for wheat and rice in the marginal lands for the growing seasons between 2005 and 2007.

Wheat (2005-2006 and 2006-2007)			Rice (2006-2007)		
Irrigation treatment	**Net returns (EGP/ha)**	**Water (EGP/m^3)**	**Irrigation treatment**	**Net returns (EGP/ha)**	**Water productivity (EGP/m^3)**
Farmer	5,194	1.00	Farmer	5,773	0.45
Full requirement	5,676	1.14	Every 4 days	5,710	0.51
70% deficit	5,021	1.35	Every 8 days	5,513	0.56
			Saturation	4,369	0.52

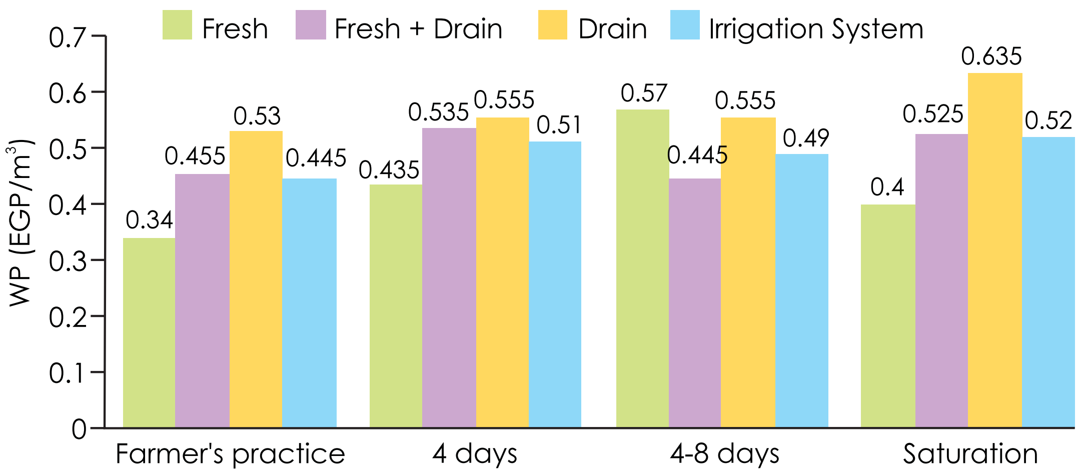


Figure 5.6. Average WP for rice grown under different irrigation options for the summer seasons of 2006 and 2007 in the marginal land.

summer crop, deficit irrigation is a promising option only for groundnut on the new lands. Given the existing data, more investigation is needed to identify the most promising option for the summer crops in the old and marginal lands.

Wide furrow and deficit irrigation (70% of the full requirement) options, at all the communities had, on average, higher net returns per unit of water. These amounted to EGP 1.57/m³ for wide furrow and EGP 1.32/m³ for deficit irrigation. These compare favorably with EGP 1.04/m³ under the farmers' practice and EGP 1.15/m³ for the full requirement option (see Figure 5.7). Wide furrow irrigation had in fact the highest value for WP for comparable treatments. for all qualities of water. Also, the drain water system has the highest WP under all options.

A study was designed to investigate the influence of the new irrigation options (wide

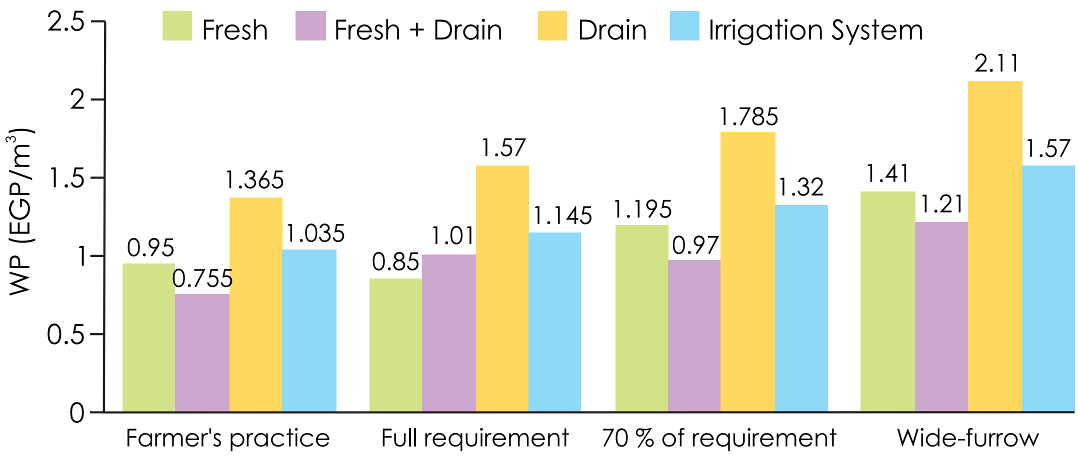


Figure 5.7. Average net WP (EGP/m³) for wheat grown under different irrigation options for two seasons 2005-2006 and 2006-2007 in the marginal lands.

furrow) on yields, costs, and gross benefits. This study was applied to demonstration fields of faba beans grown during the winter of 2006-2007 across neighboring governorates - Bohaira, Fayoum, and Minia. Several economic yield indicators including total return (gross return), net benefit, costs, cost that vary due to the intervention, and the B/C ratio were explored in Tables 5.4, 5.5, and 5.6 as follows;

5.5 Conclusions and lessons learned

Enterprise analysis, partial budget, and economic analysis indicated the superiority of the new irrigation benchmark options for increasing net returns per unit of water, reducing costs, and saving water as well as offering the potential to increase farm income, livelihood, and alleviating poverty.

Table 5.5. Partial budget for different irrigation options for faba bean in different areas during the 2006-2007 season in Fayoum Governorate.

Fayoum district	Irrigation options	Yield (t/ha)	Total Return (EGP/ha)	Total variable costs (EGP/ha)	Net return (EGP/ha)	Intervention costs that vary (EGP/ha)	Benefit/ cost ratio
Abshway	Wide furrow	1.9	13,137.6	2,668.0	10,469.6	95.2	4.9
	Traditional furrow	1.6	10,852.8	2,715.6	8,137.2	142.8	4.0
	Difference	0.3	2,284.8	-47.6	2,332.4	-47.6	
	Difference (%)	18.7	21.1	-1.8	28.7	-33.3	
Fayoum	Wide furrow	1.9	5520.0	1,115.5	4,404.5	62.5	4.9
	Traditional furrow	1.7	5040.0	1,123.0	3,917.0	70.0	4.5
	Difference	0.2	480.0	-7.5	487.5	-7.5	
	Difference (%)	11.8	9.5	0.7	12.5	10.7	

Table 5.6. Partial budget for different irrigation options for faba bean in different areas in the 2006-2007 season in Menia Governorate.

Fayoum districts	Irrigation options	Yield (t/ha)	Total return (EGP/ha)	Total variable costs (EGP/ha)	Net return (EGP/ha)	Intervention costs that vary (EGP/ha)	Benefit/ Cost ratio
Banymazar-A	Wide furrow	1.9	14280.0	3189.2	11090.8	238.0	4.5
	Trad furrow	1.4	10710.0	3308.2	7401.8	357.0	3.2
	Difference	0.5	3570.0	-119.0	3689.0	-119.0	
	Difference %	33.3	33.3	-3.6	49.8	-33.3	
Banymazar-B	Wide furrow	1.9	13994.4	3324.9	10669.5	238.0	4.2
	Trad furrow	1.2	9329.6	3443.9	5885.7	357.0	2.7
	Difference	0.6	4664.8	-119.0	4783.8	-119.0	
	Difference %	50.0	50.0	-3.5	81.3	-33.3	

Table 5.4. Partial budget for different irrigation options for faba bean in areas during the 2006-2007 season in Bohaira Governorate.

Bohaira district	Irrigation options	Yield (t/ha)	Total return (EGP/ha)	Total variable costs (EGP/ ha)	Net return (EGP/ha)	Intervention costs that vary (EGP/ha)	Benefit/ cost ratio
Shobrakheit	Wide furrow	1.9	11,650.1	3,205.9	8,444.2	100.0	3.5
	Traditional furrow	1.6	10,210.2	3,255.8	6,954.4	149.9	3.0
	Difference	0.3	1,439.9	-49.9	1,489.8	-49.9	
	Difference (%)	18.7	14.1	-1.5	21.4	-33.3	
Abouhmos	Wide furrow	1.9	10,567.2	3,420.1	7,147.1	100.0	3.0
	Traditional furrow	1.2	6,640.2	3,520.0	3,120.1	199.9	1.8
	Difference	0.7	3,927.0	-98.9	4,026.9	-99.9	
	Difference (%)	58.3	59.1	-2.8	129.1	-50.0	

Specifically, the wide-bed furrow option was best suited for wheat and faba bean in the winter season and for maize in the summer season. It was also found that the saturation option had a potential for rice in the marginal land of El-Serw. The deficit irrigation option was found to be the second choice for winter crops, especially wheat. However, productivity might decrease under the saturation and deficit options.

- Results of the experimental field trials and the M&E information analysis revealed that wide furrow irrigation has a higher potential to enhance the net return on a unit of water for wheat and faba bean in all ecosystems and for maize crops in the old lands as compared to other irrigation options.
- Partial budget analysis of scaling-out in the governorates showed that wide furrow always has a higher benefit to cost ratio (B/C ratio), The average increase in the net benefits and B/C ratio of the new option, wide furrow, were, on average, 40% and 20% in all the governorates studied. Meanwhile, the wide furrow option reduced variable costs by 30% on average. Scaling-out analysis showed that wide furrow was a more profitable option, widely accepted and adopted by communities in the project areas and the neighboring governorates.

On marginal lands, farmers usually irrigate their wheat every seven days and keep the water level at 15cm on rice. However, the quantities of water applied vary from season to season and between farmers even for the same treatment. This makes the results of the experiment extremely difficult to interpret. Moreover, experiments were not conducted with the same set of farmers in the two seasons and input use and management levels vary significantly between farmers. For example, some farmers manure their plots, while others do not and the quantity of nitrogen applied varied between farmers and between years. This is very critical in these trials since water productivity is influenced significantly by the productivity of other inputs. Given the small sample (2 to 3 farmers), further analysis of the data to account for all these factors is not possible. Therefore, these results should be taken with caution and final recommendations should be subject to further experimentation and monitoring with a proper experimental design, suitable sample size, and accurate monitoring and measurement of other management practices and input use.