

**PRODUCTION OF MAIN WINTER CROPS UNDER IRRIGATION WATER
SHORTAGE - A CASE STUDY OF TWO VILLAGES IN EGYPT**

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Abstract

Egypt suffers from water shortage. Rainfall is very low, and it is irregular and unpredictable. The available water from the Nile River is limited (55.5 BCM/yr). Because the irrigation water is the most important input for crops production; the irrigation water shortage affects strongly both the productivity and profitability of the main winter crops in Egypt. This study tries to evaluate the impacts of irrigation water shortage, and examine the utilization of different inputs including irrigation water on production of the main winter crops in both Upper and Northern Egypt.

The study found that the irrigation water shortage is more serious in Northern Egypt compared with Upper Egypt. Wheat, clover tahreesh, and broad bean cultivated in the mentioned regions have higher elasticity in irrigation water input in Northern Egypt (up to 0.67) compared with Upper Egypt. The study put a potential policy to improve the productivity and profitability of the main winter crops through an appropriate irrigation water investment in the two regions.

Key words: winter crops, water shortage, irrigation, farm management, sustainable rural development, Egypt.

1. INTRODUCTION

Rainfall in Egypt is very low, irregular and unpredictable except for a very small strip along the coast of the Mediterranean Sea. Egypt depends mainly on the Nile River for its supply of fresh water, and it is the last downstream country in the Nile basin. It has a limited share of Nile water about 55.5 BCM/yr (AQUSTAT, 2005). However, the water flows are controlled during the entire year especially since the High Aswan Dam (HAD) had built. The irrigation network extends about 1,200 km from Aswan City to the Mediterranean Sea. It occupies about 13% of the agricultural lands area. In addition, it includes about 33,200 km of main and sub canals, and about 8,000 km of the special narrow canals called "Mesqas" (ESIS, 2007).

Due to the water shortage and the great length of irrigation network, the irrigation water decreases dramatically in both quality and quantity from Southern to Northern Egypt. The salinity of drainage water South of the Nile Delta is low (less than 1,000ppm), and increases toward the North of the Nile Delta to 5,000ppm (Allam, 2007). On the other hand, most parts of Northern Egypt suffer from the irrigation water shortage.

This study focuses on the impacts of irrigation water shortage on the main winter crops in both Upper and Northern Egypt. These crops include wheat, broad bean, and clover tahreesh. Wheat is the most important crop in Egypt. Most people in Egypt depend on it as a staple food. Although Egypt produces annually about 8 million metric tons, it is the first importer of wheat all over the world. It imports

annually about 8.3 million metric tons (USDA, 2009). Broad bean usually forms the main plate in the breakfast for the majority of low and middle classes in Egypt. On the other hand, rainfall is very low in Egypt (51mm/yr). Consequently, pasture lands are very rare. Egypt depends mainly on green fodders particularly clover tahreesh to feed farm animals to produce milk, and meat. It also imports annually big amounts of meat which reach about 340 thousand tons (FAOSTAT, 2007).

2. OVERVIEW OF STUDY VILLAGES

Figure 1 shows the locations of the study villages. West Alsawamah Village is located in the Northwest of Sohag governorate, Upper Egypt. It is about 35 km Northwest of Sohag City. While the number of land holding farmers is 1,455, the total cultivated area of the village is 1,450 feddan. Thus, the average of land holding size is about 1 feddan per farmer. The farmers of the village depend mainly on groundwater to irrigate their lands, as well as they use Nile water, and mixed-water (Nile water mixed with drainage water). These resources represent 80%, 63%, and 10% of the sample farmers respectively. All sample farmers in this village can easily access to alternative source of irrigation water to irrigate their lands.

On the other hand, Elarkoub Village is located in the Northern part of Albehaira governorate, Northern Egypt. It is about 20 km South of Alexandria City. While the number of land holding farmers is 1,095, the total cultivated area of the village is 3,590 feddan. Thus, the average of land holding size is about 3.3 feddan per farmer. The farmers of the village depend on Nile water and mixed-water to irrigate their lands. These resources represent 77%, and 23% of the sample farmers respectively. They can not access to any alternative sources of irrigation water. They can not use the groundwater in that region because of its salinity.

In order to obtain information on actual farm irrigation practices, a farm-level survey was conducted in the two villages between December 1, 2009 and January 20, 2010. Thirty farmers from West Alsawamah Village and 30 farmers from Elarkoub Village were randomly selected and interviewed about their agricultural activities in the 2008/09 cropping seasons.

3. CROPPING PATTERN OF WINTER SEASON IN THE TWO VILLAGES

Table 1 shows the 2008/09 winter season cropping patterns of the two villages. In W. Alsawamah Village, the main winter crops include wheat, clover tahreesh, broad bean, and onion representing about 33%, 28%, 4%, and 15% respectively of its total area. They represent about 29%, 36%, 8%, and 2% respectively of the total area in Elarkoub Village. While, 4% of the total area in Elarkoub Village is cultivated by sugar beet, none of the farmers cultivate it in W. Alsawamah Village. Sugar factories which depend on sugar beet crop are not available in Upper Egypt. Similar to sugar beet, artichoke is not cultivated in Upper Egypt. It is mainly cultivated in Northern parts of Northern Egypt. In that region, there are many nearby sea ports on the Mediterranean Sea to export it directly, in a fresh case, to the foreign markets in Arab and European countries. However, it represents about 2% of the total area in Elarkoub Village (see Table 1). Other crops such as orchards, and other vegetables occupy 297 feddan, and 691 feddan representing 20%, and 19% of the total area in W. Alsawamah, and Elarkoub respectively.

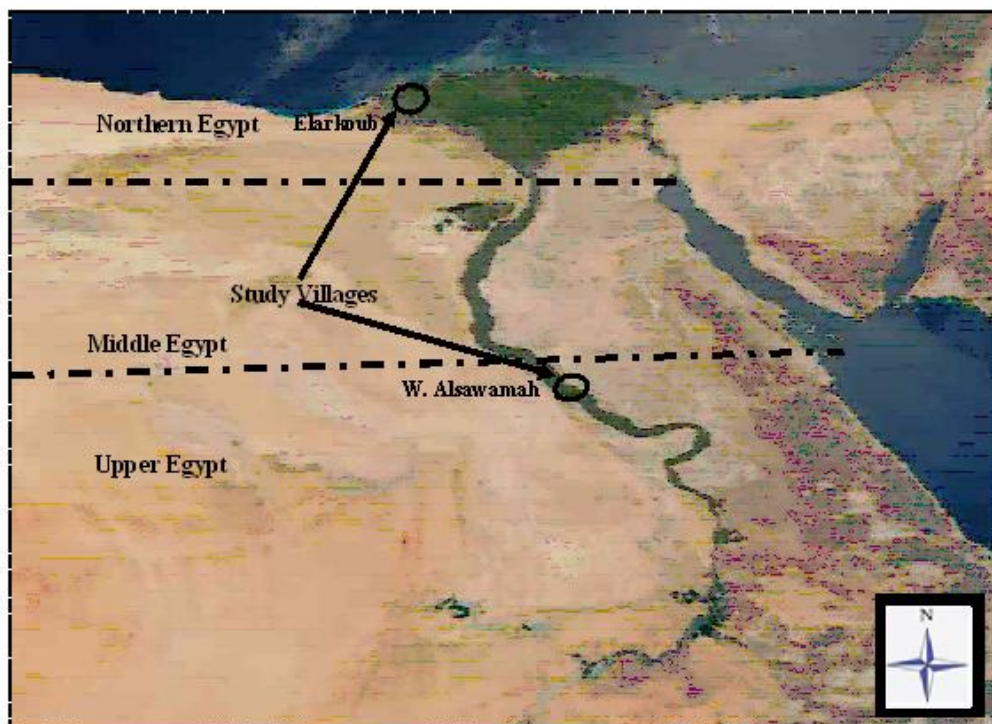


Figure 1. Locations of the study villages

Table 1. Cropping patterns in the study villages in winter season (2008/09)

Crops	W. Alsawamah		Elarkoub	
	Area (feddan)	%	Area (feddan)	%
Wheat	478	33	1041	29
Clover Tahreesh	406	28	1292	36
Broad bean	58	4	287	8
Onion	211	15	72	2
Sugar beet	0	0	126	4
Artichoke	0	0	81	2
Other Crops	297	20	691	19
Total	1450	100	3590	100

Source: Added and computed from:

The Agricultural Administrations, Tahta and Kafrelwdwar Cities, different records.

4. RESOURCES UTILIZATION IN MAIN WINTER CROPS OF SAMPLE FARMERS

4.1 Utilization of Labor

Table 2 shows utilization of different resources and total cost of the main crops in the two villages during the 2008/09 winter season. The study found many types of labor in the two villages including family and hired labor. In addition, there is another type observed in this study. It is possible to call cooperative labor. In this type of labor the farmers work together periodically in their fields without wages. The cooperative labor is common in Northern Egypt, and it decreases significantly in Upper Egypt where there are some customary rules against it. Farmers in Upper Egypt believe that this type of labor is not suitable for their society position. A worker works 6 hours per day. During the winter season, he works from 8 o'clock in the morning till 3 o'clock in the afternoon, and he takes about one hour as a lunch time in both W. Alsawamah, and Elarkoub Villages. Children under 15 years old are calculated as a half man. The average worker wage per day is about 40 EGP, and 30 EGP in W. Alsawamah, and Elarkoub respectively. The high wage in W. Alsawamah is related to the labor shortage in that region because workers are increasingly travelling abroad to work. The study estimated opportunity cost for family and cooperative labor for the main winter crops and added it to the cost of labor.

For wheat, the average workforce is about 16.2 men/f, and 26.4 men/f in W. Alsawamah, and Elarkoub respectively. Whereas the hired labor is the most important workforce for wheat crop in W. Alsawamah Village with 9.2 men/f (57%), the cooperative labor is the most important workforce for it in Elarkoub Village with 11.4 men/f (43%). Family labor and cooperative labor, for wheat crop, are about 4 men/f, and 3 men/f which represent 25%, and 18% of the total workforce for wheat respectively in W. Alsawamah Village. On the other hand, hired labor and family labor, for the mentioned crop, are about 8 men/f, and 7 men/f which represent 30%, and 27% of its total workforce respectively in Elarkoub Village.

For clover tahreesh, the average workforce is about 8.5 men/f, and 9.5 men/f in W. Alsawamah and Elarkoub respectively. Family labor is the most important workforce in the two sample villages. It equals about 6 men/f, and 6.5 men/f which represents 71%, and 68% of the total workforce of clover tahreesh in W. Alsawamah, and Elarkoub respectively. Next, hired labor equals 2.5 men/f, and 1 man/f which represents 29%, and 11% of the total workforce of the mentioned crop in the above villages respectively. Finally, cooperative labor equals 2 men/f which represents about 21% of the total workforce of the clover tahreesh in Elarkoub Village (NE) without any share of cooperative labor in W. Alsawamah Village (UE).

For broad bean, the average workforce is about 12 men/f, and 10 men/f in W. Alsawamah, and Elarkoub respectively. Similar to clover tahreesh, family labor for broad bean is the most important workforce in the two sample villages. It equals about 6 men/f, and 4 men/f which represents 50%, and 40% of the total broad bean workforce in W. Alsawamah, and Elarkoub respectively. Hired labor and cooperative labor equal about 5 men/f (42%), 1 man/f (10%) respectively in W. Alsawamah Village. They are about 3 men/f (30%) for both of them in Elarkoub Village.

4.2 Utilization of Irrigation Water

Irrigation water is the most important and essential input for high productivity of winter crops. 80% and 63% of the sample farmers in W. Alsawamah (UE) use groundwater, and Nile water from watercourses respectively to irrigate their lands. In addition, 10% of the sample farmers in the mentioned village use mixed-water to irrigate their lands. The administration of irrigation sometimes reduces the released irrigation water for the Northern Egypt during winter season, and usually turns off its running completely during about 20 days of January every year. The administration of irrigation depends on the low water consumed for crops and the relative heavy rainfall during the mentioned season in this region. This action has negative impacts on the productivity of some winter crops, because

it causes irrigation water shortage in the above regions. Although, rainfall rate is about 200mm/yr in Elarkoub village (NE) during winter season, this rainfall is irregular and unpredictable. Consequently, the farmers must depend on other sources to irrigate their lands. However, 77% of the sample farmers in Elarkoub Village depend on Nile water from watercourses to irrigate their lands. Whereas, 23% of them depend on the mixed-water. There are no alternative irrigation water sources in this region. Moreover, the farmers can not use the groundwater because of its salinity. All sample farmers in the two villages depend on the submergence method to irrigate their lands. None of them use advanced irrigation methods such as sprinkle and drop.

Table 2. Costs of different inputs (EGP) per feddan for the main winter crops by sample (2008/09)

Particulars		Wheat		Clover Tahreesh		Broad bean	
		W.Alsawamah	Elarkoub	W.Alsawamah	Elarkoub	W.Alsawamah	Elarkoub
Labor	Man-hours	16.2	26.4	8.5	9.5	12	10
	(EGP)	648.0	791.4	340.8	286.2	460	296
Irrigation	Volume(100m ³)	16.3	13.0	23.8	19.8	13	11.5
	(EGP)	190.5	284.3	209.6	435.0	156	70
Chemical Fertilizer ^{*1}	(Package ^{*2})	9.0	8.3	6.0	4.8	7	10.2
	(EGP)	540.0	414.3	360.0	169.6	490	510
Capital Expenditure ^{*3} (EGP)		640.5	660.5	340.0	400.4	372.5	728.6
Rent (EGP)		3000.0	2000.0	3000.0	2000.0	3000	2000
Other expenses		162.5	137.6	235.0	165.4	140	250
Total Cost (EGP)		5181.5	4288.1	4485.4	3456.5	4618.5	3499

Note :(*¹) Chemical fertilizers include Urea, Potash, Gypsum, and Triple Super Phosphate

(*²)1 Package = 50 Kg

(*³) Capital Expenditure = Cost of Machinery services

Source: Field Survey, (2009/10)

In W. Alsawamah Village, the volume of irrigation water consumed for one feddan of wheat is about 1,630 m³ with a cost of 190.5 EGP which represents about 4% of total cost of the crop. While in Elarkoub, the volume of irrigation water consumed for one feddan of wheat is 1,300 m³ with a cost of 284 EGP which represents about 7% of total cost of the crop (see Table 2). In W. Alsawamah Village, the volume of irrigation water consumed for one feddan of clover tahreesh is 2,380 m³ with a cost of 210 EGP which represents about 5% of total cost of the crop. While in Elarkoub Village, the volume of irrigation water consumed for one feddan of clover tahreesh is 1,980 m³ with a cost of 435 EGP which represents about 13% of its total cost. In W. Alsawamah, the volume of irrigation water consumed for one feddan of broad bean is 1,300 m³ with a cost of 156 EGP which represents about 3 % of total cost of the crop. While in Elarkoub, the volume of irrigation water consumed for one feddan of broad bean is 1,150 m³ with a cost of 70 EGP which represents about 2% of its total cost. The differences in volume of irrigation water consumed for wheat, clover tahreesh, and broad bean between the two villages is related to their differences in weather. In addition, these crops consume less irrigation water in Northern Egypt than in Upper Egypt because irrigation water shortage sometimes occurs during the winter season in Northern Egypt.

4.3 Utilization of Chemical Fertilizers

The Nile River flood was annually providing the agricultural lands of Egypt with rich sediment. Thus, the agricultural lands needed only a small amount of chemical fertilizers. However, this situation changed completely after the High Aswan Dam (HAD) had built. Meanwhile, chemical fertilizers are important and essential to improve the productivity of crops. The high and fluctuating market prices of chemical fertilizers are considered the main obstacles for their non-rational use in Egypt.

For wheat, 9 packages and 8.3 packages of chemical fertilizers are used per feddan in W. Alsawamah Village (UE), and Elarkoub Village (NE) respectively. Whereas, the cost of chemical fertilizers per feddan of wheat is about 540 EGP, and 414 EGP representing about 10% for the both of its total cost in the two villages respectively. For clover tahreesh, 6 packages, and 5 packages of chemical fertilizers are used per feddan in W. Alsawamah, and Elarkoub Villages respectively. The cost of chemical fertilizers per feddan of clover tahreesh is 360 EGP, and 170 EGP representing about 8%, and 5% of its total cost in the mentioned villages respectively. For broad bean, 7 packages, and 10 packages of chemical fertilizers are used per feddan in W. Alsawamah, and Elarkoub respectively. While, the cost of chemical fertilizers per feddan of broad bean is 490 EGP, and 510 EGP representing about 11%, and 15% of its total cost in the two villages respectively.

4.4 Utilization of Farm Machinery

The sample farmers in the two study villages use different types of farm machinery such as tractors, pumps, and thresher. There is lack of the small machines especially in W. Alsawamah Village. At the same time, most of the high-capacity machines such as big tractors in the mentioned village work below their capabilities because the holding land sizes are small and fragmented. However, this study focuses on computing the cost of machinery services for winter crops. It calculated the cost of hired machines, and estimated the opportunity cost of their services in case they are owned by farmers. The opportunity cost was estimated based on the respective hiring prices of those services in the same regions.

The costs of machinery services are about 640 EGP, and 660 EGP per feddan of wheat in W. Alsawamah, and Elarkoub respectively. These costs represent about 12%, and 15% of its total cost in the mentioned villages respectively. The costs of machinery services are about 340 EGP, and 400 EGP per feddan of clover tahreesh in W. Alsawamah, and Elarkoub respectively. These costs represent about 8%, and 12% of its total cost in the above villages respectively. While, the costs of machinery services are about 372 EGP, and 728 EGP per feddan of broad bean in the W. Alsawamah, and Elarkoub respectively. These costs represent about 8%, and 21% of its total cost in the two villages respectively.

5.PRODUCTIVITY AND PROFITABILITY OF MAIN WINTER CROPS

Table 3 shows the productivity, profitability, and Output/input ratio per feddan of the main winter crops in the study villages. Wheat achieves a higher average yield per feddan in W. Alsawamah Village (19 Ardab) compared with Elarkoub village (18.4 Ardab) because it is cultivated in small sizes of lands in West Alsawamah. The small sizes of lands are usually well controlled. Consequently, the productivity of them became higher than the productivity from the big sizes of lands. The average cost of wheat production is also higher in W. Alsawamah (5,181 EGP) compared with its cost in Elarkoub (4,288 EGP). The profits from one feddan of wheat are about 757 EGP and 1,511 EGP with Output/input ratios about 1.15, and 1.35 in W. Alsawamah, and Elarkoub respectively. It is mentioned that there is other profit from wheat crop in both regions. The farmers feed their farm animals with its secondary yield (wheat straw). Consequently, they obtain extra income from milk and meat production.

Clover tahreesh achieves an average of 30.6 tons per feddan in W. Alsawamah Village compared to 28.2 tons per feddan in Elarkoub Village. Due to many of sample farmers in Elarkoub Village and few of them in W. Alsawamah Village did not use the last cutting of clover tahreesh as a green fodder; its

average yield is lower in Elarkoub compared to W. Alsawamah. These farmers use the last cutting of it to produce its seeds. Consequently, they obtain extra income from its seeds production. The average cost of clover tahreesh production is also higher in W. Alsawamah (4,485 EGP) compared with its cost in Elarkoub (3,456 EGP). The profits from one feddan of clover tahreesh are about 1,270 EGP, and 847 EGP with Output/input ratios of 1.28, and 1.24 in W. Alsawamah, and Elarkoub respectively.

Broad bean achieves an average of 10.7 Ardab per feddan in W. Alsawamah Village compared to 9.8 Ardab per feddan in Elarkoub Village. The average cost of broad bean production is also higher in W. Alsawamah (4,618 EGP) compared with its cost in Elarkoub (3,499 EGP). The profits from one feddan of broad bean are about 862 EGP, and 1,835 EGP with Output/input ratios of 1.19, and 1.52 in W. Alsawamah, and Elarkoub respectively.

Table 3. Total cost, Total revenue, and profitability per feddan of the main winter crops in the study villages in (2008/09)

Crops Particulars	Wheat (Ardab)		Clover tahreesh (Ton)		Broad bean (Ardab)	
	W.Alsawamah	Elarkoub	W.Alsawamah	Elarkoub	W.Alsawamah	Elarkoub
Average of Yield	19	18.4	30.6	28.2	10.7	9.8
Total Cost (EGP)	5181.5	4288.1	4485.4	3456.5	4618.5	3499
Total Revenue (EGP)	5938.5	5799	5755.2	4303.1	5481	5334
Profit (EGP)	757	1511	1269.8	846.5	862.5	1835
Output/Input Ratio *	1.15	1.35	1.28	1.24	1.19	1.52

Note: (*) Output/Input Ratio = Total Revenue/Total Cost

Source: Field Survey (2009/10)

It is mentioned that the average costs of wheat, clover tahreesh, and broad bean are higher in W. Alsawamah Village compared with their average costs in Elarkoub Village mainly because of the differences in lands rent which is higher in W. Alsawamah than Elarkoub (see Table 2)

6. EFFICIENCY OF RESOURCES UTILIZATION

The above findings show that it is necessary to examine the efficiency of different inputs including irrigation water which are used in production of the main winter crops in order to recommend appropriate policy measures in the future. To ascertain the efficiency of resources utilization, the production functions were estimated for the main winter crops in W. Alsawamah (UE), and Elarkoub (NE) Villages. The study depended on the following model to estimate the production functions of the mentioned crops.

$$Y_i = A L_i^b W_i^c F_i^d K_i^r$$

Then, it is possible change this function to be a linear relationship as follows

$$\text{Log } Y_i = \text{Log } a + b \text{ Log } L_i + c \text{ Log } W_i + d \text{ Log } F_i + r \text{ Log } K_i$$

Where,

Y_i = Productivity of the main yield of a winter crop of i^{th} farmer (Ardab, or Ton /feddan)

L_i = Labor utilization of i^{th} farmer (Man-hours/feddan)

W_i = Irrigation water utilization of i^{th} farmer (100 m³/feddan)

F_i = Chemical fertilizers utilization of i^{th} farmer (package/feddan)

K_i = Capital expenditure of i^{th} farmer (EGP/feddan)

a = Intercept

b = Elasticity of labor

c = Elasticity of water

d = Elasticity of chemical fertilizers

r = Elasticity of capital expenditure

Table 4 shows the estimated elasticities of the production of main winter crops in W. Alsawamah (UE), and Elarkoub (NE) Villages. According to the estimations for wheat, the elasticity of irrigation water is 0.31 in W. Alsawamah, and it is 0.92 in Elarkoub because of irrigation water shortage with significance levels of 5%, and 1% in the two villages respectively. On the other hand, labor input is positive response to the wheat productivity in both W. Alsawamah, and Elarkoub Villages with elasticities of 0.25, and 0.75 respectively. The elasticity of chemical fertilizers in wheat is 0.18, and 0.17 in W. Alsawamah, and Elarkoub respectively. In addition, expenditures of machinery services are also positive response to the productivity of wheat in both Upper and Northern Egypt with elasticity results of 0.29 in W. Alsawamah, and 0.21 in Elarkoub.

According to the estimations for clover tahreesh, the elasticity of irrigation water is 0.48 in W. Alsawamah Village, and it is 0.67 in Elarkoub Village with a significance level of 5% for the both villages. The elasticity of labor is 0.27 in W. Alsawamah, and it is 0.17 in Elarkoub. The results also show the elasticity of chemical fertilizers. It is about 0.29 in W. Alsawamah, and it is about 0.14 in Elarkoub. The elasticity of capital expenditures has a positive response which reached about 0.37 in W. Alsawamah, and about 0.28 in Elarkoub with a significance level of 1% in both villages.

According to the estimations for broad bean, the elasticity of irrigation water is 0.42 with a significance level of 5% in W. Alsawamah, and it is 0.80 with a significance level of 1% in Elarkoub because of irrigation water shortage. The elasticity of labor input is 0.83 with a significance level of 1% in W. Alsawamah because of labor shortage, and it is 0.40 with a significance level of 5% in Elarkoub Village. The elasticity of chemical fertilizers is 0.36 in W. Alsawamah, and it is 0.25 with a significance level for the both of 5%. The results also show a serious shortage of machinery services for broad bean crop in the two villages. While the elasticity of capital expenditures is 1.45 in W. Alsawamah, it is 1.47 in Elarkoub with a significance level for the both of 1%.

Table 4. Estimated production functions of the main winter crops in the study villages

Crop	Particulars	W. Alsawamah				Elarkoub			
		Elasticity	t value	Adj. R ²	No. of obs.	Elasticity	t value	Adj. R ²	No. of obs.
Wheat	Labor (Man-hours)	0.25*	2.47	0.97	20	0.75*	2.37	0.98	21
	Irrigation water (100 m ³)	0.31*	2.85			0.92**	5.89		
	Chemical fertilizers (Package)	0.18*	2.2			0.17*	2.85		
	Capital expenditure (EGP)	0.29*	2.41			0.21**	4.57		
Clover tahreesh	Labor (Man-hours)	0.27**	3.16	0.98	25	0.17*	2.24	0.98	26
	Irrigation water (100 m ³)	0.48*	2.4			0.67*	2.36		
	Chemical fertilizers (Package)	0.29**	3.92			0.14*	2.46		
	Capital expenditure (EGP)	0.37**	3.84			0.28**	2.86		
Broad bean	Labor (Man-hours)	0.83**	5.96	0.99	10	0.40*	3.19	0.99	8
	Irrigation water (100 m ³)	0.42*	3.15			0.80**	14.53		
	Chemical fertilizers (Package)	0.36*	2.92			0.25*	3.6		
	Capital expenditure (EGP)	1.45**	11.88			1.47**	7.58		

Note: * and ** indicate 5% and 1% levels of significance respectively

Source: Computed based on Field Survey (2009/10)

7. POTENTIAL POLICY TO IMPROVE PRODUCTIVITY OF THE MAIN WINTER CROPS

The above findings indicate that the irrigation water shortage occurs in Northern Egypt (Elarkoub Village) for the main crops during the winter season. This problem occurs because the administration of irrigation usually reduces the released irrigation water during the mentioned season. Consequently, main winter crops suffer from water shortage. This problem became more serious in the lands which are located in the end of watercourses. Therefore, the estimated elasticities of irrigation water are significantly high for those crops in that region. Some winter crops in Upper Egypt (W. Alsawamah Village) are also adversely affected by water shortage problem (see Table 4) because of the lack of irrigation machines and the periodical system of irrigation. In that region the farmers sometimes can not irrigate their lands in a suitable time because the irrigation machines are used by other farmers at the same time. Furthermore, the rainfall is very rare and irregular in the mentioned region.

The high elasticity of labor input for some winter crops in the two regions indicates that there is a labor shortage problem. Broad bean suffers from labor shortage in the two regions, while wheat suffers from this problem in Northern Egypt. The problem of labor shortage occurs because the workers travel abroad to work. In addition, labor shifting occurs from the agricultural sector to the other sectors. This is due to the large gap in wages between agricultural and non-agricultural activities. During the survey, it was found that the average worker wage per day was 40 EGP in W. Alsawamah (UE), and 30 EGP in Elarkoub (NE). In contrast, 70 EGP per day is the average wage for unskilled labor in the construction sector.

In both regions, it was observed that there are differences between farms in the unit price of a yield of the same crop between farms in the same region. This is partly because of the differences in the quality of individual yields leading to differences in their prices, and partly because farmers are obliged to sell their yields at low prices to specific traders. Many farmers usually need to loans during the production of high cost winter crops. They borrow funds from traders, and consequently the traders set lower prices for the crops than the actual farm prices.

The study tried to determine an appropriate agricultural policy. This policy would ensure improvement in the productivity, and maximization of the profitability of the main winter crops. Predictions of the

productivity and profitability of the mentioned crops were conducted. These predictions were performed to estimate the costs and benefits of cultivation of the same crops under the following conditions: 1) when the farmers increase the labor hours by 10%; 2) when the farmers increase the volume of irrigation water by 10%; 3) when the farmers increase the amount of fertilizers by 10%; and 4) when the farmers increase expenditures for farm machinery services by 10%.

For wheat, the results show that increasing the irrigation water by 10% ensures a higher Output/input ratio of 1.18 compared with the actual (1.15) in W. Alsawamah (UE) with a profit of about 922 EGP (see Table 5). This occurs because of the low cost of irrigation water and the high elasticity of it (0.31) in the above village. The second prediction shows that increasing the expenditures of machinery services by 10% also ensure an increase in the Output/input ratio to 1.16 with a profit of about 865 EGP. The same Output/input ratio (1.16) will be achieved in case of increasing the labor input by 10%, but with a slightly lower profit of about 841 EGP. As a result of the high prices of chemical fertilizers and their low elasticity (0.18), a non-significant increase occurs in profitability of wheat when the use of chemical fertilizers increases by 10% in W. Alsawamah Village. In this case, the same Output/input ratio (1.15) achieved like the actual. On the other hand, the actual Output/input ratio of wheat is 1.35 with a profit of 1,511 EGP per feddan in Elarkoub Village (NE). This ratio increases to its highest value (1.47) with a profit about 2,016 EGP when the volume of irrigation water increases by 10%. This reflects the importance of irrigation water increase in this region. The Output/input ratio increases to 1.43 with a profit of 1,867 EGP per feddan when labor input increases by 10%. A small increase in the mentioned ratio occurs to be 1.36 with a profit of 1,568 EGP when the use of chemical fertilizers increases by 10% because of their high prices and low elasticity (0.17). The same result occurs when the expenditures of machinery services increase by 10%. In this case, the Output/input ratio will be 1.36 with a profit of 1,567 EGP (see Table 5).

Table 5. Predicted productivity and profitability of wheat by increasing different inputs

Particulars	Actual	10% increase in Labor		10% increase in Irrigation water		10% increase in Chemical Fertilizer		10% increase in Capital expenditure	
		Predicted	Growth (%)	Predicted	Growth (%)	Predicted	Growth (%)	Predicted	Growth (%)
Yield (Ardab/Feddan)	19	19.48	2.50	19.59	3.10	19.34	1.80	19.55	2.90
Total Cost (EGP)	5181.5	5246.30	1.25	5200.50	0.37	5235.50	1.04	5245.55	1.24
Total Revenue (EGP)	5938.5	6086.96	2.50	6122.59	3.10	6045.39	1.80	6110.72	2.90
Profit (EGP)	757	840.66	11.05	922.09	21.81	809.89	6.99	865.17	14.29
Output/Input Ratio	1.15	1.16	0.89	1.18	2.37	1.15	0.41	1.16	1.30
Yield (Ardab/Feddan)	18.4	19.78	7.50	20.09	9.20	18.71	1.70	18.79	2.10
Total Cost (EGP)	4288.1	4367.24	1.85	4316.53	0.66	4329.53	0.97	4354.15	1.54
Total Revenue (EGP)	5799	6233.93	7.50	6332.51	9.20	5897.58	1.70	5920.78	2.10
Profit (EGP)	1511	1866.69	23.54	2015.98	33.42	1568.05	3.78	1566.63	3.68
Output/Input Ratio	1.35	1.43	5.74	1.47	8.67	1.36	0.90	1.36	0.73

Source: Computed based on Tables 2, 3, and 4

Table 6 shows that the Output/input ratio of clover tahreesh is 1.28 with a profit of 1,270 EGP in W. Alsawamah Village (UE). According to the present conditions, increasing the volume of irrigation water by 10% ensures a higher Output/input ratio of 1.34 compared with the actual (1.28) in the mentioned village with a profit of about 1,525 EGP. The previous result indicates the importance of irrigation water increase for clover tahreesh crop in W. Alsawamah Village (UE). The big extra profit in this case

because of the low cost and high elasticity of irrigation water in the mentioned village. Increasing the machinery utilization by 10% also ensures an increase in Output/input ratio to be 1.32 with a profit of 1,449 EGP. Next, increasing the use of chemical fertilizers by 10% ensures an increase in the Output/input ratio to 1.31 with a profit of about 1,401 EGP. Finally, increasing labor input by 10% ensures an increase in the Output/input ratio to be as the pervious (1.31), but with a less profit of about 1,391 EGP. On the other hand, the actual Output/input ratio of clover tahreesh is 1.24 with a profit of 846 EGP per feddan in Elarkoub Village (NE). This ratio increases to its highest value (1.31) with a profit about 1,091 EGP when the volume of irrigation water increases by 10%.

This result occurs because of the irrigation water shortage, and it reflects the importance of irrigation water increase in this region. The Output/input ratio increases to 1.27 with a profit of 927 EGP per feddan when the machinery services input increases by 10%. The same Output/input ratio (1.26) achieved when the labor input, and the use of chemical fertilizers increase separately by 10% with profits of about 891 EGP, and 890 EGP respectively.

Table 6. Predicted productivity and profitability of clover tahreesh by increasing different inputs

Village	Particulars	Actual	10% increase in Labor		10% increase in Irrigation water		10% increase in Chemical Fertilizer		10% increase in Capital expenditure	
			Predicted	Growth (%)	Predicted	Growth (%)	Predicted	Growth (%)	Predicted	Growth (%)
West Alsawamah (UE)	Yield (Ton/Feddan)	30.6	31.43	2.70	32.07	4.80	31.49	2.90	31.73	3.70
	Total Cost (EGP)	4485.4	4519.40	0.76	4506.36	0.47	4521.40	0.80	4519.40	0.76
	Total Revenue (EGP)	5755.2	5910.59	2.70	6031.45	4.80	5922.10	2.90	5968.14	3.70
	Profit (EGP)	1269.8	1391.19	9.56	1525.09	20.10	1400.70	10.31	1448.74	14.09
	Output/Input Ratio	1.28	1.31	2.17	1.34	4.56	1.31	2.33	1.32	3.17
Elarkoub (NE)	Yield (Ton/Feddan)	28.2	28.68	1.70	30.09	6.70	28.59	1.40	28.99	2.80
	Total Cost (EGP)	3456.5	3485.12	0.83	3500.00	1.26	3473.46	0.49	3496.54	1.16
	Total Revenue (EGP)	4303.1	4376.25	1.70	4591.41	6.70	4363.34	1.40	4423.59	2.80
	Profit (EGP)	846.5	891.13	5.27	1091.41	28.93	889.88	5.13	927.05	9.52
	Output/Input Ratio	1.24	1.26	1.27	1.31	5.79	1.26	1.31	1.27	2.03

Source: Computed based on Tables 2, 3, and 4

Table 7 shows that the actual Output/input ratio of broad bean is 1.19 with a profit of 862 EGP in W. Alsawamah (UE). The small profit from broad bean yield in this region illustrates why farmers have recently decreased its cultivation area. According to the present conditions, the Output/input ratio of broad bean will increase to its highest value (1.35) with a profit of 1,620 EGP when the machinery services for the mentioned crop increase by 10%. This reflects lack of the machinery services for broad bean in W. Alsawamah Village (UE). Next,

Table 7. Predicted productivity and profitability of broad bean by increasing different inputs

Village	Particulars	Actual	10% increase in Labor		10% increase in Irrigation water		10% increase in Chemical Fertilizer		10% increase in Capital expenditure	
			Predicted	Growth (%)	Predicted	Growth (%)	Predicted	Growth (%)	Predicted	Growth (%)
West Alsawamah (UE)	Yield (Ardab/Feddan)	10.7	11.59	8.30	11.15	4.20	11.09	3.60	12.25	14.50
	Total Cost (EGP)	4618.5	4665.79	1.02	4635.00	0.36	4667.50	1.06	4655.75	0.81
	Total Revenue (EGP)	5481	5935.92	8.30	5711.20	4.20	5678.32	3.60	6275.75	14.50
	Profit (EGP)	862.5	1270.13	47.26	1076.20	24.78	1010.82	17.20	1620.00	87.83
	Output/Input Ratio	1.19	1.27	6.91	1.23	3.55	1.22	2.23	1.35	13.27
Elarkoub (NE)	Yield (Ardab/Feddan)	9.8	10.19	4.00	10.58	8.00	10.05	2.50	11.24	14.70
	Total Cost (EGP)	3499	3528.60	0.85	3506.00	0.20	3550.00	1.46	3571.86	2.08
	Total Revenue (EGP)	5334	5547.36	4.00	5760.72	8.00	5467.35	2.50	6118.10	14.70
	Profit (EGP)	1835	2018.76	10.01	2254.72	22.87	1917.35	4.49	2546.24	38.76
	Output/Input Ratio	1.52	1.57	3.43	1.64	8.10	1.54	1.32	1.71	12.69

Source: Computed based on Tables 2, 3, and 4

the Output/input ratio increases to 1.27 with a profit of 1,270 EGP per feddan when labor input increases by 10%. It reaches 1.23 with a profit of 1,070 EGP per feddan when the volume of irrigation water increases by 10%. Due to the high price of chemical fertilizers, a small increase occurs in profitability of broad bean to be 1.011 EGP per feddan when the use of chemical fertilizers increases by 10% in W. Alsawamah Village (UE). On the other hand, in Elarkoub Village (NE) the actual Output/input ratio of broad bean is 1.52 with a profit of 1,835 EGP per feddan. This ratio increases to its highest value (1.71) with a profit about 2,546 EGP per feddan when the machinery services increase by 10%. Similar to W. Alsawamah Village, this also reflects lack of the machinery services for broad bean in Elarkoub Village (NE). Next, the Output/input ratio will be 1.64 with a profit of 2,255 EGP when the volume of irrigation water increases by 10%. This reflects the importance of irrigation water increase for broad bean in the Northern Egypt. The Output/input ratio increases to 1.57 with a profit of 2,019 EGP when labor input increases by 10%. Finally, when the use of chemical fertilizers increases by 10%, the Output/input ratio will be 1.54 with a profit of 1,917 EGP.

8. CONCLUSION

Egypt has a limited share of Nile water about 55.5 BCM/yr. The water flows are controlled by a long and complicated irrigation network. As a result of water shortage, the irrigation water decreases dramatically from Southern to Northern Egypt. This study focused on the impacts of irrigation water shortage on production of the main winter crops. It compared two villages in Egypt. One of them located in Upper Egypt (W. Alsawamah), and the other located in Northern Egypt (Elarkoub). A farm-level survey was conducted to examine the actual farm practices during the winter season. Consequently, the study tried to determine an appropriate policy to improve the productivity and profitability of the main winter crops in both regions.

The study found that the production of main winter crops suffers from irrigation water shortage. The administration of irrigation sometimes reduces the released irrigation water for the Northern Egypt, and

usually turns off its running completely during about 20 days of January every year. This action has negative impacts on the productivity of some winter crops. On the other hand, there is a labor shortage problem for some winter crops in the two regions. Broad bean suffers from labor shortage in both study villages, while wheat suffers from the mentioned problem in Elarkoub Village (NE). Many workers prefer to travel abroad, shift to other sectors to work instead of working in the agricultural sector. This occurs mainly because of the higher wages in other sectors compared with the agricultural sector. The study also found that there are many types of labor; family, hired. In addition, there is another type. The study called it “cooperative labor”. In this type, the farmers work together periodically in their fields without wages. This type of labor is common in Northern Egypt especially in crops which need a lot of workers, but it decreases significantly in Upper Egypt because of some customary rules. The high and fluctuating market prices of chemical fertilizers are considered the main obstacles for their non-rational use in Egypt. On the other hand, there is a lack of the small machines in the study villages especially in W. Alsawamah Village (UE). At the same time, most of the high-capacity machines such as big tractors in W. Alsawamah Village (UE) work below their capabilities because the holding land sizes are small and fragmented.

The study estimated production functions of the main winter crops in the study villages. It was found that wheat, clover tahreesh, and broad bean have higher elasticity (up to 0.67) in irrigation input in Northern Egypt compared with Upper Egypt. Consequently, the irrigation water shortage is more serious in Northern Egypt. Clover tahreesh, and broad bean in Upper Egypt also have high elasticity (more than 0.40) for irrigation water input because of the lack of irrigation machines and the periodical system of irrigation.

The study put a detailed policy to improve productivity of the main winter crops. This policy is adjusted in case of increasing separately the different inputs including irrigation water by 10%. It can easily help farmers and policy makers to take appropriate decisions in order to make rational use of the different resources. It also helps them to improve productivity and maximize profitability of the main winter crops.

ACRONYMS AND DEFINITIONS

Ardab	Egyptian measuring unit for crops (volumetric measurement) Ardab of wheat = 0.15 Ton Ardab of broad bean = 0.16 Ton
EGP	Egyptian Pound (1 EGP = 0.18 US \$)
Feddan (f)	Egyptian area unit (1 feddan = 0.42 ha)
ME	Middle Egypt (Nile Valley from Asyut City to Cairo)
m³	Cubic Meter
NE	Northern Egypt (Cairo and Delta)
UE	Upper Egypt (Nile Valley upstream of Asyut City)

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