CONSIDERATION OF THE AGRICULTURAL PROBLEMS AS A BASE OF WATER RESOURCE MANAGEMENT IN EGYPT

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ABSTRACT

Egypt has a fixed share of the Nile water, which may limit future water resources development projects. The agriculture in Egypt was developed over the last century in large measures as a result of technological change. As a matter of fact, the Egyptian agriculture consumes about 85% of Egypt's limited water resources. In the beginning of the 90's, the government gave the authorization for farmers to choose their own crop pattern. The Free cropping pattern is considered a major problem for the water distribution engineers. The difficulties issued from the randomized crop distribution along the network canals, with their different degrees. The fundamental factors contribute to Egypt's food security challenge are the rapidly growing population, the availability of agricultural land and the restricted water resources. Expanding agricultural land in Egypt is tightly constrained by many factors and the availability of water is on top of these factors.

This research is performed to emphasis the main agriculture problems in Egypt and discuss the reasons behind these problems. It also gives historical assessment of the crop pattern during two important periods. The 1st period is just after the construction of High Aswan Dam (1965-1985), while the 2nd one is following through to the Liberalization of agriculture sector including the crop pattern (1990 - 2010). This research also sets up three scenarios to help in determining an accurate observation of the best possible crop pattern with less water consumption according to the available water resources in Egypt. It was concluded that the best crop pattern scenario is the 3rd one in which its cultivated area of rice should not exceed 1100 thousand feddan and the cultivated areas of sugar beet and cotton have been increased by 50%, on the other hand fixing all cultivated areas of the other crops according to the sustainable agricultural development strategy towards 2017.

Keywords: Water Resources in Egypt, Agricultural problems, Historical Cropping Pattern in Egypt.

1. INTRODUCTION

Egypt is one of the countries facing great challenges due to its limited water resources represented mainly by its fixed share of the Nile water (55.5 billion m3/year), most of which originate from external resources, and its aridity as a general characteristic. Formulation of Egypt's water resources policy for the 21st century requires a major shift from the classical pattern used in water resource planning and management to a new innovative paradigm. Dynamic interrelationships among water resource system components impose the integrated approach on policy makers.

The Egyptian Government prepared its first national policy after the construction of the Aswan High Dam in 1970. Since then, several water policies were formulated to accommodate the dynamics of the water resources and the changes in the objectives and priorities. The most recent policy was issued in January 2005. It included several strategies to ensure satisfying the demands of all water users and expanding the existing agricultural area of 7.9 million feddans by about 3 million feddans to be 10.9 feddans in 2017. Also it gave farmers the chance to share in the different responsibilities concerning the water distribution system and the drainage water reuse besides choosing their own crop pattern.

In fact, the agricultural sector plays a central role in the Egyptian economy, contributing by 14% to GDP in 2010; and it is the largest absorber of employment as it accounts for more than 30% of the work force (WB, 2011). Egyptian policymakers pay special attention on the agricultural sector for its importance in ensuring food security to the rapidly growing population. Throughout the past five decades, the Egyptian agricultural sector was subject to major policy changes that had substantial impact on this sector; and that had greatly caused major shifts in the cropping pattern. This research is shedding light on the main features and problems of the agricultural sector in Egypt, examine their evolution over time, and study their effects on the cropping pattern during different periods which can help in setting the best feasible crop pattern with respect to the accessible water resource in Egypt.

2. METHODOLOGY

As the water scarcity is considered a major limitation for the expansion of agricultural sector, an efficient crop pattern should be shaped to minimize the amount of the consumed water. This research focuses on the vertical expansion of agricultural sector through attempting different scenarios to determine the best possible cropping pattern according to the available water resources in Egypt. This scenarios are based on some important constrains to help putting an optimum crop pattern in Egypt. Three crop patterns scenarios are proposed to investigate the best possible cropping pattern according to the available water resources in Egypt under two water use efficiency conditions; 60% & 65%. Two main asumptions are identified in determining the best possible crop patren for Egypt as follows; land allocation asumption to meet the domestic demand of crop production and water requirements asumption as well, to minimize the use of water. The main source of data is the statistical year book of agricultural economics department published in yearly basis.

3. KEY FEATURES OF THE EGYPTIAN AGRICULTURAL

Egyptian agriculture possesses certain features that make it unique among other agricultural systems all over the world. Such uniqueness is the outcome of the combined effects of these features. The Old Lands in the Nile valley are the main growing areas in Egypt that are characterized by complex-year long cropping pattern. The richest crop production area is the Mid-Delta region due to the high quality of soil. The Northern Delta region is characterized by high salinity, especially near the Mediterranean Coast and lakes. Upper Egypt is characterized by arid weather; thus, certain types of crops are being grown there. Reclaimed agricultural lands in the desert are characterized by having advanced technology; yet their constraints arise from the low fertility (El- Shaer, 1996).

Crop cultivation in Egypt takes place during three consecutive cropping seasons; the winter, summer and nili (Kharif) seasons, depending on the irrigation rotation. Winter season crops (including wheat, barely, beans and clover) are irrigated during the period October – December, and are harvested in May. Following the winter, crops of the summer season are irrigated from April – June and are harvested in October. Those include rice, cotton, maize and sugar cane. The irrigation of Nili season crops takes place during the months of July and August and harvest takes place in November. Crops of the Nili season are mainly similar to summer crops (mainly maize, peanuts, and cotton). Vegetables and fruits are grown all year round, depending on their type. Table 1 shows The Cropping Pattern Suggested by the Sustainable Egyptian Agricultural Development Strategy.

Two development strategies for the agricultural sector are currently being implemented;

- The Agricultural Sustainable Development Strategy towards 2017 aims at achieving a growth rate in the agricultural sector of 4.1% per annum; The strategy aims at improving the efficiency of water use in agriculture through modifying the crop pattern.
- The 2030 Sustainable Agricultural Development Strategy aims at achieving economic and social development in the agricultural sector, through achieving a number of goals

including an efficient utilization of natural agricultural resources, food security through reaching self-sufficiency of strategic agricultural crops.

Table 1: The Cropping Pattern Suggested by the Sustainable Agricultural Strategies

Commodity Group	2010	Estimates for 2017	Estimates for 2030
I. Cereals			
Wheat	3066	3750	4200
Rice	1095	1250	1300
Maize	1968	3150	3700
Total Cereal Crops	7120	9038	10258
II. Sugar Crops			
Sugar Cane	320	340	350
Sugar Beet	386	500	800
Total Sugar Crops	706	840	1150
III. Oilseed Crops			
Groundnut	159	230	350
Sesame	88	85	100
Total Oilseed crops	318	378	525
IV. Legume Crops			
Broad Beans	202	300	400
Other Legumes	30	38	45
Total Legumes	232	338	445
V. Fiber Crops			
Cotton	369	750	1000
Other Fibers	8	18	21
Total Fiber Crops	377	768	1021
VI. Fodder Crops			
Perennial Clover	1612	1900	2200
One-cut Clover	310	540	650
Total Fodder Crops	2685	3300	4250
Total Vegetable Crops	2112	2280	2645
Total Fruits	1377	1500	1755
Total Cropped Area	15334	19162	22984

Source: MALR, 2009

Table 2 summarizes mainly the key targets for 2017 and 2030 regarding achieving a better utilization of agricultural resources comparing with the present situation. The total water quantities expected to be saved as a result of improvement of field irrigation systems and reducing areas planted by rice, are 5.3 and 12.4 billion m^3 of water by 2017 and 2030 respectively. An increase in total cultivated areas to reach 9.665 million feddans by 2017 and 11.5 million feddans by 2030. The strategy also aims at maximizing the benefit from rain-fed agriculture in North Coast to cultivate key crops.

Table 2: Estimated Land Areas and Water Quantities in 2017 and 2030

Item	Present	2017	2030
Projected Land Area (million feddans)	8.4	9.6	11.5
Areas Projected to be Reclaimed(million feddans)	-	2.250	5.0
Cropped Area (million feddans)	15.4	19.2	22.9
Intensification (%)	184	199	200
Quantity of water used in irrigation (billion m^3)	58	61	64
field water use efficiency (%)	50	75	80
total water quantities expected to be saved as a result of developing the irrigation system (mn m^3)	-	5,300	12,400
average water share per feddan	6,900	6,320	5,565
average return per water unit (egp)	1.91	3.2	4.17

Source: MALR, 2009

4. THE AGRICULTURAL PROBLEMS

The major determinants of the current agricultural sector problems are presented as the following headlines;

4.1 Water Availability

Water availability is a key challenge facing the sustainable development of the agricultural sector in Egypt. Egypt's water resources are highly limited, whereby total annual water resources are estimated at about 73 billion m^3. Renewable water resources are estimated at 57.3 billion cubic meters per year, almost 97% of which originate from external resources (FAO, 2011). Nile River is the major source of surface renewable freshwater with an annual quota of 55.5 billion m^3, set by the "Nile Water Agreement" signed in 1959 with Sudan. Other sources of water supply in Egypt include groundwater in the Western desert, and rainfalls in the Western desert and Sinai. In addition to renewable water, Egypt depends on other non-renewable sources of water that include reusing the agricultural drainage water, recycling sewage water, in addition to the desalination of sea water (FAO, 2011; and MWRI, 2005). Indeed, water availability is the major constraint to the horizontal expansion of agricultural land in Egypt. Figure 1 shows Water Resources in Egypt

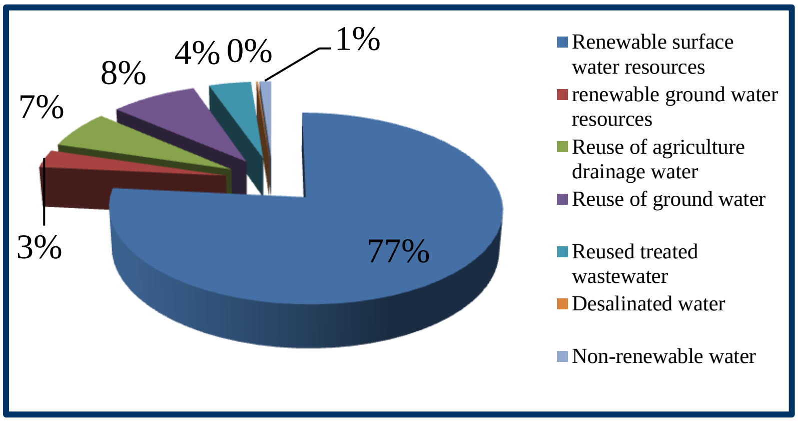

Figure 1: Water Resources in Egypt (Source: FAO, 2011)

4.2 Water Losses in Agriculture

The agricultural sector in Egypt is considered the major consumer of water; as 85% of Egypt's freshwater withdrawal from the Nile is directed to agriculture. Therefore, water availability directly impacts the state of food security in Egypt. In fact, Egypt imports about 236 m^3 of water per capita annually in the form of food (Hamza and Manson, 2004). However, water resources in Egypt are subject to inefficiency in utilization. Large amounts of irrigation water are actually being lost during water transfer from Aswan High Dam (AHD) to fields. According to table 3, irrigation water at the Aswan Dam has increased by about 20% from 2000 to 2009. Yet, losses during the process of transferring irrigation water from AHD to fields due to transpiration and evaporation has increased from 30.90% in 1985 to 35.46% in 2005, and reached 33% in 2010. In addition, to water losses during the transfer process, the efficiency of the field irrigation system is estimated at about 50% (MALR, 2009). In addition, Egyptian farmers are still using traditional irrigation techniques, which result in excessive use of irrigation water.

Table 3 : Agricultural Water Losses in Egypt

Period	Irrigation Water			Total Losses	
	At AHD	At Canals	At Fields	Amount	%
1990	56.17	50.26	42.72	13.45	23.95
1995	50.15	49.11	48.07	2.8	4.15
2000	52.50	47.25	39.38	13.12	24.99
2005	46.13	35.44	29.78	16.36	35.46
2006	59.70	47.08	40.94	18.76	31.42
2007	61.14	48.14	42.08	19.06	31.17
2008	62.10	48.85	42.85	19.25	31.00

Source: Bulletin of Water Resources and Irrigation (various issues); Saleh (2008); and author's calculations

Given the scarcity of water resources in Egypt, there is an urgent need for the use non-conventional water resources. According to Hamza and Mason (2004), reuse of drainage and sewage water, in addition to improving efficiency in irrigation systems and adopting more water efficient cropping patterns, can save additional 29.3 billion m^3 by 2017 (table 3), equivalent to almost 40% of the total amount of water used in 2005. Given the government's plan to expand the cultivated area to reach 10.8 million feddans in 2017, up from 8 million feddans that are currently cultivated, it is estimated that the amount of water needed for irrigation in 2017 will be 63.6 billion m^3, of which 42.3 billion m^3 will actually be used (33% loss) (MWRI, 2005).

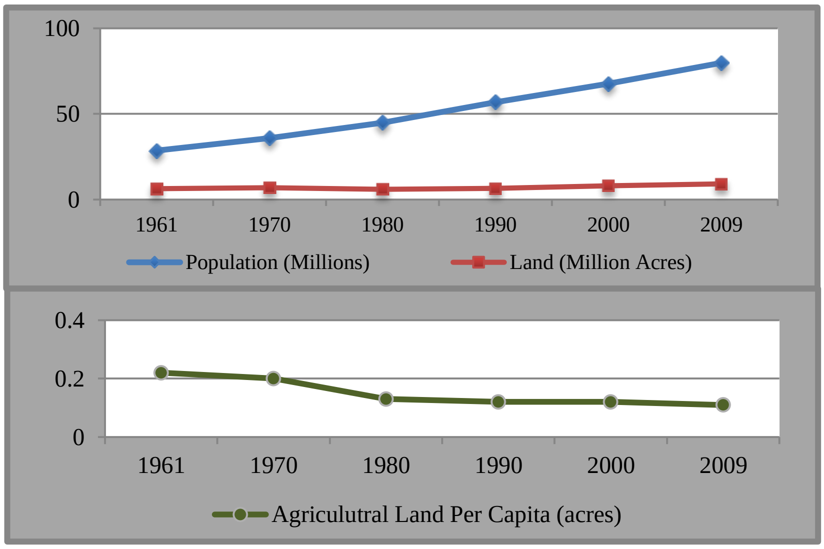

Figure 2: Populations and Agricultural Land Progressing in Egypt
(FAO, 2011 and Author's calculations)

4.3 Land Availability

Land is considered the most limiting resource for agricultural production in Egypt. Egypt is among the lowest in the world in terms of the per capita share of agricultural land. The steady decline in agricultural land per capita is attributed to many reasons. The most important of which is the rapidly growing population. Egypt's population is growing at an annual average rate of 1.8%, compared to an average growth rate of 1.3% per annum for agricultural land, thus resulting in the steady decline in the per share of agricultural land, (Shehata and Mohammad, 2010). Currently the total agricultural land in Egypt stands at 8.7 million feddans (9.1 million acres), representing 3.66% of total land area, of which 3.2 million ha lies within the irrigated Nile Basin and Delta. Agricultural land covers three different production zones;

- The "Old Lands" along the Nile Valley and the Delta that are the most fertile, with an area of 6.1 million feddans (6.33 million acres).
- The New Lands that were reclaimed, as part of the government's efforts to
- horizontally expand agriculture, with an area of 1.1 million feddans (1.15 million acres),
- A small portion of agriculture in Egypt is rain fed, located in the Northwest Coast and North Sinai, with area about 1.5 million feddans (Abdel Hady, 2004; MALR, 2009).

4.4 Land Quality

Another key reason for the continuous decline of the per capita share of agricultural land in Egypt is urbanization and the expansion of residential areas at the expense of agricultural land. In spite of enacting several laws to limit this trend, encroachment on agricultural land is still taking place at an annual rate of 20,000 feddans (MALR, 2009). Furthermore, the quality of agricultural land in Egypt has been deteriorating over the past 5 decades due to various reasons;

- The low investment in drainage since the 1950s, which led to salinity problems. According to Richards (1982), the FAO estimated that in mid-1970s, 35% of the cultivated area in Egypt suffered from salinity problems; thus leading to reduction in yield.
- The problem of fertility is the second major reason for the deterioration of the quality of land in Egypt.
- The absence of silt from the Nile; as it remained in canals under the system of perennial irrigation, adopted instead of the basin irrigation system.
- Furthermore, the use of the top layer of the soil to manufacture bricks adds to the loss of fertility in agricultural land (Richards, 1982).
- Finally, the rising ground water level, due to not applying the scientifically recommended crop rotations and the repeated cultivation of particular crops, is another reason for the declining fertility of agricultural land in Egypt (MALR, 2009).

4.5 Climate Change

The agricultural sector in Egypt is highly vulnerable to climate change. This is attributed to different reasons including the heavy dependency of agricultural sector in Egypt on the Nile as a primary water source, and the long coastline in Egypt that is enduring erosion (El-Shaer et al., 1996). However, according to El-Shaer et al. (1996), the future of agriculture in Egypt is very hard to project in light of the expected impact of climate change on water availability and the potential effects of the sea-level rise phenomenon. Therefore, it is highly advisable for policymakers in the agricultural sector in Egypt to adopt appropriate measures to limit the impact of climate change, basically through tackling the water waste, as well as paying special attention to adapt practices in the cropping pattern in order to alleviate the hardship of the changing weather condition.

4.6 High consumption of fertilizers

The data of fertilizers consumption retrieved from FAO as shown in Figure 3, demonstrates clearly fertilizers input on agricultural land in Egypt has increased over the past two decades. The average total annual fertilizers consumption during the mentioned period is about 1250 ton/year.

The Egyptian agriculture is a heavy user of chemcial fertilizers that increase land productivity in order to increase total annual production to meet the growing demand for food. However, the extensive use of chemical fertilizers results in increasing the pressure on soil and water (Abdel Hady, 2004). As a matter of fact, Nitrogen and Phosphorus fertilizers are the greatest concern to water quality

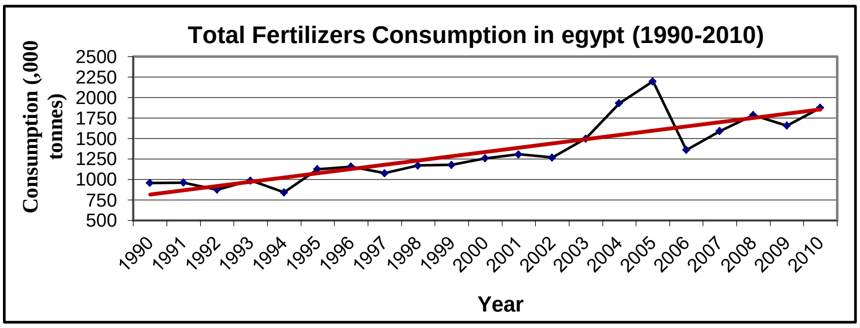

Figure 3: The total fertilizers consumption in Egypt (http://faostat.fao.org)

5. ANALYSIS OF CROPPING PATTERN IN EGYPT

5.1 Cropping Pattern Progress after High Dam

The mentioned different problems in the Egyptian agricultural sector have, indeed, affected the cropping pattern significantly. Table (3) tracks the evolution of the cropped area of key crops in Egypt during the 1960s, 1970s and 1980s. Given the heavy price and area restrictions, the cropping pattern shifted away from major field crops with controlled prices towards untaxed, higher value products. The cropped area of cotton and grains, whose prices were highly controlled, declined relative to other high-value, less regulated crops, such as clover, rice, vegetables and fruits (Richards, 1982; and Moursi 1993).

Table 3 Cropping Pattern Progressing: After High Dam Construction (1965 - 1985)

	1965		1970		1975		1980		1985	
Crops	**'000 feds**	**Water M m3**	**'000 feds**	**Water M m3**	**'000 feds**	**Water M m3**	**'000 feds**	**Water M m3**	**'000 feds**	**Water M m3**
Wheat	**1501**	**2.90**	**1387**	**2.68**	**1268**	**2.45**	**1302**	**2.51**	**1345**	**2.60**
Rice	**641**	**4.85**	**791**	**5.98**	**1028**	**7.78**	**1093**	**8.27**	**1042**	**7.88**
Maize	**1850**	**8.06**	**1727**	**7.52**	**1510**	**6.58**	**1593**	**6.94**	**1831**	**7.98**
Grains	**586**	**2.44**	**600**	**2.533**	**609**	**2.73**	**575**	**2.32**	**560**	**2.25**
BroadBeans	**353**	**0.89**	**365**	**0.92**	**349**	**0.88**	**283**	**0.71**	**260**	**0.66**
Clover	**2362**	**8.75**	**2444**	**9.05**	**2630**	**9.74**	**2801**	**10.38**	**2834**	**10.50**
Sugar Cane	**111**	**1.50**	**122**	**1.65**	**145**	**1.96**	**197**	**2.67**	**248**	**3.36**
Cotton	**1791**	**10.20**	**1751**	**9.97**	**1694**	**9.65**	**1551**	**8.83**	**1296**	**7.38**
Vegets	**395**	**1.31**	**447**	**1.49**	**668**	**2.22**	**761**	**2.53**	**914**	**3.04**
Fruits	**114**	**0.59**	**147**	**0.76**	**208**	**1.08**	**255**	**1.32**	**311**	**1.61**
Total	**9704**	**41.52**	**9781**	**42.60**	**10109**	**45.11**	**10411**	**46.52**	**10641**	**47.29**

Source: Richard (1982)

According to table 3, the relative importance of wheat has declined from 15% in the period 1955-1959 to 12% in 1975-1979. The same happened for maize and broad beans, which had negative implications on food security. Also, the relative importance of cotton has declined from 17.8% in the period 1955-1959 to 14.3% in the period 1970-1974 and further declined to 11.7% in the period 1975-1979. Meanwhile, the relative importance of rice, clover, sugar cane and horticultural crops has increased noticeably as shown in figure 3.

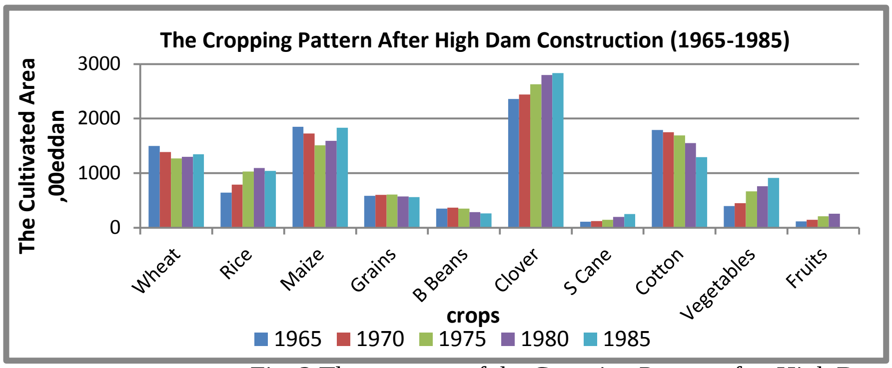

Fig. 3 The progress of the Cropping Pattern after High Dam

5.2 Evolution of the Cropping Pattern after Liberalization

Table 4 presents the evolution of the cropping pattern since the liberalization of the agricultural sector. Indeed, the liberalization of the agricultural sector in the early 1980s brought about fundamental changes in the cropping patter. With the liberalization of the sector, agricultural output increased significantly as cultivation of most crops became more profitable for farmers.

Table 4 :The progress of the Cropping Pattern: After Liberalization (1990 - 2010)

	1990		1995		2000		2010	
Crops	**'000 feds**	**Water million m3**	**'000 feds**	**Water million m3**	**'000 feds**	**Water million m3**	**'000 feds**	**Water million m3**
Wheat	**1320**	**4.25**	**1955**	**6.30**	**2463**	**7.93**	**2890**	**9.31**
Rice	**1013**	**8.44**	**1375**	**11.45**	**1550**	**12.75**	**1790**	**14.54**
Maize	**1953**	**8.46**	**1975**	**8.55**	**1928**	**8.35**	**1968**	**8.52**
Other Grains	**350**	**1.45**	**490**	**2.04**	**695**	**2.89**	**632**	**2.63**
Broad Beans	**326**	**0.815**	**345**	**0.86**	**307**	**0.76**	**202**	**0.50**
Sugar Beet	**18**	**0.063**	**34**	**0.12**	**136**	**0.47**	**386**	**1.35**
Clover	**2736**	**10.03**	**2457**	**9.00**	**2423**	**8.88**	**2685**	**9.84**
Sugar Cane	**249**	**3.32**	**263**	**3.50**	**319**	**4.25**	**320**	**4.26**
Cotton	**998**	**4.65**	**993**	**4.63**	**518**	**2.41**	**369**	**1.722**
Vegetable	**1031**	**3.43**	**1122**	**3.74**	**1690**	**5.63**	**1950**	**6.5**
Fruits	**404**	**2.77**	**866**	**5.93**	**1019**	**6.99**	**1277**	**8.235**
Total	**10398**	**49.72**	**11875**	**56.17**	**13253**	**63.24**	**14774**	**67.31**

Source: Annual Bulletin of Indicators of Agricultural Statistics, MALR (various issues)

However, according to Shousha and Pautsch (1997), the response of the aggregate cropping pattern to the liberalization strategy was very slow, which is another evidence for the moderate success of the agricultural liberalization strategy. The cropped area has increased from 11.18 million feddans in 1985 to 12.18 million in 1990 and further to 13.82 million feddans in 1995. In 2010, the cropped area stood at 15.3 million feddans, with a crop intensification rate of 175%.

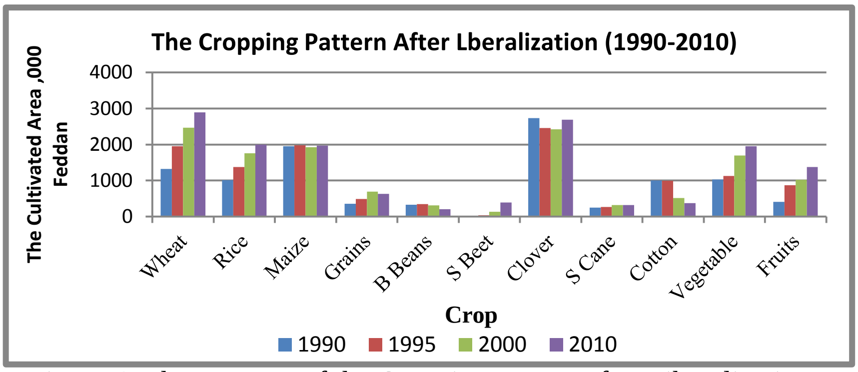

Figure 4: The progress of the Cropping Pattern after Liberalization

5.3 The Annual agricultural Water Requirements

The annual agricultural water requirements data of both periods (the period (1965-1985) after HAD construction) and (after the beginning of the liberalization period (1990-2010)) are shown in Figure 5. It is obliviously that the total annual agricultural water needs are increasing during (1990-2010) than during the period (1965-1985). This is due to the deteriorating efficiency of the field irrigation system as well as the contradiction between the actual water demand of agriculture and what is already available by our irrigation system.

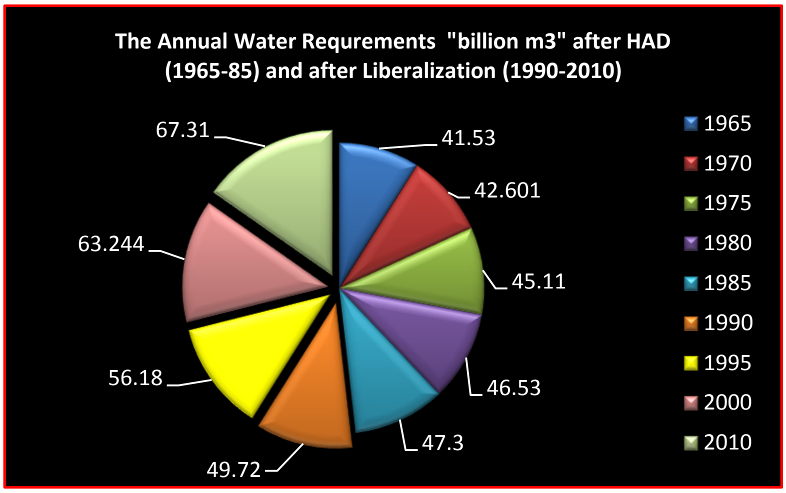

Fig. 5 The Annual Water Requirements during two periods before and after the Liberalization of agriculture

6. RESULTS AND DISCUSSION

As a matter of fact, the proposed three scenarios are based on four important crops (rice, cotton, sugar cane and sugar beet). The importance of these crops is clarified as follows;

Rice : Rice production is critical for the environment of the Northern Delta. After the instruction of Aswan High Dam, it was estimated that 700,000 feddans of rice cultivation are required annually in order to prevent salt-water intrusion and to maintain soil quality. Rice is the third largest crop in terms of cultivated area and total production after wheat and corn. Rice is particularly important because of its extensive use of irrigation water. for instance, on a per feddan basis the irrigation requirement of rice is 76% more than of cotton and 126% more than of corn. Rice could become one of the Egypt's important export commodities.

Cotton : Egypt's "white gold" continues to face several challenges which have led to an obvious deterioration in its status on the international market. Experts believe that unless the government takes serious steps to recover the reputation of its cotton crop by increasing production, introducing new cotton varieties, reducing costs and implementing a clear pricing policy. The most pressing problem facing Egyptian cotton crop is dwindling land areas on which it is grown. According to Ministry of Agriculture and Land Reclamation, there are 450,000 feddans available for cultivating cotton -- a far cry from the two million feddans of cotton harvested in the 1950s. The reason behind the decrease in land area is that farmers are no longer interested in the crop because of inconsistent pricing policies.

Sugar Cane / Sugar Beet : Sugar, primarily, is still obtained from cane, but sugar beet can be a feasible alternative due to its increased yield per feddan and low consumption of water. The tuber of sugar beet plant, Beta vulgarism, contains high concentration of sucrose. In view of the increasing water scarcity in Egypt, Sugarcane is a high crop requiring intensive amount of watering (more than 10,000 m3 / feddan) and occupying land for 10-14 months, whereas a low crop, like sugar beet, occupies land for only 4-5 months and needs fewer watering (about 3000 m3 / feddan).

6.1 Scenario 1

Fixing the cultivated area of rice at 1500 thousand feddan and increasing the cultivated areas of sugar beet and cotton by 30%. Alternatively, all cultivated areas of the other crops have been fixed according to the sustainable agricultural development strategy towards 2017.

Table 5-a: The 1st Proposed Scenario

Crop	Cropped Area ,000 fedan	Water Requirements billion m3 With Water efficiency	
		60%	65%
Wheat	3750	9.857	9.1
Rice	1500	10.776	8.7
Maize	2000	7.55	6.733
Other Grains	700	2.154	1.867
Broad Beans	250	1.154	1
Sugar Beet	500	1.615	1.3
Clover	2500	4.553	4.7
Sugar Cane	320	3.355	3.1
Cotton	480	2.511	2.176
Vegetable	2000	4.55	3.855
Fruits	1377	7.773	6.554
Total	15177	58.443	50.453

6.2 Scenario 2

Fixing the cultivated area of rice at 1300 thousand feddan and increasing the cultivated areas of sugar beet and cotton by 40%. Alternatively, fixing all cultivated areas of the other crops as the sustainable agricultural development strategy towards 2017.

Table 5-b: The 2nd Proposed Scenario

Crop	Cropped Area,000 fedan	Water Requirements billion m3 With Water efficiency	
		60%	65%
Wheat	3750	9.857	9.134
Rice	1300	8.552	7.212
Maize	2000	7.55	6.233
Other Grains	700	2.154	1.867
Broad Beans	250	1.154	1
Sugar Beet	540	1.546	1.433
Clover	2500	4.434	4.365
Sugar Cane	320	3.355	3.1
Cotton	520	2.733	2.233
Vegetable	2000	4.55	3.855
Fruits	1377	7.773	6.554
Total	15257	53.563	46.529

6.3 Scenario 3

Fixing the cultivated area of rice at 1100 thousand feddan and increasing the cultivated areas of sugar beet and cotton by 50%. On the other hand fixing all cultivated areas of the other crops as stated in the sustainable agricultural development strategy towards 2017.

Table 5-c: The 3rd Proposed Scenario

Crop	Cropped Area,000 feddan	Water Requirements billion m3 With Water efficiency	
		60%	65%
Wheat	3750	10.962	9.5
Rice	1100	7.615	6.6
Maize	2000	7.55	6.933
Other Grains	700	2.154	1.867
Broad Beans	250	1.154	1
Sugar Beet	600	1.615	1.4
Clover	2500	5.769	5
Sugar Cane	320	3.355	3.1
Cotton	560	2.511	2.176
Vegetable	2000	4.55	3.855
Fruits	1377	7.773	6.554
Total	15157	46.423	41.767

According to the preceding different cropping pattern scenarios, the common issue of them is to fix the cultivated areas of all crops except rice, sugar beet and cotton. It is understandable that the rice crop is playing a very serious role in the amounts of the agricultural water requirements as it is considered a very high water consumer. With respect to sugar beet, it will compensate for the shortage of sugar cane yield as its cropped area will be decreased through the different scenarios due to its high water consumption. Cotton is measured strategically as one of the most important national crops in Egypt and any increase in this crop yield will lead to an increase in the national income.

In scenario 1, the cultivated land area and water requirements in both cases of 60% and 65% water efficiency are **15177** thousand feddans, **58.443** billion m3 and **50.453** billion m3 respectively. While, in scenario 2, the cultivated land area and water requirements in both cases of 60% and 65% water efficiency are **15257** thousand feddans, **53.563** billion m3 and **46.529**billion m3 respectively. the cultivated land area and water requirements in both cases of 60% and 65% water efficiency are **15157** thousand feddans, **46.423**billion m3 and **41.767**billion m3 respectively.

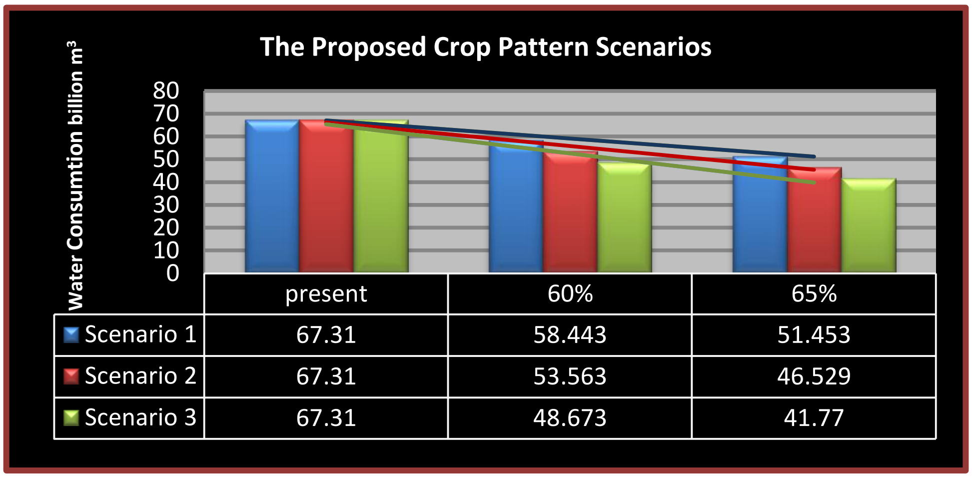

Figure 6 the proposed different three crop pattern scenarios

Out of these scenarios the most reasonable agricultural water requirement scenario is the third one in which the rice cropped area should not exceed 1100 thousand feddans as shown in Table 5-c. On the other hand, the cropping pattern of this scenario will fit the needs of sugar beet and cotton as they will be raised by 50%. Figure 6 shows the proposed different three scenarios and clarifies the amount of water requirements in each scenario.

7. CONCLUSIONS AND RECOMMENDATIONS

Two development strategies for the agricultural sector are currently being implemented, the first towards 2017 and the second towards 2030. The major determinants of the current agricultural problems of the agricultural sector are: Water Availability, Water Losses in Agriculture, The Land Problem (Land Availability& Land Quality), Climate Change, and Intensification of Agricultural Production

The progress of the agricultural land, availability of water, and the change in the cropping pattern have been evaluated during two important periods; firstly, after the construction of High Aswan Dam (1965-1985) and the 2nd period is after liberalization of agriculture (1990-2010).

Three crop pattern scenarios are proposed to investigate the best possible cropping pattern according to the available water resources in Egypt under two water use efficiency conditions:60% & 65%.Two main assumptions are identified in determining the best possible crop patren for Egypt as follows: Land Allocation Assumption to meet the domestic demand of crop production and Water Requirements Assumption to minimize the use of water.

It was found that the best crop pattern scenario is the 3rd one in which its cultivated area of rice should not exceed 1100 thousand feddan and the cultivated areas of sugar beet and cotton have been increased by 50%, on the other hand fixing all cultivated areas of the other crops according to the sustainable agricultural development strategy towards 2017.

Being a key objective in the Sustainable Strategy of Agricultural Development towards 2017, policymakers are concerned with achieving the state of food security through increasing the self-sufficiency rate of strategic food items. Additionally to the horizontal expansion of cultivated land, increasing crop production can also be achieved via vertical expansion through improving agricultural productivity and increasing plant yields within the accessible amount of water resources in Egypt. Greater attention shall be paid to the development and cultivation of high salinity resistant varieties suitable for the use of agricultural drainage water, in addition to early maturing varieties that lead to saving irrigation water and achieving higher crop intensification rates.

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