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REVIEW AND ANALYSIS OF WATER USE EFFICIENCY AND WATER PRODUCTIVITY IN EGYPT

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SUMMARY - This paper presents analysis of water resources availability and water uses in Egypt. More focus will be given to agricultural water use and productivity since agriculture sector represents the major water-consuming sector in Egypt. Nile River is the major source of water where rainfall is rare and groundwater is limited. The nature of the irrigation network and system of the Nile river is rather unique. Water lost from one point is usually used in the downstream, and hence the global water use efficiency is relatively high. Moreover, there is a multiple system for water use in Egypt. Water is used for agriculture, municipal and industry, navigation, hydropower generation, and fisheries. Emphasis in this paper is given to agriculture water use and productivity. Agriculture sector consumes about 85% of the total available water. There are several applied policies for improving water use efficiency. Irrigation Improvement project is currently implemented to enhance water distribution and minimize water losses through physical and institutional measures. Participatory approach is also being implemented in water management followed by modification of laws and institutional reform. Future water policies include introducing integrated water management approach to increase water use efficiency and maximize water productivity. The paper presents the productivity of the main crops in Egypt and water crop productivity compared to some international figures. The results show that crops have a relatively high productivity particularly rice crop which has the highest productivity over the world.

Key words: water resources, cropping pattern, crop production, Egypt.

INTRODUCTION

Water, always, plays an essential role for providing the basis of population stability and civilization. The Nile River in Egypt has supported the longest civilization over the world which lasted more than seven thousands years. Egyptians, throughout the history, were skillful enough to utilize the Nile water. During this century, they installed an invaluable water structure; High Aswan Dam (HAD). This dam helped in providing more controllable water releases pattern over the year, serving the Egyptian population who are living on the small batch along the river. Egypt's annual share of Nile water that controlled by the dam is 55.5 billion cubic meters as stipulated and agreed upon between Egypt and Sudan in 1959. After the construction of the HAD in 1986, the cultivated area has been expanded to reach 8.0 million feddans, which is cultivated about twice a year. The government of Egypt continues to invest heavily in expanding the cultivated area, and is planning to add another 3.4 million feddans of the cultivated land by year 2017.

Water Supply augmentation has been practiced in Egypt since several decades through recycling the drainage water and use of shallow groundwater. Drainage reuse started in 1970s and reached now a level of 4.0 billion cubic meters annually and it is planned by the government to increase the reuse up to 8.0 billion cubic meters annually. Simultaneously, the groundwater withdrawals are planed to increase from 4.0 to 7.0 billion cubic meters per year in Nile valley and Delta. The groundwater aquifers in the Nile Delta and Nile valley are replenished from the leakage water from the river, irrigation canals and drains. Therefore water supply augmentation through recycling (drainage water reuse) and capturing of the water losses (groundwater utilization) increases the overall efficiency of the water resources system in Egypt.

Although the water requirements of municipal and industrial sectors have the first priority to be met, the agricultural policies and innovations had its impact and pressure on the operation of the Nile water system. During the last decade the government of Egypt has liberalized the cropping pattern

and farmers became free to select the crops they like to grow, except for rice which is restricted to the permission of the government.

The Nile system is viewed as two sub-global systems; Nile valley and Delta. In Nile valley, drainage water returns back to the river and drainage reuse practices are limited and occur only on a very small scale. Delta region is the potential area for drainage reuse promotion. The linkage between the different hydrological areas, i.e. between global or sub-global and the local levels, is the water flows and change in salts concentration. The water and salt balance analyses are, therefore, viewed essential for evaluating these levels.

At present, operation of the Nile system is successful in meeting the current water demands. However, Egypt must do more with less water (Abu Zeid, 1997) to cope with future development plans for the country and with projected future increase in population. Egypt has introduced different innovations to the existing system in order to save water from old lands to be diverted to the new lands. These innovations included Irrigation Improvement Project which started in 1980's, and drainage water reuse program which started in 1970's. The irrigation improvement project activities include improvement of secondary and tertiary irrigation delivery network and leveling of agricultural fields. It is expected that this project will result in saving irrigation water and improving the agricultural productivity. Drainage water is one of the valuable water resources in Egypt created by the intensive and large irrigation/drainage system. It accumulates the excess of irrigation water with appropriate quality that can be reused within the system.

WATER RESOURCES

Water resources in Egypt are represented with the annual quota from the Nile water; the limited amount of rainfall; the shallow and renewable groundwater reservoirs in the Nile Valley, the Nile Delta and the coastal strip; and the deep nonrenewable groundwater in the eastern desert, the western desert and Sinai. The non-traditional water resources include reuse of drainage and municipal waste water, and desalination of seawater and brackish groundwater. The rainfall is very limited, and mainly at the north coast on the order of 200 mm/year. The more we go southward to Cairo the less this amount is, then the decrease is rapid until the southern areas where there is almost no rainfall. Rainstorms in Egypt take place in autumn, winter and spring and their frequency and intensity differ from year to year. Table 1 shows the available water resources in Egypt and the water use of the different sectors at year 2000.

Table 1. Water Uses and Available Resources in Year 2000

Water Uses (bcm/year)		*Water Resources (bcm/year)*	
Sector	*Amount*	*Resource*	*Amount*
Municipalities	5.25	Nile river	55.50
Industry	3.50	Groundwater (Delta and Valley)	5.50
River Transport	0.25	Deep Groundwater	0.8
Fisheries	-	Drainage Water Reuse	
Hydropower	-	- Canals in the Delta Region	4.5
Agriculture	63.00	- Nile river and Bahr Youssef	5.0
		- Illegal Uses	3.0
		Waste Water Reuse	0.2
		Rainfall and Flash Floods	0.5
		Evaporation Losses	(3)
Total	*72.00*	*Total*	*72.00*

GOVERNMENT POLICIES AND FARMER PRACTICES ON CROPPING PATTERN

Crop Liberalization Policy

Selection of crops, mainly cotton and basic food grains, to be grown every year was controlled by the government till year 1985. Farmers were responsible to deliver a preset quota of grains or cotton to the government. The government was controlling all marketing channels and prices. This policy resulted in an average of 30% net tax on agricultural outputs, which enabled the government to continue subsidizing consumers and financing industrialization. The government controlled also the crop rotation among growers. Figure (1) shows a typical crop rotation types (3-turn crop rotation). During the period 1985-1990, partial free cropping pattern policy was applied. It included liberalizing most of crops except for cotton and rice.

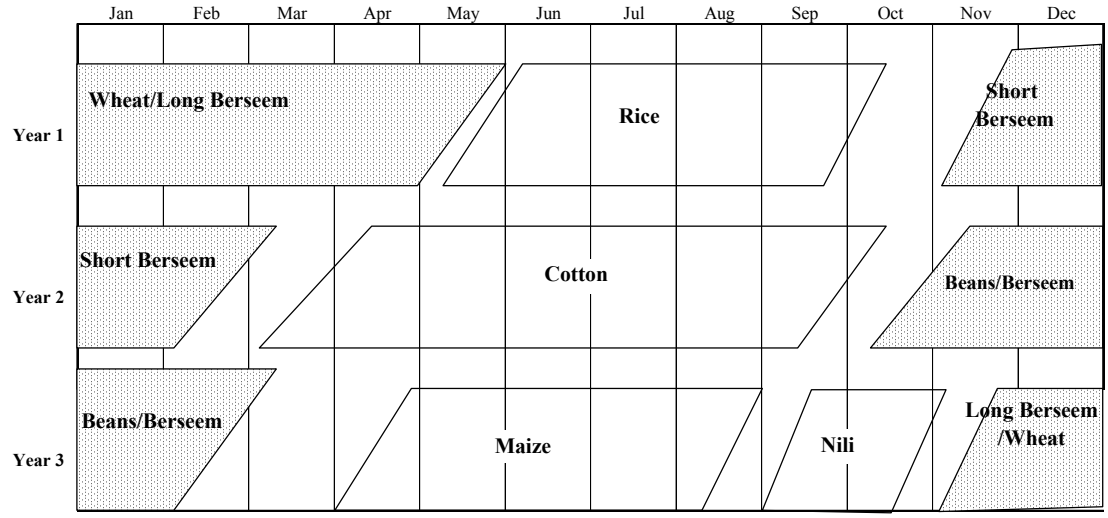

Fig. 1 Three-Turn Crop Rotation

By year 1995, all crops were liberalized except for rice and sugar cane, which was restricted to the availability of water resources and future expansion plans. In fact this policy resulted in a wide variation in crop selection among growers. Cotton and rice areas were clearly affected, as most of growers shifted from cultivating cotton to rice. Although the MPWWR restricted the rice area not to exceed 1.0 million feddans, but the actual cultivated rice area reached 1.5 million feddans in year 1995, i.e. 50% more than the targeted area. On contrary, the cotton area declined to reach about 0.7 million feddans. Then, the government started to motivate cotton growers through creating new mechanisms for cotton marketing.

Among different regions in Egypt, crop diversification varies according to the climatic and soil conditions. In Upper Egypt sugar cane is the largest single crop in summer, particularly in Aswan and Qena governorates. The second summer crop which competes with sugar cane in this region is sorghum and maize. In winter, wheat and clover are the major crops. In middle Egypt region, maize is major summer crop where it covers about 40% of the cultivated area. In winter, wheat and clover cover, situation looks different as the temperature is rather lower and soil conditions are different. In southern part of the Delta, rice is not allowed to be grown. Then, maize is the major summer crop and wheat is the major crop in winter. In the northern part of Delta rice is allowed to be grown where the water table is rather high. Figure (2) shows crop diversification for the different regions of Egypt.

Introducing short-duration crops

The government of Egypt has launched, in 1999, a program for introducing the short-term varieties of rice, to replace the log-duration one. The short-duration rice can be harvested after 120 days instead of 160 days of the long-term rice. It is assumed that the short-term varieties will consume less water compared to the traditional varieties.

Transplanting and Salt-Tolerant Crops

Cultivating the drought tolerant varieties will result in maximizing the crop water use efficiency. Moreover, using the transplanting method in cultivating some crops instead of direct seed sowing will reduce the water requirements of those crops. In the case of rice, the reduction in the water requirement is estimated by 10-15%.

Replacement sugarcane by sugar beet for sugar production, is another governmental plan. The government already introduced with great success the sugar beet in the western delta. The problem in upper Egypt that sugar cane is necessary for the sugar factories in the region. Sugar cane agriculture in upper Egypt therefore is expected to continue along the life time horizon of these factories. Introduction of modern irrigation in the sugar cane fields is being carried out to reduce the water application and to increase water use efficiency of this high water requirement crop.

Cultivating the salt tolerant crop varieties will save the fresh water as they can be irrigated by marginal low quality water. Agricultural drainage water can be used either directly or after mixing with fresh water, based on the salinity of drainage water. This is practiced in Egypt on a large scale and mainly in the north of the Nile Delta as well as in EI-Salam canal project in the eastern Delta and Sinai.

Intensifying Cropping Pattern

The crop intensity indicates how land is cultivated. In many case the land is cultivated twice in one year; winter and summer crops. The crop intensity ranges from 1.3 to 2.36. The higher intensity indicates that the land is cultivated three times a year. Crop intensity is higher in Lower Egypt compared to other regions. The overall crop intensity in Egypt is about 1.81.

Winter Crops

Long-duration clover occupies about 85% of the total cultivated area in Port Said. Damietta and Menoufia Governorates showed also about 50% and 42% of its area, respectively, grown with long-duration clover.

Wheat and Long-duration clover occupies about 38% for each, of the cultivated in Fayoum. While in Beni Suef, wheat occupies about 40% of the cultivated area and long duration clover occupies less than 20%. Long-duration clover is the dominant crop in Giza that constitutes more than 35% of the cultivated area, but wheat represents less than 10%. n upper Egypt governorates, the dominant crop is wheat which occupies 40%, 57%, 37%, 22% of the cultivated area in Assuit, Sohag, Qena, and Aswan. Long-duration Clover is rather less than 20 % in these governorates.

Summer Crops

Maize, Rice, Cotton and Sorghum are the major summer crops in Egypt as illustrated in Figure 2. Rice occupies the largest area in Lower Egypt (35% of the total area). Maize Occupies 37% of the cultivated area in Middle Egypt, 24% in Lower Egypt and 23% in Upper Egypt. Cotton occupies 18% of the cultivated area in Lower Egypt, 13% in Middle Egypt and 6% in Upper Egypt. Sorghum is a dominant crop in Upper Egypt where it occupies 25% of the total cultivated area and 4% in Middle Egypt.

Nili Crops

Nili Crops are planted during the period July – September. These crops are minors and occupy 7%, 21% and 8% in Lower, Middle and Upper Egypt, respectively. Nili crops include mainly maize.

Perennial Crops

Perennial crops include Sugar Cane and Orchards. Sugar Cane is the most dominant crop in Upper Egypt where it occupies 24% of the total cultivated area. In Middle Egypt Sugar Cane occupies

only 8%. Orchard occupies 9%, 8% and 4% in Lower Egypt, Middle Egypt and Upper Egypt, respectively. Orchards showed a high percentage in Desert Governorates; 47% of the

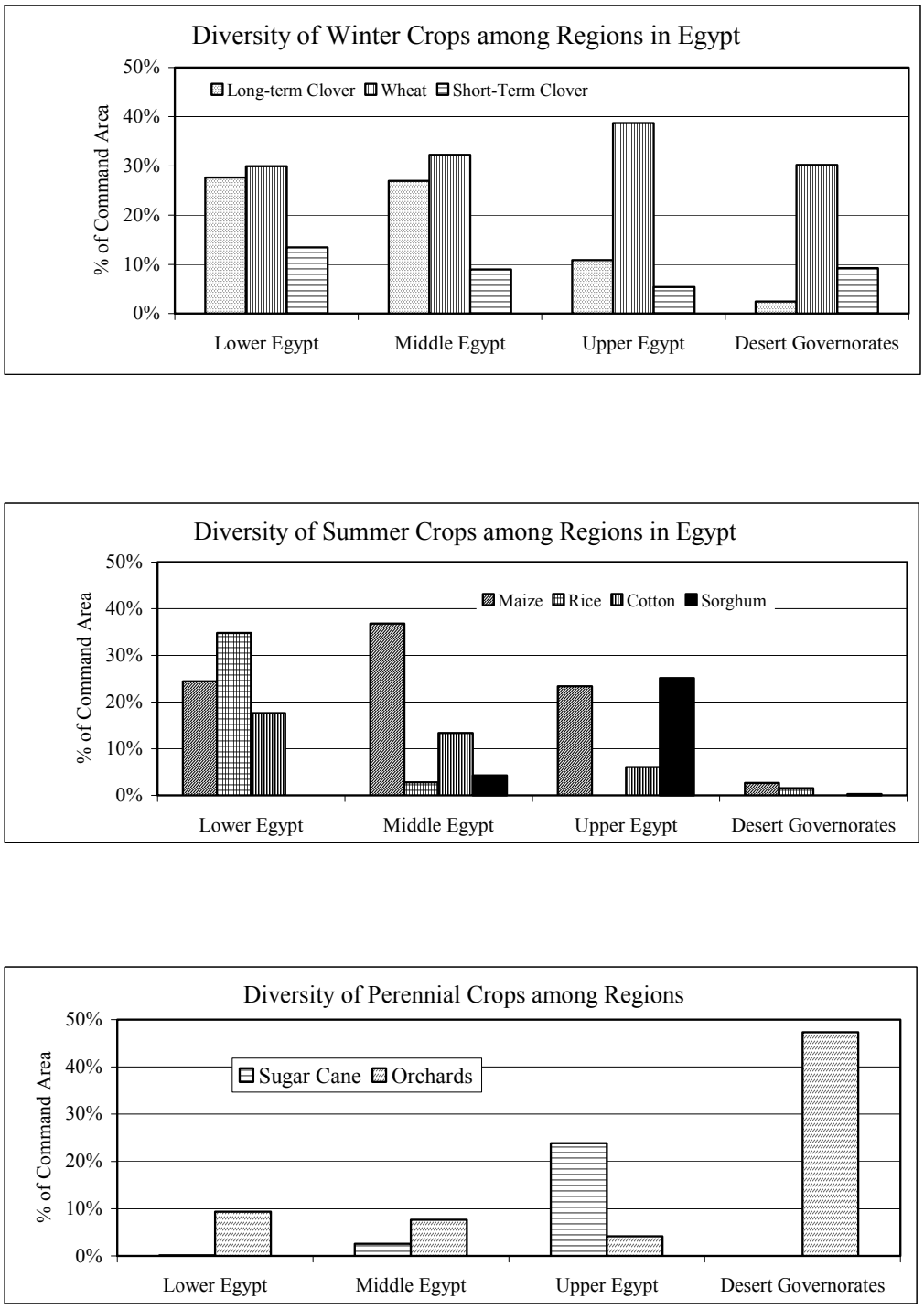

Fig. 2 Crop diversity in Different Regions

CROP PRODUCTION

Crop yield and production is affected by different factors such as availability of water, quality of irrigation water, soil type and climatic conditions. As mentioned before, irrigation water deteriorates as moving northwards downstream the system but still within the safe limits. However, the new reclaimed

areas at the end of the system such as in the north of Delta are depending, on a great extent, on drainage water which has salinity of higher than 1500 ppm.

Winter Crop Yield

Table 2 presents the crop yield on governorate basis (MALR, 1996). It includes Wheat, Barely, Beans, Clover and Tomato. It could be concluded from these data that there is no big difference of wheat yield in Lower, Middle and Upper Egypt where the average yield are 17.03, 17.71 and 16.5 Ardeb/fed, respectively. But, there is significant difference in yield for tomato crop. The average yield of tomato was 14.3, 12.24 and 20.29 in Lower, Middle and Upper Egypt regions, respectively. This may indicate the impact of low water quality on tomato production.

Table 2. Winter Crop Yield at Governorate Level (Source: MALR, 1996)

Governorate	Wheat (Ardeb/fed)		Barely (Ardeb/fed)		Beans (Ardeb/fed)		Clover (Tons/fed)		Tomato (Tons/fed)	
	Old Land	New Land	Old Land	New Land	Old Land	New Land	Old Land	New Land	Old Land	New Land
Nobaria		11.03		8.87		9.44		19.40		13.77
Alxandria	15.54	13.00	8.49	8.18					8.90	
Beheira	17.04		13.83		7.91		28.27		7.23	
Gharbia	16.75		17.05		10.72		23.84		9.73	
Kafr Elsheikh	17.58	13.63	11.97	8.23	10.06		25.77	20.00	9.17	
Dakahlia	17.05	14.42	17.50	12.87	9.75		21.38	14.50	7.24	
Damietta	14.41		9.22		8.59		21.96		6.55	
Sharkia	17.1	13.36	16.52		9.64	7.00	25.35	14.00	13.76	
Ismailia	13.87	13.01	13.52	8.24	6.36	4.00	14.11		29.18	
Port Said	8		4.00		7.00		15.08	17.00	6.00	
Suez	13.19	13.13	13.99	10.30	6.88		19.98		8.70	
Menoufia	17.99	14.18	16.00		8.92	6.00	28.18	26.60	8.98	
Qaliobia	16.79		17.74		8.91		33.34		14.16	
Cairo	12.06	6.76	13.50				19.51		7.91	
Total for Lower Egypt	**17.03**		**14.16**		**9.34**	**9.37**	**25.40**		**14.28**	**13.77**
Giza	20.67	14.00	18.55		8.50		32.73		14.24	
Beni Suef	15.86		13.77	13.00	5.91		32.80	13.00	14.26	
Fayoum	16.81	14.00	11.70	12.00	7.64		18.60	20.00	9.90	
Menya	19.39	13.00	12.79	10.64	6.88		22.00	12.00	11.02	
Total for Middle Egypt	**17.71**		**12.08**		**6.92**		**24.41**		**12.24**	
Assuit	16.49	12.44	14.10		8.05		35.52		15.35	
Sohag	16.96	14.00	12.63	8.84	6.96	6.98	34.26	39.50	25.07	
Qena	15.79	11.45	10.95	11.22	6.16	5.64	23.58	23.34	25.64	
Aswan	15.99	5.00	8.94		6.02		21.65		6.06	
Luxor	18.13	10.56	0.00		7.50	6.50	26.11		13.00	
Total for Upper Egypt	**16.49**		**11.00**		**7.59**	**6.01**	**34.25**		**21.77**	
Total for Nile Valley & Delta	**17.06**	**12.11**	**13.50**	**9.38**	**8.55**	**9.28**	**25.84**	**20.29**	**16.78**	
New Valley	12.83		10.24	12.31	7.49		23.65		13.15	
Matrouh	1.17		1.73		8.50		22.00			
North Sinai	1.56		1.81						4.00	
South Sinai	4.14		0.00						10.53	
Total for Desert Govern.	**3.95**		**2.23**	**12.31**	**7.84**		**23.32**		**10.07**	

Note: Ardeb = 150 kg; feddan = 0.42 hectares

Summer Crop Yield

Table 3 shows the crop yield for Sorghum, maize, rice, sugar cane and cotton. There is no significant difference in maize yield among different regions in Egypt. But, cotton yield showed significant variation among regions. Cotton yield was found 6.97 Qentar/ fed1. In Lower Egypt, 8.2 Qentar/fed. In Middle Egypt and 11.42 Qentar/fed. In upper Egypt. This indicates the impact of water quality on cotton yield among different regions.

Table 3. Summer Crop Yield at Governorate (Source: MALR, 1996)

Governorate	Sorghum (Ardeb/fed)		Maize (Ardeb/fed)		Rice (Tons/fed)		Sugar Cane (Tons/fed)		Cotton (hair) (Qenta/fed)	
	Old Land	New Land	Old Land	New Land	Old Land	New Land	Old Land	New Land	Old Land	New Land
Nobaria		8.25		21.22				21.76		
Alxandria			18.10		3.21		40.00			
Beheira			23.40		3.65		24.73		6.52	
Gharbia			22.70		3.41		41.75		5.81	
Kafr Elsheikh			20.63	14.47	3.39		31.94		5.39	
Dakahlia			21.85	17.00	3.65		31.20		5.85	
Damietta			19.98		3.05		31.25		6.21	
Sharkia			20.28		3.48		39.37		7.95	
Ismailia			18.72		3.04				3.78	
Port Said			8.48		2.29				4.74	
Suez			15.73		2.00		29.46			
Menoufia			19.79	16.44	2.71		36.01		8.19	
Qaliobia			20.33	20.00	3.41		40.30		9.06	
Cairo			12.27				28.81			
Total for Lower Egypt		**8.25**	**21.25**		**3.51**		**36.07**	**21.76**	**6.97**	
Giza	15.82		22.74				33.51		4.14	
Beni Suef	19		18.75				25.63		8.75	
Fayoum	11.1		19.13	5.95	2.96		31.33		6.17	
Menya	14.78		21.92	19.50			46.54		9.04	
Total for Middle Egypt	**11.74**		**21.07**		**2.96**		**44.33**		**8.20**	
Assuit	14.09		20.12		3.49		40.77		11.80	
Sohag	12.89	12.45	20.60	20.00			47.66		10.64	
Qena	12.74	11.65	18.72	13.61			46.88	42.49	4.18	
Aswan	11.65		15.95				47.42			
Luxor	10.37		15.63	8.00			48.95			
Total for Upper Egypt	**13.4**	**11.07**	**19.77**				**47.22**	**42.49**	**11.42**	
Total for Nile Valley & Delta	**13.11**		**20.98**	**19.57**			**46.73**	**40.47**		
New Valley	11.49		8.81		2.76		20.00			
Matrouh			14.00							
North Sinai										
South Sinai										
Total for Desert Govern.	**3.95**		**2.23**	**12.31**	**7.84**		**23.32**		**10.07**	

Qnetar = 50 kg for cotton

Crop Yield in New Lands

New lands have more deteriorated water quality in delta region. The current cultivated new lands is still have safe limits for water quality, but the future reclamation areas may have more deteriorated water quality due to using drainage water on a great extent particularly on Northern Delta. The current production of crops in new lands showed nearly equal levels of production particularly for vegetables and maize.

It could be concluded that the crop production is higher in the upstream reaches of the Nile (Upper Egypt) and then decline as moving northwards to Delta region. But the difference is not very big. The current production of new lands is not far less than the old lands.

Crop yield compared to international Figures

Table 4 presents a comparison for crop yields for different countries. Egypt showed a high level of crop yield compared to other countries. Egypt is ranked on the top for sugar cane, rice, sesame and sorghum yield.

Table 4 Egypt's Rank among World Countries According to Productivity of Main Crops

Egypt's Rank	Crop	Yield (ton/fed)
1	Sugar cane	50.4
1	Rice	4.133
1	sesame	.531
1	Sorghum	2.397
2	Peanut	1.329
2	Broad bean	1.372
3	Lentil	.74
4	Wheat	2.755
7	Dry onion	14.064
9	Cotton	1.1
10	Maize	3.466
10	Barely	1.153
12	Potatoes	10.27
13	Sugar beet	20.29

Note: Number of countries used for comparison are 20
Source: Compiled by the General Department of Agricultural Studies (From FAO data)

Water Use Efficiency

The overall efficiency of the water system in year 2000, a shown in Figure 3, equals the consumption as a percentage of the total inflow, is about 71%. This efficiency is relatively high taking into consideration that the prevailing irrigation method is surface irrigation, which has a low efficiency. This high system efficiency is probably attributed to the intensive efforts of government in O&M, and to the current recycling practices, in addition to the considerable experience of Egyptian farmers.

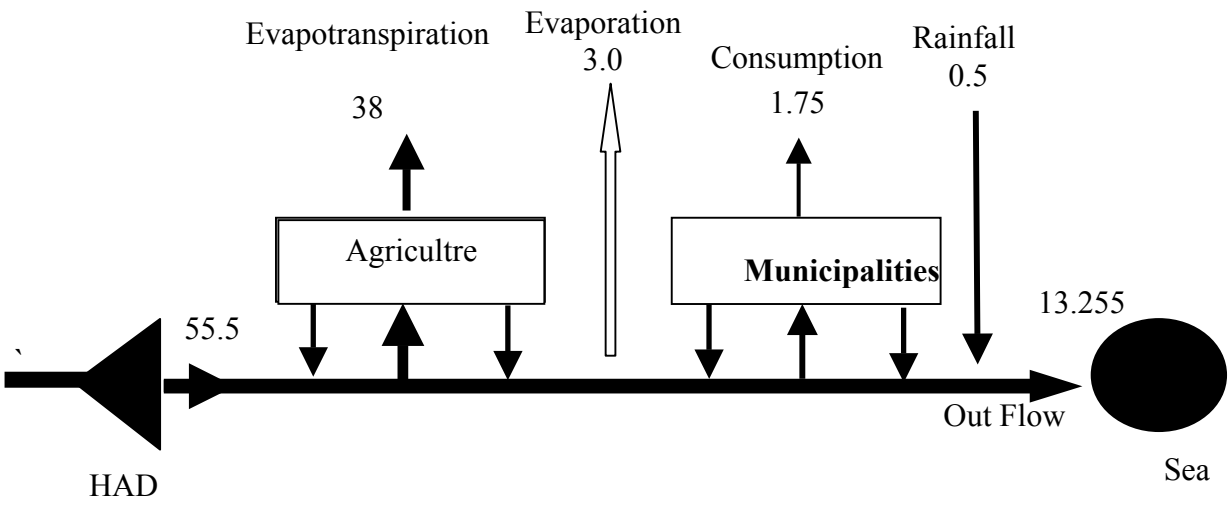

Fig. 3 Water Status in Year 2000

Note: all figures are in BCM/y

CONCLUSIONS

Although water resources are limited and scarce in Egypt, great efforts have been and are being conducted to increase water use efficiency and water productivities. The current water use efficiency exceeds 70% on the national level. However, plans are being prepared to increase this level of efficiency in order to increase the cultivated area by about 40% by year 2017. These plans include improvement of irrigation delivery systems, introducing low-water-consuming crops, introducing salt-tolerant crops, and reuse of drainage water. Intensifying cropping pattern was one of the factors contributed to increasing the water productivity.

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