Water Resources Use of the Great Man-Made River For Sustainable Agricultural Production: System Characterization

Abdul Aziz A.M. and A.I. Ekhmaj
Department of Soil and Water, Faculty of Agriculture,
Al Fateh University, Tripoli, Libya

ABSTRACT

The Libyan Arab Jamahiriya lacks permanently running rivers except for some temporal wadis. Underground water is the main source of water used for various purposes and activities accounting for about 98 % of the whole water consumption. Underground water is found in geological formations that differ in thickness, structure and depth. They are divided into renewable underground water reservoirs that receive direct feeding from rain and non-renewable underground aquifers. The Northern coastal part of Libya (the Libyan Coast) present one of the most vital and fragile ecosystem. As urbanization and other forms of development expanded, and population congregated 81.3 % of the total population found within the coastal territories, demand for fresh water escalated so the ground water resources was gradually exploited, extraction exceeded replenishment, water levels subsided and aquifers were subject to seawater intrusion. Facing this situation, the government planned and initiated implementation of an ambitions water-transfer scheme through the great man-made river. This area contains most of the farmlands yielding most of the crops, which depend mostly on permanent irrigation, and requires more supplies of water. Therefore, the Great Man-made River Project was carried out to transport fresh water from underground reservoirs in south of Libya to more fertile and cultivable lands where most people live, through a network of pipes that are buried at a depth of 7 meters under the ground. The pipe is 7.5 meters long and its inner diameter is 4 meters. After the termination of all its networks the pipes will be approximately 4,000 km long, which rightfully makes it the largest artificial irrigation network in the world. This paper discusses the importance and objectives of the Great Man - Made River Project. The water transferring system and recommended locations for agricultural investment for this project were also included in this paper.

Keywords: Great man-made river project, Water scarcity, Water transferring system

INTRODUCTION

In the beginning of the sixties, when oil drilling penetrating southerly inside the Libyan desert, a tremendous great storage of fresh underground water was discovered. The most important rock strata carrying water were formed in the geologic time when the Mediterranean Sea water used to flow southerly till they reach the Tibisti Mountains. In addition, sea water level changed occasionally and this led to the formation of sedimentary rocks of different kinds. These geological activities resulted in the emergence of

Nafusah Mountain and the Al-Akhdar Mountain and the formation of the underground water aquifers. These aquifers are porous sedimentary rocks where water accumulates in it and are surrounded by non-porous rocks. About 14,000 year ago to 38,000 year, the climate of North Africa was mild. Libya used to have high rainfall therefore, rainwater leaked inside the porous rocky strata and stored in it forming fresh underground water. There are five main reservoirs of underground water. These are Al-Kufrah, Sirt, Murzuq, Al-Hamadah and Jifarah, Fig.(1). The first three reservoirs collectively contain around 35,000 km^3 of water. These huge storage amounts of underground water will provide the coastal areas with great quantities of water.

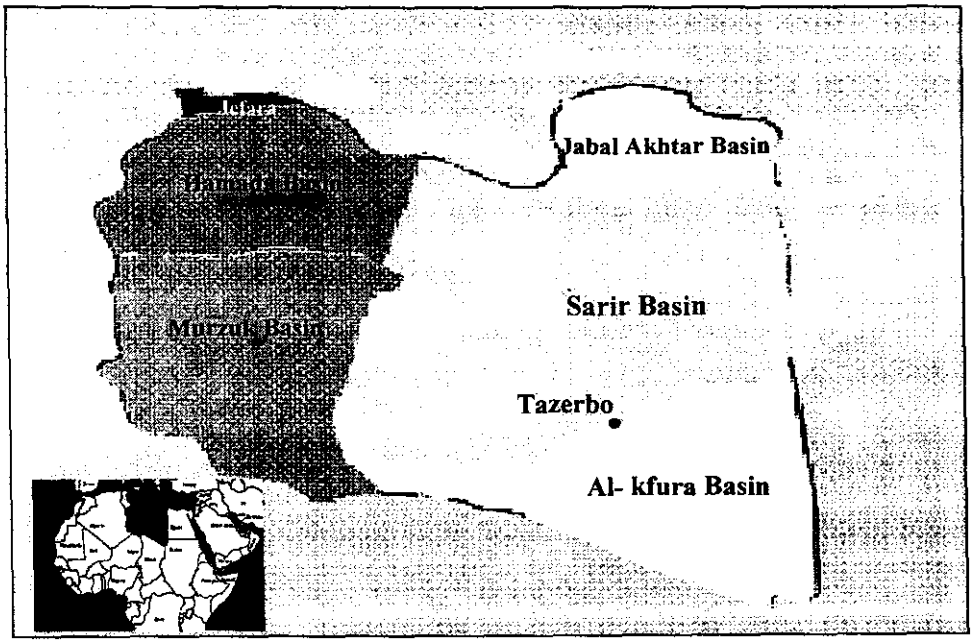

Figure 1: The main groundwater Basins in Libya.

1. The Importance of the Great Man - Made River Project:

As it is shown from the water balance of the Libyan Arab Jamahiriya, Tables (1&2) show that there is a huge surplus of underground fresh water the south which still awaits utilization (Al-Ghariani 1996). This surplus amounts to be about 90 % of the underground storage for Al-Kufrah

reservoir, and 84 % of the surplus of Sarir reservoir stock can be used in compensating the severe shortage of waters in the coastal cities (Annihum 1994).

Table 1: Population's water needs for different applications based on present growth rates (million m^3/ year)

Population and water demand	Year					
	2000	2005	2010	2015	2020	2025
Population (million capita)	5.7	6.7	7.8	9.0	10.3	11.7
Agricultural needs	4800	5060	5325	5590	5850	6640
Human needs	647	830	1015	1260	1512	1759
Industrial needs	132	185	236	330	422	566
Total needs	5579	6075	6576	7180	7784	8965

Source: Al-Ghariani (1996)

Table 2: The expected future water balance for the Libyan Arab Jamahiriya (million m^3/year)

	Year					
	2000	2005	2010	2015	2020	2025
Underground water	3430	3430	3430	3430	3430	3430
Surface water	120	120	120	120	120	120
Desalinated water	130	135	140	145	150	160
Treated water	220	250	300	400	450	520
Total available	3900	3935	3990	4095	4150	4230
Total needs	5579	6075	6576	7180	7784	8965
Shortage	1679	2140	2586	3085	3634	4735

Source: Al-Ghariani (1996)

More than alternative was studied and discussed in the method of dealing with underground water in the two areas of Al-Kufrah and Sarir which are thousands of kilometers away from the inhabited areas. The first approach was to establish agricultural assemblages in Al-Kufrah areas where water sites are found and irrigating assemblages through digging wells. However, this was prevented by the poor soil in the southern desert areas and the difficulty of transferring the agricultural products to consumption areas especially vegetables and fruits which spoil in a short time in addition to the lack of sufficient manpower to cultivate the desert land. The alternative of transporting humans from increasing demand for

water sites in coastal areas to underground reservoirs sites in the middle of the desert was suggested however, the idea did not receive any response nor approval by coastal cities inhabitants who kept living in these cities for long times, as well as, it was accepted because many oil industries, which the Libyan Arab Jamahiriya depends on, exist near the northern coastal cities. So, the necessity of transferring the underground water from the south to the coastal consumption areas in the north was suggested, and supported by the economical feasibility studies which proved that the cost of extracting a cubic meter of underground water from Al-Kufrah and Sarir reservoirs and transport it to the coastal cities through a concrete pipeline under the earth surface does not exceed 100 Durham (0.35U$) compared to 1,271 Durham (3.75U$) which is the cost of desalinization of a cubic meter of salt water and 950 Durham (2.80U$) which is the cost for transferring a cubic meter of water by marine carriers from the neighboring countries to the Libyan Arab Jamahiriya, Fig.(2).

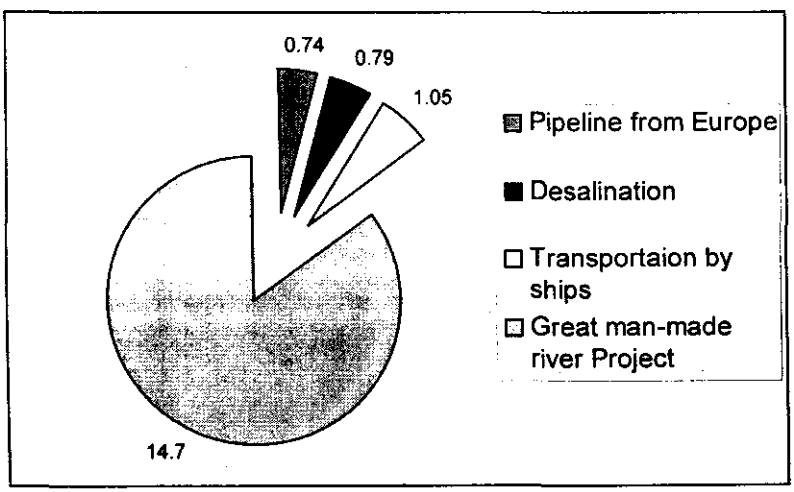

Figure 2: Cost comparison to Great man-made River

2. Objectives of the Great Man-Made River Project:

The project aspires through the agricultural investment programs (Al-Rabty, 1996) to achieve the following objectives: 1- Achieving food security and increasing self-efficiency of different strategic commodities. 2- Increasing the contribution of agriculture sector in the total local product, and expanding production base, increasing income and providing

alternative source for oil in the national income. 3- Achieving the social development in the targeted areas by investing through increasing income and providing work opportunities and stability. 4- Maintaining the environment and natural resources protection in the investment areas by soil and vegetation cover conservation programs and growing windbreaks and establishing check dams to preventing soil erosion.

3. Stages of the Project:

The great man-made river project is a civil engineering project and it is considered a new conquest of desert secret areas in order to utilize what it has underneath of fresh water resources. This is represented through extending an enormous system to transfer water from the desert to the fertile coastal areas through huge buried pipes at approximately a depth of 7 meters with an interior diameter of 4 m. When completing all its stages its length will be approximately 4,000 km., which forms an enormous artificial irrigation network.

Figure (3) illustrates the different phases of the great man-made river project as follows:

1- Sarir-Sirt / Tazerbo-Benghazi system.
2- Al-Hasawinah-Al-Jifarah plain system.
3- Connection link of Al-Gardabia-Assidada.
4- Al-Jaghbub-Tubruq system.
5- Al-Kufrah-Sarir system.
6- Ghadamis-Zuwarah-Azzawiyah system.

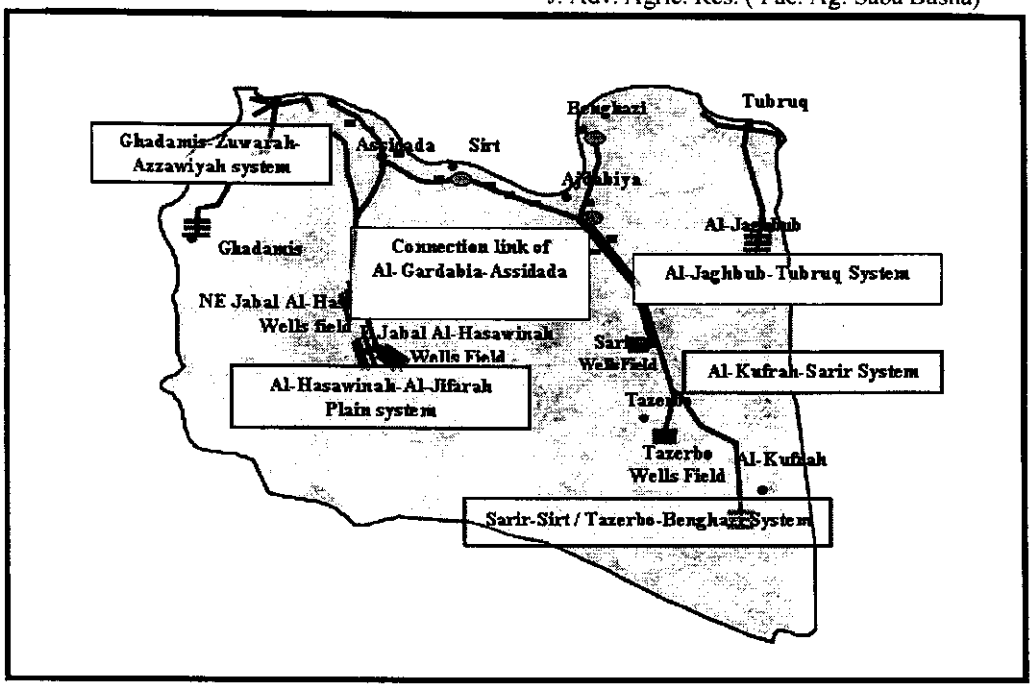

Figure 3: The main phases of the great man-made river project.

4. Water Transferring System (Sarir-Sirt / Tazerbo-Benghazi):

The system (Sarir-Sirt / Tazerbo-Benghazi) of the Great Man-Made river project consists of two parallel lines of pipes, each of 4 meters in diameter. The first line is Sarir-Sirt and the second is Tazerbo-Benghazi. The system transports 2 million m^3 of water daily from the 2 well fields in Sarir and Tazerbo to balance reservoir in Ajdabiya with a 600 kilometers length of wells field of Tazerbo. The system is divided beyond Ajdabiya reservoir to two branches, one of which goes westward to transport water to locations extending from Ajdabiya to Sirt by water allocated 287 million m^3 annually, of which 228 million m^3 are allocated to agriculture, Water Utilization and Agricultural Development (WUAD) (1997). The other branch goes northwards in the direction of Benghazi till the final reservoir near the village of Suluq the water resources of this branch are 413 million m^3 annually, of which about 275 million m^3 are allocated to agriculture Water Utilization and Agricultural Development WUAD (1998) Table (3).

Table 3: The allocating of water in the (Sarir-Sirt / Tazerbo-Benghazi) system for the Great Man-Made river project

	Quantity of water (million m^3 / year)	
	Ajdabiya-Sirt	Ajdabiya-Benghazi
Total Flow	287.000	413.000
Total loss in pipelines and reservoirs	8.036	11.564
Civil and industrial	50.340	126.884
Agriculture	228.624	274.552

Source: WUAD (1997), and WUAD (1998)

5. Sarir and Tazerbo Well's Fields:

There are enormous stored quantities of fresh water in the desert in underground aquifers. These waters are being pumped to the ground level through wells their depth reach to 450 m. These wells lie in both areas of Tazerbo and Sarir. Tazerbo wells field is composed of 108 productive wells whose waters gather in water collecting pipelines in order to pour into a reservoir at Tazerbo whose capacity is 170,000 cubic meters. From this reservoir, water flows naturally under gravity for a distance of 667 km through pipelines whose diameter is 4 meters to Ajdabiya reservoir. Sarir wells field is composed of 126 productive wells whose waters accumulate in water collecting pipelines in order to pour into two reservoirs at Sarir. The capacity of each is 170,000 cubic meters.

6. Ajdabiya Balancing Reservoir:

Waters flow from Sarir and Tazerbo naturally through two pipelines whose diameters are 4 meters for a distance of 381 km from Sarir and 667 km from Tazerbo till Ajdabiya reservoir, which was designed to absorb 4 million m^3 of water. This reservoir is considered as the assembling and storage point through which water can be distributed to any of the two main branches.

7. Sirt and Benghazi Terminal and Agricultural Reservoir:

Water flow naturally from balancing reservoir at Ajdabiya with a rate of 820,000 m^3 daily to Sirt terminal reservoir and with a rate of 1,180,000 m^3 daily to Benghazi end reservoir. The capacity of Sirt terminal reservoir amounts to 6.8 million m^3 and Sirt agricultural reservoir 15.4 million m^3. The capacity of Benghazi terminal reservoir is 4.7 million m^3 and Benghazi agricultural reservoir 24 million m^3.

8. Locations of the Agricultural Investment:

They were defined in the system of transporting water (Sarir-Sirt / Tazerbo-Benghazi) for the Great Man-Made River project so that they achieve the general strategy of agricultural development in the Libyan Arab Jamahiriya through the following pattern WUAD (1997),WUAD (1998) and Brown and Root (1988).

I- Supporting the existing farms with irrigation water in the following locations:

A- Locations pertaining to the Ajdabiya-Sirt system:

1 Western wadis (Tilal, Jaref, Gebeba).
2 Swawah and Abou Zahia.
3 Sultan and Al-Ammara.
4 Wadi Harawa.
5 Wadi Al-Henawa.
6 Eastern Wadis (Kehila, Matratin, Mas'ouda and Al-Shadg).

B- Locations pertaining to the Ajdabiya-Benghazi system:

1 Ghut Sultan.
2 Arrajmah Project.
3 Benghazi Plain.
4 Annawwaqiyah.

II- Reclaiming new areas and providing them with permanent irrigation system as general projects or settlement projects. These areas can be classified into three sections:

A- Limited projects specified either to serve some societies based on Industrial projects, or to support agricultural settlement projects. The patterns of small (settlement) farms were ratified for these projects:

1 Bishr project: which aims at covering the agricultural needs of Al-Brayqah Company for Oil and petrochemicals.
2 Annuwfaliyah Project: which aims at covering the agricultural needs of the Ras Lanuf Company for petrochemicals.
3 Benghazi project for small farms.
4 Wadi Tamit and Zukir projects to support agriculture settlements in these areas.

B- Projects for public usage:

2 Al Wadi Al-Ahmar Pastures Project
3 Growing palms project in Al-Wadi Al-Farigh.

4 Large Projects that aim at achieving the general policy of the Libyan Arab Jamahiriya in the field of agricultural production. These projects lie in the following areas:
5 Al-Gardabia.
6 The Northeast Al-Khadra area.
7 The Al-Khadra West.

The trends were remarkably contradictory since the beginning of investing the Great Man-made River water till now about the investment pattern targeted in those large projects. The original trend was towards large farms pattern (public productive projects). The recent trend was to limit the small farms pattern to locations with necessary infrastructure. Except for this, investment is directed towards large farm pattern in these projects.

8-1. Ajdabiya-Sirt System:

Total water allocations for the Ajdabiya-Sirt system are about 287 million m^3 annually, with a daily flow that reaches 820,000 m^3 for 350 days. The system stops working for 15 days for regular maintenance WUAD (1997), and Brown and Root (1988). Agricultural allocations for this system are about 228 million m^3, or 80 % of the whole allocations. These allocations suffice to irrigate an area of 25,000 hectares the rest is allocated to urbanization purposes WUAD (1997), and Brown and Root (1988).

Recommended Locations for Agricultural Investment:

From the economic and technical studies, Sasi *et al.* (1987), WUAD (1997), and Brown and Root (1988). Done on the regions overlooking the Ajdabiya-Sirt System, the locations targeted for agricultural investment were marked in the most suitable soil so that it lies near large communities (Sirt). The investment philosophy focused on two principal criteria:

- First/ supporting some existing projects with irrigation water.
- Secondly/ Reclaiming new areas and subduing them to permanent irrigation as public productive projects (Large Farms) or as settlement small farms.

A- Small Farms Pattern (a settlement project)

The total number of small farms targeted for this system is about 4,200 farms. This pattern will be applied in Swawah, Abou Zahia, Bishr, Annuwfaliyah, Eastern Wadis (Kehila, Matratin, Mas'ouda and Al-Shadg), Wadi Al-Ahmar, Wadi Harawa, Sultan, Al-Ammara, Wadi Al-Henawa, Western Wadis (Tilal, Jaref, and Gebeba), Wadi Tamit and Zukir. The irrigated area for each farm ranges between 5 – 6 hectares. The already

existing small farms had 6 hectares as net irrigated area. As for new small farms in the investment region, the net irrigated area inside each farm was 5 hectares.

B- Large Farms Pattern (a production project):

Agricultural projects have been made and designed on the basis of large units of irrigation, each unit is called a large farm and its area varies according to irrigation equipment. The total area of the pattern of large productive farms targeted for this system is about 5,500 hectares. It is applied in Al-Gardabia and Al-Wadi Al-Farigh.

8-2. Ajdabiya-Benghazi System:

Total water allocations for Ajdabiya-Benghazi system are about 413 million m^3annually, with a daily flow that reaches 1,180,000 million m^3 for 350 days. The system stops working for 15 days for maintenance WUAD (1998), and Brown and Root (1988). Agricultural allocation for this system is about 275 million m^3, or 70 % of the whole allocation. It suffices for irrigating an area of around 40,000 hectares. The rest is allocated for urbanization purposes WUAD (1998), and Brown and Root (1988).

Recommended locations for agricultural investment:

As mentioned in the Ajdabiya-Benghazi System, the targeted locations were determined in the most suitable soil from the technical and economic studies Moumen *et al.* (1989), WUAD (1998), & Brown and Root (1988).These locations were existed on the Ajdabiya-Benghazi system, so that they lie near to large communities (Benghazi). The investment philosophy focused on two principal criteria:

- First / supporting some already existing projects with irrigation water.
- Secondly/ reclaiming new regions and subjugating them to a permanent irrigation system as public productive projects (Large Farms) or as small settlement farms.

A- Small farms pattern (a settlement project):

The total number of small farms targeted on this system is estimated to be about 3,200 farms. This pattern will be applied in Northeast Al-Khadra, Ghut Sultan, Wadi Al-Qattara, Benghazi Plain and Annawwaqiyah. The total area of the small farm ranges between 7 – 12 hectares, of which 6 hectares represent the net irrigated area.

Infra structure works required for these projects include:

1 Establishing of water distribution networks.
2 Establishing of electricity distribution networks.
3 Constructing networks of internal roads between farms.
4 Constructing water reservoirs in each farm, with a 240 m^3 capacity.
5 Constructing windbreaks and enclosures around each farm.
6 Constructing networks of drainage to protect farms against floods.

B- Large Farms Pattern (productive project):

This pattern cares about constructing agricultural projects designed on the basis of large units of irrigation; each is called a large farm and its area varies according to the type of irrigation equipment used. The whole area of the large farms pattern (the productive ones targeted on this system) is about 11,300 hectares. This pattern is applied in the Northeast Al-Khadra, Al-Khadra West and Ghut Sultan. The action aimed at carrying out the projects includes water distribution networks, networks of electricity, road networks and constructing large irrigation equipment.

9. Crop Pattern for Investment Projects:

Targeted crops were chosen either in small farms or in large farms, based on making an adequate crop pattern that can achieve a good economic result from using the great Man-Made river water, and can match the general food security strategy of the Libyan Arab Jamahiriya on the basis of achieving a high rate of self sufficiency in agricultural production, especially in grains and fodder. Moreover, it puts into consideration simplifying the necessary agriculture action, especially in small farms.
There was a focus in the proposed crop pattern on the field crops to produce grain and necessary to cover the food needs of sheep, besides guaranteeing local marketing of them when there is a surplus. A limited area was allocated to the production of fruits and vegetables inside every small farm to cover the needs of the families besides the ability of providing extra income for every family when these crops are locally marketed.

The following crops were chosen for investment projects on the Ajdabiya – Sirt system and the Ajdabiya – Benghazi system for the following technical reasons.

1. Barley: it's an essential crop in small farms because it is the traditional winter grain to all farmers, and it is the most acclimatizing of all crops. It is also source of energy for sheep.
2. Wheat: a strategic crop targeted in the general plan of the Libyan Arab Jamahiriya to achieve food security through achieving self-sufficiency of it. Therefore, it is the principal grain in these crops.
3. Alfalfa: it's a highly productive fodder. It surely gives high quantity of protein and energy to livestock throughout the whole year. It is also of great economic value in the local market, which makes good income for the farmer when he sells the surplus. It is also a perennial crop that lasts more than 3 years in the soil and forms a strong basis for crop rotation that guarantees improving the soil fertilities, hence improving its productive power.
4. Vetch and Oat mixture: they are considered seasonal fodder's when the growth of Alfalfa is slow, the Vetch and Oat mixture play that role in winter, while Sorghum or Corn play that role in summer. Oat mixture and Sorghum may not be familiar to a farmer, but they do not differ from other fodders in the way they are cultivated, however they are cut while they are green before they become mature.
5. Fruit trees and Vegetables: crops of small farms included limited areas specified for producing vegetables and fruits that are most suitable to irrigated agriculture under the local and environmental conditions such as tomatoes, beans, marrow's, okras, grapes figs, pomegranates and olives. This area was specified for achieving self-sufficiency of these crops in the farm, besides being able to sell the surplus in the local market to achieve extra revenues for the farms.

CONCLUSION

The main aspire of the great man-made river project is to provide water for municipal, industrial and agricultural use. The greatest quantity is devoted to irrigation and agricultural development. Maximum food security will be achieved by the development of large farms producing cereals, meat, milk products. New employment opportunities and family occupation will be provided for by the development of small family farms with the necessary back-up services.

REFERENCES

Al-Ghariani, S. A. 1996. Integrated water management for sustainable development conference on water resource of the Arab world, Faculty of Agriculture, Al-Fateh University, Tripoli-Libya.

Al-Rabty, A. 1996. Great Man-Made River, Workshop on the utilization of semi-saline and saline water for irrigation, Tripoli, (11–17 May 1996). The Arab Center for the studies of arid zones and dry land, (ACSAD, (In Arabic).

Annihum, S. 1994. The Great River the Libyan battle against thirsty. Technovision. Ltd, London-UK.

Brown and Root Limited 1988. Water Utilization and Agriculture Development, Master Plan Report, (3 Volumes).

Great Man-Made River. 1997. Water utilization and agricultural development (WUAD) master plan updating. Part II. Ajdabiya-Sirt System.

Great Man-Made River, 1998. Water utilization and agricultural development (WUAD) master plan updating. Part I. Ajdabiya-Benghazi System.

Moumen, N.M., Tobail K.M., Mohamed A.A. and Summra, M. 1989, Detailed soil survey of Northeast Al-Khadra. Great Man Made River Water Utilization Department (In Arabic).

Sasi, A, Suleiman K.A., Rahouma A. and Rabia A.1987. A detailed Soil Survey of Al-Gardabia and Swawah Plain, Sirt, Soil and Water Department, Al-Fateh University, Tripoli – Libya, (In Arabic).

الملخص العربى

استخدام الموارد المائية للنهر الصناعى العظيم للانتاج الزراعى المستدام : توصيف منظومة النهر

عبدالرزاق مصباح عبدالهادى و أحمد أبراهيم خماج

قسم التربة والمياه – كلية الزراعة – جامعة الفاتح – طرابلس – ليبيا

تفتقر الجماهيرية العربية الليبية الى الموارد المائية السطحية ماعدا بعض الاودية الجافة. وتعتبر المياه الجوفية هى المورد الاساسى للمياه لمختلف الاستخدامات والانشطة وتوفر حوالى ٩٨% من الاستهلاك المائي. وتتواجد المياه فى التكوينات الجيولوجية التى تختلف فى السمك والبناء والعمق. وتقسم هذه الموارد المائية الى متجددة يتم تغذيتها مباشرة من مياه الامطار، والاخرى غير متجددة. ويعتبر الجزء الساحلى الشمالى من ليبيا من اكثر النظم البيئية هشاشة، نتيجة للامتداد العمرانى والصور الاخرى من التنمية، حيث يسكن هذا الجزء حوالى ٨١,٣% من مجموع السكان، وهذا يتطلب توفير المياه العذبة بكميات كبيرة مما نتج عنه تدهور موارد المياه الجوفية حيث زاد السحب عن معدل اعادة التغذية، وبالتالى انخفض مستوى المياه مما نتج عنه تداخل مياه البحر وتمليح المياه الجوفية. ولمواجهة هذا الموقف، فقد قامت الحكومة بتخطيط والبدء فى تنفيذ خطة طموحة لنقل المياه من خلال النهر الصناعى العظيم الى المنطقة الساحلية الشمالية. وتحتوى هذه المنطقة على معظم الاراضى الزراعية التى تنتج المحاصيل المختلفة والتى تعتمد على الرى المستديم وتحتاج الى امدادات كبيرة من المياه. ولذلك تم تنفيذ مشروع النهر الصناعى العظيم لنقل المياه الجوفية العذبة من جنوب ليبيا الى اراضى الزراعة الخصبة فى الشمال من خلال شبكة من الانابيب قطرها ٤ متر و مدفونة على عمق ٧ امتار من سطح الارض. وبعد الانتهاء من كل شبكة النهر سوف يصل طولها الى ٤٠٠٠ كم والتى تجعل منه اكبر شبكة رى صناعية فى العالم. ويناقش هذا البحث اهمية واهداف مشروع النهر الصناعى العظيم، من حيث نظام نقل الماء والمواقع المقترحة لتنفيذ مشروعات الاستثمار الزراعى.