Advances in Environmental Biology, 5(10): 3270-3275, 2011
ISSN 1995-0756

This is a refereed journal and all articles are professionally screened and reviewed

ORIGINAL ARTICLE

The Effects of Water Transfer via the Man-Made River Project on Agricultural Activity in the Plain of Benghazi, Libya.

[1]Gadalmola Salem Mansor and [2]Mohd Ekhwan Toriman

Faculty of Social Sciences and Humanities University Mebangsaan, Malaysia, Bangi.

Gadalmola Salem Mansor and Mohd Ekhwan Toriman: The Effects of Water Transfer via the Man-Made River Project on Agricultural Activity in the Plain of Benghazi, Libya.

ABSTRACT

This article mainly focuses on assessing the effect of the Man-Made River Project (MMRP) - a major water transfer scheme in Libya - on the agricultural activity in the plain of Benghazi, Libya. A questionnaire survey on a sample of 200 farmers was carried out in July 2010. Then, SPSS (version 17) software was used to analyse the responses by using simple regression analysis and the paired-sample t-test technique. The study analyses the relationship between the availability of water via the MMRP and agricultural production. It also measures the relationship between water availability via the MMRP and household income in the plain of Benghazi. Moreover, the study compared the land area cultivated and crop diversification before and after the MMRP. The findings revealed that agriculture production and household income have improved due to the availability of water via the MMRP. Simple regression analysis indicates that there is a significant relationship between the water provided by the MMRP and an improvement in agriculture production at 0.000 p-value and the derived R^2 was 0.325. In addition, there is a significant relationship between the water provided by the MMRP and an increase in annual income at 0.000 p-value. Likewise, land area cultivated and crop diversification also increased, as shown by the results of the paired-sample t-test technique which yielded t=3.9 at 0.00 p-value and t= 2.6 at p-0.000, respectively.

Introduction

Water resources have played an important function throughout the history of human civilization. Most of the Arab countries are located in arid and semi-arid zones that are well known for their scant annual rainfall, very high rates of evaporation due to high temperatures around the year and therefore highly inadequate renewable water resources. Water scarcity is becoming more and more of a constraint on development, slowing down the economic growth of many countries in the region. Agriculture is the greatest single worldwide consumer of water (70%), followed by industry (20%) and homes (10%) [13].

In many semi-arid and arid regions about 30% of groundwater is extracted for irrigation, and the trend is increasing. The demand for fresh water in the mostly desert country of Libya to keep up its economy, especially in agriculture sector, goes beyond its conventional supplies.

Algeria, Tunisia and Libya share the consumption of the groundwater of the North Sahara Aquifer System, and over recent decades their use of this source has increased from 0.6 to 2.2 billion m^3 per annum. Libya, which has very limited water resources, has been in a situation of imbalance between water resources and water needs. To equalize this imbalance, Libya has an alternative to non-conventional water and to mining as a means of making use of its underground water resources, which are non-renewable [10].

Benghazi is considered the second large city in the country of Libya. The Benghazi region has suffered water shortages for a long time. All the development projects which have been initiated in the region have failed due to limited water resources in the plain of Benghazi. [7] indicates that the plain of Benghazi is in need of 61.52 million cubic metres of water per year for the purpose of irrigation, which accounts for 86% of the total water needed by the plain for various uses (71.54 million cubic metres annually). The plain of Benghazi also suffers from a falling groundwater rate which started in the early 1970s. [12] indicated that water levels fell between 0.5 to 2 metres during the period 1970-1971. For the period between 1970-1974, a study focused on the Benghazi plain water basin and carried out on some of the wells in the field of Benina (the main groundwater basin in the plain of Benghazi) shows that there was a decline in water levels as a result of a great withdrawal, which amounted to 1.57 metres by 0.31 metres/year [8].

Corresponding Author

Gadalmola Salem Mansor, Faculty of Social Sciences and Humanities University Mebangsaam Malaysia, Bangi.
E-mail: jad990124@yahoo.com

Policymakers in Libya established the Man-Made River Project (MMRP) to transport the groundwater from the south to the north part of Libya to cover the water requirement in the country as a whole and in the plain of Benghazi particularly. This study investigated the effects of water transfer via the MMRP on agricultural production, land use, crop diversification and households income in the plain of Benghazi, Libya.

Materials and Methods

A questionnaire survey was designed in order to collect data from a sample of 200 farmers in the study area. The questionnaire was administered by the researcher and assistants who conducted personal interviews during July 2010.

The questionnaire sought to determine the most important benefits that have to date been derived from the MMRP. The following variables were analysed in order to measure the impact of MMRP on agriculture activity in the plain of Benghazi: agricultural production level, size of area planted, number and type of crops and farming income.

All gathered data were classified and categorized and interpreted to obtain as complete a quantitative picture as possible and to show the situation in the Benghazi Plain before and after the introduction of the MMRP. SPSS software (v.17.0) was mainly used to analyse the data collected. Observation, the main qualitative method used, also helped to provide a fuller, more descriptive picture of the farming situation and quality of life for farmers in the area. Tables were used for the descriptive analysis.

The statistical methods that have been used for this study are simple regression and paired-sample t-test. Simple regression is a method of predicting one variable using another variable. There are only two variables involved in this analysis [1] The study analyses the relationship between the availability of water via the GMMRP as independent variable and agricultural production, farming income and employment rate as dependent variables both separately as following;

Water from the MMRP “Independent variable” and agricultural production “dependent variable.

Water from the MMRP “Independent variable” and farming income “dependent variable.

The study used this method of statistical analysis to define the relationship between the variables, thus identify the impact of the MMRP on agricultural production and farming income.

Paired-sample t-test is used when a researcher is engaged in a study involving two situations separated by an event, namely ‘before’ and ‘after’ [1] for this study this kind of statistical method has been used to compare the land area cultivated and crop diversification before and after the MMRP.

The Study Area:

The plain of Benghazi is located in the western corner of north-eastern Libya, which is bordered by the Mediterranean Sea to the north and west. The Plain borders Al-Jabal Al-Akhdar in the east and north-east and, from the south, it meets with the plain of Sirte, without any natural barriers in between them, Figure (1) shows the location of the study area.

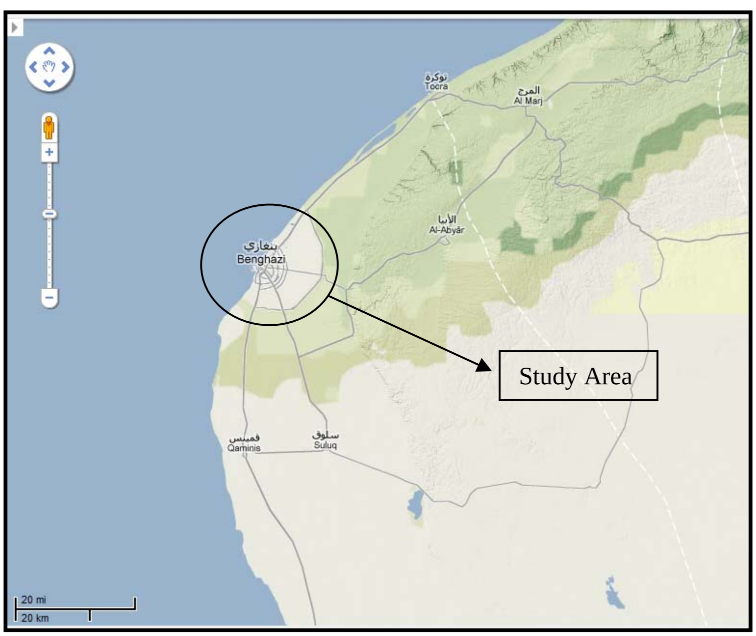

Fig. 1: Location of Benghazi plain.
Source: Google Earth.

The plain of Benghazi is astronomically located between longitudes 45°-19° and 00° -21° south of the equator and between latitudes 58°-30° and 44°-32° north of the equator [9].

Benghazi has a warm semi-arid climate. Summers in Benghazi are hot and dry. In winter, there is occasional rainfall and milder temperatures. Annual rainfall is low at 268 mm per year (BBC weather. Available online at: http://en.wikipedia.org/wiki/Libya. For details of precipitation see Figure (2).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average high °F (°C)	63 (17.2)	64 (17.8)	70 (21.1)	73 (22.8)	79 (26.1)	82 (27.8)	84 (28.9)	85 (29.4)	82 (27.8)	81 (27.2)	73 (22.8)	66 (18.9)	85 (29.4)
Average low °F (°C)	50 (10)	52 (11.1)	54 (12.2)	57 (13.9)	63 (17.2)	68 (20)	71 (21.7)	72 (22.2)	70 (21.1)	66 (18.9)	61 (16.1)	54 (12.2)	50 (10)
Precipitation inches (mm)	2.6 (66)	1.61 (41)	0.79 (20)	0.2 (5)	0.12 (3)	0 (0)	0 (0)	0 (0)	0.12 (3)	0.71 (18)	1.81 (46)	2.6 (66)	10.55 (268)

Fig. 2: Climate data for Benghazi.
Source*:* BBC Weather.

According to the 2006 census, about 1,382,688 people live in the plain of Benghazi. The plain of Benghazi is considered the centre of population concentration in the eastern region of Libya; the proportion of population in the plain of Benghazi accounts for about 53.4% of the eastern region. This due to the attractiveness of the plain of Benghazi and especially the main cultural centre of the city of Benghazi, which has a strong influence on the movement of internal migration from neighbouring areas and other areas at state level. The population density of the city of Benghazi is approximately 54.3 persons/km^2 [5].

The Man-Made River Project:

In the early 1960s, searches for new oil in the desert of south Libya led to the discovery of major oil reserves as well as of aquifers containing huge quantities of fresh groundwater. Most of this fossil water was collected over 35,000 years ago. Soon after this discovery of fresh groundwater reserves, the MMRP was conceived to pump and transport water from these aquifers in the desert to Libya's Mediterranean coast where around 80% of its people live.. The construction of this 'river' of pipes, pumps and reservoirs began in the mid 1980s and continues today [10].

The MMRP is a network that supplies water from the Nubian Sandstone Aquifer System fossil aquifer to the Sahara Desert in Libya. It is the largest underground network of pipes and aqueducts in the world. It consists of more than 1,300 wells, most of them more than 500 m deep, and supplies 6,500,000 m³ of water/day to the cities of Tripoli, Benghazi, Sirt and elsewhere [2].

Fig. 3: Laying pipes for the project.
Source: www.gmmra.org.com.

Water Transfer:

The MMRP consists of five phases and on completion of the network, a large water mains supply with a length of about 4000 km, covering most parts of Liby ,Phase I accounts for the bulk of the stages of the transfer of water, and transports 2,000,000 m^3 of water/day. It is composed of two pipeline systems. The one from Tazrbo to Benghazi includes first drilling 120 wells and extending the

Adv. Environ. Biol., 5(10): 3270-3275, 2011

line of the previously set-up concrete pipe for a distance of 800 km from Tazrbo to Benghazi. During this phase, water collects from wells via three networks parallel to the pipe assembly to connect the 120 wells, with a distance of 10 km between each network, while the distance between each well is 1.3 km. This produces 1,000,000 m^3 of water a day from the well field of Tazrbo by utilizing the water of 98 wells only (the rest of the wells are kept in reserve). The second pipeline system stretches from al-Sarir to Sirte and consists of of 126 wells, including 113 already in use and the rest of the wells will be kept in reserve [6].

Results and Discussion

The results that have been gathered are divided into two parts. The first part (5.1) discusses the relationship between the roles of the MMRP in providing water with agricultural production. This part includes a comparison of land area cultivated and crop diversification before and after the MMRP reached the Plain of Benghazi.

The second part (5.2) measures the relationship between the role of the GMMRP in providing water and farmers' annual incomes.

Agricultural Production:

This part discusses the relationship between the availability of water via the MMRP and its implications for agricultural production in plain of Benghazi it includes land area cultivated and crop diversification.

The MMRP and Agricultural Production:

Agriculture is the largest consumer of freshwater resources - around 70% of all freshwater withdrawals are used for food production [4]. Regarding the opinions of the respondents about the impact of the MMRP on the increase of the production of their farms, 70.0% of them strongly agreed that the MMRP had increased the production, 23.0% said there had not been much of an increase, and only 7.0% of them mentioned that the production had not increased.

One of the hypotheses of this study is that water from the MMRP can predict the level of agricultural production. Simple regression analysis using water from the MMRP as the explanatory variable produced a significant result at the 0.05 level (p=0.000), see Table 1. The derived R^2 was 0.325; indicates that around a 32% increase in agricultural production can be explained by water becoming available via the GMMRP.

Table 1: Simple regression model "Water from the MMRP and Agricultural production.

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	.451	.101		3.443	0.000
	Water from the GMMRP	.736	.076	.570	9.754	0.000

Dependent variable: Agricultural Production.
Source: Field work 2010.

Size of Area Planted Before and After the MMRP:

Based on a comparison between the size of the plantation area in the farms before and after the MMRP, the result leads to state that the MMRP has increased the size of the area where crops are grown. It was found that 76.0% of the farmers said that the size of area used for plantation in their farms was less than 3 hectares before the MMRP, but after the MMRP this percentage decreased to only 7.0%. Moreover, while only 4.5% of them had an area of more than 7 hectares for plantation before the MMRP, after the MMRP this percentage had increased to around 52.5%. In this respect, the results reveal that the size of area used for plantation in the farms increased from 658 hectares to 1,434 hectares. The main reason for the increase in agriculture land is that the MMRP has supplied a large quantity of water, enabling agricultural-based activities to be performed**.**

An examination of the data indicates a difference in the size of area planted in farms before and after the MMRP provided farms with water. The data in Table 2 shows that the mean size of area planted before and after the MMRP was 3.27 and 7.01 hectares, respectively. A test of mean difference using the paired-sample t-test technique yielded the two-tailed p-value=0.00, which is less than the conventional 5% or 1% level of significance. It can be safely concluded that the MMRP significantly increased the size of area cultivated in farms.

Table 2: Size of Area Planted in Farms Before and After the MMRP.

Situation	Mean	N	Standard deviation
Before the GMMRP	3.27	200	1.36
After the GMMRP	7.01	200	1.66

T=3.9 significance 0.00
Source: Field work 2010.

Number and Types of Crops Before and After the MMRP:

The number of crops in the farms has been used in this study as an indicator to determine the impact of the MMRP on agricultural activities in this particular area through a comparison of the number of crops in the farms before and after the MMRP. The results reveal that 76.0% of the respondents said that the number of crops grown on their farms was 2 crops or less before the MMRP. After the MMRP only 7.0% of the respondents said the number of crops grown on their farms was still 2 crops or less. Before the MMRP, 19.5% of them mentioned that the number of crops in their farms was 3-5 crops. However, after the MMRP this percentage had increased to 40.5%. Meanwhile, only around 4.5% of the respondents said the number of crops before the MMRP was more than 5 crops, 52.5% of them responded that the number of crops in their farms had increased to more than 5 crops after the MMRP.

An examination of the data indicates a difference in the number of crops grown on Farms before and after the MMRP provided farms with water. The data in Table 3 shows that the mean number of crops before and after the MMRP was 1.94 and 4.75 crops, respectively. The paired-sample t-test technique 'Test of mean difference' indicator has a 0.00 p-value, which is less than the conventional 5% or 1% level of significance. It can be safely concluded that the MMRP increased crop diversification.

With regards to the type and number of the crops, those grown by farmers were wheat, barley, and alfalfa before providing the farms with water via the MMRP, but after the MMRP provided the farms with water, the farmers started to cultivate other types of crops such as maize, vegetable and fruit. These kinds of crops need large quantities of water that eventually bring about crop diversification [11].

Table 3: Number of Different Types of Crops Grown on Farms Before and After the \MMRP.

Situation	Mean	N	Standard deviation
Before the GMMRP	1.94	200	1.03
After the GMMRP	4.75	200	1.55

T=2.6 significance 0.00
Source: Field work 2010.

Household Income:

The second part of this discussion relates to the effect of the MMRP on farming income.

The Relationship Between Water from the MMRP and Farming Income:

Most of the respondents, in actual fact 60.0% of them, agreed that the MMRP had increased the annual farming income and 30.0% totally agreed that the annual farming income had been on the rise due to the arrival of water via the MMRP, whereas 10.0% said the MMRP had had no impact on their annual income. It has been found that; overall, the annual income of the farmers has obviously increased after the arrival of the MMRP.

Simple regression analysis using water from the MMRP as the explanatory variable produced a significant result at the 0.05 level (p=0.000). The derived R^2 was 0.168; indicating that around a 16% variation in farming income could be explained by water becoming available from the GMMRP.

Table 4: Simple Regression Model "water from the MMRP and farming income"

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.996	0.113		8.842	.000
	water from the GMMRP	0.529	0.084	.409	6.313	.000

Dependent variable: farming income. Significant leve 0.5. R^2=0168.
Source: Field work 2010.

Farming Income Before and After the MMRP:

The MMRP has a positive effect on the annual farming income. This finding is based on a comparison of the annual farming income before and after the MMRP. The result shows that 56.5% of the farmers earned less than Libyan Dinar (LD) 2,000 before the MMRP, but after the MMRP this percentage decreased to only 6.0%. It was found that 29.5% of the farmers earned LD2,001-4,000 before the MMRP and this became 19.5% after the MMRP. On the other hand, the farmers who were earned LD4,001-6,000 before the MMRP stood at only 5.5%, but after the MMRP this percentage increased to 60.5%. Only 2.5% of the farmers earned more than LD6,001 before the MMRP, but after the MMRP that proportion increased to 14.5%.

However, it should be noted that the annual farming income reported by farmers in the survey is likely to be an underestimation because farmers are generally reluctant to provide details about their annual farming income. So, the actual annual farming income might be more than that reported in the survey results.

Adv. Environ. Biol., 5(10): 3270-3275, 2011

Conclusion:

The availability of water via the MMRP has a positive impact on the agricultural production. Based on the statistical analysis that was done, the MMRP improved the agricultural and livestock production in the plain of Benghazi. The simple regression analysis using water from the MMRP as the explanatory variable produced a significant result at the 0.05 level (p=0.000). The derived R^2 was 0.325.

The area of land cultivated and crops diversification have increased as the results show that the mean size of area used for plantations before and after the MMRP was 3.27 and 7.01 hectares respectively. The size of crops' area in the farms increased from 658 hectares before the MMRP to 1,434 hectares after the MMRP. The results also exhibit that the mean number of crops before and after the MMRP was 1.94 and 4.75 crops respectively. The type and number of the crops grown by farmers are wheat, barley, and alfalfa before providing the farms with water via the MMRP, but after the MMRP has provided the farms with water, the farmers started cultivating other types of crops such as maize, vegetable and fruit, which need large quantities of water that lead to crop diversification. The introduction of the MMRP to the Benghazi plain contributes towards the cultivation of new crops such as maize, vegetables and fruits.

The MMRP has contributed to improve the farming income of the people in the plain of Benghazi. Around 60% of the respondents had pointed out that their farming income had increased due to the water from the MMRP. About 56.5% of the farmers earned less than 2,000LD before the MMRP, but after the MMRP 60.5% of the farmers earned an annual income of 4,001-6,000LD. The simple regression analysis yields a significant relationship between the water from the MMRP and farming income at 0.05 level (p=0.000). The derived R^2 was 0.168.

References

1. Abd Rahim Md Nor, 2009. Satatistical Methods in Research. Kuala Lumpur. Prentice Hall. Pp: 80-153.
2. Anon, 2010c. Wikipedia.
3. BBC weather. Available online at: http://en.wikipedia.org/wiki/Libya
4. Calzadilla, Alvaro A.B., R. Katrin and S.J. Richard, 2010. The economic impact of more sustainable water use in agriculture: A computable general equilibrium analysis. *Journal of Hydrology* 384: 292.
5. Census, Libya, 2006.
6. El Geriani, A.M., O. Essamin, P.J.A. Gijsbers and D.P. Loucks, 1998. Cost-Effectiveness Analyses of Libya's Water Supply System. Journal of water Resources Planning and Management, 124(6): 323.
7. GEFLI, 1972. Soil and Water Resources survey for Hydro-agricultural Development, western Zone. Unpublished Report. Tripoli: Libyan Agricultural Ministry, pp: 4.
8. Libyan Arab Republic, 1977. General Water Authority Benghazi Investigation of the Municipal Well Field Beninah Area, Benghazi, pp: 26.
9. Lamah, M., 1999. The plain of Benghazi Physiographic study, First Edition, National Center for Research and scientific studies, Tripoli, pp: 27,145-152.
10. Loucks, D., 2004. The Great Man-Made River in Libya: Does it Make Sense? Lecture in fluid Mechanics, Cornell University-USA.
11. Ministry of Agricultural, Benghazi, Libya, 2006. Report on Agricultural Development, pp: 17.
12. Pallas, P., 1978. Water Resources of the Socialist's People Libyan Arab Jamahirya, Tripoli, pp: 52.
13. Wheida, E., 2004. Desalination as a water supply technique in Libya, Desalination, 165: 89-97.