Eng. & Tech. Journal, Vol.28, No.17,2010

Hydrological Operation Requirements for Restoration and Improving Water Quality of Abu Zirig Marsh

Dr.Mahmoud S. Al Khafaji*, Haitham A. Hussein & Ammar Adel Ali*****

Received on: 22/3/2010
Accepted on: 30/6/2010

Abstract

A hydrological routing study for Abu Zirig Marsh was carried out to estimate the hydrological state within the marsh for the Present and future conditions of the marsh.The water surface elevation, area and storage within the marsh at the present and for the future conditions were estimated and the effect of uncontrolling outlets on the hydrological and water quality state of the marsh at the present conditions was specified.

The salt mass balance equation was used to estimate the inflow and outflow discharges that required for reducing the effect of evapotranspiration on the water quality and flashing out the accumulated mass of salts and then improving the marsh water quality. This equation was applied on the future conditions of the marsh and inflow and outflow discharges that required for this purposes were estimated. The results of the hydrological routing for the present conditions showed that the maximum water surface area is 79 km^2 which occur during Spring. While it is between 34 to 43 km^2 during Summer and Autumn and it can not be increased during these months since the outlet of the marsh is uncontrolled. The TDS concentration within the marsh increases during the months of high evapotranspiration although the inflow increases during these months.

For the future conditions, the inflow discharges required to sustain the restoration requirements must be increased to decrease the deterioration in the marsh water quality. These discharges increase with the increase in the marsh area during the months of high evapotranspiration values.

Keywords: Hydrological Operation, Restoration, Improving Water Quality, Abu Zirig Marsh

متطلبات التشغيل الهيدرولوجية لإنعاش وتحسين نوعية مياه هور أبو زرك

الخلاصة

تم تنفيذ دراسة إستتباع هيدرولوجي لهور أبو زرك لتحديد الوضع الهيدرولوجي في الهور وفقاً للظروف الحالية والمستقبلية للهور.

تم حساب منسوب ومساحة سطح الماء والخزن في الهور للظروف الحالية والمستقبلية وتم تحديد تأثير المنافذ غير المسيطر عليها على الوضع الهيدرولوجي وعلى نوعية المياه في الهور للظروف الحالية.

تم إستخدام معادلة الموازنة الملحية لتحديد التصاريف التي يجب إدخالها وإخراجها من الهور لتقليل تأثير التبخر - نتح على نوعية المياه و تصريف كتلة الأملاح المتجمعة وبالتالي تحسين نوعية مياه الهور. تم تطبيق هذهِ المعادلة على الظروف المستقبلية للهور وتم إيجاد التصاريف المطلوبة لهذا الغرض.

* Building & Const. Engineering Department, University of Technology/ Baghdad
** Engineering College, University of Al- Nahrain/ Baghdad
*** Engineering College , University of Baghdad/ Baghdad

https://doi.org/10.30684/etj.28.17.17
2412-0758/University of Technology-Iraq, Baghdad, Iraq

بينت نتائج الإستتباع الهيدرولوجي للظروف الحالية إن اقصى مساحة لسطح الماء هي 79 كم^2 وتحصل في فصل الربيع في حين تتراوح بين 34 و43 كم^2 في فصلي الصيف والخريف ولايمكن زيادتها اكثر من ذلك بسبب محدودية المياه المتوفرة ولعدم وجود منشأت سيطرة على منافذ الهور. كما إن تراكيز المواد الصلبة الذائبة تزداد في الهور خلال تلك الأشهر على الرغم من زيادة التصاريف خلال هذهِ الأشهر.

إن التصاريف المطلوبة لتلبية متطلبات إعادة الإغمار يجب زيادتها لتقليل التدهور في نوعية مياه الهور وهذهِ الزيادة تزداد مع زيادة مساحة الهور خلال الأشهر التي تكون فيها قيم لتبخر–نتح عالية.

Introduction

Abu Zirig Marsh, is located to the east of Al Nassiriya City by about 40 km, it starte from the south of Islah town after Abu Lihia dyke on Al Gharraf River and ends at Al Fuhud village.

The decrease in water discharges into the marsh during the last two decades destroyed the ecological system of this marsh.

During spring 2003, water again has been flowing into this marsh, the inundated area has increased, and vegetation appears to be regrowing.

Ministry of Water Resources, MoWR, and Center of Restoration of the Iraqi Marshland, CRIM, proposed and design two hydraulic structures to control and develop the hydraulic and then the environmental conditions of the marsh.

Restoration and conserving the ecological system of this marsh required continuous monitoring and control to the hydrological and water quality conditions in this marsh.

Hydrological routing was used to estimate the hydrological conditions within the marsh for the Present, before constructing the proposed hydraulic structures, and Future, after constructing the proposed hydraulic structures, conditions. The salt mass-balance equation was used to estimate the required inflow and outflow discharges for reducing the effect of evapotranspiration on the marsh water-quality.

Hydrological System of the Marsh

Abu Zirig Marsh, which covers 120km^2, lies at the tail end of Al Gharraf River southerly of Al Islah District at a location of latitude (31º 09' 54.9''), longitude (46º36'33'), Figure (1).

The two main towns around the marsh are the cities of Al Islah (9000 cap) in the north and Al Fuhud (18000 cap) in the south. Scattered villages of fishermen lie all along the embankments that surround the marsh, (IMET, 2006).

The main supply of water to the marsh is through Shatt Abu Lihia which is ramifying from Al Gharraf River. Al Gharraf River originate from the Tigris River right bank upstream the Kut barrage and runs into Shatt Abu Lihia through two small marshes named Al Ghamukah (250 hec) and Al Uwaynah (420 hec).

Water leaving Abu Zirig Marsh through Abu Smesum River and Abu Aljerry River at Al Fuhud village and joins the water flowing directly from the Euphrates River and into the lower zones of the central marshes through two apertures (Aperture 1 and Aperture 2) at the left bank of the mash. Further to the east. Some of the marsh water is diverted into the network of irrigation channels that feed the cultivated areas situated around the embankments that bound the marsh.

A hydraulic control structure is designed to be built at the outlet of Abu Zirig Marsh in the southern part of this marsh (MoWR and IMELS, 2007), They are named as AZ21 and AZ24, Figure (1). The AZ21 and AZ24 each consist of two gates and a weir , the gates of AZ21 can discharge up to 20 m^3/sec, while that of AZ24 10 m^3/sec. both structures can handle up to 30 m^3/sec. It is proposed that the two aperture, (Aperture 1 and Aperture 2), are to be closed.

Ground Surface Elevation

Abu Zirig Marsh topographical survey data presented in New Eden Water and Energy Project in Southern Iraq, (IMET, 2006), were adopted to implement the DEM for this marsh. Figure (2). According to the implemented DEM the area-elevation and storage-elevation curves of this marsh were constructed and shown in Figures, (3) and (4) respectively.

The Inflow and Outflow Discharges

The inflow and outflow discharge of the feeders and outlets of the marsh were studied and tabulated according to the present and future conditions. In the hydrological routing of the marsh for the present conditions, the measured discharges at Shatt Abu Lihia near Al Islah Bridge, Aperture 1 and Aperture 2, Abu Smesum and Abu Aljerry Rivers during the year 2008 (CRIM, 2008) for the period from February to December were adopted. While, for the future conditions, the discharges of the feeders and outlets of the marsh were specified according to the historical data and the recommendations of the studies and plans concerning this marsh, especially that of the Ministry of Water Resource

The Inflow and Outflow Discharges for the Present Conditions

The inflow and outflow discharge of the feeders and outlets of the march measured, seasonally, during the year 2008 (CRIM, 2008) for the period from February to December. These discharges listed in Table (1).

The Inflow and Outflow Discharges for the Future Conditions

The inflow discharges of the marsh for the Wet, Moderate and Dry water years were specified by MoWR (MoWR and IMELS, 2007), according to the restoration requirements of the marsh ignoring the water quality requirements, Table (2). So, these discharges were adopted in the hydrological routing of this marsh. The 100%, 75% and 50% restoration requirements were considered for the Wet, Moderate and Dry years, respectively. The two aperture, (Aperture 1 and Aperture 2), will be closed. A hydraulic control structure is designed to be built at the outlet of Abu Zirig Marsh in the southern part of this marsh. They are named as AZ 21 and AZ 24 both structures can handle up to 30 m^3/sec.

Evapotranspiration within the Marsh Area

Since the monthly evapotranspiration represent the major losses within the marsh area, the computed evapotranspiration by New Eden Master Plan (MoWR and IMELS, 2007), was adopted to compare the results of the present study with that of New Eden Master Plan and Rehabilitation of Al Huweizah Marsh Ecological System, (CRIM, 2007). The calculated monthly Evapotranspiration for the marsh area is listed in table (3). The annual precipitation within the marsh are approximately 150 mm which less than 10 % of the existing evapotranspiration within the marsh area. Accordingly, the effective rainfall will not be considered in the hydrological routing.

Marsh Water Quality

Because there is no systematic monitoring for the quality of the marsh water, the new hydraulic situation since 2003, and the available recorded data concerning the water quality, within the marsh and their feeders, is not covered the whole contaminants and is not continuous or consequential for an enough period to ensure the accurate estimation for the seasonal average concentration of the water contaminants during the Wet, Moderate and Dry water years, then the seasonal average concentration of the water contaminants for the marsh feeders were estimated based on the available recorded data as follows

Dry years: the collected water samples at Al Islah City during the year 2008 for the period from February to December, (CRIM, 2008), were used in this study. Thee measured concentrations or values of the water quality parameters during this period are listed in table (4).

Moderate years: All the available recorded water quality data of the marsh feeders and outlets and their sources (MoWR, 2006), Tigris and Euphrates, were collected and studied and then the necessary recorded concentrations or values of the water quality parameters were listed in table (5).

Wet years: The estimated water quality of the moderate years was adopted for the wet years since there is no recorded data during such year.

Hydrological Routing

Water balance equation, Eq. (1), was used to determining the flow hydrographs for the marsh inlet and outlet, the area and storage variation with time within the marsh. This routing requires hydraulic data (discharges and stages) for the marsh feeders and outlets, climatological and topographical data.

$$S(i+1) = S(i) + [Qin(i) - Qout(i) - Qe(i)]\Delta T \quad \text{……..(1)}$$

Where:

S is the storage (L^3).

Qin is the inflow discharge (L^3/T) from the marsh feeders.

Qout is the outflow discharge (L^3/T) from the marsh outlets.

Qe is the evapotranspiration discharge (L^3/T) from the marsh area.

ΔT is the time interval of the hydrological routing (T).

i is the time index of the hydrological routing, (i = 0, 1, 2, 3, ……,n), n is the total period of the hydrological routing.

The hydrological state of the marsh was studied according to the present and future conditions of the marsh, and accordingly, two monthly hydrological routings were implemented and applied for the marsh. The first; concerns the present conditions, and the second; concerns the future conditions.

Hydraulic Operation Requirements for Improving the Marsh Water Quality

The inflow discharges into the marsh during the Wet, Moderate and Dry years were specified by CRIM

(CRIM, 2007) according to the restoration requirements, as previously mentioned, ignoring the water quality issue. Then these discharges were studied and re-estimated considering the water quality requirements. Based on the salt mass-balance equation, Eq.. (2), and using the TDS concentration within the marshes and their feeders and considering the evapotranspiration effect on the water quality of the marsh, the hydraulic operation requirements were specified.

$$S(i+1)\,Cm(i+1) - S(i)\,Cm(i) = (Qin(i)\,Cin(i) + Qe(i)\,Cm(i) - Qout(i)\,Cout(i))\,\Delta T \quad ..... \quad (2)$$

where

Cm is the TDS concentration within the marsh (M/L^3).

Cin is the TDS concentration of the inflow discharge (M/L^3).

Cout is the TDS concentration of the outflow discharge (M/L^3).

Taking in consideration that the flow velocity within the marshes is low, because of the flat topography of the marshes and the effect of vegetation. Then the TDS concentration of the outflow water (Cout(i)) can be estimated considering the effect of Evapotranspiration on the marsh quality at the time interval (i) using equation (3).

$$Cout(i) = \frac{(Qe(i)\,Cm(i)\,\Delta T + S(i)\,Cm(i))}{S(i)} \quad ......(3)$$

In order to reduce the effect of the evapotranspiration and conserving the water quality within the marsh, to be near to that of the inflows water into the marsh, an equally extra inflow into the marsh and outflow from the marsh is required. This value of extra inflow and out flow must be added to the required inflow and outflow that specified by CRIM, 2007, to maintain the restoration requirements. The total change in the mass of the TDS due to the extra inflow minus extra outflow must be equal to that due to the evapotranspiration, so:

$$Qe(i)\,Cm(i) = Qextout(i)\,Cout(i) - Qextin(i)\,Cin(i) \quad .....(4)$$

where

Qextin is the extra inflow required to decrease the TDS concentration and to flash out the accumulated TDS.

Qextout is the extra outflow required to flash out the accumulated TDS.

Since; $Qextin(i) = Qextout(i)$, as mentioned above, then

$$Qe(i)\,Cm(i) = Qextin(i)\,Cout(i) - Qextin(i)\,Cin(i) \quad ....(5)$$

$$Qextin(i) = \frac{Qe(i)\,Cm(i)}{Cout(i) - Cin(i)} \quad ....(6)$$

then by substituting eq. (3) in eq. (6).

$$Qextin(i) = \frac{Qe(i)\,Cm(i)}{\frac{Qe(i)\,Cm(i)\,\Delta T + S(i)\,Cm(i)}{S(i)} - Cin(i)} \quad ....(7)$$

Equation (7) was used to estimate the required inflow and out flow to develop Water Quality of the marsh during the present and future conditions.

Results

Based on the constructed area and storage elevation curves for the marsh, Figures (3) and (4), and the estimated evapotranspiration, Table (3), and using the tabulated discharges of the feeders and outlets of the marsh, Table (1), for the present condition and the tabulated discharges of the feeders and outlets of the marsh, Table (2), for the future conditions the hydrological routing of the marsh for the present and future conditions was carried out using equation (1). According to the above conditions the variation of water surface elevation, water surface area and storage within the marsh were obtained and shown in Figures (5) to (7) and , for the present condition, and Figures (8) and (9), for the future conditions.

According to the tabulated TDS concentration, Table (4), area and storage and inflow discharges for the future conditions of the marsh and applying equation (7), the estimated required inflow and outflow discharges for the marsh during the Wet, Moderate and Dry water years are shown in Figures (10) to (12).

Discussion

Results of the hydrological routing for the present conditions, Figures (5) to (7), showed that the water surface area and then the storage and water surface elevation are decreased during the period from June to November Although the inflow discharges into the marsh increase because of the high flow in Tigris River during these months, but this increase concedes with increase in the outflow from the marsh, since the outlets of the marsh are uncontrolled, and the evapotranspiration values are high during these months. The effect of losses due to evapotranspiration on the marsh during these months is greater than the gain due to the net inflow (inflow minus outflow). The losses due to evapotranspiration cause an increase in the TDS concentration during these months. To decrease this effect the inflow and outflow discharges must be increased during these months to flash out the accumulated TDS in the marsh.

Results of the hydrological routing for the future conditions, Figures (8) and (9), showed that the marsh area can be increased during the period from October to June to be greater than 80 km^2, for the Wet, Moderate and Dry water years, by making use of the proposed control structure at the outlet of the marsh.

Increasing the area of the marsh during this period causing an increase in the water losses due to evapotranspiration during the months of high evapotranspiration values. More TDS will accumulate in the marsh due to these losses.

The required inflow and outflow discharges to flash out the accumulated TDS, Figures (10) to (12), are increasing with the increase in the marsh area during the months of high evapotranspiration values.

Conclusions

The following conclusions are obtained:

1- The low inflow into the marsh decreases the water surface area of the marsh to be with maximum of 79 km^2, with water surface elevation 3.8 (m.a.m.s.l), at March and between 34 to 43 km^2, with water surface elevation 2.5 to 2.9 (m.a.m.s.l), during October, November, June, July, August and September.

2- The TDS concentration within the marsh increases during the months of high evapotranspiration although the inflow is increasing during these months. Therefore, the inflow and outflow discharges during these months must be increased to flash out the accumulated TDS.

3- The water surface area of the marsh can not be increasing during the months of low flow since the outlet of the marsh is uncontrolled.

4- After constructing the proposed control structure, the area of the marsh can be increased during the months of low flow.

5- The inflow and outflow discharges that specified by CRIM, 2007, to sustain the restoration requirements must be increased to decrease the deterioration in the marsh water quality through flashing out the accumulated TDS.

6- The inflow and outflow discharges that required to flash out the accumulated TDS increase with the increase in the marsh area during the months of high evapotranspiration values.

References

[1]IMET,(2006)." Overview of present conditions and current use of the water in the marshlands area" .BOOK 4.Iraq Foundation.

[2]MoWR and IMELS, 2007, "The New Eden Project - Master Plan For Integrated Water Resources Management In The Marshlands Area"; Outlet Of The Huweizah Marsh Along The Kassara River, technical Report; Baghdad, Iraq.

[3]CRIM, 2008, "Recorded Field Measurements"; Iraqi Ministry of Water Resources, CRIM.

[4]CRIM, 2007, "Study the Rehabilitation of Al Huweizah Marsh Ecological System"; Iraqi Ministry of Water Resources, CRIM.

[5]MoWR, 2006, "Recorded Data"; Iraqi Ministry of Water Resources, General Directorate of Water Resourses.

[6]CRIM, 2007, "Restoration of the Central Marshes"; Iraqi Ministry of Water Resources, CRIM.

Table (1) Measu harge of the feeders and outlets (m^3/sec).
(*after CRIM, 2008*)

Feeders and outlets		Spring	Summer	Autumn	winter
Feeder	Al Islah Shatt Abu Lihia)	37.7	29.0	9.0	25.2
outlets	Abu smesum and Abu Aljerry	0.5	0.3	7.8	2.9
	Aperture -1	3.3	2.8	3.8	3.3
	Aperture -2	2.8	3.21	2.3	2.8

Table (2) Discharges of the feeders (m^3/sec). (after MoWR and IMELS, 2007).

Month	Al Islah		
	Wet Year	Moderate Year	Dry Year
Oct.	14.0	11.0	9.0
Nov.	10.0	10.0	9.0
Dec.	6.0	6.0	5.0
Jan.	7.0	5.0	4.0
Feb.	9.0	7.0	5.0
Mar.	14.0	10.0	7.0
Apr.	16.0	13.0	9.0
May.	13.0	10.0	7.0
Jun.	5.0	5.0	4.0
Jul.	5.0	5.0	4.0
Aug.	5.0	5.0	4.0
Sep.	12	10.0	8.0

Table (3) Calculated monthly Evapotranspiration (mm/month) for the marsh area (*after MoWR and IMELS, 2007*).

Month	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Yearly
ETo	49	80	132	229	364	495	462	418	375	266	114	66	3050

Table (4). Measured Concentration or value of the water quality parameters at Al Islah City for Dry year (*after CRIM, 2008*).

Season	Water quality parameters					
	PH	T (C^0)	DO (mg/l)	EC (µS/cm)	TDS (mg/l)	Cl (mg/l)
Spring	8.1	25.5	8.5	1020	740	200
Summer	7.7	25.8	7.0	1087	1217	307
Autumn	7.6	12.3	9.4	1200	1324	290
Winter	7.6	15.9	8.2	1044	871	299

Table (5) Measured Concentration or value of the water quality parameters at Al Islah City for Moderate year (*after MoWR, 2006*).

Season	Water quality parameters					
	PH	T (C^0)	DO (mg/l)	EC (**µS/cm**)	TDS (mg/l)	Cl (mg/l)
Spring	8.0	24.7	8.2	1320	627	153
Summer	8.2	28.3	8.1	1920	675	185
Autumn	7.9	20.0	8.2	1750	645	190
Winter	8.0	10.0	8.4	1530	636	172

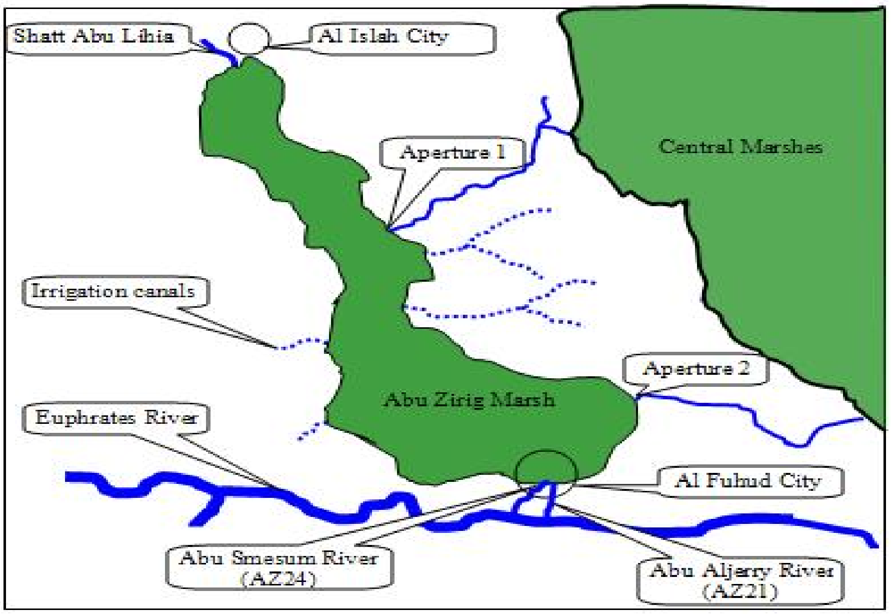

Figure (1) The hydrologic network of Abu Zirig Marsh.

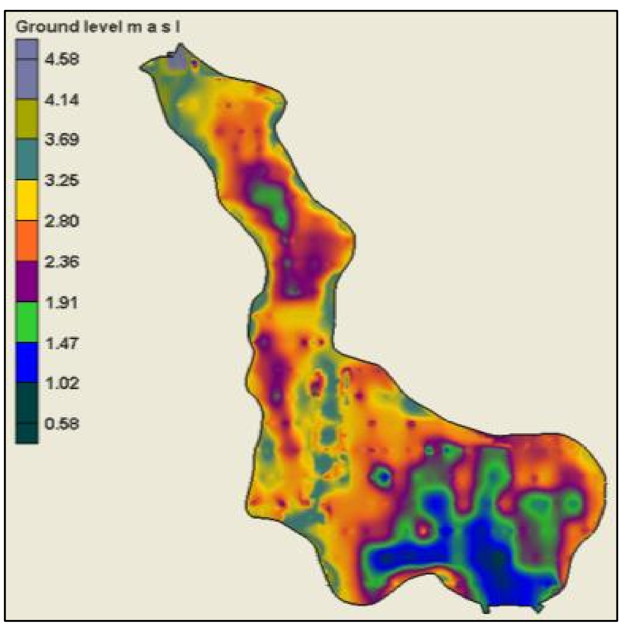

Figure (2) Digital Elevation Model (DEM) of Abu-Zirig Marsh.

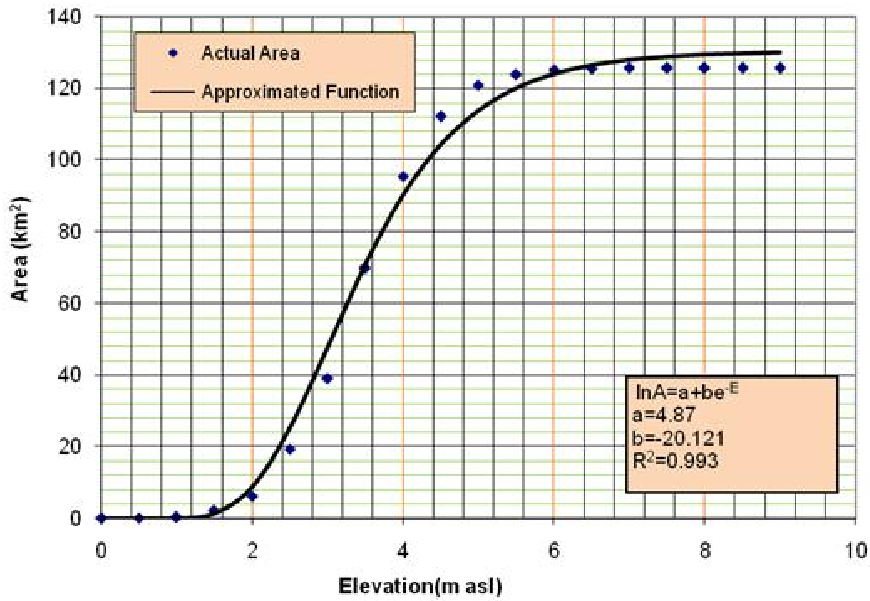

Figure (3) Area-Elevation Curve of Abu-Zirig Marsh.

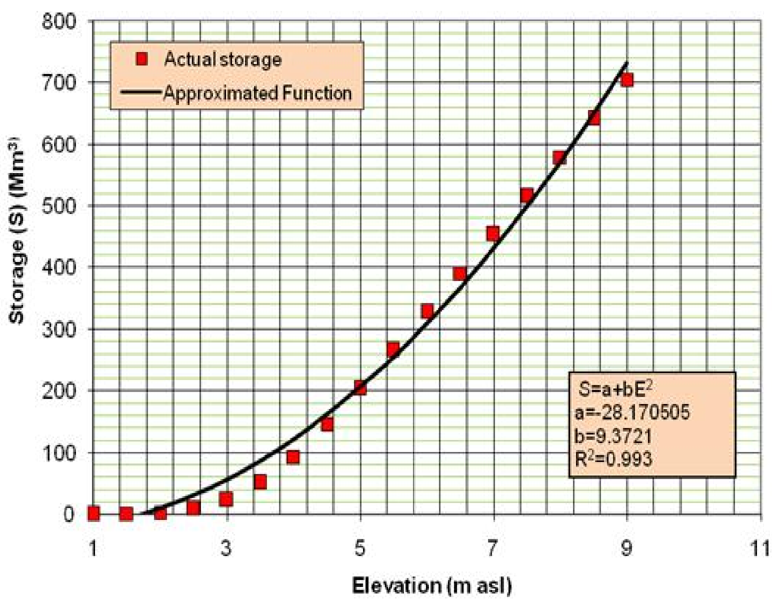

Figure (4) Storage-Elevation Curve of Abu-Zirig Marsh.

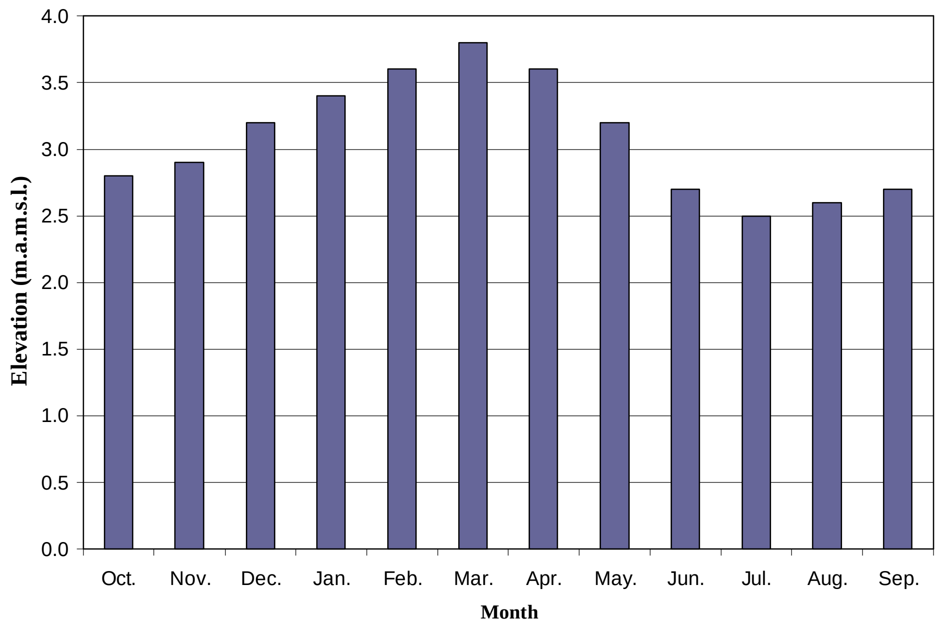

Figure (5) Variation of Water Surface elevation within the marsh.

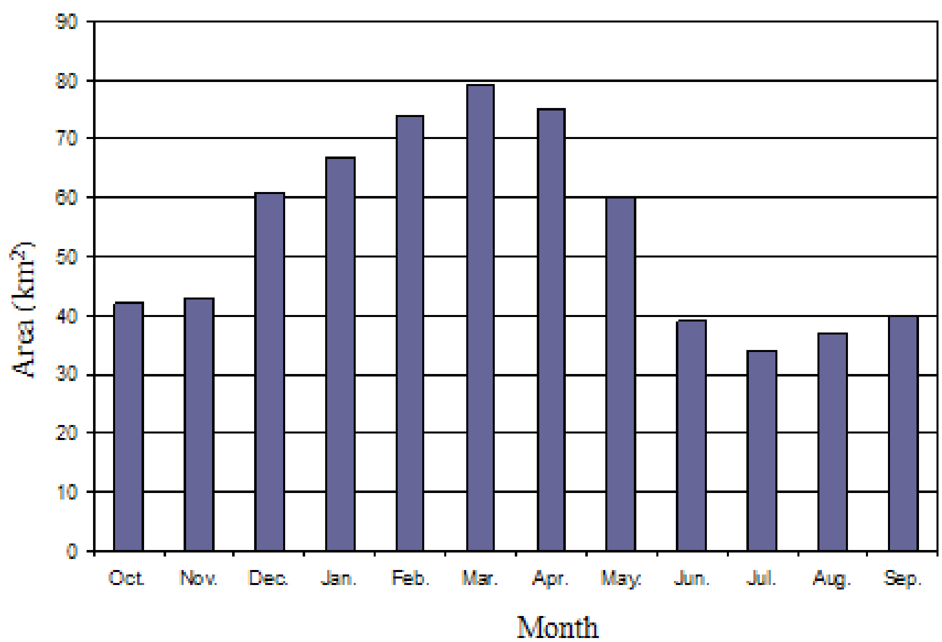

Figure (6) Variation of Water Surface Area within the marsh.

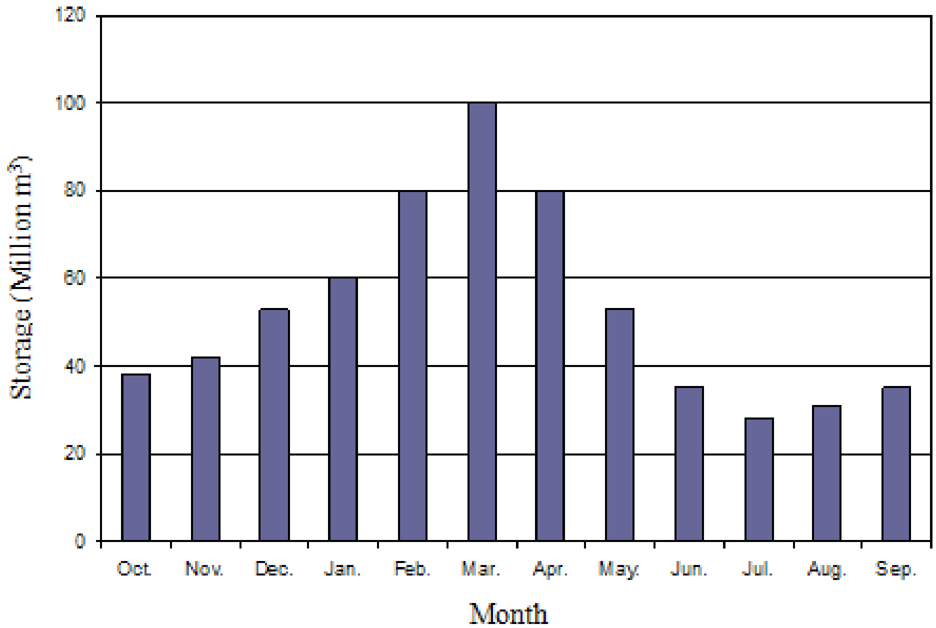

Figure (7) Variation of storage within the marsh.

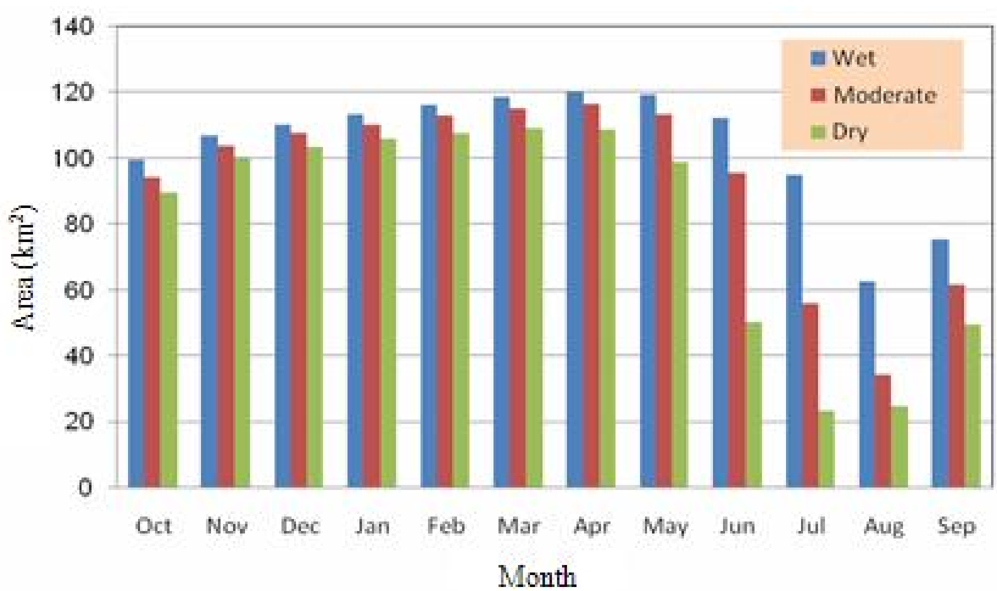

Figure (8) Variation of water surface area within the marsh during Wet, Moderate and Dry years for the future conditions.

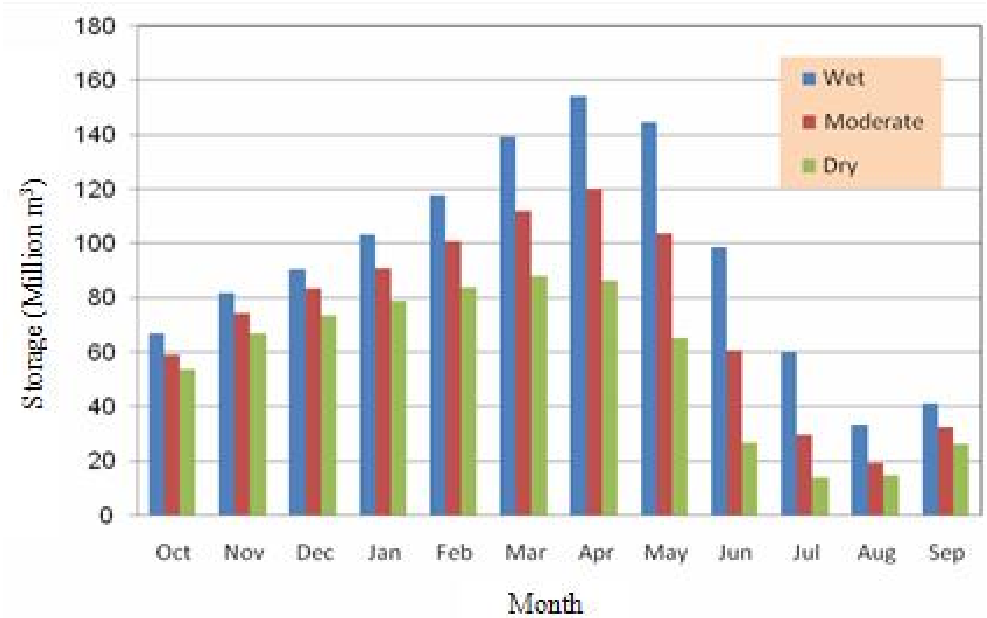

Figure (9) Variation of storage within the marsh during Wet, Moderate and Dry years for the future conditions.

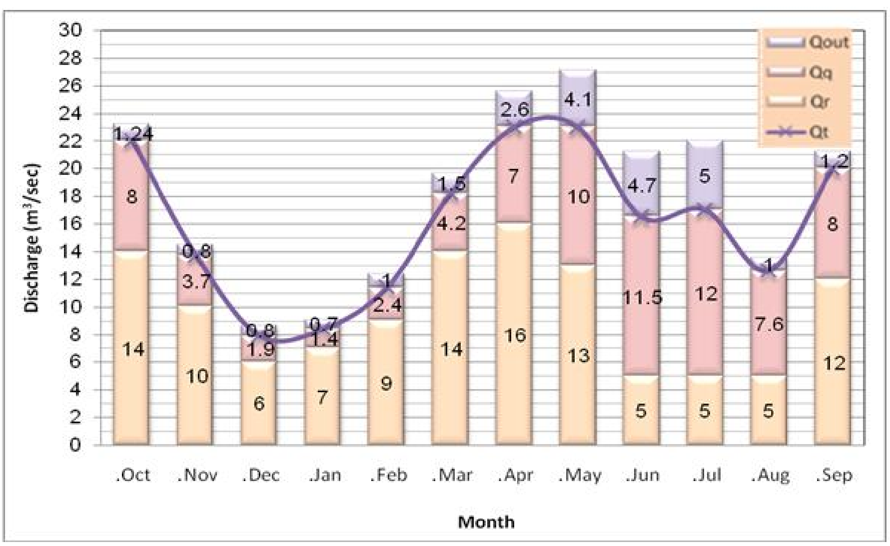

Figure (10) Required inflow and out flow for Restoration, Qr, and for Water Quality Development, Qq, during the Wet year.

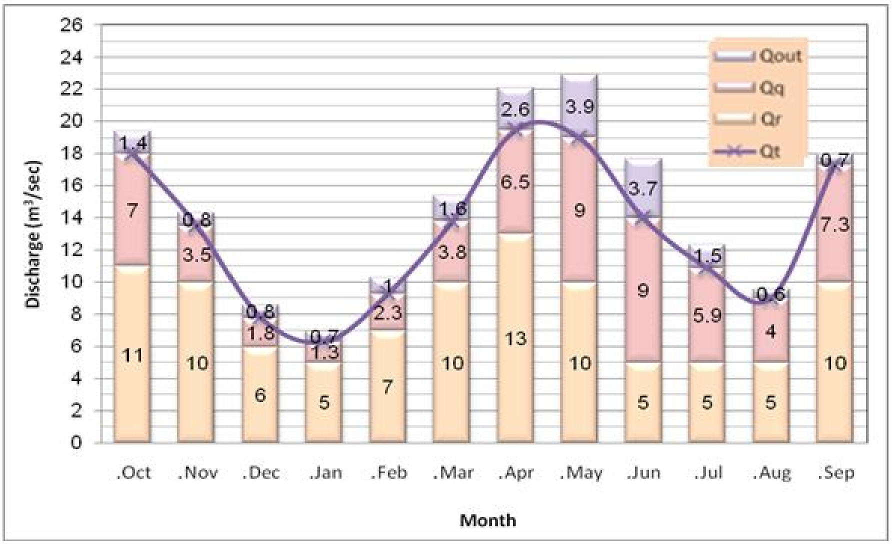

Figure (11) Required inflow and out flow for Restoration, Qr, and for Water Quality Development, Qq, during the Moderate year.

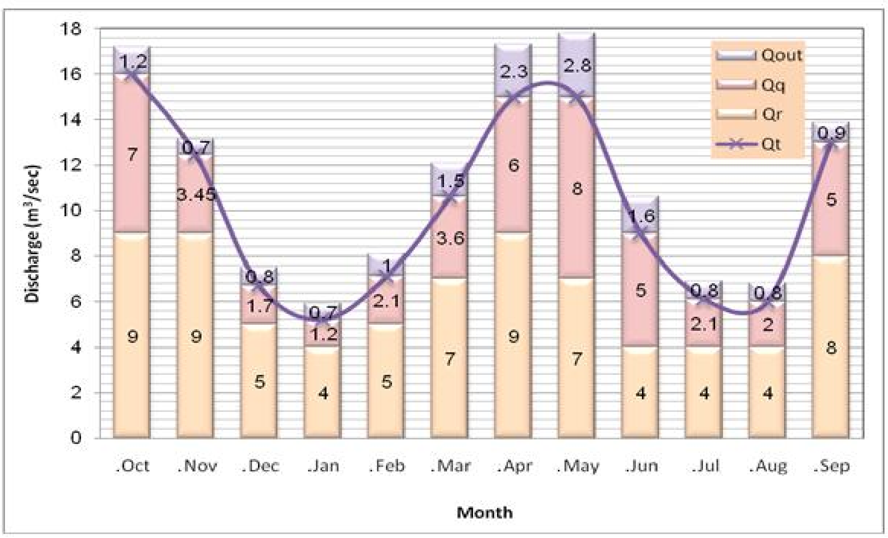

Figure (12) Required inflow and out flow for Restoration, Qr, and for Water Quality Development, Qq, during the Dry year.