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Modelling the Ecosystem Behavior of Abu-Ziriq Marsh in South of Iraq Under Different Water Discharges Scenarios

Abstract- *The marshlands are of fundamental importance to Iraq, a unique ecosystem providing local inhabitants with an essential source of habitat and livelihoods. This paper aims to study the ecosystem behavior of Abu-Ziriq Marsh in the south of Iraq under different scenarios using the Ecosystem Functions Model Program (HEC-EFM) and Hydrologic Engineering Center Data Storage System Visual Utility Engine (HEC-DSSVue). To this end, data was converted from tri-monthly and semi-monthly to daily data using the HEC-DSSVue program. The daily data natural$_{(flow,\ stage)}$ was used for five years between 2013 and 2018. The prediction process was evaluated using three criteria: correlation coefficient (R), root mean square error (RMSE), and the Nash–Sutcliffe effectivity coefficient (NSE). Results of R, RMSE and NSE for the daily inflow discharge (stage) of natural were 0.98 (0.93), 1.55 (0.19) and 0.95 (0.73). Five scenarios of a percentage decrease in gage$_{(flow,\ stage)}$ with 2%, 4%, 6%, 8% and 10% were investigated. Results showed that the decrease in discharge from 2% to 8% did not significantly affect environmental relations and could be used by the competent authorities. However, when the discharge was reduced to 10%, the environmental relations were greatly affected and threatened the life of the organisms. In addition to that, results for wetland health reverse lookup at the fifth scenario show that Abu–Ziriq Marsh need (70.2%) as a percent of the time, when flows equal or exceed four m3/sec. This discharge was chosen because it can be supplied on most days of the year, which is the time needed to be revived when flows equal or exceed 4 (m^3/sec).*

Keywords- *HEC-EFM; HEC-DSSVue; Ecosystem requirements; Abu-Ziriq Marsh; Water quantity.*

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1. Introduction

The Iraqi Marshlands are considered to be the largest wetland ecosystem in the Middle East, and they played an essential role in global ecosystems by supporting rare wildlife and rich biodiversity [1], and complex landforms [2]. They provide a shifting temporal and spatial mosaic of habitats for flora and fauna [3]. In the aftermath of floods, spectacular increases may occur in populations of water birds [4], fish [5-7], macro invertebrates [8], zooplankton [9], and other biotas. Between floods, the disconnection and isolation of wetlands alter the composition and structure of ecological communities [8-10] .

The presence of water is significant in any ecosystem, where the ecosystem depends on the quantity and quality of water. The low water quantity has a significant impact on the ecosystem and the food chain of living organisms, although water has the ability to self-cleansing contaminants, this may causing a loss of biodiversity and a lack of natural food sources (such as fish). Recovery may require very periods, which makes scientists think about studying environmental changes accurately. Iraqi Marshes, which were also known as the "Venice of Iraq", are freshwater wetlands of a unique ecosystem. The biome mostly includes the plants, which were successful in freshwater, and many animals, which inhabit this productive environment [11]. The area of the Iraqi Marshlands, formerly known as the Garden of Eden, ranges from 15,000 to 20,000 km^2 and is located in the lower part of the Mesopotamia. These marshes have played a prominent role in human history and have existed for a very long time. The Iraqi government dried up the marshes for political reasons during the 1990s, and in 2000 less than 10% of the original marshes area remained. After 2003, due to the political change that took place, the Iraqi marshes began to recover despite the enormous difficulties they faced. It is believed that 75% of the original marshes can be recovered [12]. Water is an integral part of any ecosystem, both in qualitative and quantitative terms. Reduced water quantity

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and deteriorated water quality both have serious negative impacts on ecosystems. Manipulation of the flow regimes of rivers, to provide water when and where people need it, has resulted in a growing deterioration in the condition (health) of riverine ecosystems. The science of environmental, or in-stream, flow assessments have evolved over the last five decades, as a means to help contain, and perhaps to some extent reversed, this degradation [13]. Two flow regimes will be analyzed. The "Gaged" flow regime has flows and stages that reflect the current management plan for Abu-Ziriq marsh, which is regulated by the upstream regulator (Al-Badaa regulator) in the south of Iraq. The "Natural" flow regime has flows and stages that reflect how the river would behave without any regulation [14].

Recently, many studies have been interested in studying the environmental changes that are taking place in the wetlands. Al-Khafaji et al. [15] conducted a hydrological routing study for Abu Zirig Marsh to estimate the hydrological state within the marsh for the present and future conditions. The effect of the out controlling outlets on the hydrological and water quality state of the marsh at the present conditions was specified. Besides, for the future conditions, the inflow discharges required to sustain the restoration requirements to prevent the deterioration in the marsh water quality were computed. Al Suhili et al. [16] used the MATLAB 7, HEC-RAS, HEC-GeoRAS, and ArcView GIS software to predict the optimal flow of Abu-Ziriq Marsh in the south of Iraq, the HEC-EFM program was used to study ecological-ecological relationships to forecast the environmental system. Three scenarios were studied for optimal flow (24, 30.3 and (33.6 m^3 /sec) during the year. The study showed that the optimal flow occurs when the flow from the Abu Jiry entrance increases to the minimum flow. Bhattacharjee et al. [17] used the HEC-RAS program and the Ecosystem Function Model (HEC-EFM) program to study the impact of the construction of the Ocmulgee River power plant on ecological and ecosystems. The study indicated that the HEC-EFM program could be used to analyze future environmental and ecological changes that will occur when the power plant built. Oonge [13] used HEC- EFM to study and analysis of future environmental and ecological changes that will occur when a dam on the Kibos River is constructed, where three species of fish (Clarias, Labeo, Barbus) and total invertebrates were studied at Kibos River in Kenya. The study concluded that the HEC-EFM program had predicted environmental changes happen on the Kibos River as well as a significant migration of fish to the upstream because of the proposed dam. Hassan [18] studied the climate and environmental changes in Hammar Marshes using GIS through Arc Map v.9.3 for the period 1973 to 2006. The study found indicated a decline in the area of the Hammar Marsh, in addition to the loss of many species of fish and mammals and the migration of the local population. Hickey et al. [19] used HEC-EFM and Geographic Information Systems (GIS) to study potential ecological and environmental changes in the San Joaquin River and the wetland stretching from it in California, USA. The results showed that there are promising places where the ecological system can be restored quickly, easily and inexpensively. Shayyish [20] used a predictive model to study the levels of nitrogen and phosphorus in the Hawiza Marsh. The increase in phosphorus concentrations and their effect on the production of phytoplankton, and benthic algae was discussed. The study showed a positive correlation between phosphorus concentrations and the production of phytoplankton and benthic algae. This increase threatens ecological ecosystems because it causes a decrease in dissolved oxygen, which threatens aquatic life.

The main aim of this study is to understand the environmental and ecological changes that occur in Abu-Ziriq Marsh south of Iraq under different water discharges scenarios through the use of HEC-EFM. To this purpose, the model was set up , and different discharges scenarios were postulated and used to predict the ecological behavior of the marsh. HEC-EFM is a planning tool that assists in analyzing the ecosystem response to changes in the flow system stage [14]. The study area was selected based on its importance in terms of the amount of inflow water; representing a good example of the ecological system.

2. Materials and Methods

I. Hydrologic Engineering Center Data Storage System Visual Utility Engine (HEC-DSSVue)

U.S. Army Corps of Engineers Hydrologic Engineering Center has developed and released HEC-DSSVue. HEC-DSS is used in HEC-EFM modeling programs to store data, estimate miss data, and exchange data in time-series data. Such data includes, but is not limited to, time-series, curve data, spatial-oriented gridded data, and others [14]. In this study, HEC-DSSVue was used to convert data from three times a month to daily data for the period 2013-2018 to be used in modeling HEC-EFM. These daily data were used in several scenarios, and the impact on environmental relations was analyzed.

II. The Ecosystem Functions Model (HEC-EFM) Relationship

HEC-EFM is a planning tool that aids in analyzing ecosystem response to the change in flow regime [14]. Through using the HEC-EFM program, the amount of water required to recharge into Abu-Ziriq Marsh can be estimated according to ecosystem requirements. In this study, historical flow data for the period from water year (2013-2014) to water year (2017-2018) was used. HEC-EFM relationships are statistical representations of links between hydrology and ecology, and these relationships were selected to demonstrate how the discharge restoration would affect ecosystem habitat in the marsh. Each scenario described below represents' information about an aspect of the ecosystem of the marsh [14].

3. Studied Species

I. Little minnow spawning habitat

Little minnow spawning habitat is a species of small fish threatened significantly in Abu Ziriq Marsh. The number of these fish has declined significantly due to lack of water and the construction of dams and diversions limited access to upstream river stretches [21]. Little minnow spawn in shallow vegetated floodplain areas (which do not exceed depth 0.91m) between February and May. Eggs require sustained high flows for approximately 21 to 28-days before hatching. Right spawning conditions need to occur, on average, at least once every four years. These fish grow and reach maturity within a year or two and have an approximate lifetime of 6 years. Scientists believe that right hatching conditions should not occur every year but enough if they occur in 25% of years [14].

HEC-EFM Relationship
Season: 02/01 to 05/31, Duration: 24 days, Minimums (sustained highs) and then Maximum (Most substantial extent), Rate of change: Not applied, Percent exceedance: 25% (of time) - Flow frequency.
Comments. The season is defined as the period in which the relationship occurs. Duration is the amount of time that the relationship requires a defined flow. The rate of change defines a change in water level over the length of time required for the relationship. Flow frequency is the frequency of ideal hydrologic conditions, usually defined in years. The percent exceedance query offers a choice of either flow frequency or flow duration. When flow frequency is selected, EFM ranks the seasonal results for each year and interpolates to obtain the flow that is equaled or exceeded for the user-defined percentage of years.

II. Benthic macro invertebrate biodiversity reservoirs

Reservoirs act to reduce high flows and increase low flows, causing a stable ecosystem due to the stability of the flow system. In these stable systems, benthic invertebrates communities caused degrading biodiversity because the few species that thrive in the most stable flow conditions compete with all other species. After a while, the floods begin to return to normal, helping the community revert to the original biodiversity. Scientists believe the timing is not essential, but high flows should occur every two years, on average. In regulated systems like Abu-Ziriq Marsh, flood flows initiate a return to more natural conditions, which encourages communities of benthic macroinvertebrates to rebound to their original biodiversity. The timing of the floods is not important, but high flows should occur in 50% of the years (on average) [14].

HEC-EFM Relationship
Season: 10/1 to 9/30, Duration: 1 day, Means and then Maximum, Percent exceedance: 50% (of time), Flow frequency.

III. Wetland health water

The health of wetlands depends heavily on the process of water exchange between rivers and wetlands. The process of continuous exchange leads to the rapid restoration of the marshes and the improvement of water quality. However, when isolation of these lands occurs, the number of dissolved oxygen decreases, the water temperature rises, Wetlands are severely degraded, aquatic species die, and living organisms become threatened. These conditions are often repeated in the hot summer months. In Abu-Ziriq marsh, the exchange is especially important between mid-January and mid-May [22,23]. Active exchange for 30% of the time in this season will support healthy conditions.

HEC-EFM Relationship

Season: 1/15 to 5/15, Duration: 1 day, Percent exceedance: 30% (of time), Flow duration.

IV. Indices

When analyzing the multiple relationships of a particular flow system, some of the environmental relationships work correctly, and others are not good. From some indicators, the different effects on different flow systems can be deduced. Indicators are calculated for active flow systems rather than reference. Each indicator is calculated using a set of information about relationships and statistical results based [14],on the following equation:

$$Index = \sum_{i=1\ldots n}(Direction\ of\ Change_i) * (Confidence_i) * (\%\ Change\ in\ Eco - value_i) \quad (1)$$

Where:

i = counter from $1\ to\ n$, n = number of relationships in the index, $Direction\ of\ Change_i = 1, -1, or\ 0$ for $relationship_i$,

1 Indicates that $relationship_i$ experienced a positive change from the reference flow regime.

-1 Indicates that $relationship_i$ experienced a negative change from the reference flow regime.

0 indicates that $relationship_i$ experienced no change from the reference flow regime.

$Confidence_i$ = an integer from 0 to 5 based on the confidence value for $relationship_i$.

$$\%\ Change\ in\ Eco - value_i = \frac{(\text{Eco}-\text{value for } relationship_i - \text{Eco}-\text{value for } relationship_{reference})}{(\text{Eco}-\text{value for } relationship_{reference})} \quad (2)$$

V. Macrophytes habitat

Plants in the Iraqi marshes can be divided into three types relative to the amount of submerging: partially submerged plants, completely submerged plants, and floating plants. Phragmites australis (reed) and Typha domengns (barrdi) are among the most important plants in Abu-Ziriq Marsh, characterized by their leaves and long stalk. These plants are self-purification of the water entering the marshes. These plants have great economic importance to the local people, which is involved in many industries, including houses and furniture, and are used as feed for livestock [21].

HEC-EFM Relationship

Season: 01/01 to 04/28, Duration: 1 day, Percent exceedance: 15% (of time) - Flow duration.

VI .Big Bass mortalities habitat

Fish deaths occur due to a chronic lack of habitat. Usually, deaths occur when poor conditions persist for more than two weeks. Poor conditions are caused when water is significantly reduced due to low flows. Scientists said that these chronic conditions are best represented by an average of low flows. Big bass mortalities are caused by a lack of habitat during low flow conditions between July and October. Mortalities begin to occur when poor conditions persist for more than two weeks [14].

HEC-EFM Relationship

Season: 7/1 to 10/31, Duration: 14 days, Means (average) and then Minimum (low), Percent exceedance: 50% (of time) - Flow frequency

VII. Wetland health reverse lookup

Analyze all water years in the period of record. Then, select flow exceeding these criteria 30% of the time. Within each year, the peak flow having the specified duration will be computed for each day in the season. Reverse lookup of the healthly wetland relationship to look at the percent of time flows equal or exceed (discharge) cum [14].

HEC-EFM Relationship:

Season: 03/15 to 06/15, Duration: 1 days, Percent exceedance: 30% (of time) - Flow duration.

3. Study Area and Data

I. Abu-Ziriq Marsh Description

Abu Ziriq Marsh, which covers 120 km^2, it is about 3% of all marshes area, lies at the tail end of Al Gharraf River southerly of Al Islah District at a location of latitude 31°09' 54.9" N and longitude 46°36'33' E. The primary source of water supply to the marsh is through Shatt Abo-Lihia River, and the channel of this river runs through the marsh until it dissipates at the tail end into the Central Marshes. The two main towns around the marsh are Al-Islah in the North and Al-Fuhod in the south of Thi Qar Governorate (Figure 1). Scattered villages of fisher are located all along the embankments that surround the marsh [24].

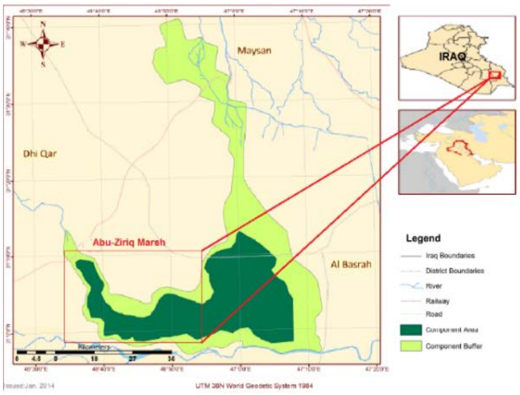


Figure 1: Location of Abu-Ziriq Marsh

II.Data used

The dataset used in this study, which include natural$_{(flow,\ stage)}$ three times a month at Abu-Ziriq Marsh, was provided by the Ministry of Water Resources (MoWR), Center for Restoration of Iraqi Marshes and Wetlands (CRIMW) in the south of Iraq between 2013 and 2018 (Figure 2) (unpublished data, MoWR 2018) . This data was converted to daily data using HEC-DSSVue. The computed data was calibrated for 2017 and comparing them with real daily data for the same year collected by the MoWR, State Commission on Operation of Irrigation and Drainage Projects (SCOIDP).The statistical parameters of water quantity in the wetland indicates is listed in Table 1.

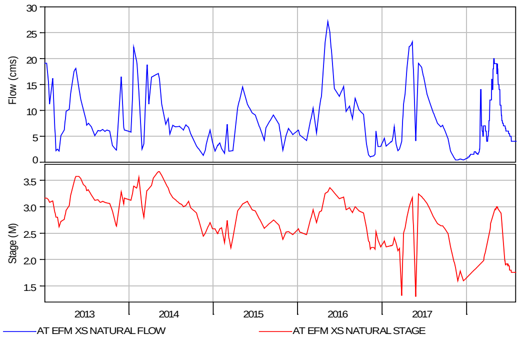


Figure 2: Time series of daily natural$_{(flow,\ stage)}$ by using HEC-DSSVue in the Abu-Ziriq Marsh, south of Iraq (according to unpublished data, MoWR 2018)

Table 1: Summary of statistical parameters of dataset in Abu-Ziriq Marsh (n = 2037), (according to unpublished data, MoWR 2018)

Variable	Unit	Range	Minimum	Maximum	Mean		Std. Deviation	Variance
		Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
$Flow_{Natural}$	m^3/sec	26.70	0.40	27.10	8.23	0.12	5.43	29.59
$Flow_{Gage-2\%}$	m^3/sec	26.17	0.39	26.56	8.07	0.11	5.33	28.42
$Flow_{Gage-4\%}$	m^3/sec	25.63	0.38	26.02	7.90	0.11	5.22	27.27
$Flow_{Gage-6\%}$	m^3/sec	25.10	0.38	25.47	7.74	0.11	5.11	26.14
$Flow_{Gage-8\%}$	m^3/sec	24.56	0.37	24.93	7.57	0.11	5.00	25.04
$Flow_{Gage-10\%}$	m^3/sec	24.03	0.36	24.39	7.41	0.10	4.89	23.97
$Stage_{Natural}$	m	2.36	1.30	3.66	2.76	0.01	0.47	0.22
$Stage_{Gage-2\%}$	m	2.31	1.27	3.59	2.70	0.01	0.46	0.21
$Stage_{Gage-4\%}$	m	2.27	1.25	3.51	2.65	0.01	0.45	0.20
$Stage_{Gage-6\%}$	m	2.22	1.22	3.44	2.59	0.01	0.44	0.19
$Stage_{Gage-8\%}$	m	2.17	1.20	3.37	2.54	0.01	0.43	0.18
$Stage_{Gage-10\%}$	m	2.12	1.17	3.29	2.48	0.01	0.42	0.18

4. Performance Measures

In this study, the importance of the HEC-EFM outputs lies in its ability to link between hydrology and eco-system to the restoration of Abu Ziriq Marsh. There are many scenarios that allow us to operate and monitor the ecological restoration inside the marsh. The wetland recovery scenario depends on water quantity as well as on time mainly. HEC-DSSVue program was used to find daily data (flow, stage). Data was converted from tri-monthly and semi-monthly to daily data using the HEC-DSSVue program. The daily data of natural and gage$_{(flow,\ stage)}$ were used for five years between 2013 and 2018. To evaluate the performance, many statistical parameters used in the literature [25]. In this study, the three widely used statistical parameters were employed: The Root Mean Squared Error (RMSE), Correlation Coefficient (R) and Nash–Sutcliffe Coefficient of Efficiency (NSE) [26].

5. Results and Discussion

I. Models performance

The daily data natural$_{(flow,\ stage)}$ was used for five years between 2013 and 2018. The prediction process was evaluated using three criteria: correlation coefficient (R), root mean square error (RMSE) and Nash–Sutcliffe effectivity coefficient (NSE). The results of R, RMSE and NSE for the stage (daily inflow discharge) of natural were 0.98, 1.55, 0.95 and 0.93, 0.19, 0.73, respectively, as in Figure 3. These results are satisfactory according to criteria and references.

In this study, five scenarios were studied: 2% reduction, 4% reduction, 6% reduction, 8% reduction, and 10% reduction, which were adopted as gage$_{(flow,\ stage)}$. These scenarios were chosen because of the continuous reduction in inflow discharge into Abu Ziriq Marsh due to the lack of water revenues entering Iraq. Each case was studied, and its impact on environmental relations in the Abu-Ziriq Marsh was analyzed.

In the first scenario, when the gage$_{(flow,\ stage)}$ is reduced to 2% from natural$_{(flow,\ stage)}$ the ecosystem relationships were affected (Table 2). Three of the five relationships show a positive change for the gaged flow regime. significant bass summer habitat and Benthic biodiversity show a negative change. Benthic biodiversity had the most significant change in terms of the difference in flow results when the level of wetland health is based on the data entered without improving (confidence level *), the index values show a positive response (+1.2) for all relationships and positive response (+2) for the fish (Table 2). While improving the health of the wetlands and rehabilitating well (confidence level *****) to transform negative relationships that have emerged positively. A positive value suggests that the positive changes outweigh the negatives for the relationships in the index. While at confidence level five star for more wetland health, the index value for all relationships goes from positive (+1.2) to positive (+2.9) (Table 3), there is no noticeable change.

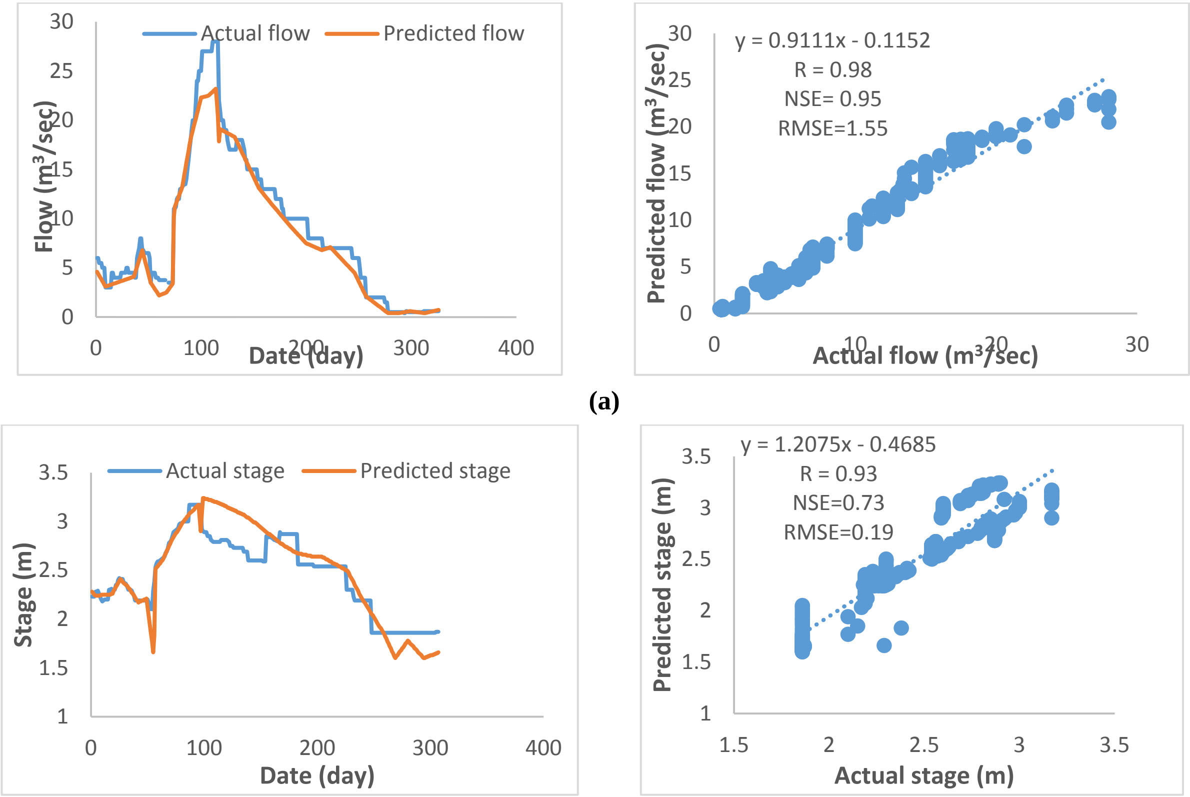
In the second scenario, when the gage$_{(flow,\ stage)}$ is reduced to 4% from natural$_{(flow,\ gage)}$. Three of the five relationships show a positive change for the gaged flow regime (Table 4). Benthic biodiversity and big bass show a negative change. Benthic biodiversity had the most significant change in terms of difference in flow results. At confidence level (*), the index values show a positive response (+0.8) for all relationships and a positive response (+4.2) for the fish as in Table 4. The confidence level (*****) for more wetland health, the index value for all relationships goes from (+0.8) to (+4.2) for all relationships as in Table 5, the environmental relations are still good despite the reduction gage$_{(flow,\ stage)}$ in this scenario

In the third scenario, when the gage$_{(flow,\ stage)}$ is reduced to 6% from natural$_{(flow,\ stage)}$. Big bass summer habitat and Benthic biodiversity show a negative change, and the others show positive for the gaged flow regime (Table 6). At wetland health (*), the index values show a positive response (+3.8) for all relationships and a positive response (+6.4) for the fish (Table 6). While at confidence level (*****) for more wetland health, the index value for all relationships goes from (+3.8) to (+8.9) for all relationships (Table 7). This process indicates that the ecosystem relationships in wetlands have not changed in the third scenario.

In the fourth scenario, when the gage$_{(flow,\ stage)}$ is reduced to 8% from natural$_{(flow,\ stage)}$. Three of the five relationships show a positive change for the gaged flow regime (Table 8). Big bass summer habitat and Benthic biodiversity show a negative change while the others show a positive. At wetland health without improving (confidence level *), the index values show a positive response (+1.7) for all relationships and a positive response (+8.7) for the fish (Table 8). While at confidence level (*****) for more wetland health, the index value for all relationships goes from (+1.7) to (+8.7) for all relationships (Table 9). This process indicates that the ecosystem relationships in wetlands have not changed in the fourth scenario.

In the fifth scenario, when gage$_{(flow,\ stage)}$ is reduced to 10% from natural$_{(flow,\ stage)}$. Little minnow spawning, wetland health and, Macrophytes habitat show a negative change while the others show a positive (Table 10). The index values show a negative response (-2.2) for all relationships and a negative response (-11.1) for the fish at wetland health (*) (Table 10). While at confidence level (*****) for more wetland health, the index value for all relationships goes from (-2.2) to (-11.1) for all relationships (Table 11). This process gives the impression that environmental relations have become unstable, fragile, and weak, so the amount of reduction in discharge should not exceed 10% from natural$_{(flow,\ stage)}$. Al Suhili et al. [16] applied the HEC-EFM model to study ecological-ecological relationships to forecast the environmental system of Abu-Ziriq Marsh. HEC-EFM model could achieve high efficiency in understanding the environmental and ecological changes that occur in Iraqi Marshes. Woodrow [27] used HEC-EFM to study ecological changes that occur at Bill Williams River in Western Arizona. Through HEC-EFM modeling, more informed decisions considered regarding recruitment strategies for ecological changes.

A reverse lookup of the healthly wetland relationship to look at the percent of time flows equal or exceed (4) m3/sec, and this discharge was chosen because it supplied on most days of the year (Table 11). Results for wetland health reverse lookup show that both flow regimes were above the 30% criteria. Results for the gaged flow regime (73.9%), note that it has increased where it was 70.2% of time natural flows in Abu-Ziriq Marsh, which is the time needed to be revived when flows equal or exceed 4 (m3/sec) (Table 12). John [28] used the program (HEC-EFM) and a reverse lookup successfully to understand the environmental changes in reservoir and water management.



(a)

(b)

Figure 3: Comparative plots of observed and predicted flow in Abu-Ziriq Marsh using HEC-DSSVue for (a) flow and (b) stage

Table 2: Relationships results of HEC-EFM with first scenario at wetland health one star

		Gage		**Natural**		
Relationship	**Conf.**	**Stage (m)**	**Flow (m^3/sec)**	**Chg.**	**Stage (m)**	**Flow (m^3/sec)**
Little minnow spawning hobitat	*	2.7	20	Pos	3.2	20
Benthic Macroinvertebrate Biodiversity	*	3.3	15	Neg	3.5	16
Wetland Health	*	3.1	9	Pos	2.9	9
Macrophytes Habitat	*	3.2	15	Pos	3.3	15
Big bass summer habitat	*	2.1	2	Neg	1.9	2

Index Values

Index	**NATURAL**
A - All	1.2
B - Fish	2.0

*. Wetland health without any improvement

Table 3: Relationships results of HEC-EFM with first scenario at wetland health five star

		Gage		**Natural**		
Relationship	**Conf.**	**Stage (m)**	**Flow (m^3/sec)**	**Chg.**	**Stage (m)**	**Flow (m^3/sec)**
Little minnow spawning hobitat	*	2.7	20	Pos	3.2	20
Benthic Macroinvertebrate Biodiversity	*	3.3	15	Neg	3.5	16
Wetland Health	*****	3.1	9	Pos	2.9	9

Macrophytes Habitat	*	3.2	15	Pos	3.3	15
Big bass habitat	*	2.1	2	Neg	1.9	2
Index Values						
Index	**NATURAL**					
A - All	2.9					
B - Fish	2.0					

*****. Improving the health of the wetlands and rehabilitating them well.

Table 4: Relationships results of HEC-EFM with second scenario at wetland health one star

		Gage		**Natural**		
Relationship	**Conf.**	**Stage (m)**	**Flow (m^3/sec)**	**Chg.**	**Stage (m)**	**Flow (m^3/sec)**
Little minnow spawning hobitat	*	3.5	13	Pos	2.8	14
Benthic Macroinvertebrate Biodiversity	*	3.6	15	Neg	3.5	16
Wetland Health	*	3.2	14	Pos	2.5	15
Macrophytes Habitat	*	3.7	15	Pos	3.3	15
Big bass habitat	*	2.6	2	Neg	1.9	2
Index Values						
Index	**Natural**					
A - All	0.8					
B - Fish	4.2					

Table 5: Relationships results of HEC-EFM with second scenario at wetland health five star

		Gage		**Natural**		
Relationship	**Conf.**	**Stage (m)**	**Flow (m^3/sec)**	**Chg.**	**Stage (m)**	**Flow (m^3/sec)**
Little minnow spawning hobitat	*	3.5	13	Pos	2.8	14
Benthic Macroinvertebrate Biodiversity	*	3.6	15	Neg	3.5	16
Wetland Health	*****	3.2	14	Pos	2.5	15
Macrophytes Habitat	*	3.7	15	Pos	3.3	15
Big bass habitat	*	2.6	2	Neg	1.9	2
Index Values						
Index	**NATURAL**					
A - All	4.2					
B - Fish	4.2					

Table 6: Relationships results of HEC-EFM with third scenario at wetland health one star

		Gage		**Natural**		
Relationship	**Conf.**	**Stage (m)**	**Flow (m^3/sec)**	**Chg.**	**Stage (m)**	**Flow (m^3/sec)**
Little minnow spawning hobitat	*	3.1	15	Pos	3.6	16
Benthic Macroinvertebrate Biodiversity	*	3.2	15	Neg	3.5	16
Wetland Health	*	3.1	14	Pos	2.5	15
Macrophytes Habitat	*	3.3	15	Pos	3.3	15
Big bass summer habitat	*	2.0	2	Neg	1.9	2
Index Values						
Index	**NATURAL**					
A - All	3.8					
B - Fish	6.4					

Table 7: Relationships results of HEC-EFM with third scenario at wetland health five star

		Gage		**Natural**		
Relationship	**Conf.**	**Stage (m)**	**Flow (m^3/sec)**	**Chg.**	**Stage (m)**	**Flow (m^3/sec)**
Little minnow spawning hobitat	*	3.1	15	Pos	3.6	16
Benthic Macroinvertebrate Biodiversity	*	3.2	15	Neg	3.5	16

Wetland Health	*****	3.1	14	Pos	2.5	15
Macrophytes Habitat	*	3.3	15	Pos	3.3	15
Big bass habitat	*	2.0	2	Neg	1.9	2
Index Values						
Index	**NATURAL**					
A - All	8.9					
B - Fish	6.4					

Table 8: Relationships results of HEC-EFM with fourth scenario at wetland health one star

		Gage		**Natural**		
Relationship	**Conf.**	**Stage (m)**	**Flow (m^3/sec)**	**Chg.**	**Stage (m)**	**Flow (m^3/sec)**
Little minnow spawning hobitat	*	2.9	13	Pos	2.8	14
Benthic Macroinvertebrate Biodiversity	*	3.3	14	Neg	3.5	16
Wetland Health	*	2.6	14	Pos	2.5	15
Macrophytes Habitat	*	3.2	14	Pos	3.3	15
Big bass habitat	*	1.9	2	Neg	1.9	2
Index Values						
Index	**NATURAL**					
A - All	1.7					
B - Fish	8.7					

Table 9: Relationships results of HEC-EFM with fourth scenario at wetland health five star

		Gage		**Natural**		
Relationship	**Conf.**	**Stage (m)**	**Flow (m^3/sec)**	**Chg.**	**Stage (m)**	**Flow (m^3/sec)**
Little minnow spawning hobitat	*	2.9	13	Pos	2.8	14
Benthic Macroinvertebrate Biodiversity	*	3.3	14	Neg	3.5	16
Wetland Health	*****	2.6	14	Pos	2.5	15
Macrophytes Habitat	*	3.2	14	Pos	3.3	15
Big bass habitat	*	1.9	2	Neg	1.9	2
Index Values						
Index	NATURAL					
A - All	8.7					
B - Fish	8.7					

Table 10: Relationships results of HEC-EFM with fifth scenario at wetland health one star

		Gage		**Natural**		
Relationship	**Conf.**	**Stage (m)**	**Flow (m^3/sec)**	**Chg.**	**Stage (m)**	**Flow (m^3/sec)**
Little minnow spawning hobitat	*	2.6	13	Neg	2.8	14
Benthic Macroinvertebrate Biodiversity	*	3.2	14	Pos	3.5	16
Wetland Health	*	2.2	13	Neg	2.5	15
Macrophytes Habitat	*	3.0	14	Neg	3.3	15
Big bass habitat	*	1.7	2	Pos	1.9	2
Index Values						
Index	**NATURAL**					
A - All	-2.2					
B - Fish	-11.1					

Table 11: Relationships results of HEC-EFM with fifth scenario at wetland health five star

		Gage		**Natural**		
Relationship	**Conf.**	**Stage (m)**	**Flow (m^3/sec)**	**Chg.**	**Stage (m)**	**Flow (m^3/sec)**
Little minnow spawning hobitat	*	2.6	13	Neg	2.8	14
Benthic Macroinvertebrate Biodiversity	*	3.2	14	Pos	3.5	16
Wetland Health	*****	2.2	13	Neg	2.5	15
Macrophytes Habitat	*	3.0	14	Neg	3.3	15
Big bass habitat	*	1.7	2	Pos	1.9	2
Index Values						
Index	**NATURAL**					
A - All	-11.1					
B - Fish	-11.1					

Table 12: Reverse look-ups - flow duration of HEC-EFM with fifth scenario showing present of time flows above 4 (m^3/sec)

		Natural	Gage	
Relationship	**Conf.**	**% X, of time**	**Chg.**	**% X, of time**
Wetland Health reverse lookup	*****	70.2	Pos	73.9

6. Conclusion

The presence of water is significant in any ecosystem, where the ecosystem depends on the quantity and quality of water. The low water quantity has a significant impact on the ecosystem and the food chain of living organisms, although water can self-cleansing contaminants, but may require this Causing a loss of biodiversity and a lack of natural food sources (such as fish).

In this study, different scenarios were studied for understanding ecosystem relationship impact. Five discharge reduction scenarios were studied: 2%, 4%, 6%, 8% and 10% were adopted as gage$_{(\text{flow, stage})}$.

The results of HEC-EFM showed no significant change in environmental relations when the flow is reduced from 2% to 8% from the natural flow. However, the environmental relations studied have begun to deteriorate significantly when drainage is reduced to 10%, as the ecosystem in Abu-Ziriq Marsh cannot be repaired. The study recommends avoiding the reduction of the flow to greater than 10% by the competent authorities to restore environmental relations in the marshes of Abu- Ziriq Marsh. In addition to that, results for wetland health reverse lookup at the fifth scenario show that Abu -Ziriq Mrash need (70.2%) as a percent of the time, when flows equal or exceed (4 m^3/sec). This discharge was chosen because it can be supplied on most days of the year, which is the time needed to be revived when flows equal or exceed 4 m^3/sec. HEC-EFM demonstrates the ability to analyze the various environmental relationships of the Abu- Ziriq Marsh and their potential for use in the study of Iraqi wetlands. Further studies and research should be undertaken to prevent the deterioration of the rest of the Iraqi marshes.

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