Hydrological Damage of Iranian Separation Dike on the Iraqi Part of Al Huweizah Marsh

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ABSTRCT

Iran has recently started constructing a separation dike which is planned to cross through the functioning marsh along the border line. If completed, this will bisect the marsh and can potentially control water flows from the Iranian (Al Azim) Marsh into the Iraqi Marsh (Al Huweizah). The environmental and hydrological consequences of these changes are likely to be great. In order to study the hydrological changes within the Iraqi part hydrological routing is adopted. Hydrological routing is recognized as a procedure required in order to determine the hydrograph at the marsh outlet or the storage variation with time in the marsh. The hydrological effect of the constructed dike can demonstrated by constructed the hydrological routing for the whole marsh area. Two cases were considered, case 1; in the absence of Iranian dike and case 2; the existence of the dike. The main results of the comparison showed that there is no contribution from Al Karkheh River into the Iraqi part of the marsh during dry years.; while the contribution of this River will be 36% and 31% from its inflow into the marsh during wet and normal years respectively. The inundated area varied between 92 % and 78 % from the inundated area in the Iraqi part of the marsh in case 1 and the water levels would be lower than in case 1 by about 1 m. The Iranian part of the marsh will be a salty marsh and causes harmful environmental effect on the ecological system within the Iraqi part of the marsh according to the surface and subsurface inflow from the Iranian area.

الخلاصة

باشرت الحكومة الايرانية مؤخراً بانشاء سدة فاصلة ومخططاً لها ان تفصل الجزء الايراني من هور الحويزة عن الجزء العراقي على طول خط الحدود. ولذا ستكون التاثيرات الهيدرولوجية والبيئية الناتجة عن انشاء هذه السدة كبيرة ولغرض دراسة التغيرات الهيدرولوجية الناجمة عن هذا الاجراء ضمن الجزء العراقي من هور الحويزة تم اعتماد الاستنباع الهيدرولوجي باعتباره الطريقة المناسبة لايجاد علاقة التصريف الخارج من الهور مع الزمن والتغير في الخزين ضمن المسطح المائي مع الزمن. ان حجم التاثيرات السلبية الناتجة عن انشاء السدة الايرانية ستكون واضحة اذا ما قورنت الخواص الهيدرولوجية للهور بغياب السدة (حالة ١) وبوجودها (حالة ٢). ان اهم نتائج الاستنباع الهيدرولوجي بينت ان نهر الكرخة لن يسهم في تغذية الجزء العراقي من هور الحويزة خلال السنوات الجافة وانخفض إسهامه بين (٣١%-٣٦%) من التصاريف الواصلة إلى هور الحويزة خلال السنوات المعتدلة والفيضانية على التوالي. و اخيراً ستتراوح المساحة المغمورة في الجزء العراقي بين (٧٨%-٩٢%) من المساحة المغمورة في الحالة ١ وان منسوب الماء في الحالة ٢ سيكون اقل بحدود ١ م عن الحالة ١.اضافة لما تقدم فأن الجزء الايراني من هور الحويزة سيصبح مسطح مائي شديد الملوحة مسببا تاثيرات بيئية ضارة على النظام الاحيائي ضمن الجزء العراقي من الهور من خلال المياه السطحية والجوفية المتاتية من الاراضي الايرانية.

INTRODUCTION

Al Huweizah Marsh, **Figure 1,** is located on the eastern side of Tigris River in Maissan and Basrah Governorates, extending from AsSanna'f Marsh outfall down south to AsSwaib River. The eastern part of this marsh is located beyond the Iranian borders. Only a small part of this depression lies within the Iranian territory, about one third of the total area, and the larger part is located in Iraq where it is used to receive flows from Tigris River. Flood protection dikes, which are known as the frontier dikes, were constructed along west bank of Al Huweizah Marsh to protect the areas on the west bank of Tigris River (*Ministry of Water Resources, 1982*). Iran has recently started constructing a separation dike which is planned to cross through the functioning marsh along the border line. If completed, this will bisect the marsh and can potentially control water flows from the Iranian (Al Azim) Marsh into the Iraqi Marsh (Al Huweizah), **Figures 1** and **16**. The hydrological properties of the Iraqi part of the marsh with the presumed dike were studied according to the hydrological routing of Iranian functional and degraded marshes. The interface between the two Iranian marshes (Functional and Degraded Iranian marshes, **Figures 6** and **7**) and the elevation of the presumed dike will be considered. It is to be noted that the flow over the presumed dike is taken as flow over broad crested weir. Finally, the inflow into the Iraqi part of the marsh from the Iranian two marshes will be specified. The resulting hydrological properties then will be comparing with the hydrological routing of the whole marsh area without the presumed dike the marsh area is shown in **Figure 1** and the feeder from Iran will be Al Karkheh River.

REQUIRED DATA

Some of the data required to carry out the flow routing through the Marsh were available at the CRIM (Centre for Restoration of Iraqi Marshlands), these data are presented in the following sections.

Topographical Field Survey

CRIM, 2007, developed a complete topographical map for Al Huweizah Marsh, **Figure 2**, by using the topographical survey which has been carried out by CRIM during the year 2006 for the Iraqi part of Al Huweizah Marsh and the topographical map of the Iranian part of the marsh which is presented in the Azadegan Environmental Baseline Studies (*UNEP, 2004*).

Hydraulic data:

The hydraulic data include the discharges of all marsh feeders at their outfalls into the marsh during wet, normal and dry water years. The discharges of the feeds AsSanna'f Marsh, Al Karkheh River, Al Msharah River, and Al Ka'hla River are listed in **Table 1**. The outflows from the marsh for the future condition were obtained depending on the rating curves of the proposed control structures at the marsh outlets, Al Kassara, **Figure 3,** and AsSwaib, **Figure 4**. The calculated monthly Evapotransperation (ET) for Al Huwayza Marsh area, are listed in **Table 2.** The annual precipitation within the marsh is approximately 150 mm which is less than 10 % of the existing Evapotransperation within the marsh area. Accordingly, the effective rainfall will not be considered in the hydrological routing.

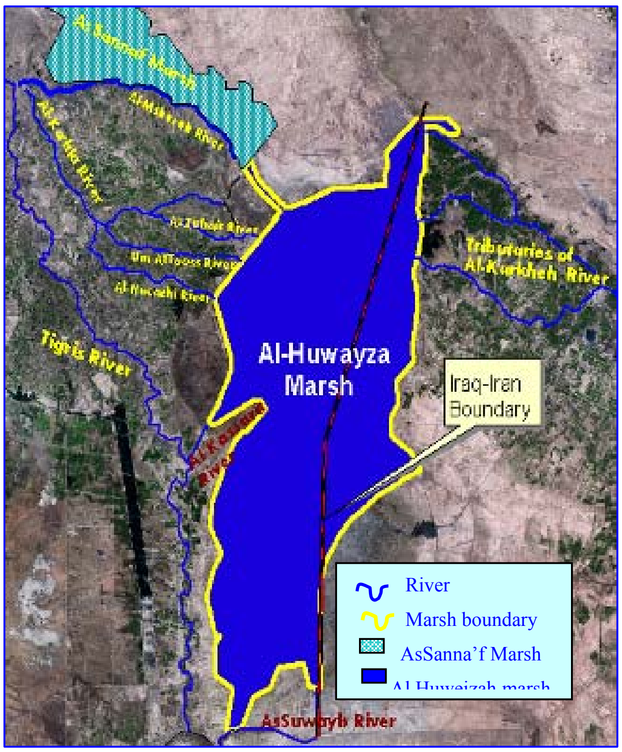

Figure 1. General Satellite Image of Al Huweizah Marsh.

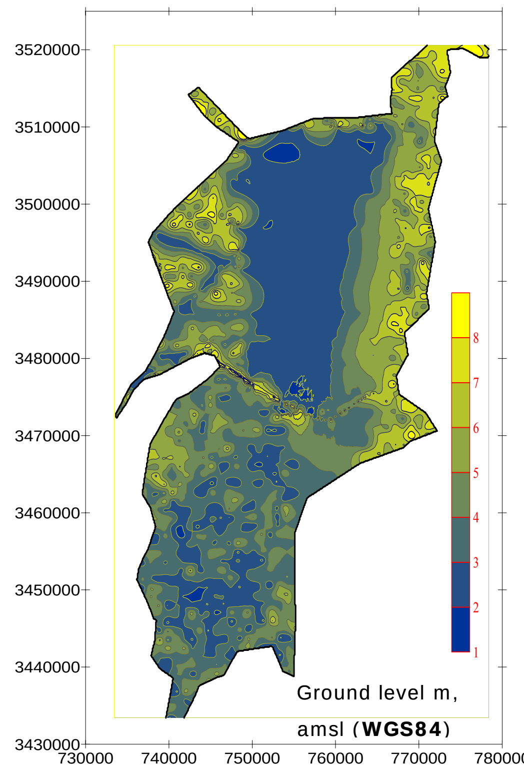

Figure 2. The DEM of Al Huweizah Marsh, (after CRIM 2007)**.**

Table1. Monthly averaged discharges of all Marsh feeders (*after General Directorate of Water Resources Management, 2008*)

	Al Karkheh River			**Al Msharah River**			**Al Ka'hla River**			**AsSanna'f Marsh**		
	Wet	Normal	Dry	Wet	Normal	Dry	Wet	Normal	Dry	Wet	Normal	Dry
Oct	25	15	10	30	13	6	89	34	10	0	0	0
Nov	25	20	10	30	13	6	151	51	10	0	0	0
Dec	40	25	15	23	12	4	145	51	13	0	0	0
Jan	50	25	20	30	26	4	150	137	10	191	101	20
Feb	100	75	40	30	19	3	150	90	10	94	52	10
Mar	240	150	75	20	10	3	150	48	9	13	11	8
Apr	340	225	105	30	14	6	150	56	6	9	8	7
May	200	150	75	20	10	4	145	45	6	8	6	4
Jun	80	60	25	17	10	5	103	41	9	6	4	1
Jul	60	40	20	17	9	4	66	33	6	0	0	0
Aug	55	30	20	20	10	5	57	28	10	0	0	0
Sep	50	25	18	16	10	4	64	30	10	0	0	0

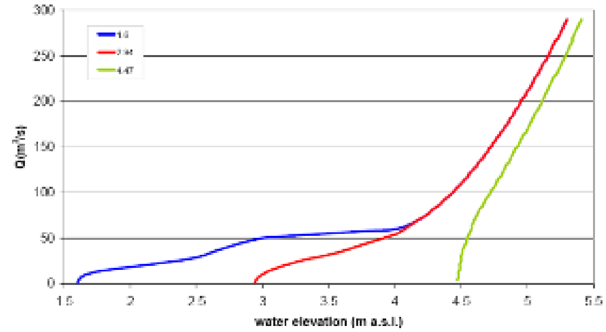

Figure3 .The rating curve of Al Kassara outlet structure**.**

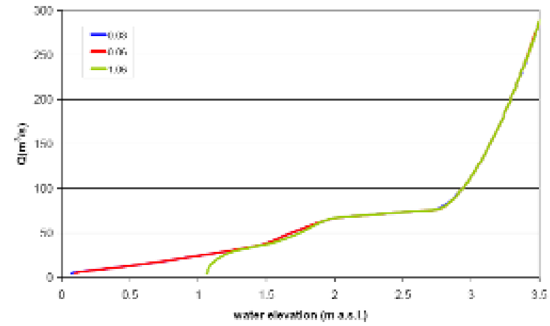

Figure 4. The rating curve of AsSwaib outlet structure**.**

Table 2. Calculated monthly evapo-transpiration, (*after NEW EDEN PLAN, 2006*).

Month	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
ET (mm)	53.5	76.8	126.1	199.9	278.4	375.2	423.9	390.9	279.1	174.4	99.1	59

COMPUTATION OF STORAGE CAPACITY

Iran has recently started constructing a dike which is planned to cross through the functioning marsh along the Iraq-Iran border line. If completed, this will bisect the existing marsh into two separated parts, Iraqi and Iranian parts. The presuming dike elevation is 6 m asl .The functional Iranian part of the marsh is separated from a degraded area by an existing dike whose elevation of 6 m asl, (UNEP, 2004). The area of the Iraqi part of Al Huweizah Marsh is about 1360 km^2**,** as shown in **Figure 5**, while the area of functional part, as shown in **Figure 6**, and the dredged part, as shown in **Figure 7**, of Al Huweizah marsh within the Iranian border are about 300 and 400 km^2, respectively.

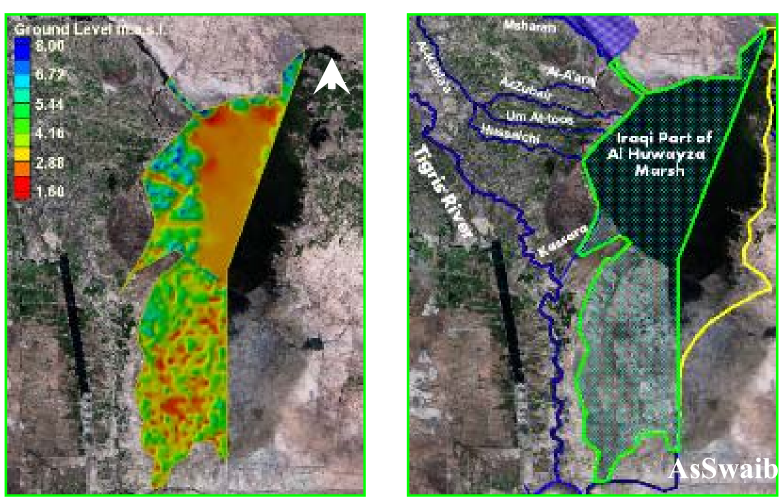

Figure 5. The Layout and DEM of Iraqi part of Al Huweizah Marsh**.**

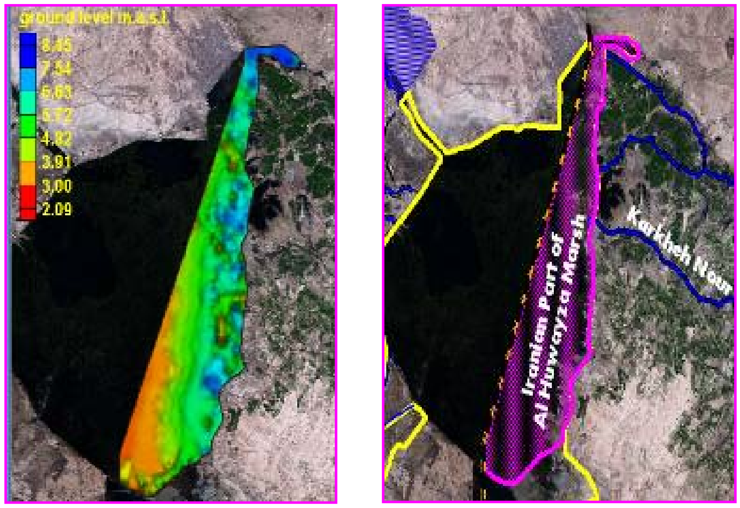

Figure 6. The Layout and DEM of the functional Iranian part of Al Huweizah Marsh.

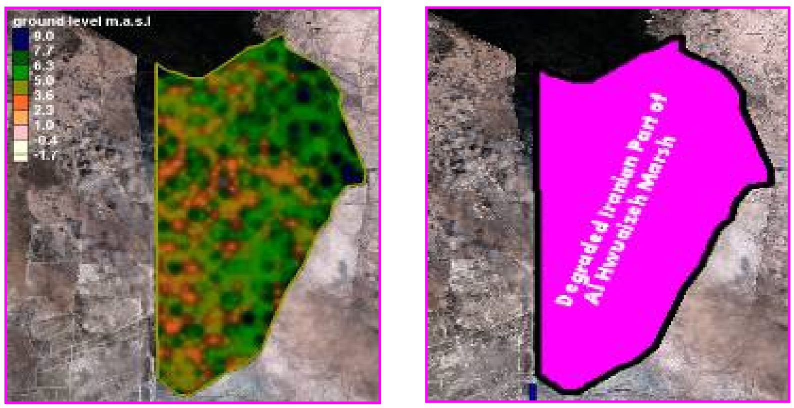

Figure 7. The Layout and DEM of the degraded Iranian part of Al Huweizah Marsh.

In order to obtain an accurate area and storage elevation curves for Al Huweizah Marsh, They curves were constructed by using two approaches based up on:

1- the achieved DEM of the marsh , using Arc-view GIS software, and assuming that water surface profile within the marsh is horizontal (hypothetical case).

2- a steady- one dimensional hydraulic model prepared by using the HEC-Geo RAS extension under Arc-view and HEC-RAS softwares. The upstream boundary condition is at the northern side of the marsh while the downstream boundary condition is at the southern side of the marsh as shown in **Figure 8**. The number of cross sections along the marsh area was 104. A constant flow rate was adopted as the upstream boundary condition with a normal depth at the downstream boundary.

The averaged water level along the marsh with the resulting surface area and the stored water within the marsh which were obtained by using the two approaches are shown in **Figure 9**. The comparison between the results of the two approaches shows that, for a water level of 5masl, the surface area and storage of the mash using the steady-one dimensional hydraulic model are 8% and 13 %, respectively, higher than that of the first approach (hypothetical case).

Since both the surface area and storage that were obtained by using the hydraulic model are almost higher than that of the hypothetical case and the marsh outlets at Al Kassara and AsSwaib will be controlled in the future, the stored water within the marsh may be stagnant when the marsh outlets are closed. So the hypothetical case will be more efficient than the steady-one dimensional model.

Depending on the achieved DEM of the marsh, by using Arc-view GIS software, and assuming that the water surface profile within the marsh is horizontal (hypothetical case), the area and storage elevation curves for the Iraqi part of the marsh, and the functional and degraded Iranian part of the marsh were obtained and are as shown in **Figures 10** through **15**.

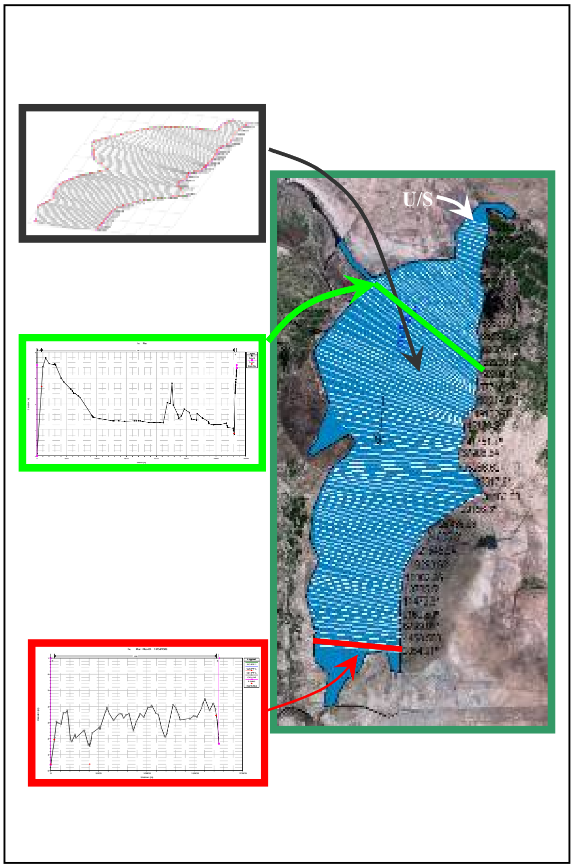

Figure 8. The layout of the steady one dimensional hydraulic model by using the HEC-RAS model.

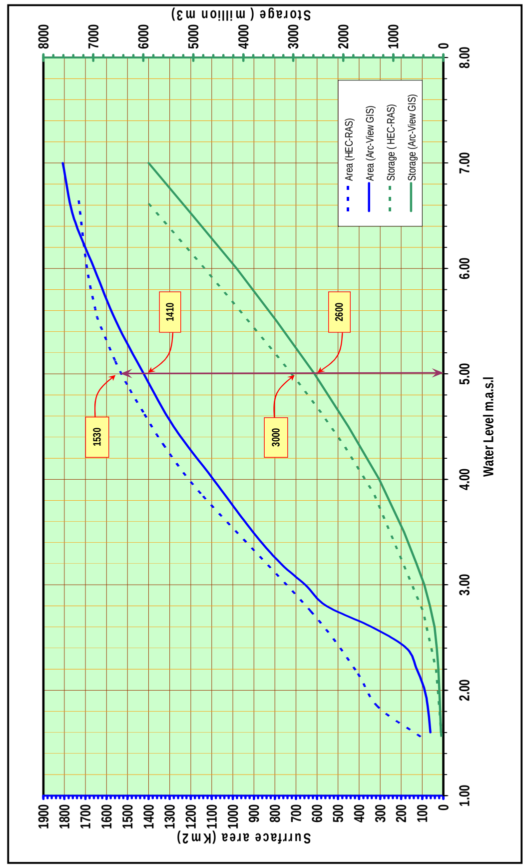

Figure 9. Comparison of the Area and storage elevation curves by using two different approaches.

HYDROLOGICAL ROUTING:

According to the present and future condition of the marsh the hydrological states of the marsh can be classified into two cases:

Case 1: The expected future condition of the marsh with the existence of the outlet control structures and the presumed dike is ignored, the marsh area will be considered as one unit, and the proposed outlet control structures (Al Kassarah and AsSwaib) are assumed to exist. The hydrological routing of the future condition (Case 1), considering a series of 15 sequential years (one wet year, 4 normal years, one dry year

, four normal years, one dry year, two normal years, one dry year and finally one normal year), was carried out by utilizing the hydraulic data of the wet, normal, and dry years. The area and storage elevation curves of case 1, **Figure 9,** the calculated evapotransperation, **Table 2** and regarding the rating curves of the proposed marsh outlets control structures (Al Kassara and AsSwaib), **Figures 3** and **4.** The monthly and seasonal variation of storage, surface area and water surface elevation for this case were obtained and shown in **Figures 17** through **19**. The monthly variation of inflow and outflow from the marsh during wet , normal, and dry years is shown in **Figure 20**.

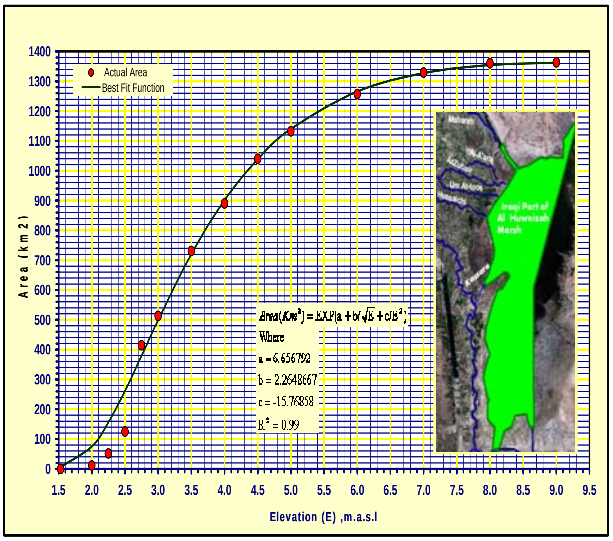

Figure 10. Area-elevation curve of the Iraq part of Al Huweizah Marsh.

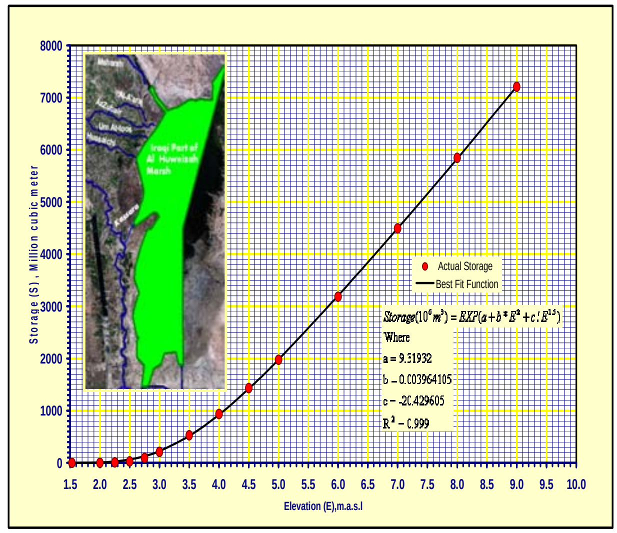

Figure 11. Storage-elevation curve of the Iraq part of Al Huweizah Marsh.

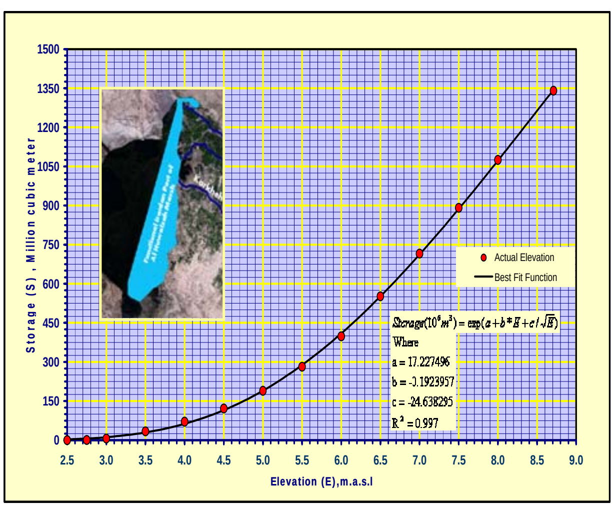

Figure 12. Storage-elevation curve of the functional Iranian part of Al Huweizah Marsh

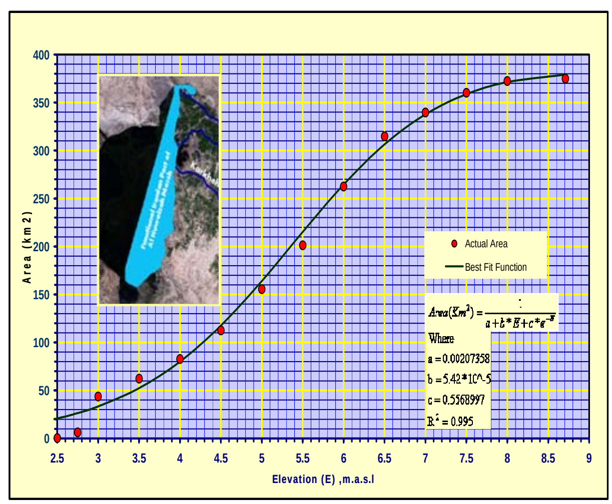

Figure 13. Area-elevation curve of the functional Iranian part of Al Huweizah Marsh

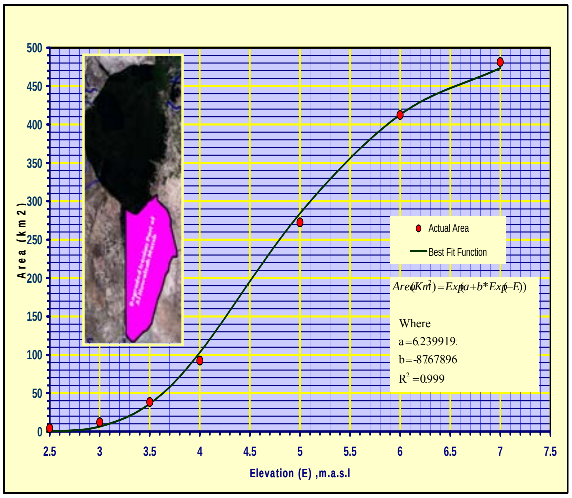

Figure 14. Area-elevation curve of the degraded Iranian part of Al Huweizah Marsh.

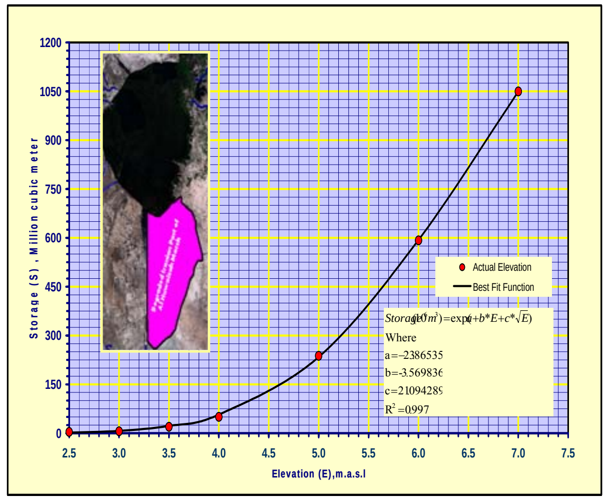

Figure 15. Storage-elevation curve of the degraded Iranian part of Al Huweizah Marsh.

Case 2: The expected future condition of the marsh with the existence of the presumed dike and outlet control structures. In this case the presumed dike and the proposed outlet control structure are assumed to exist and the marsh will be bisected into Iraqi and Iranian parts. The hydrological routing of the future condition (Case 2),considering a series of 15 sequential years as in Case 1, and with the hydraulic data of the Iraqi feeders of the marsh during the wet, normal and dry years , **Table 1**. The area and storage elevation curves of Case 2, **Figures 10** and **11,** the calculated evapotransipiration, **Table 2,** and regarding the rating curves of the proposed marsh outlets control structures (Al Kassara and AsSwaib), **Figures 3** and **4.** The inflow from Iranian side into the Iraqi part of the marsh ,which is represent the water spill over the presumed dike towards the Iraqi part , will be obtained from a hydrological routing of the Iranian part of the marsh which is divided into functional and degraded marshes that were implemented for this purpose. The inflow discharges into the two Iranian parts are based on the Iranian proposed future plan, **Table 3**, (*UNEP, 2004*).

Table 3. Projected inflow (m^3/sec) into Functional and Degraded Iranian Marshes (after *UNEP, 2004*).

Month	Functional wetland			Degraded wetland		
	Wet	Normal	Dry	Wet	Normal	Dry
Oct.	18	17	0	9	16	8
Nov.	14	20	0	12	11	10
Dec.	8	26	10	18	9	16
Jan.	10	29	0	24	9	21
Feb.	19	78	24	22	11	21
Mar.	337	142	20	19	18	16
Apr.	933	220	19	21	23	19
May	507	134	17	22	22	19
Jun.	145	59	5	22	19	20
Jul.	40	39	0	16	21	14

Aug.	35	35	0	11	21	10
Sep	31	30	0	9	22	8

The hydrological routing of the functional Iranian part of the marsh was implemented depending on the area and storage elevation curves of functional part of the marsh, **Figures 12** and **13**, the calculated evapotransipiration **Table 2**, and considering the inflow into this part of the marsh from the Iranian side during the wet, normal and dry water year, **Table 4.** Results of this routing show that the water in this marsh will spill over the presumed dike between the Iraqi and Iranian part, 50km, and the existing dike between the functional and degraded Iranian parts, 14 km, into the Iraqi Part and the degraded Iranian part, respectively, during the wet and normal years. The outflow from this part of the Iranian marsh into Iraqi and the degraded Iranian marshes are 78% and 22%, respectively. These percentages are based on the dike length between the functional part and the degraded and Iraqi parts of the marsh. The obtained monthly total inflow into the Iraqi and degraded parts from the functional part of the marsh during the wet and normal years are listed in **Table 4.**

Table 4. Monthly total inflow into the Iraqi and degraded parts from the functional part of the marsh (m^3/sec).

Month	Total outflow		Iraq Part (78% from the total)		Degraded Part (22% from the total)	
	Wet	Normal	Wet	Normal	Wet	Normal
Sep.	0	0	0	0	0	0
Oct.	0	0	0	0	0	0
Nov.	0	0	0	0	0	0
Dec.	0	0	0	0	0	0
Jan.	0	0	0	0	0	0
Feb.	0	25	0	20	0	6
Mar.	260	135	203	105	57	30
Apr.	910	200	710	156	200	44
May	480	100	374	78	106	22
Jun.	108	20	84	16	24	4
Jul.	5	0	4	0	1	0
Aug.	0	0	0	0	0	0

Now, the hydrological routing of the degraded part of the marsh is studied by taking into consideration that the total inflows into this part as the inflow from the Iranian side during the wet, normal, and dry water years, **Table 3,** plus the extra inflow into this marsh from the functional part of the marsh during the wet and normal water years, **Table 4**. The results of the hydrological routing showed that the water in the degraded part of the marsh spills over the presumed dike into the Iraqi part of the marsh during the wet water year only. The monthly outflow is shown in **Table 5**. According to the results of the hydrological routing of the two Iranian parts of the marsh, functional and degraded, and the hydraulic data of the Iraqi feeders; the inflow discharges into the Iraqi part of the marsh were obtained and listed in **Table 6.**

Table 5. Monthly outflows from the degraded part into the Iraqi part of the marsh during the wet water year (m^3/sec).

Month	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Total outflow	0	0	0	0	0	0	0	117	84	0	0	0

A schematic diagram for the hydrological interference between the Iraqi part and the functional and degraded Iranian part of the marsh is shown in **Figure 16**. Depending on the obtained inflow discharges into the Iraqi part of the marsh, **Table 6**, the hydrological routing was implemented to this part of the marsh .So, the monthly and seasonal variation of water surface elevation, surface area, storage, storage, and inflow and outflow for this case were obtained and shown in **Figures 17** through **20**.

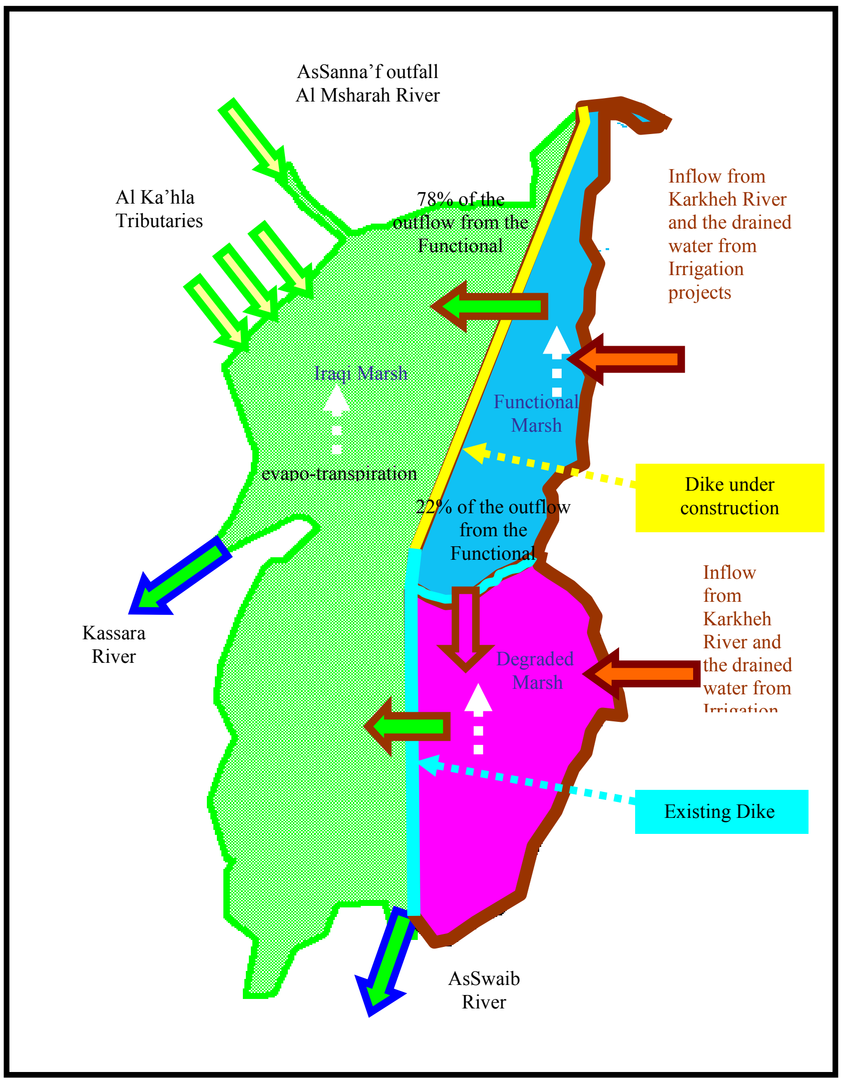

Figure 16. Schematic diagram for the hydrological interference.

Table 6. The inflow discharges (m^3/sec) into the Iraqi part of the marsh.

Month	Iranian parts of the marsh				Iraqi feeders			Total		
	Wet		Normal		Wet	Normal	Dry	Wet	Normal	Dry
	Functional	Degraded	Functional	Degraded						
Sep.	0	0	0	0	130	65	65	130	65	65
Oct.	0	0	0	0	144	62	26	144	62	26
Nov.	0	0	0	0	206	84	26	206	84	26
Dec.	0	0	0	0	208	88	32	208	88	32
Jan.	0	0	0	0	230	188	34	230	188	34
Feb.	0	0	20	0	290	184	53	290	204	53
Mar.	203	0	105	0	450	208	87	653	313	87
Apr.	710	117	156	0	570	295	117	1397	451	117
May	374	84	78	0	380	205	85	838	283	85
Jun.	84	0	16	0	200	111	39	284	127	39
Jul.	4	0	0	0	143	82	30	147	82	30
Aug.	0	0	0	0	132	68	35	132	68	35

HYDROLOGICAL EFFECT OF THE CONSTRUCTED DIKE ON THE IRAQI PART OF THE MARSH

A comparison was made between cases 1 and 2, during wet, normal and dry years in order to explain the effect of constructing the presumed dike when the outlets of the marsh are controlled by the proposed hydraulic structures, Al Kassarah and AsSwaib). Results of the hydrological routings for cases 1 and 2 showed that the annual water surface elevation in case 2 is 100 cm, 90 cm ,and 50 cm higher than that for case 1 during wet, normal and dry years, respectively, **Figure 17**. The main reason is that the annual inflow discharges from Iranian feeders after the development, that enter the marsh through the functional and degraded marshes, will be a bout 44 % from annual inflow discharges before the development. Additionally, the surface area of Iraqi part of the marsh with the existence of presumed dike is about 72 % of the total area. Accordingly; the monthly variation in the surface area and storage during the considered period for cases 1 and 2 are as shown in **Figures 18** and **19**. The percentage of annual outflow to the annual inflow for Case 1 during wet, normal and dry water years is 73%, 63% and 55% respectively. While for case 2 is 78%, 54% ,and 38% respectively, **Figure 20**. It is clear that the control structure will reduce the outflow from the marsh during normal and dry years. So the control structures at marsh outlet will maintain the water surface elevation within the marsh higher than 2.6 m asl. The maximum water level for case 1 and 2 will be 9 and 8 m asl , respectively, for a flood of 100 year return period. During dry years , deterioration of the surface area of the marsh in case 1 is higher than that of case 2 because the marsh area will be limited in case 2 and the losses due to evapotransipiration will be lower than that of case 1. This fact is clear if the existing storage between the two cases is compared.

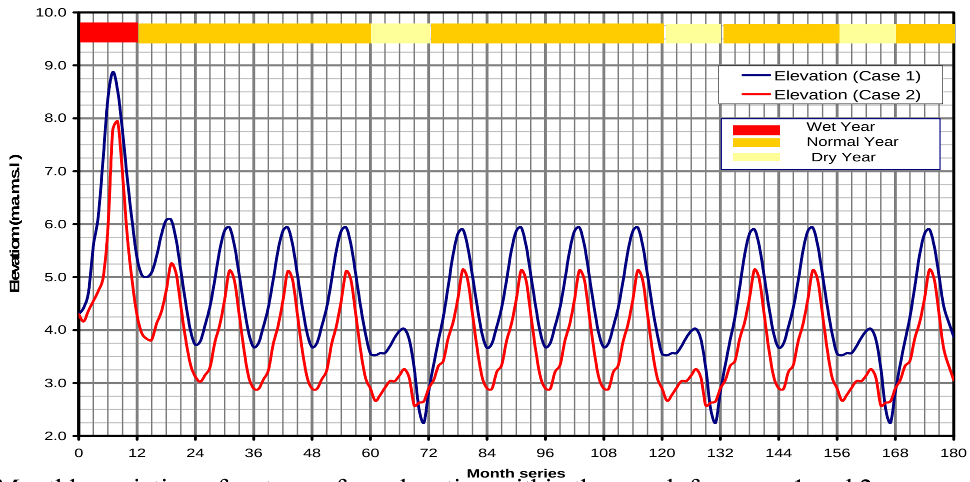

Figure 17. Monthly variation of water surface elevation within the marsh for cases 1 and 2.

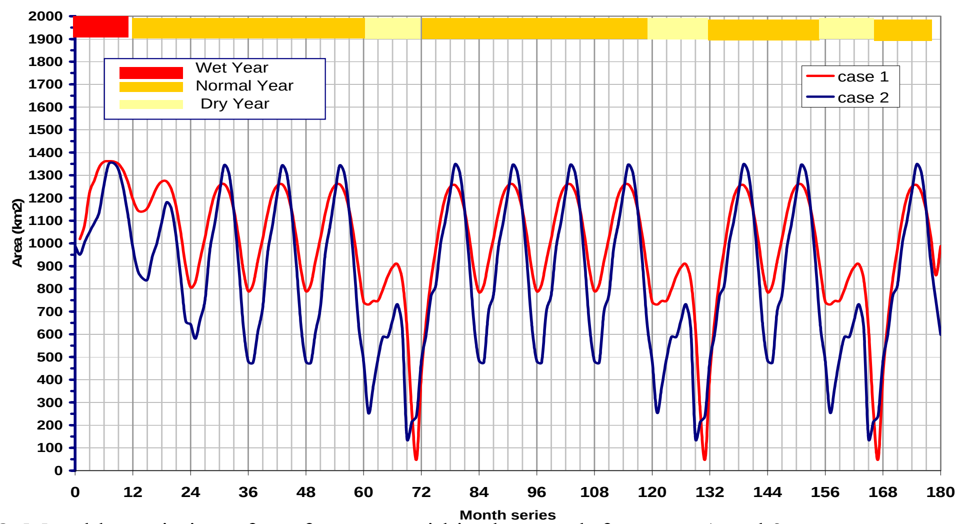

Figure 18. Monthly variation of surface area within the marsh for cases 1 and 2.

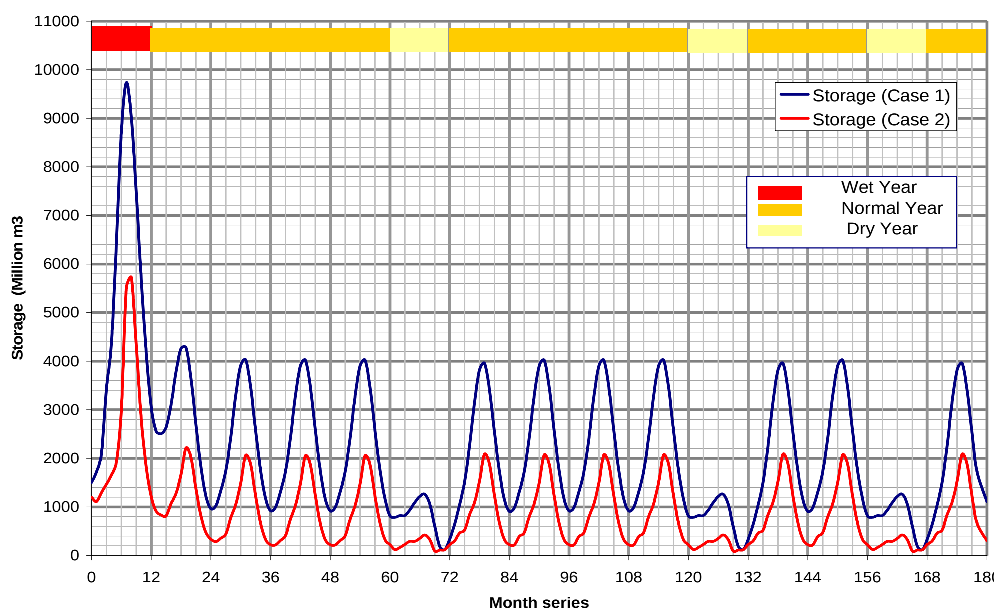

Figure 19. Monthly variation of storage within the marsh for cases 1 and 2.

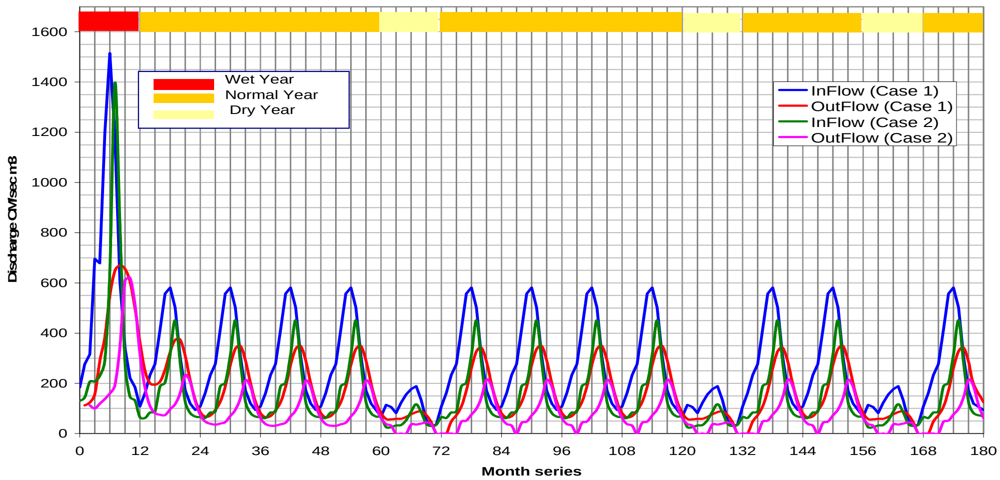

Figure 20. Monthly variation of the inflow and out flow within the marsh for cases 1 and 2.

CONCLUSIONS:

From the concluded study, the following conclusions can be withdrawn:

1- No contribution from Al Karkheh River into Iraqi part of the marsh during dry years.; while the contribution of this river will be 36% and 31% from its previous inflow into the marsh during wet and normal years.

2- The presumed Iranian dike will reduce the inundated area within Iraqi part of the marsh during wet, normal, and dry years by about 92 %, 82%, and 78 %, respectively, and reduces the averaged water level within the Iraqi part of the marsh by about 1 m during wet and normal years. But the minimum water level will be higher than that in case of dike absence.

3- The quality of the inflow from the Iranian part will be worse than before since the drained water from the new Iranian irrigation projects (near the marsh area) into the Iranian part will be accumulated into Iranian part of the marsh. Additionally, the evaporation and the elevation of the presumed dike (no outflow when the water level is less than 6 m asl) will deteriorate the quality of water and the Iranian part of the marsh will be as a huge drainage sump that causes harmful effect on the ecological system within the Iraqi and Iranian marshes.

4- The contribution of Tigris River in the Iraqi part of the marsh must be higher than the present operation shares to maintain the quality and quantity of water within the Iraqi marsh within acceptable limits.

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