Marshlands of Mesopotamia and the rivers that feed them

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ABSTRACT
The Mesopotamian marshlands are a place of great environmental and cultural importance to the world. This wetland once covered 20,000 km^2 and was the largest in the Middle-East region. The near total destruction of the marshlands during the 1990s by the previous Iraqi regime reduced it to a mere 1400 km^2. The remaining section of the marshlands is on the border with Iran and has been kept alive by the continuing flow of a small Iranian river, the Karkhe. Following the 2003 regime change in Iraq the rehabilitation and restoration of this devastated ecosystem was placed firmly on the new political agenda. Scientists and advisors in the field have come to the conclusion that at least a partial rejuvenation of the marshes is possible given the right set of environmental, political and economic circumstances. The restoration programs have been largely organized by the United Nations Environment Program (UNEP) with financial, material and scientific contributions from many governments as well as many non government organizations. However the unstable political situation existing in Iraq since 2003 has hampered such efforts. Some re-flooding has taken place but mostly by the local people and without any scientific backing and there are some signs of recovery in parts of the re-flooded marshlands, and the return of some of its native plant and animal species. All of the three rivers (the Euphrates, Tigris and Karkhe) that feed the marshlands originate from neighboring countries and all of these countries have extensive plans for dam building and the expansion of their irrigated agriculture. The future of the marshlands are entirely dependent on the continuation of flow from these rivers, and in one of the worlds driest regions this fact means that a hitherto unprecedented level of collaboration and goodwill between these often adversarial states of Iraq, Iran, Turkey and Syria need to be established. However, the plan by Turkey to build 22 new dams on Tigris and Euphrates and to bring large tracks of land under irrigation agriculture is bound to create more tension between Turkey Iraq and Syria, and therefore puts a big question mark on the future of the marshlands restoration plan. Another challenge to this restoration project is the need to balance the social and economic needs of the local inhabitants with the environmental requirements for success, while simultaneously enabling them to preserve their ancient culture which has been entirely dependant on the marshes for thousands of years. The task ahead is highly complex and likely to be an extremely expensive and lengthy process, but success in at least partial restoration of the drained marshlands is possible.

Keywords Euphrates River; marshland restoration; Mesopotamian Marshlands; Persian Gulf; Tigris River; Shat-Al-Arab.

INTRODUCTION
The Mesopotamian marshlands are located mostly in south-eastern Iraq but also extend across the border into Iran. They once covered an area 20000 km^2 between the three Iraqi cities of Amarah in the north, Basra in the south, Naseriyah in the west and the Iranian town of Hawizeh in the east (Fig

1). The marshlands straddled the Euphrates and Tigris rivers and part of the Shat-al-Arab which forms when these two rivers join together. The area consisted of interconnected lakes, mudflats and wetlands, and supported an indigenous population of 500,000 as well as numerous endemic species of birds, mammals, amphibians, reptiles, fish and invertebrates (Dehghanpisheh, 2003). They were described as “paradise on earth” for all of the organisms that inhabited them, including humans. The marshlands are widely believed to be the site of the biblical “Garden of Eden”, and are of great historical significance to three major monotheistic religions of Christianity, Islam and Judaism. Ancient cultures such as the Sumerians of Mesopotamia who invented writing lived among the reeds of these marshes as long ago as 3000 BC. The descendants of the Sumerians who most recently inhabited this area are known as “Ma’dan”, colloquially referred to as “Marsh Arabs”. They had continued to live largely as their ancestors had done over 5000 years ago, living entirely off their environment, using reeds to build their homes (and for just about everything else), eating fish, milk from their water buffalo, and rice grown among the reeds (UN, 2002; Dehghanpisheh 2003; Pearce 1993).

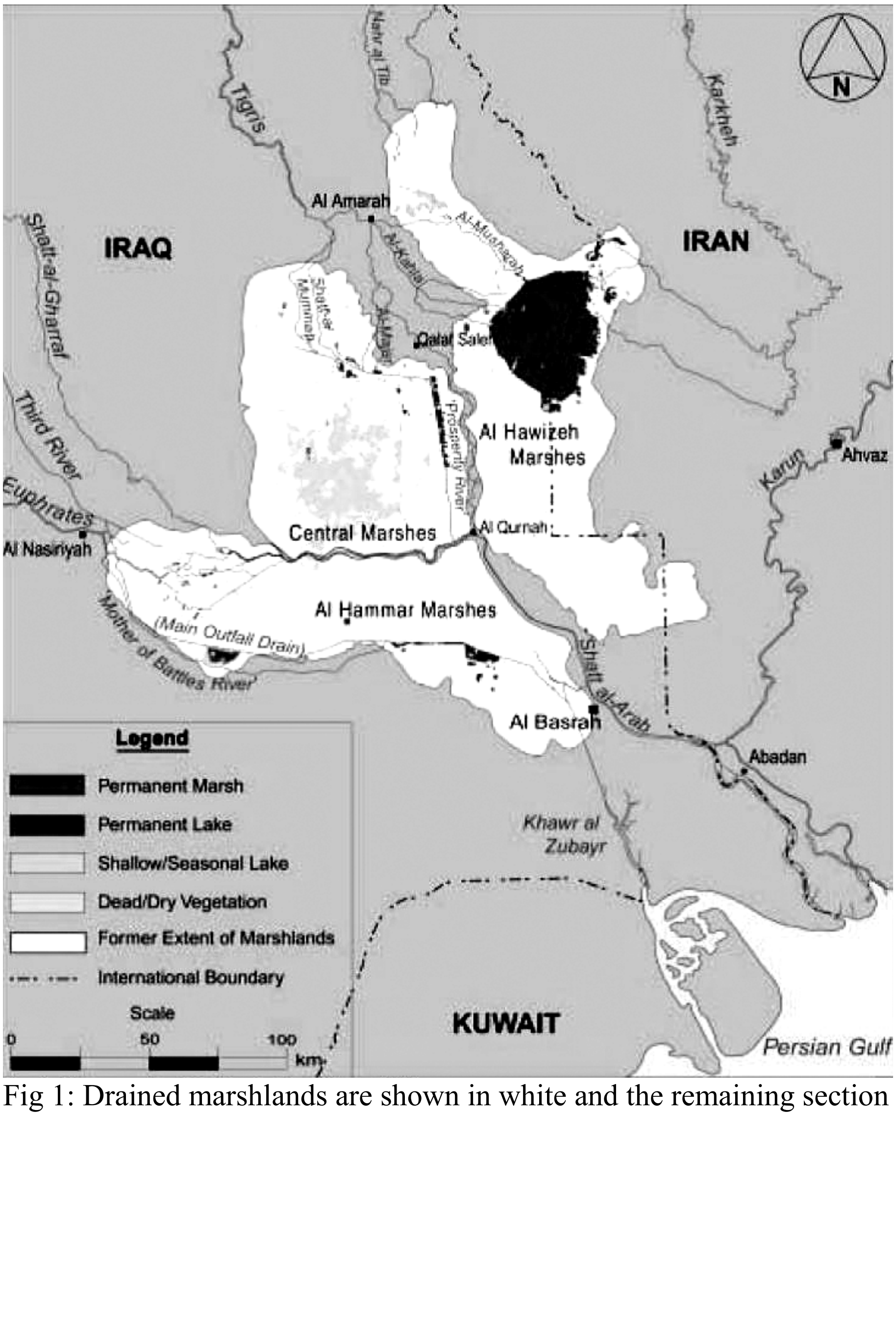

Fig 1: Drained marshlands are shown in white and the remaining section in green

The Mesopotamian marshlands comprised of three major wetland areas; the Al-Hawizeh, Al-Hammar and Central marshes (Fig 1). All three were connected by the Tigris and Euphraties rivers from Iraq and the Karkhe River from Iran which converged to form the Shatt-al-Arab waterway in the centre of the three marshes. The Shatt-al-Arab is later joined by Iran's largest river, the Karun, and forms a major shipping waterway on the border of the two countries. Both countries have their major port cities, Basra (Iraq), Khoramshahr and Abadan (Iran), on this river (Ghadiri and Afkhami, 2005a). The two countries have had three major wars over the ownership of this navigable and strategically important waterway (Fig 2).

Fig 2: The formation of Shat-Al-Arab by the convergence of Tigris, Euphrates and Karun rivers

ECOLOGY OF THE MARSHLANDS

The Mesopotamian marshlands were the largest wetland area in the entire Middle-East region and served an important repository of biodiversity, including many endangered and rare species. This important wetland area was a complex of permanently inundated regions with tall reeds, seasonal marshes where terrestrial shrub and grasses were dominant, shallow and deep-water lakes, slightly brackish seasonal lagoons, and regularly inundated mudflats Millions of migratory birds would use this lush ecosystem as a way-station on their long flights between Africa and Eurasia, or as an abundant breeding ground (Dehghanpisheh 2003; Partow 2001; Pearce 1993; UNEP 2003a). Endangered mammals such as the Smooth-coated Otter (*Lutra perspeicillata),* Bandicoot Rat

(*Erthyronesokia bunnii) and* Harrison's Gerbil (*Gerbillus mesopotamicus)* could only be found among the tall reeds of these marshlands (Table 2). The marshes provided a vital spawning area for multiple fish and shrimp species that inhabit the Persian Gulf (UN, 2002).

DRAINING THE MARSHLANDS

The Mesopotamian marshlands were undergoing a gradual reduction in size since 1960s and 70s as a consequence of the construction of numerous dams upstream of both the Euphrates and Tigris by all three riparian countries, namely Turkey, Syria and Iraq, which was especially effecting the Euphrates flow into the Al-Hammar marshes (George, 1993; Lowi, 1995, UNEP, 2003b). Nevertheless the marshes remained relatively intact until the early 1980s. The deliberate and systematic destruction of the marshes started at the conclusion of Iran-Iraq war in 1989 and accelerated at the conclusion of the first Gulf War in 1991. When the Iraqi Shi'ite uprising of 1991 failed the remnants of the resistance fled to the marshes of southern Iraq where the local Marsh Arabs, who are also of the Shi'ite faith, offered them support and shelter. Thus the marshes with their thick cover of reeds became the stage for a guerilla war with government forces (Dehghanpisheh, 2003). The government troops found it difficult to fight in the marshes as their heavy equipment and vehicles could not move through such terrain. As a result the decision was taken to intensify and expand the plans to drain the marshes completely, thus denying the rebels a place to hide. This plan was fully and rapidly implemented by Saddam's régime and the March Arabs and the Shi'ite fighters were killed, captured or driven out and into refugee camps mostly inside Iran (UNEP, 2003b).

As mentioned before the systematic draining of the marshes was already underway in 1989 albeit on a more limited scale and slower pace, to facilitate the movement of military forces through the area during the Iran-Iraq war. However the marsh Arabs had not been deliberately targeted for extermination then, as they were after the 1991 Gulf war. Chemicals weapons, artillery and minefields (laid to protect the newly constructed dykes from sabotage) were used to flush out the remaining marsh people. Widespread mass executions and forced relocations meant that by the year 2000 only 20,000 marsh Arabs out of a total population of 500,000 remained in their traditional areas (Carpenter & Ozernoy, 2003; Flint, 1993; UN, 2002).

Ironically, the Iraqi régime's plans to completely drain the marshlands were based on the same plans originally drawn up by the British run civil service of Iraq in the 1950s and the British consultancy firm Murdoch MacDonald (now Mott MacDonald) in the 1960s. Officially the draining of the marshes was for the purpose of opening up new land for agriculture by desiccating the wetlands and by diverting the river waters to saline agricultural lands and leaching the salt from the soil (Pearce, 1993). The highly saline runoff and drainage water would then be channeled into newly dug canals and then onto the Shatt-al-Basra canal which would bypass the marshes and deliver it directly into the Persian Gulf (Fig 1). This was also the basis for the British plan and was only achieved through the construction of a maze of dykes which subdivided the marshlands and cut off the flow of water to each sub division until it was completely desiccated.

By the year 2000, of the three marshes that comprised this wetland only a small part the Al-Hawizeh marsh, which straddles the border with Iran, remained intact, kept alive by the relatively small Karkhe River from Iran (UN, 2002; UNEP, 2003c). The remaining wetland area in the year 2000 is shown in Fig 1. Both the Al-Hammar and Central marshes had been completely drained, and stripped of all natural vegetation and wildlife. A complex maze of dykes, dams and canals were designed and constructed to change the flow of the Tigris and Euphrates rivers away from the wetlands. Once starved of water the vegetation, which was primarily comprised of reeds (*Pharagmites communis*) dried out. Once the area was completely desiccated, the remnant vegetation was set alight, sometimes using napalm bombs (Carpenter & Ozernoy, 2003; Dehghanpisheh, 2003).

Table 1: Changes in Surface Area of Mesopotamian Marshlands, 1973-76 – 2000 (in km^2)

Marshland	73-76	2000	2000 as % of 73-76
Central			
Permanent Marshes	2,853	69.8	2.4
Permanent Lakes	112	5.7	5.1
Seasonal/Shallow Lakes	156	22.5	14.4
Total	**3,121**	**98.0**	**3.1**
Al-Hawizeh			
Permanent Marshes	2,715	837.4	30.8
Permanent Lakes	186	129.4	69.4
Seasonal/Shallow Lakes	175	58.1	33.3
Total	**3,076**	**1025.0**	**33.3**
Al-Hammar			
Permanent Marshes	1,675	27.9	1.7
Permanent Lakes	362	88.7	24.5
Seasonal/Shallow Lakes	692	57.2	8.3
Total	**2,729**	**173.9**	**6.4**
Total Wetlands	**8,926**	**1,296.9**	**14.5**

(From Partow, 2001)

By the year 2002 all hopes for the survival of any part of the marshlands seemed lost as fresh studies showed that a further 325 square kilometers of marshlands had dried out since 2000, leaving just seven per cent of the original area. It was well understood by the scientific community that unless urgent action was taken to reverse the trend and re-habilitate the marshlands, the entire wetland known as the Hawr Al-Hawizeh in Iraq and Hawr Al-Azim in Iran, were likely to disappear in three to five years(UNEP, 2003a).

Environmental and ecological damages caused by draining marshlands

Within a decade 93% of the area of the Mesopotamian marshlands was turned into agricultural lands, barren wasteland encrusted with salt deposits, industrial and agricultural wastes, untreated sewage and discarded military equipment. The United Nations Environment Program's director, Klaus Toepfer, and other high ranking officials in UNEP have called it one of the largest environmental disasters of the 20th century, on par with the destruction of the Amazon rainforest in Brazil. Migratory birds can no longer stop there on their way north and some have even declined in numbers to such an extent as to become endangered themselves (Carpenter & Ozernoy, 2003). Fish and shrimp numbers have declined substantially not only in the marshes but all the way to the Persian Gulf and Iraq's river systems. The biodiversity of the entire region has undergone such an unprecedented decline that the damage can never be reversed and this important ecosystem will never return to a state resembling anything like it did during the 1970s and before.

Loss of wildlife. Many species such as the Smooth-coated Otter (*Lutra perspeicillata maxwelli*) which were endemic to these marshes are now extinct. Also the globally threatened Marble Teal (*Marmaronetta angustirostris*) is known to have bred widely in the marshlands. A list of endangered marsh animals is given in Table 2

Table 2: Highly Threatened Species of the Marshlands

Class	*Common name*	*Scientific Name*
Bird	Iraq Babbler (endemic) Basrah Reed Warbler (endemic) African Darter (sub-species) Dalmatian Pelican Goliath Heron Imperial Eagle Marbled Teal Pygmy Cormorant Sacred Ibis Slender-billed Curlew White–Tailed Eagle	*Turdoides altirostris* *Acrocephalus griseldis* *Anhinga rufa chanteri* *Pelecanus crispus* *Ardea goliath* *Aquila heliaca* *Marmaronetta angustirostris* *Phalacrocorax pygmaeus* *Threskiornis aethiopicus* *Numenius tenuirostris* *Haliaeetus albicilla*
Mammals	Smooth-coated Otter (sub-species) Grey Wolf Long-fingered Bat Bandicoot Rat Harrison's Gerbil	*Lutra perspeicillata maxwelli* *Canis lupus* *Myotis capaccinii* *Erthyronesokia bunnii* *Gerbillus mesopotamicus*
Amphibians and reptiles	Soft-shelled Turtle Desert Monitor	*Rafetus euphraticus* *Varanus griseus*
Fish	Gunther (endemic species)	*Barbus Sharpeyi*
Invertebrates	Dragonfly	*Brachythemis fuscopalliata*

(From Partow, 2001)

Impact on marshlands fish population. From both an ecological and a management perspective, floodplain river fish may be usefully divided into two main categories, reflecting their behavioral responses to seasonal changes in the floodplain environment. The 'whitefish' species inhabit rivers and other flowing channels and undertake seasonal spawning and/or feeding migrations either longitudinally (upstream) or laterally onto the floodplain. Whitefish species are generally intolerant of the extreme conditions that exist in the floodplain habitat during the dry season (low oxygen and high temperatures), and hence they must return to the rivers each year to survive. 'Blackfish' species are generally still-water fish with only limited migrations. Many blackfish species are adapted to survive low oxygen concentrations, high temperatures and even desiccation.

In the Mesopotamian marshes, fish stocks used to be dominated by a variety of fish of the *Cyprinidae* family. Catch composition has changed radically in recent decades both due to the negative effects of the marsh drainage program especially on the whitefish species, and to the introduction of some highly competitive carp species. In the 1960s, the most common fish caught in the marshes, in order of importance, were *bunni* (*Barbus sharpeyi*), *khatan* (*B. xanthopterus*), *hemri* (*B. luteus*), and *shabut* (*B. grypus*). Of these four culturally important Barbus species, the largest *shabut* and *khatan* are both migratory whitefish, while the two smaller species, *bunni* and *hemri* are more floodplain greyfish or blackfish species (Table 3). *Bunni* is the only fish species found in the marshes that is endemic to the Tigris and Euphrates rivers (UNEP 2001). Current fish stocks are now dominated by catfish or *juri* (*Silurus triostegus)*, and two introduced carp species, the crucian carp (*Carassius carassius)*, and common carp (*Cyprinus carpio)*. In the western central marshes, the introduced carps now contribute about 80 percent of the catches, while *juri* comprised 15 to 30 percent.

In addition to its freshwater stocks, the marshes also provide valuable spawning grounds for Sbour *(Hilsa shad)* and Pomphret *(Pampus argenteus)* that migrate annually upstream from the gulf to spawn. In contrast, the *Metapenaeus affinis* shrimp stocks spawn in the marine or estuarine waters and migrate upstream as juveniles to nursery waters in the marsh. During their spawning run, *Hilsa* may contribute over 50 percent of the catches in Basra market.

Table 3: Common Freshwater fish species in the marshes

Common Name	***Latin Name***
Silver Carp	*Hypophthalmychthys molitrix*
Grass Carp	*Ctenopharyngodon idella*
Common Carp	*Cyprinus carpio*
Bunni	*Barbus sharpeyi*
Shaboot	*Barbus grypus*
Qattan	*Barbus xanthopterus*
Himri	*Barbus luteus*
Sheliq	*Aspius vorax*
Kishni	*Liza abu*
Jerri	*Silurus triostegus*
Crucean Carp	*Carassius carassius*

RESTORATION EFFORTS

Soon after the regime change in Iraq in 2003 the restoration of the marshlands was put firmly on the policy agenda of the new Iraqi government. NGOs such as Eden Again had for years been studying satellite images of the marshlands and during this time developed a theoretical restoration project (Whipple, 2003). This plan received strong support from the new authorities in Iraq and was seen as a way not only to save this unique ecosystem but also to help the long oppressed and impoverished Ma'dan people. The first physical actions towards this goal were the removal of some dykes, which held back the waters of the Euphrates and Tigris rivers. However these actions were not sanctioned by the Iraqi authorities, UN or other foreign organizations, but rather an impulsive action by the marsh people themselves, who began the destruction of the dykes as soon as Saddam's security forces were removed from these areas. They could not wait for the arrival of the new authorities or scientists as they were impatient to return to the way of life which for the previous decade they had lived only in their memories. However while this impulsive approach brought some relief to small areas of their parched lands, it also created new problems for the overall restoration project. The restoration of the desiccated marshlands has many constraints, as described in the following section, and success can only be guaranteed, albeit partially, through a carefully planned and scientifically based integrated approach.

Constraints on the restoration of the marshlands

The restoration of the marshes is particularly challenging for several reasons.

Irreversible social and cultural changes amongst March Arabs since the start of the marshlands draining program:

(a) Not all Marsh Arabs want the re-flooding to go ahead for various reasons. Some have undergone a seminal shift in their way of living, from reed based floating to terrestrial based habitation.

They are completely against reflooding and the return to their traditional way of life as they have began growing agriculture products on their drained lands with far higher returns than before (Table 4). Livestock herders too have replaced their water buffalo with sheep and cow.

Table 4: Financial return in US Dollars from different crops

	Wheat	Barley	Maize	Sorghum	Tomato	Broad Bean	Okra	Date Palm*
Total returns	90	94	660	900	1600	1100	1050	500
Variable costs	37	38.25	398.5	241	970.25	323	316	250.9
Gross margins	53	55.75	261.5	659	629.75	777	734	249.1

*The data for date palm trees assumes trees in full production (From Partow, 2001)

(b) The majority of the Ma'dan people simply have moved on to live in Iraq's major cities where access to health care, schools and employment are far better than in their ancestral lands. Without the provision of such facilities the return of the Marsh Arabs to their ancestral lands will fail even if the reflooding takes place. To this end UNEP has organized meetings, the first of which gathered together scientists, aid and development officials and representatives of non-governmental organizations to share ideas and information on the Marshland's problems and their possible solutions (Carpenter & Ozernoy, 2003).

(c) The revival or rehabilitation of the Marsh Arab culture is a big challenge. For example the skills and knowledge needed to build reed houses and boats or locate and catch seafood in the marshes has declined rapidly and can disappear in less than a generation (Jacobson, 2003; UN, 2002).

Re-flooding alone does not guarantee marsh restoration. Wetlands are not like coffee that can be made by simply adding water. You have to add water in the right quantity, the right quality and the right timing. Areas high in salt deposits need to be treated before flooding as they may create large pools of salty water instead of the regeneration of reeds (UNEP, 2003b). The desiccation of the marshlands has created large tracks of saline lands and the random destruction of the network of dykes that hold back the waters of the Tigris, Euphrates and their tributaries will result in the formation of large saline and toxic pools where the lakes and lagoons once existed (Table 5). These areas need to be identified so that the contaminants can be removed while still dry, and only then the area can be flooded. Other considerations include the changes in soil chemistry (due to burning of dead reeds), sewage, industrial, agricultural and military waste which has been deposited on the desiccated land (Jacobson, 2003). The concentration of such pollutants in the marsh waters would have obvious detrimental effects on all organisms within this wetland ecosystem.

Table 5: Soil and water salinity in the re-flooded Hammar marshland

Measurements	***Soil***	***Flooded water (from Euphrates)***	***Euphrates water***
EC (dS/m)	20.4	4.47	1.55
Ph	7.04	8.11	8.14
Eh (mV)	-340	-130	-

The problems associated with water availability for re-flooding. Even if the reflooding is implemented, the future of the marshes is still not secure. The Tigris and Euphrates river basin which is the only source of fresh water for these marshlands covers the territories of four countries; Iraq, Iran Turkey and Syria. All of these countries have gradually increased construction of dams (Table 6) along the rivers and tributaries which feed the marshes (Norman, 1991; Kolars, 1992; George, 1993; Peace, 1993; UN, 2002). As a result water volume and quality has been in decline over the past three decades and it was considered, prior to the full scale draining of the marshes, that they would eventually disappear due to this reason alone. Given that the process of damming outside Iraq has intensified the possibilities of implementing a successful regeneration of the entire marshes seem unlikely. At the current rate of damming the survival of the remaining portion of the Al-Hawizeh/Hawr Al-Azim marsh remains in question, and with it any hope of reintroducing the species of plants and animals that have survived in that last remaining vestige into the Central and Al-Hammar marshes (Dehghanpisheh, 2003). The main river which feeds what remains of intact marshlands is the Karkhe River which is situated on the Iranian side of the border. Iran has plans to pipe 760 thousand cubic meters of water per day 540 km from its dam (constructed in 2001) on the Karkhe directly to Kuwait for sale, thus removing the last source of water which has kept this marsh alive (Partow, 2001; UNEP, 2003a). Problems such as this one which require multilateral solutions have not been properly addressed.

The current amount of water delivered to northern Iraq via the Tigris is 40-44 billion cubic meters (bcm) and via the Euphrates 13-14 bcm. The principal additional supply from Iran is the Karkhe, but this has now diminished as a result of dam construction, which stores about 8 bcm, and its flow may be reduced further as a result of dike construction along the Iran-Iraq border. Restoring half of the original marsh would require roughly 25 bcm of water to meet the evaporation loss in southern Iraq, not accounting for the amount of water required to maintain through flow and permanent water bodies in the marshlands. That level of restoration would consume nearly half of the total available supply in the catchments and would represent an unrealistic allocation given other sector needs in all four countries (Dinar and Wolf, 1994).

The economic and political constraints. An operation of such magnitude and complexity as the restoration of these marshlands requires careful planning, technical expertise, a vast amount of money, a stable security environment and a hitherto unprecedented level of cooperation between all neighboring countries. Economically speaking, whether the project becomes a reality or not depends to a large extent on the level of funding that is made available by the major international and political actors in Iraq; the USA, the UN and other donor nations.

The problems associated with the re-introduction of marsh vegetations. Reeds and most other marsh vegetations have survived in the small remaining parts of the Al-Howzeh/Al-Azim marshes and this is the only positive indicator for the future restoration of the marshlands. It can supply the rest of the marshlands with the necessary seeds for re-planting of the crucial reeds, if flow from Karkhe River is not halted (Carpenter & Ozernoy, 2003). This remaining wetland area holds the hopes of all of the rest of the marshes. As well as serving as a seed bank, it is the last bastion of the many remaining mammals, birds and insects of the marshes. UNEP believes there is still a last window of opportunity to reverse desiccation of the Al-Howzeh/Al-Azim marsh and achieve at least partial restoration. In the short term, an emergency release of water from reservoir dams in Iran and Iraq to simulate the seasonal flood is required. Iran has cooperated with UNEP to increase the flow of water from its reservoirs into the marshes in the past. In March and April 2002, Iran released water from its dam upstream flooding the core northern part of the Al-Howzeh/Al-Azim marsh. However more international co-operation is needed to sustain the flow of water from all four countries on the basin (UNEP, 2003c).

Integrated restoration and management approaches are needed
The best approach for an orderly and sustainable restoration of the drained marshes is an integrated one which recognizes that people are at the heart of the ecosystem and that marshland restoration is not only compatible with, but can indeed support, a wide range of economic activities contributing to human welfare and sustainable development. The approach should recognize the limitations imposed by the water availability and the importance of achieving ecological, environmental, and human interactions. Properly restored marshland ecosystems support biodiversity, improve environmental quality and generate goods and services, such as fisheries and grazing, providing benefits to communities living inside, adjacent to, and outside their boundaries. The integration of different uses of the marsh and adjacent land needs to take account of the ecosystem's capacity to function and not exceed that capacity which would lead to change and degradation. The implementation of such a plan is still a long way off as the security situation in Iraq does not allow such activities.

RIVERS WHICH FEED THE MARSHES

1. Euphrates River
The Euphrates River has its springs in the highlands of eastern Turkey and its mouth at the Persian Gulf. It is the longest river in southwestern Asia measuring 2,700 km, and its actual annual volume is 35.9 billion cubic meters (Kolars and Mitchell, 1991). The Euphrates River is formed in Turkey by two major tributaries; the Murat and the Karasu. After entering Syria, two more tributaries, the Khabur and the Balikh, both originating from Turkey, join this river (Cooley 1992). After entering Iraq, the river reaches the city of Hit, where it is only 53 m above sea level. From Hit to its delta in the Persian Gulf, for 735 km the river loses a major portion of its waters to irrigation canals and to Lake Hammar. The remainder joins the Tigris River near the city of Qurna, and the combined rivers are called "Shatt-al-Arab". The Karun River from Iran also joins the Shatt-al-Arab near the Iranian port city of Khoramshahr (Ghadiri and Afkhami, 2005b).

The Euphrates River, along with the Tigris, was the cradle of the early Mesopotamian civilizations and irrigation water from these two rivers made it possible for the locals to develop agriculture. This resulted in the development of great ancient civilizations in this region. Mesopotamia, the land between the Euphrates and the Tigris, remained as the center of many different civilizations and gave life to millions of inhabitants.

Turkey contributes 88 per cent of the water carried by this river, Syria contributes around 12 per cent and Iraq none, except for water diverted to this river from Tigris. The observed average annual flow across the Turkish Syrian border is 29.8 bcm. The natural flow of the river is around 35 bcm annually (Kolars and Mitchell, 1991). Until recently Turkey utilized only a small portion of this river's water but the GAP (Southeastern Anatolia Development project, or GAP with its Turkish initials) project is going to change this significantly. Currently there are three major dams operational on the Euphrates River: Keban, Karakaya, and Ataturk. The Birecik dam is being constructed and the fifth and final dam, the Karakamis, is at the beginning stages of its construction.

However, those are only a small part of the GAP, and a full utilization of the Euphrates River will not be achieved until the year 2020 according to current plans (Biswas, 1994).

Syria also built the Tabqa Dam on this river in 1973 and has another one under construction. Lake Assad was formed behind the Tabqa Dam, and it was used for Syria's increasing irrigation needs, which was predicted by the Syrian's to be around 640,000 hectares (Braun, 1994). However , the recent reports from Syria suggest that the waters from Lake Assad have been utilized to an absolute maximum and only 240,000 ha of land has been irrigated. The future Syrian hydro-development programmers have to deal with two problems; they must respond to the Turkish manipulation of the river upstream and their own needs.

Iraq has been using the Euphrates River since the ancient times and is by far the major consumer of this water for agriculture and domestic uses. Currently Iraq has seven dams in service on this river (Table 6). The Haditha Dam is used for hydroelectric production, and the others either regulate the river or divert water to irrigation canals. According to estimates, Iraq irrigates 1.2 million ha of land with the waters of the basin. The amount of land used is believed to reach to 1.8 million ha with full utilization of the Euphrates River (Braun, 1994).

Table 6: The number and the total reservoir capacities of dams built by the countries sharing the Euphrates and Tigris river catchments.

Country	***Euphrates river basin***		***Tigris river basin***	
	Number of Dams	**Total storage capacity (bcm)**	**Number of dams**	**Total storage capacity (bcm)**
Turkey	12	95	12	18
Syria	4	15	0	106
Iraq	6	38	16	0
Iran	0	0	18	27

2. Tigris River

The Tigris is the second longest river in Southwest Asia at 1,840 km. The city of Baghdad is located on the conjunction of the Tigris and Diyala rivers and navigation is possible from Baghdad downstream. Because of the irregularities of the tributaries' flows, the Tigris is widely known for its infamous floods during the flood season. To control these floods, the Iraqis divert some water from the Tigris to the Euphrates. The Tigris too contributed greatly to the development of the Mesopotamian civilizations and many ancient cities were built on the banks of this river. The major contribution of the river to the civilizations was its high quality and suitability to irrigation, and as a result the earliest farmlands were developed around the Tigris River.

The Tigris River also has its origin in the highlands of eastern Turkey, but the main contribution to the river comes from the tributaries in the northern parts of Iraq or the Kurdish region of this country. The Tigris follows a southeastern route in Turkey to the city of Cizre, where it forms the border between Turkey and Syria for 32 km before entering Iraq. In Iraq it meets its four main tributaries, the Greater Zap, the Lesser Zap, the Adhaim, and the Diyala. It joins the Euphrates in Qurna and continues its journey as the Shatt-al-Arab to the Persian Gulf. The Tigris carries more water than the Euphrates, but the extensive irrigation and diversification canals remove around 70-80 per cent of its waters before forming Shatt-al-Arab (Kolars and Mitchell, 1991). At Baghdad, the

Tigris records a maximum annual average flow of 70.4 bcm, and 55 % of this flow originates from its tributaries in Iraq. Turkey contributes the rest of its water and Syria nothing at all.

Turkey currently uses only a small fraction of the waters of the Tigris River. There are no major dams built on the river and a number of projects are continuing, including the construction of the Kralkizi and Dicle dams, eight more dams are at the stage of being planned and designed (Table 6) (Biswas, 1994). Because of its geographic location, the Tigris River has been the last major river system in Turkey to be developed. Its waters travel through mountainous terrain, and only the lower parts of the Tigris River are going to be utilized for the irrigation purposes. Also, the Turkish government plans to use the Tigris River for extensive hydroelectric production in its GAP program. GAP is the biggest development project ever undertaken by Turkey, and one of the biggest in its kind in the world. The integrated multi-sectoral project includes 13 major projects which are primarily for irrigation and hydropower generation, and have been planned by the State Hydraulic Works. The project envisages the construction of 22 dams and 19 hydroelectric power plants on the Euphrates and Tigris rivers and their tributaries. It is planned that at full development, over 1.7 million hectares of land will be irrigated and 27 billion kilowatt hours (kWh) of electricity will be generated annually with an installed capacity over 7,500 megawatts.

Along with the Euphrates River, the Tigris has been heavily dammed by the Iraqis too. There are 8 operating dams on Tigris and its tributaries and four more are either being planned or constructed for future use (Braun, 1994). Increasing use of the Euphrates River by Turkey and Syria presents a great challenge for the Iraqi government, and they may have to divert more water from the Tigris Euphrates River in order to utilize the basin to their needs. Syria and Iraq are complaining about the Turkish development projects, which they believe will reduce the flow of the Euphrates River to Syria and Iraq by 40 per cent and 90 per cent respectively.

The quality of Tigris and Euphrates waters

In general, the water quality of the Tigris River is much better than that of the Euphrates. Baghdad normally has water with salinity of 500-600 parts per million (ppm) for the Tigris, which increases to around 800 ppm as it reaches the city of Kut which is 170 kilometers to the south of Baghdad. The Garraf River, a branch of the Tigris at the city of Kut, is the water feeder to Abu Siriq marsh, which is within an acceptable quality of 800-1000 ppm. Within the reach of the Tigris River, between Kut and Al-Amarah, the quality of water deteriorates. Salinity changes significantly according to the seasons, due to the volume of water released and pollutants coming from the Hor Al-Shewacha, the Al Chabab seasonal river and the entering drainage water.

The salinity levels in the Euphrates and Shatt-al-Arab are generally very high (Table 7). Evaporation from Hadith dam reservoir and Tharthar Lake, the main contributors to the Euphrates, normally raise the salinity levels of the water starting in Faluga Barrage (Table 7). The increase in salinity becomes significant between the cities of Samawa and Nasariya. It is believed that salty ground water from the desert area contributes to a rise in salinity of Euphrates River. The presence of salt lakes and salt deposits in the desiccated Central and Hammar marshes has resulted in the raised salinity of the water of these reflooded marshes. Table 7 also shows that all other indicators of water pollution are also higher in the reflooded marshes compared with the natural Al-Hawizeh or upstream river water. Table 7 shows that the concentration of all major cations and anions are also significantly higher in the water of the reflooded marshes. The continuous dumping of overflow waters into the Al-Sanaf marsh, situated north of the Al-Hawizeh marsh near the city of Al-Amarah, and the high evapotranspiration in southern Iraq have turned this marsh into a salt flat displaying near toxic levels of salts and some ions, especially selenium (Richardson, et al., 2005).

As for Hawizeh marsh, the quality of water is highly affected by the share of water that flows annually into it from Iran. The three rivers that originate in Iran and contribute to Hawizeh marsh are the Karkhe, Teeb, and Dewaireg. The last two are seasonal rivers, while the flow of the first is controlled by a new dam in Iran. The increased activities of agriculture may have resulted in an increase of the drainage water flow into Al-Hawizeh downstream of the dam. Within Iraq, the main contributors to the Hawizeh marsh are the rivers of Al-Kahla, Al-Mesharah, and sometimes the Crown-of-Battles Canal. The quality of these rivers' water changes between summer and winter and depends also upon the levels of release of water from Tigris into Euphrates River.

Table 7: Water quality at selected river and marsh locations in June 2003

Constituent	Upstream Euphrates	Natural Ai-Hawizeh	Re-flooded Al-Hammar	Reflooded Al-Sanaf	Downstream Shatt-al-Arab
EC (dS/m)	1.55	1.74	1.91	28.41	4.10
pH	8.14	7.64	7.95	9.40	7.51
DO (mg/L)	8.11	7.71	7.03	8.79	4.89
TDS (g/L)	1.01	1.13	1.24	18.46	3.02
TN (mg/L)	0.76	0.46	1.65	2.05	0.85
TP (mg/L)	0.11	0.13	0.66	0.09	0.15
DOC (mg/L)	4.79	4.68	13.92	37.86	4.95
Ca (mg/L)	105	90	160	1072	145
Mg (mg/L)	80	50	175	695	135
Na (mg/L)	300	200	680	5324	520
K (mg/L)	6	4	13	63	8
SO4 (mg/L)	580	400	1050	5324	1010
Cl (mg/L)	450	350	960	8610	670

(Based on data and graphs given in Richardson et al., 2003)

CONCLUSIONS

The brutality of Iraq's previous regime towards its own Marsh Arab people and the indifference shown towards environmental issues were not the only factors in the destruction of the Mesopotamian marshlands. Turkey, Syria and Iran have also contributed to the damage through their upstream damming projects. However now that the political situation of the region has changed a new opportunity for saving the marshlands has presented itself. International cooperation and increased aid is essential if what remains of the biodiversity of the wetlands is to be saved and reintroduced to the devastated Central and Al-Hammar marshlands. UNEP and Eden Again have been instrumental in bringing this issue to the attention of the US backed administration in Iraq and also internationally. The next steps include the stopping squandering of water resources through pollution and inefficient irrigation practices now that sanctions no longer limit the importation of the necessary technology and equipment into Iraq. Intense and thorough scientific testing and analysis needs to be conducted on the ground as a matter of extreme urgency. For now the rainfall in the region has been good and has allowed a certain amount of breathing space for the remaining marshes and those areas that have been re-flooded. However this situation is unlikely to continue indefinitely in one of the driest regions of the world and therefore action must be taken immediately to develop a sustainable plan for the rehabilitation of the marshlands. All this needs to be done while simultaneously rebuilding the culture and society of the Ma'dan people. Due to the current instability of Iraq, it is unlikely that the necessary funding will be made available to fully implement the rehabilitate program. Full restoration of the marshlands to their pre 1980s condition is unrealistic and un-achievable. However given the right circumstances and enough determination by the Ma'dan people, the Iraqi government and the international organizations a partial rehabilitation is possible. A high level of cooperation and common sense has to be established between the four riparian countries of Turkey, Syria, Iraq and Iran to allow sufficient flow of water from all three rivers of Euphrates, Tigris and Karkhe into these marshlands to secure the rehabilitation and the existence of this unique wetland.

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