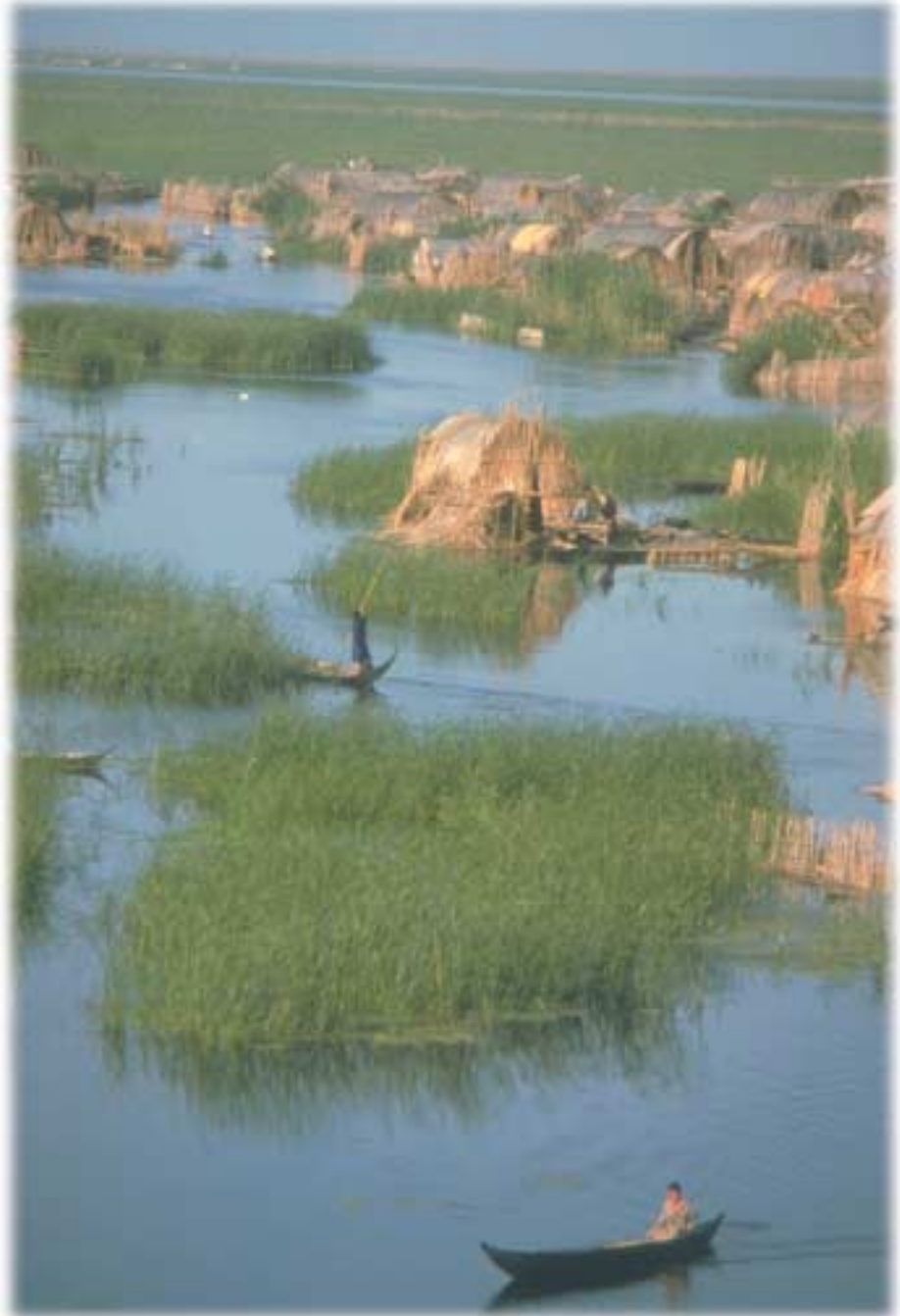


The Mesopotamian Marshlands: Demise of an Ecosystem



UNEP

The Mesopotamian Marshlands:

Demise of an Ecosystem

*'Ever the river has risen and brought us the flood,
the mayfly floating on the water.
On the face of the sun its countenance gazes,
then all of a sudden nothing is there'.*

– 'He who saw the Deep',
(*The Epic of Gilgamesh*, 1,200 B.C.)

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DEWA/GRID-Geneva in cooperation with
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To obtain copies of this publication, please contact:

UNEP/DEWA/GRID – Geneva
International Environment House
11 Chemin des Anémones
CH-1219 Châtelaine
Geneva, Switzerland

Tel: +41-22 9178294/95 Fax: +41-22 9178029

E-mail: info@grid.unep.ch

The full report is available online at:

<http://www.grid.unep.ch/activities/sustainable/tigris/marshlands/>

UNEP/DEWA/GRID – Sioux Falls

USGS EROS Data Center

47914 252nd Street

Sioux Falls, SD 57198-001 USA

Tel: 1-605-594-6117 Fax: 1-605-594-6119

E-mail: info@na.unep.net

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Front Cover Photo:

The 'exhilaratingly beautiful' Mesopotamian Marshlands as described by Gavin Young in 1975: canoes are the means of transportation in a world of reeds and water.

Acronyms

BCM	Billions of cubic meters
DCW	Digital Chart of the World
DEM	Digital Elevation Model
EIA	Environmental Impact Assessment
ESRI	Environmental Systems Research Institute
ETM	Enhanced Thematic Mapper
FAO	Food and Agriculture Organisation of the United Nations
GAP	Guneydogu Anadolu Projesi (Southeast Anatolia Development project)
GRID	Global Resource Information Database (UNEP)
HEPP	Hydroelectric Power Plant
IUCN	World Conservation Union
MOD	Main Outfall Drain
MCM	Millions of cubic meters
MSS	Multispectral Scanner
SPOT	Satellite Pour l'Observation de la Terre (Satellite for Earth Observation)
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNHCR	United Nations High Commission for Refugees
WCD	World Commission on Dams
WWF	World Wide Fund for Nature

At the dawn of the new millennium, the tragic loss of the Mesopotamian marshlands stands out as one of the world's greatest environmental disasters. Dams and drainage schemes have transformed one of the finest wetlands, the fabled Eden of the Fertile Crescent that has inspired humanity for millennia, into salt-encrusted desert. The ecological life-support system of a distinct indigenous people dwelling in a rare water-world of dense reed beds and teeming wildlife has collapsed. Humanity's impact on the planet's fragile ecosystems could not be more dramatically illustrated. This Mesopotamian story is yet another wake-up call alerting us to the fraying fabric of spaceship earth. We are again reminded that we need to act now to restore ecosystems on a global scale.

UNEP, as the 'environmental conscience' of the United Nations family, has prepared this study as a demonstration of its commitment to providing early warning and neutral scientific assessments on human-driven environmental problems. Satellite imaging and remote sensing, the 'eyes in the sky', have become indispensable tools providing hard evidence about the scale and speed of marshland and other ecosystem's degradation. These tools, however, need to be supplemented by ground collected data on changes in river flows, freshwater pollution and wildlife impacts. Progress can be made but only by involving all riparian countries and stakeholders with a common platform of shared information, to rationally discuss water issues and remediation measures.

The demise of the Mesopotamian marshlands is part and parcel of an underlying hydrologic catchment problem; growing demands on the dwindling water supplies of the Tigris-Euphrates basin. UNEP has always maintained that the river basin, as a natural ecosystem, is the fundamental unit for managing water resources in a holistic and sustainable manner. To help move this concept forward, UNEP's Regional Office for West Asia (ROWA) proposes to undertake a comprehensive and integrated scientific

assessment of the Tigris-Euphrates drainage basin in collaboration with riparian countries and regional organizations. Backed with scientific knowledge, countries should be in a better position to make sound decisions on the equitable sharing and optimal use of Tigris and Euphrates waters. To this end, UNEP/ROWA has initiated consultative meetings bringing together representatives from Iraq and Syria, the Arab Centre for the Studies of Arid Zones and Dry Lands (ACSAD) and the Regional Organisation for the Protection of the Marine Environment (ROPME). We trust that this cooperation will continue to grow, and that all countries sharing the watershed will rejoin cooperation efforts to address this environmental disaster.

This report conveys a sense of urgency that we hope will help catalyze the adoption of a river basin approach by riparian countries and eventually lead to a treaty on sharing the waters of the Tigris and Euphrates rivers. Such an international agreement is not only essential to safeguard the lifeblood of millions of human beings, but also to sustain the health and productive potential of plants, wildlife, coastal fisheries and natural systems to provide ecological services of clean water, clear air and fertile soils. International cooperation and action is also critical to protecting the last vestige of the marshlands straddling the Iran-Iraq border and for any future ecological recovery plans of lower Mesopotamia.

UNEP's scientists at GRID-Geneva and GRID-Sioux Falls in collaboration with ROWA, in their groundbreaking work, have demonstrated the capacity of UNEP to identify conditions and trends throughout the planet. It is up to the world's nations to act on this knowledge.



Timothy W. Foresman – *Director*
UNEP/Division of Early Warning and Assessment

The Mesopotamian marshlands are part of a major international river system, the Tigris and Euphrates; one of the great 'cradles of civilisation' and the largest river system in southwest Asia. Modern water works and associated agricultural schemes have led to extensive environmental change in the basin. These changes have not only restructured human activity, but dams and drainage schemes have drastically transformed the landscape and hydrology of the river system itself. This study addresses one of the most important changes that have occurred in the Tigris-Euphrates basin over the past 30 years: the desiccation of the vast Mesopotamian marshlands - one of the world's most significant wetlands and a biodiversity centre of global importance.

The basin's ecology has been fundamentally transformed as riparian countries entered the 'Age of Dams' in the late 1950s and which is continuing into the twenty-first century. The cumulative impacts of the construction of more than thirty large dams, particularly those recently built in the headwater region of Turkey under the Southeast Anatolia Project (GAP), have been enormous. This is graphically illustrated by the fact that the gross storage capacity of the dams on the Euphrates is five times greater than the river's annual flow, and twice that of the Tigris. Furthermore, this level of unprecedented human control of the rivers' waters is bound to rise, as at least twenty more dams are planned or are currently under construction. One of the most important impacts of such development is that it has substantially reduced the water supply and effectively eliminated the flood pulses that sustained wetland ecosystems in the lower basin. In addition, there has been a marked degradation of water quality in the mainstems of the Tigris and Euphrates, due to saline return drainage from irrigation schemes and dam retention of sediment and

nutrients, that has adversely affected marshland fertility and ecosystem processes. Other contaminants, including industrial and agricultural chemicals as well as urban effluent, have further aggravated the situation.

The Mesopotamian marshlands, which until recently extended over an original area of 15,000

– 20,000 km², have been devastated by the combined impact of massive drainage works implemented in southern Iraq in the late 1980s/early 1990s and upstream damming. The Central and Al Hammar marshlands have completely collapsed with respectively 97% and 94% of their land cover transformed into bare land and salt crusts, while less than a third of the transboundary Hawr Al Hawizeh/Al Azim remains. This remaining area is also under high risk of disappearance due to upstream activities, including the recently inaugurated Karkheh dam in Iran and associated water transfer designs to Kuwait and the planned Ilisu dam in Turkey.

The impacts of marshland desiccation on wildlife have been equally devastating. Several endemic species of mammals, birds and fish have become extinct or are seriously threatened. The marshlands' disappearance as a key wintering and staging site in the inter-continental migration of birds has placed an estimated forty species of avians at risk and caused significant reductions in their populations. Even though dam reservoirs upstream are reportedly providing habitat for migratory birds, this only compensates in a limited way for the loss experienced as a result of the drying out of the Mesopotamian wetlands. Coastal fisheries in the Persian Gulf,

**The cumulative
impacts ...
...have been
enormous.**

dependent on the marshland habitat for spawning migrations and nursery grounds, have also experienced significant reductions. In the Shatt al-Arab estuary, decrease in freshwater flows has stimulated seawater intrusion and disrupted its complex ecology. In addition, the reduced amount of sediment reaching the sea has slowed the accretion of the Shatt al-Arab coastal delta, and the whole geologic process may eventually be reversed through coastal erosion.

Marsh Arab society, whose livelihood has been entirely dependent on the wetland ecosystem for millennia, has been dealt a shattering blow. The numerous economic benefits provided by the marshlands, from fishing, hunting, rice cultivation, a prodigious reed supply for construction and paper milling as well as tourism, have been lost. As their life-supporting ecosystem vanished, at least 40,000 of the approximately half-million Marsh Arabs sought refuge in Iran, while the rest linger in unknown conditions inside Iraq. A 5,000-year-old culture is in serious jeopardy of coming to an abrupt end.

Broad recommendations aimed at promoting basin-wide co-operation, mitigating the impacts of dams in the upper basin and

instituting measures for the restoration of the Mesopotamian marshlands are proposed. Difficult political realities of the region notwithstanding, the gravity of the situation warrants that the international community catalyse dialogue between riparian countries to reach an agreement(s) on sharing the waters of the Tigris and Euphrates rivers in an equitable and optimal manner. The impact of dams needs to be mitigated by ensuring a minimal water flow to sustain life in the twin rivers and downstream ecosystems. The role of water works, particularly those that were built in an earlier era for flood protection purposes, needs to be reassessed, while dam developers and financial creditors are urged to adhere to the policy guidelines recently laid down by the World Commission on Dams and the core provisions of the United Nations Convention on the Law of the Non-navigational Uses of International Watercourses. A long-term rehabilitation strategy for the Mesopotamian marshlands should strive for at least partial re-flooding of the delta. Meanwhile, priority needs to be given to the conservation of the remaining transboundary Hawr Al Hawizeh/Al Azim marshes straddling the Iran-Iraq border.

1 Introduction

This report examines the disappearance of one of the world's greatest wetlands and the largest such ecosystem in southwest Asia, the Mesopotamian marshlands. The causes leading to the collapse of this wetland system are discussed in two sections. The first considers the role of upstream dam construction in wetland loss; the second deals with engineering works specifically implemented to drain the marshlands. UNEP has prepared this assessment study to raise awareness and stimulate dialogue about sustainable use of wetland, water and biodiversity resources in West Asia, and to draw the global community's attention on how human actions continue to alter the Earth's environment in fundamental and often irreversible ways. Although prospects for the Mesopotamian marshlands are bleak, there remains an opportunity to conserve the last vestige of the marshlands straddling the Iran-Iraq border, and to undertake measures for partial restoration through managed flooding. The urgency of the situation cannot, however, be overemphasised. The disintegration of Marsh Arab society, a unique community that has lived in the marshlands for more than five millennia, underlines a vivid human dimension to this environmental disaster.

The loss of the Mesopotamian marshlands occurs in a wider regional and global context of growing water stress, with the Tigris-Euphrates river system emerging as one of the world's leading water flashpoints in the twenty-first century. Left unresolved, this water crisis poses a potential threat to regional security with grave consequences to the basin's inhabitants and their environment that will only become fully manifest in future decades. UNEP has long advocated that only a river basin approach involving all stakeholders and emphasising the

connections between ecosystem components (land-air-water-biodiversity) offers a holistic and viable framework for the sustainable management of freshwater resources. Although this study focuses on wetlands in the lower basin, it also stresses the impacts of dams in the upper catchment on downstream ecosystems. In carrying out this analysis, Geographic Information Systems (GIS) and satellite imagery were employed to integrate and visualise the results using maps. In view of the constraints of undertaking fieldwork in this region, satellite imagery proved to be a particularly timely and useful tool in evaluating the magnitude of land cover and land use changes that have taken place. Although field verification would obviously have improved the analysis and confidence levels of interpretation, there can be no doubt that the main findings of this assessment are reliable as to the overall magnitude and range of environmental impacts.

This assessment study documenting the loss of a precious and rare wetland ecosystem also serves as a UNEP contribution to the 10-year review process of the implementation of Agenda 21 (RIO+10) endorsed by the world's nations at the United Nations Conference on Environment and Development in 1992, and which approximately coincides with the time span of marshland desiccation. It is a sobering alert not only about the accelerating pace of human-driven environmental change at the turn of the twenty-first century, but also of the unremitting pressures of the modern age that are threatening the traditions and structures of many indigenous societies, and alienating them from their natural environment.

The present study has been carried out within the framework of a broader initiative to assess the water resources of the Tigris-Euphrates drainage basin, including surface and ground waters as well as the hydrologically-linked marine coastal area in the northern Persian

Gulf. It is the first of a suite of UNEP information products aiming to stimulate dialogue and promote cooperation between riparian countries on the integrated management of the Tigris-Euphrates river system. This includes plans to prepare a comprehensive scientific assessment of the basin in collaboration with regional partner organisations and member states, resources permitting. It is within this context that UNEP's

Regional Office for West Asia hosted the "First Consultative Meeting on the Assessment of the Euphrates and Tigris River Basins" in March 2001 to lay the groundwork and develop an outline for a basin-wide study. The overall aim of this project is to provide sound scientific advice to policy and decision-makers in the region, as well as to underpin potential international donor projects to better manage the waters of the Tigris-Euphrates river system.

2 The Tigris-Euphrates Drainage Basin

Sprawling in a wide arc around the confluence of the Tigris and Euphrates rivers in southern Iraq and southwestern Iran, the Mesopotamian marshlands are dependent on the floodwater pulses of the twin rivers nourishing their very existence. As downstream receivers of water, the marshlands are highly vulnerable to the impacts of human activities upstream. An objective assessment of environmental change in the marshlands therefore needs to take stock of developments throughout the basin that may

alter the timing, quantity and quality of water flows. Consequently, prior to discussing the main issue of this study, being the fate of the Mesopotamian marshlands, this section describes the watershed's hydrology and twentieth-century water management projects impacting on the marshlands. With this background, a more comprehensive picture of the events leading to the decline of these vast wetland resources should emerge.



Map 1 - Shaded relief map of the Tigris-Euphrates basin (darker area shading and outlined in blue).

2.1 Hydrology of the Tigris-Euphrates Basin

An overview of the basin's hydrology provides critical insight to understanding how hydraulic works have affected the lower Mesopotamian marshlands. The watershed's topography is such that the headwater catchment generating Tigris and Euphrates flows is wholly located in the north and eastern parts of the basin in the highlands of Turkey, Iraq and Iran (Map 1). Arising near Mount Ararat at heights of around 4,500 m near lake Van, the Euphrates traverses

an expanse of about 3,000 kilometres. This is a considerably longer distance than that travelled by the Tigris, which rises in the small mountain lake of Hazar and whose total length is around 1,900 kilometres. Although the Euphrates drains a larger surface area (579,314 km²) than the Tigris (371,562 km²), an overwhelming 88-98% of Euphrates runoff is produced in the highlands of southeastern Turkey while the remainder of its catchment is an arid region that contributes little inflow. In contrast, the



Map 2 - Sub-basins of the Tigris-Euphrates watershed.

Tigris is less dependent on the headwater region in Turkey, which contributes an estimated 32-50% of its discharge. The balance of Tigris flows is produced by a series of major left bank tributaries descending from the Zagros Mountains of Iran and Iraq (Map 2). Prior to dam construction, estimates of the mean annual runoff of the Tigris at Baghdad ranged from 49.2 - 52.6 BCM (billion cubic meters), which is considerably greater than that of the Euphrates at Hit ranging between 28.4 – 32.4 BCM.

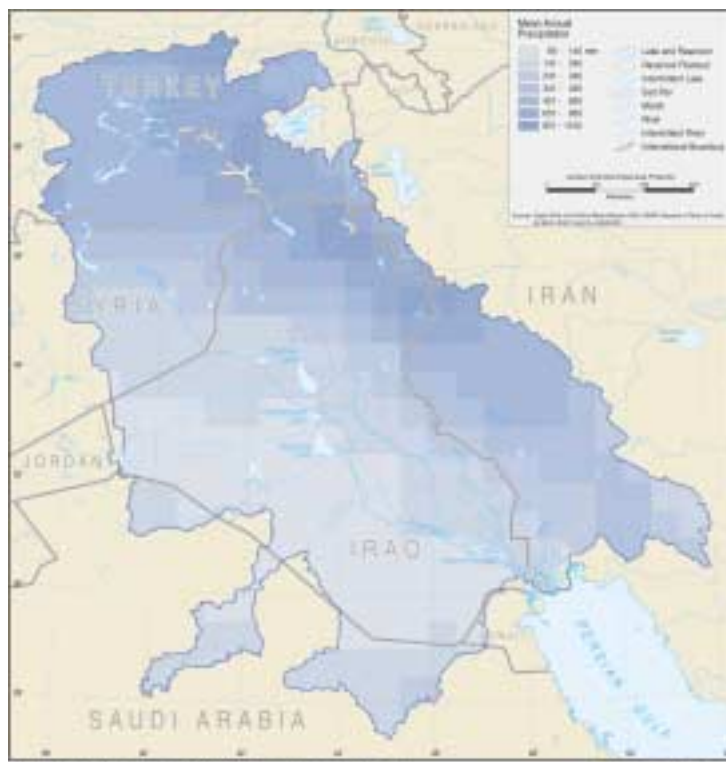
Superimposed on the natural drainage basin of the Tigris and Euphrates is a complex geopolitical reality, with several countries controlling the upper, middle and lower courses of the twin rivers. Geographically, the principal riparian nations are aligned above each other, creating a classical “dominant upstream vs. vulnerable downstream relationship”. In this hierarchical order, the Euphrates rises in Turkey and flows through

Country	Euphrates Basin	%	Tigris Basin	%
Iran*	-	-	175,386	47.2
Iraq	282,532	48.8	142,175	38
Saudi Arabia*	77,090	13.3	-	-
Syria	95,405	16.5	948	0.3
Turkey	121,787	21.0	53,052	14.0
Total	579,314	100.0	371,562	100.0

Table 1 – Area of Tigris-Euphrates Drainage Basin in Riparian Countries (km²).
 (* The country includes part of the catchment area but the main river does not flow through it. Adapted and calculated by UNEP/GRID-Geneva from Hydro1k, USGS/EDC)

Syria and Iraq, while the Tigris catchment whose source is also in Turkey is shared with Iraq and Iran (Table 1). Syria also has access to a 20 km stretch on the right bank of the Tigris, which forms its extreme northeast border with Turkey. The aforementioned difference in runoff generation patterns between the Tigris and Euphrates has important implications for water management projects. With the Euphrates’ main tributaries all located in its upper catchment, Turkey, by damming the river, is able to exert almost full command over the river’s hydrological regime. For the Tigris, dams in Turkey would also have an important impact, but only partial control of the river’s waters would be possible as it receives major water flows from tributaries along its middle course. A more complex series of dams on Tigris tributaries in Iran and Iraq are therefore necessary to yield a similar level of river control as on the Euphrates (Beaumont, 1998).

Historically and prior to dam construction, two characteristic features distinguished the hydrological regime of the Tigris-Euphrates river system. The first is sudden and violent flooding. Annual precipitation in the Anatolian and Zagros highlands, where most of the water of the twin rivers is generated, typically exceed 1,000 mm (Map 3). As most of this precipitation



Map 3 - Mean annual precipitation in the Tigris-Euphrates basin.

occurs in winter, it falls as snow and may remain fixed in a solid state for half the year (Beaumont, 1978). With snow melt in spring, vast quantities of water are rapidly released, creating periodic flooding downstream. These flood waves are a major driving force in the ecology of the Tigris-Euphrates river system, particularly of the alluvial-deltaic plains of lower Mesopotamia as it constantly shifts between desert and marsh. The other distinguishing mark is the highly irregular regime of the twin rivers, both between and within years. Hydrological records (1937-1964) at the Turkish-Syrian border for the Euphrates range from a minimum flow of 16,871 MCM/y (1961) to a maximum discharge of 43,456 MCM/y (1963), while that of the Tigris at Cizre in the upper Tigris dropped to 7,891 MCM/y (1961) rising by a factor of four to 34,340 MCM/y (1969). Similarly, there are steep differences between maximum and minimum monthly flows, which for the Tigris is nearly 80-fold and for the Euphrates 28 times as much (Kolars and Mitchell, 1991). The concentration of discharge over a short time period causes extensive spring flooding, inundating wide areas and creating a mosaic of permanent and temporary water bodies in the flat alluvial plain between the two rivers. The seasonal flood regime is thus of critical importance to the ecological dynamics of the marshlands, governing not only the physical extent of the marshes but also the range and distribution of flora and fauna it supports. The centrepiece of this vast marshland complex is around the confluence of the Tigris and Euphrates, which join to form a common outlet into the Persian Gulf: the 192 km long Shatt al-Arab. It should be noted here that the creation of the marshlands has also been significantly influenced by the deltas of the Karun and Karkheh, which descending south-westward from the Zagros Mountains of Iran, have effectively blocked the outlet of the Tigris-

Euphrates system and thereby contributed to the formation of the marshes at the combined deltas of the four rivers. The Karkheh also provides important water flows into the eastern marshlands, in to which it ultimately dissipates.

2.2 River Engineering in the Twentieth Century

Although water management projects in the Tigris-Euphrates basin extend back over six millennia, significant changes have occurred in the location and type of river control works introduced in the second half of the twentieth century. Of major impact on basin hydrology has been the construction of large dams, which has revolutionised the river system management regime. Large dams mark a fundamental departure in the course and focus of the basin's historical riverine development. They have induced a major shift from ancient downstream diversion activities by barrages and irrigation canals in the lowlands of southern Iraq, to modern water storage and hydroelectric projects in the upper basin in Turkey and Syria on the Euphrates and in Turkey, Iraq and Iran on the Tigris and its associated tributaries (Beaumont, 1998).

The diversion of floodwaters into seasonal lakes and natural depressions along the middle course of the Euphrates and Tigris signalled the first major change in river management activity. The Ramadi barrage was built in 1951 to divert water from the Euphrates River to Habbaniyah depression and in the event of extreme floods, excess water was channelled by a canal into the larger Abu Dibbis depression creating the Razzaza Lake. On the Tigris, the Samarra barrage was completed in 1954 to divert flood peaks into the Tharthar depression (Manley and Robson, 1994). While the earlier barrages aimed to regulate flood flows and divert water for irrigation purposes (e.g. Al Hindiyah, 1918, Al Kut 1939), those of Ramadi and Samarra created water reservoirs and effectively functioned as dams. This was

followed in the late 1950s by the initiation of major dam building projects in the middle and upper part of the basin to store water for irrigation purposes and to generate hydroelectricity (Map 4). The first of these dams, the Dokan (1961) and Derbendikhan (1962) were built in Iraq on two major tributaries of the Tigris, the Little Zab and the Diyala respectively. Iran completed its largest development scheme, the Dez dam, on a tributary of the Karun River in 1962. Dam

construction thereafter rapidly intensified throughout the river basin. In Turkey, work on a major hydroelectric dam the Keban was initiated in 1963 and brought on line in 1975. By regulating river flow patterns, the Keban set the stage for large-scale developments in the upper Euphrates. Also in 1975, Syria inaugurated its major engineering structure on the Euphrates, the Tabaqa dam.

A decisive restructuring in the basin's development occurred in 1977, when Turkey



Map 4 - Dams on the Tigris and Euphrates Rivers.



Fig. 1 - Keystone of the GAP project, the Ataturk dam has a reservoir capacity greater than Euphrates total annual flow which, as a result, has significantly transformed basin ecology.

merged all its water management schemes on the Tigris and Euphrates into the Southeast Anatolia Development project (commonly referred to by its Turkish acronym GAP) and which it re-launched in 1989 as an integrated regional development programme. Composed of 13 individual but related schemes, the GAP aims to bring into operation 22 dams and 19 hydropower plants in the upper Tigris and Euphrates, as well as provide an irrigation network serving 1.7 million hectares of land. Set to double the country's energy production, this massive engineering programme is costing \$32 billion (Olcay, 1998). The lynchpin of the GAP is the Lower Euphrates Project, whose main elements are the Ataturk dam (1992) and the Sanliurfa water transfer tunnels to irrigate fields in the Harran plain (Fig. 1). On the Tigris the most important structure is the planned Ilisu dam (Fig. 2), which has been mired in controversy due to a variety of social, economic and environmental reasons (Bosshard, 1999).

In the mid-1990s, Iran embarked on a multi-billion water management scheme on the Karun river. Originally modelled on the famous river engineering programme of the Tennessee Valley Authority, the Karun River Development Project comprises a series of dams and related irrigation and hydroelectric power schemes in the southwestern province of Khuzestan. An estimated 150,000 hectares of formerly marginal land is to be placed under irrigated agriculture (Whitely and Gallagher, 1995). In April 2001, Iran inaugurated its largest water reservoir on the Karkheh river, which is intended to irrigate 320,000 hectares of land (Tehran Times, 1999, 2001). Plans are also underway to transfer water from the Karkheh dam via a 540 km pipeline to the coast of southern Kuwait. A nearly 330 km pipeline will run overland in Iran, and another 210 km will be under the sea. The US \$2 billion scheme should eventually supply Kuwait with 200 million gallons of freshwater per day (IRNA, 2001).

In total, there are now 32 major dams on the Euphrates and Tigris, including the latter's associated Karkheh and Karun river systems. Eight more are currently under construction and at least 13 more are planned (Map 4 and Annex I). The total storage value of all the dams that have been constructed on the Euphrates in Turkey is 90.9 BCM; and it will go up to 94.78 BCM when all planned works are completed. This is three times the average 30.7 BCM annual discharge of the Euphrates at the Syrian border. In Iraq and Syria, the combined storage capacity of all dams is 22.88 BCM. If the two off-river reservoirs of Habbaniyah and Razzaza in Iraq are taken into account, then the water volume that can be retained by the two downstream states would augment to 52.18 BCM. All in all, the gross storage capacity of all existing hydraulic works on the Euphrates is 143.19 BCM or five times the river average annual flow. Although on the Tigris water



Fig. 2 - The planned Ilisu dam threatens to inundate the important archaeological treasures of Hasankeyf, as well as valuable riverine ecosystems along the Tigris.

retention capacity is presently less than on the Euphrates, it is nonetheless considerable. Iraq currently exercises the greatest control on Tigris waters. The massive Tharthar diversion reservoir accounts for 69% of the country's 105.95 BCM gross storage capacity, which is double the average annual flow of the Tigris

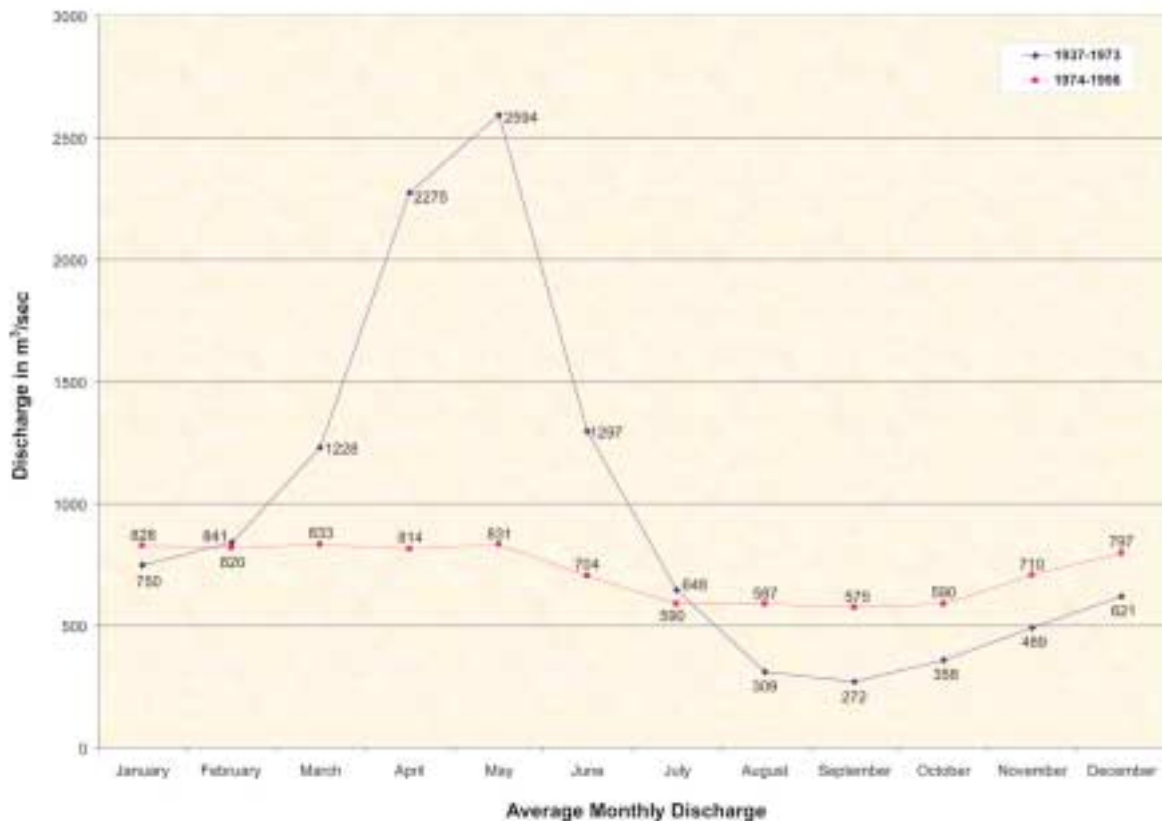


Fig. 3 - Comparison of the discharge regime for the Euphrates River at Hit-Husabia, Iraq, during the pre-dam 1937-1973 and post-dam 1974-1998 periods. (Source: ACSAD)

River of 52.6 BCM. Turkey presently has a storage capacity of 3.95 BCM on the Tigris. When all planned works are completed, Turkey's storage capacity would rise to 17.6 BCM. This is greater than the average 16.8 BCM annual flow of the Tigris at Cizre near the Turkish-Iraqi border. In terms of active or usable storage capacity, the planned dams in Turkey alone will be able to retain 42 BCM on the Euphrates and 15.5 BCM on the Tigris, which is equivalent to 137% and 92% of their average annual discharge at the Turkish-Syrian border (Bagis, 1997).

The above-mentioned figures clearly demonstrate the unprecedented level of control that humankind can now exercise on Tigris-Euphrates flows. Not only are modern hydraulic works having profound and extensive impacts on human activity, but equally on overall Mesopotamian ecology that has evolved in response to the flood regime. The hydrograph of Euphrates flow at Hit-Husaiba (Fig. 3) in Iraq graphically illustrates how dams have effectively eliminated the spring floodwaters on which the marshlands in the lower basin are dependent for their survival. Prior to intensive dam construction (1938-1973) the hydrograph shows a peak water flow of 2,594 m³/sec in May. As a result of dam construction, however, maximum flow between 1974-1998 had dropped by more than two-thirds to 831 m³/sec in May and the river's discharge pattern is now more uniform (ACSAD, 2000). Furthermore, maximum discharge has shifted from spring (April-May) to winter (January-February) months. By reducing overall water supply and altering the pattern of downstream flow (i.e. intensity, timing and frequency), storage reservoirs have invariably had a significant impact on the hydrological dynamics of the marshlands and their coverage area. With the snowmelt floods that sustained the Mesopotamian marshlands now a spent force, some experts predicted that changes in river regime and water volume caused by dams

in the upper basin alone would likely lead to a considerable reduction in the size of the marshlands and eventually to their disappearance in the medium-to long-term (Pearce, 1993, 2001; Beaumont, 1998).

Another problem affecting the marshlands as a result of the latest development projects is the general decline in Tigris and Euphrates water quality. The main cause of degradation is saline return waters from newly commissioned irrigation schemes. It is not possible to forecast with precision the scale of the changes in water quality likely to occur, but the latest measurements reveal a considerable increase in river salinity (ACSAD, 2000; Beaumont, 1996, 1998; Iraq Ministry of Irrigation, 2000). It is clear, however, that with thousands of hectares of newly-irrigated lands, salinity values are bound to rise along the mainstream as a result of backfield drainage. The lower basin, with no tributaries to dilute rising salinity and given the cessation of spring floods that typically washed away accumulated salts in the alluvial plain, will be especially vulnerable. Increasing use of agricultural chemicals and urban and industrial effluents will further degrade the quality of receiving marsh waters. While decreased flow of the Euphrates and Tigris at their confluence has stimulated seawater encroachment into the Shatt al-Arab estuary. Finally, a significant proportion of the large sediment load carried by the Tigris and Euphrates, estimated at 105 million tons per annum, will now be trapped behind the multiple dams (UNEP, 1995). Reduced silt will decrease plankton and organic carbon levels of the waters, which will adversely affect fish stocks as well as the soil fertility of the marshlands. A similar reduction in final sediment yields is also occurring in the Karkheh and Karun Rivers, as their equally large loads are sequestered behind dams. The net result is that the marshlands as the final inland sink of the river system will be particularly hard-hit by all these negative trends.

3 The Marshlands of Lower Mesopotamia

The extensive but shallow marshlands of the lower Tigris-Euphrates basin represent an outstanding natural landmark of Mesopotamia (Fig. 4). They comprise the largest wetland ecosystem in the Middle East and Western Eurasia. A rare aquatic landscape in desert milieu, the marshlands are home to ancient communities rooted in the dawn of human history. They also provide habitat for important populations of wildlife, including endemic and endangered species. The key role played by the marshlands in the inter-continental flyway of migratory birds, and in supporting coastal fisheries endows them with a truly global dimension. For these reasons, the Mesopotamian marshlands (called *Al Ahwar* in Arabic) have long been recognised to constitute one of the world's most significant wetlands and an exceptional natural heritage of the Earth. Most recently, the World Wide Fund for Nature (WWF) placed the Mesopotamian marshlands in its select list of two hundred exceptional ecoregions in the world for priority conservation (the Global 200).

Situated for the main part in southern Iraq (29°55' to 32°45' N and 45°25' to 48°30' E), the wetlands covered in 1970 an estimated area ranging from 15,000–20,000 square kilometres. The eastern margins of the marshlands extend over the border into southwestern Iran. In terms of

custodianship, they therefore constitute a transboundary ecosystem under shared responsibility.

3.1 Formation of the Marshlands

Understanding how the marshlands of lower Mesopotamia were formed historically is crucial to grasping how they have been affected by water management projects. The topography of the lower Tigris-Euphrates

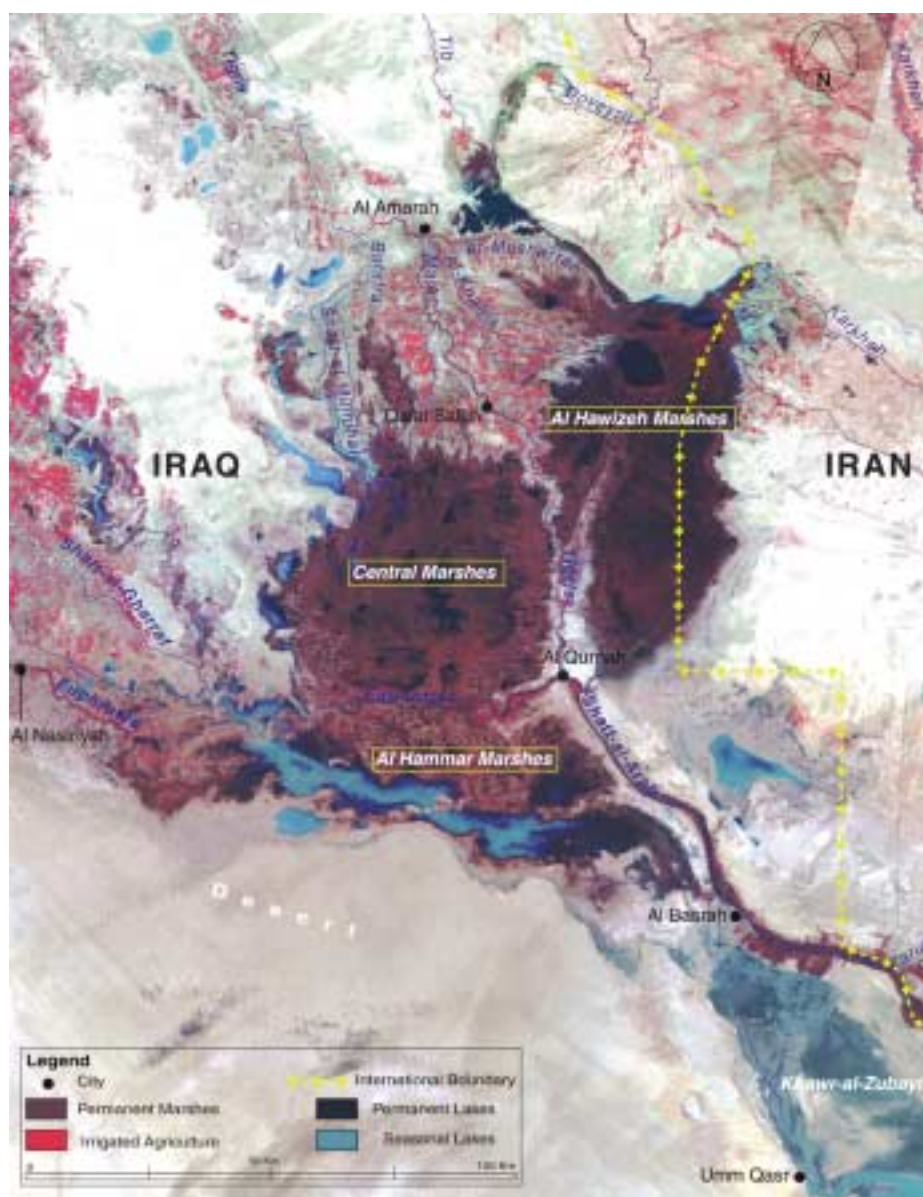


Fig. 4 - Space view of the Mesopotamian Marshlands taken by the earth observation satellite Landsat in 1973-76. Dense marsh vegetation (mainly *Phragmites*) appears as dark red patches, while red elongated patches along river banks are date palms. (Mosaic of four Landsat 1 and 2 false-colour, near-infrared images, Multi-Spectral Scanner (MSS) Bands 4, 2 and 1, taken on 16 February 1973, 14 February 1975 and 27 May 1976).

valley is distinguished by an extremely flat alluvial plain. The Euphrates falls only 4 cm/km over the last 300 km, while the Tigris has a slope of 8 cm/km (Scott, 1995). As a result of the level terrain, both rivers deviate from a straight course, meandering in sinuous loops and eventually divide into distributaries that dissipate into a vast inland delta. This is particularly true of the Euphrates, whose velocity rapidly diminishes as it lacks tributaries along its lengthy course, and begins to develop a braided pattern nearly 520 km upstream of the Persian Gulf. Immediately south of Al Nasiriyah, the Euphrates main channel dissolves into the marshes, only to re-emerge shortly before its confluence with the Tigris at Al Qurnah. The Tigris, which is drained along its eastern flank by several tributaries from the mountains and hills of the Zagros chain, has a relatively stronger hydraulic force, enabling it to maintain a more stable course. Nonetheless, in its lower stretches around Al Amarah, the Tigris also rapidly begins to lose its velocity and flares out into multiple distributary channels feeding directly into the marshes. Water extraction by an elaborate irrigation network criss-crossing the alluvial plain between the two rivers significantly reduces water flow, and contributes to the rivers' splitting into a diffuse array of shallow waters in their final stretches.

Another important factor contributing to the formation of the marshlands is that the lower Mesopotamian plain becomes very narrow towards the Persian Gulf. This is created by the large alluvial fan of Wadi Batin and the Al Dibdibah plain drawing in from the Nejd in the west, and the Karkheh and Karun river systems descending from the Zagros Mountains in the east. The Karkheh disperses into the marshes on the eastern bank of the Tigris, whose waters eventually overflow into the Shatt al-Arab via Al Suwaib River. For its part, the Karun joins the Tigris-Euphrates system below their confluence in the lower

section of the Shatt al-Arab, at the port city of Khorramshahr 72 km from the Persian Gulf. Both rivers, but particularly the latter, carry a large sediment load. By fanning out at the head of the Persian Gulf, the Wadi Batin/Al Dibdibah, the Karkheh and Karun constrict the lower Mesopotamian valley to a width of less than 45 km and prevent the twin rivers from flowing directly into the sea (Rzóska, 1980). In so doing, the natural drainage of the Tigris and Euphrates is impeded and they are forced to deposit their sediment loads inland. This results in the creation of a double delta composed of a continental marshland complex and a marine estuary.

As mentioned earlier, a notable feature of both the Tigris and Euphrates is the large fluctuation in their water discharge volumes. Spring floods, occurring from February to May, are caused by snowmelt in the headwater region in Turkey and the Zagros Mountains in Iran and northern Iraq. These short-lived but intense seasonal floods, which formerly have been on the order of 1.5 to 3 meters (with a record of 9 meters on the Tigris in 1954) cause large-scale inundations (Scott, 1995). As a result of the flat topography, the flood pulses are able to maintain an extensive complex of interconnected shallow lakes, backswamps and marshlands in the lower Mesopotamian plain. The marshlands, which are of great though changing extent, may dry up completely in shallower areas under the influence of high summer temperatures, leaving salt flats and reverting back to desert conditions. This highly dynamic ecosystem is therefore dependent on spring floods for its replenishment and very existence.

3.2 The Major Wetland Units

Gradually emerging in the area where the rivers first begin to split into many branches, the marshlands of lower Mesopotamia stretch from Samawa on the Euphrates and Kut on



Map 5 - Major wetlands of Lower Mesopotamia.

the Tigris (150 km south of Baghdad) to Al Basrah on the Shatt al-Arab (Map 5). The wetlands constitute a chain of almost interconnected marsh and lake complexes that overflow one into another. During periods of high floods, large tracts of desert are under water. Consequently, some of the formerly separate marsh units merge together, forming larger wetland complexes. The wetlands themselves are made up of a mosaic of marsh and lake units. These include permanent and seasonal marshes, shallow and deep-water lakes, and mudflats that are regularly

inundated during periods of elevated water levels. The highly-graded ecotonal environment has given rise to an array of diverse habitats and environmental conditions that stand out in strong contrast to the surrounding arid environment.

The core of the marshes is centred in the area around the confluence of the Tigris and Euphrates. It is typically divided into three major areas: (i) Al Hammar Marshes; (ii) the Central Marshes and (iii) Al Hawizeh Marshes. These three major marsh units have been at

the centre of the great changes that have been taking place over the past decade, and as such comprise the focus of this study.

3.2.1 Al-Hammar Marshes

The Hawr Al Hammar Marshes are situated almost entirely south of the Euphrates, extending from near Al Nasiriyah in the west to the outskirts of Al Basrah on the Shatt al-Arab in the east. To the south, along their broad mud shoreline, the Al Hammar Marshes are bordered by a sand dune belt of the Southern Desert. Estimates of this marsh area range from 2,800 km² of contiguous permanent marsh and lake, extending to a total area of over 4,500 km² during periods of seasonal and temporary inundation. Al Hammar Lake, which dominates the marshes, is the largest water body in the lower Euphrates. It is approximately 120 km long and 25 km at its widest point. Slightly brackish due to its proximity to the Persian Gulf, the lake is eutrophic and shallow. Maximum depth at low water levels is 1.8 m and about three meters at high water mark (Maltby, 1994). During the summer, large parts of the littoral zone dry out, and banks and islands emerge in many places. Fed primarily by the Euphrates River, which constitutes the northern limit of these marshes, these waters drain at Qarmat Ali into the Shatt al-Arab. A considerable amount of water from the Tigris River, overflowing from the Central Marshes, also nourishes the Al Hammar Marshes. Groundwater recharge is another likely source of replenishment.

The Al Hammar marsh complex boasts one of the most important waterfowl areas in the Middle East, both in terms of bird numbers and species diversity. The vast and dense reed beds provide ideal habitat for breeding populations, while the ecotonal mudflats support shorebirds. Globally significant concentrations of migratory waterfowl have been recorded during winter, and although

not properly surveyed, the area is likely to host similarly high numbers during the spring and autumn seasons (Scott, 1995).

3.2.2 The Central Marshes

Located immediately above the confluence of the two Mesopotamian rivers, the Central Marshes are at the heart of the Mesopotamian wetland ecosystem. Bounded by the Tigris River to the east and the Euphrates River in the south, the area is roughly delimited by a triangle between Al Nasiriyah, Qalat Saleh and Al Qurnah. Receiving water influx mainly from an array of Tigris distributaries, most of which branch off from the Shatt-al-Muminah and Majar-al-Kabir, as well as the Euphrates along its southern limit, the Central Marshes cover an area of about 3,000 km². During flood periods this may extend to well over 4,000 km². Interspersed with several large open-water bodies, this freshwater marsh complex is otherwise densely covered in tall reed beds. Al Zikri and Hawr Umm al Binni are some of the notable permanent lakes located around the centre of these marshes, and are approximately 3 m deep (Thesiger, 1964). Along the marshes' northern fringes, dense networks of distributary deltas are the site of extensive rice cultivation.

The Central Marshes are considered to be a highly important breeding, staging and wintering area for large populations of a broad variety of waterfowl species. Difficulty of access, however, has limited comprehensive ornithological investigations of the site. Endemic sub-species of the Smooth-coated Otter have been reported in the region (Scott, 1995).

3.2.3 Al Hawizeh Marshes

The Al Hawizeh Marshes lie to the east of the Tigris River, straddling the Iran-Iraq border. The Iranian section of the marshes is known as Hawr Al Azim. In the west, they are largely fed by two main distributaries departing from the



Fig. 5 - A typical marsh landscape. Villages are built on artificial floating islands by enclosing a piece of swamp, and filling it in with reeds and mud. For flood protection, more layers are added each year to strengthen the platform's foundation.

Tigris River near Al Amarah, the Al Musharah and Al Kahla. During spring flooding the Tigris may directly overflow into the marshes. Another important influx comes from the Karkheh River in the east. Extending for about 80 km from north to south, and 30 km from east to west, the marshes cover an approximate area of at least 3,000 km². During periods of inundation the area expands to over 5,000 km². The northern and central parts of the marshes are permanent, but towards the lower southern sections they become increasingly seasonal in nature. The permanent marshes are of moderately dense vegetation, alternating with open stretches of water. Large permanent lakes up to six meters deep are found in the northern portion of the marshes (Maltby, 1994). Marsh water flow finally joins the Shatt al-Arab 15 km south of Al Qurnah via the Al Swaib River.

The Al Hawizeh marshes provide a major breeding and wintering habitat for waterfowl.

Only limited surveys have been undertaken in the Iraqi portion of the marshes, but relatively regular counts have been made on the Iranian side. Some of the largest world concentrations of several migratory waterfowl species have been reported from the area. Sittings of the endemic Smooth-coated Otter have also been made in this region (Scott, 1995).

3.3 The Marsh People

A crucible of civilization, the marshlands have been home to ancient human communities for more than five millennia. The area's inhabitants are commonly known as the Ma'dan or "Marsh Arabs", whose population is estimated to range from 350,000 to 500,000. Heirs of the Sumerians and Babylonians, the Marsh Arabs act as a living link between the present inhabitants of Iraq and the peoples of ancient Mesopotamia. Ethnically, the population's composition has been heavily

influenced by immigrations and intermarriages with the Persians to the east and Arab Bedouins to the west (Thesiger, 1964). The Marsh Arabs are Shi'ite Muslims, and their way of life is largely based on the traditions of the Arab Bedouin. In addition, unique communities such as the Sabians, peoples of African descent, remnants of vanquished armies and other minorities have also sought refuge and freedom in the wilderness of the marshes.

The Marsh Arabs have evolved a unique subsistence lifestyle that is firmly rooted in their aquatic environment. Most of the Ma'dan



Fig. 6 - A 5,000 year old Sumerian clay tablet depicting an ancient reed house



Fig. 7 - Marshmen gather under the cathedral-like arches of the *mudhif*, a guesthouse made completely of reeds that is a cultural legacy of ancient Sumer.

are semi-nomadic, but some of them are settled in villages. Their settlements are located on the edges of the marshes, or stand on artificial floating islands that are regularly reinforced with reeds and mud (Fig. 5). Typically, a village would consist of a group of separate islands, with each one hosting an individual household. Water-buffalos play a pivotal role in Marsh Arab existence, whose standing in their social and economic life has been compared with that of the camel to Bedouin Arabs (Thesiger, 1957). Fed on young reed shoots, the buffalos provide milk, butter and yoghurt, as well as energy and crop fertiliser in the form of fuel dung and manure (Fig. 8). Fishing, waterfowl hunting and rice and millet cultivation are the other major components of livelihood, whereas reeds provide the building material for dwellings. At the apex of the Marsh Arab's socio-cultural system is the traditional guesthouse or *mudhif* (Fig. 7). These arched and elaborately decorated reed halls are living testimony to a millennial architectural

style depicted in Sumerian plaques dating back to 5,000 years B.C. (Fig. 6). The main income-generating activity is reed mat weaving, which is exported to markets throughout Iraq. For their transport, Marsh Arabs rely on long canoes called *mash-hoof*-another relic of ancient Sumer (Al-Jwaybirawhie, 1993, Thesiger, 1964; Young, 1977).

Until the outbreak of the First World War in 1914, the marsh dwellers were almost completely isolated from the outside world. Gradually, as the influence of the central government extended to remote parts of the country and through increased trade, greater although limited contact was made with the larger Iraqi society. By the early 1930s, many Marsh Arabs had joined the mass rural migration to the cities. Many resided in the shantytowns around Baghdad, Al Amarah, Al Basrah and Al Nasiriyah (Battatu, 1978). Others sought waged labour in neighbouring

agricultural farms and in the oil fields. Educational and health services began to reach the marshlands in the 1970s. Despite these efforts towards 'modernity' and 'integration' as well as land distribution programs, the estimated half-million Marsh Arabs remained an impoverished group (Young, 1977). With the outbreak of the Iran-Iraq war in 1980, their homeland was transformed into a frontline combat zone. Subsequently, they were faced with a massive programme to drain the marshlands in the early 1990s that ultimately shattered their society and way of life.

3.4 Flora and Fauna

A natural wetland vegetation typically covered the bulk of the marshes. Common reed (*Phragmites communis*) dominates the core of the permanent marshes, gradually yielding to reed mace (*Typha augustata*) in the ephemeral



Fig. 8 - Prized for their milk, butter and hides, the water-buffalo provides the main source of subsistence in the marshlands.



Fig. 9 - Wild boars on the run.

seasonal zone. Temporarily inundated mudflats are overgrown with salt-tolerant vegetation of low sedges and bulrush (*Carex* and *Juncus* spp., *Scripus brachyceras*). Deeper, permanent lakes support rich submerged aquatic vegetation typified by species such as hornwort (*Ceratophyllum demersum*), eel grass (*Vallisneria* sp.) and pondweed (*Potamogeton*

lucens spp.), as well as bottom vegetation such as stonewort (*Chara* spp.). In the smaller lakes and back swamps, floating vegetation of waterlilies (*Nymphaea* and *Nuphar* spp.), water soldier (*Pistia stratiotes*) and duckweed (*Lemma gibba*) are common (Scott, 1995; Rechinger, 1964).

A major haven of regional and global biodiversity, the marshlands support significant populations and species of wildlife. Located on the inter-continental flyway of migratory birds, they are particularly important for avians (Fig. 10 - 11). The marshlands constitute a key wintering and staging area for waterfowl travelling between breeding grounds in the Ob and Irtysh river basins in western Siberia to wintering quarters in the Caspian region, Middle East and north-east Africa. Known as the West Siberian-Caspian-Nile flyway, it represents one of three major waterfowl migratory routes in the Western Palaearctic Region. Two-thirds of West Asia's wintering wildfowl, estimated at several



Fig. 10 - The marshlands support the inter-continental migration of birds. Pelicans congregate in marshland lagoon.

million, are believed to reside in the marshes of Al Hammar and Al Hawizeh. Incomplete ornithological surveys have reported 134 bird species in significant numbers from the area, of which at least 11 are globally threatened (Table 2). Particularly dependent on the marshlands are the Dalmatian Pelican, Pygmy Cormorant, Marbled Teal (Fig. 12), White-Tailed Eagle, Imperial Eagle, the Slender-billed Curlew and an endemic sub-species of the Little Grebe (*Tachybaptus ruficollis iraquensis*). The Goliath Heron, Sacred Ibis, and African Darter whose world population has been steadily falling, are also known to breed in the marshes. Furthermore, the marshes have been singled out as one of the eleven non-marine wetland areas in the world with Endemic Bird Area status (BirdLife International). They support almost the entire global population of two species, the Basrah Reed Warbler and Iraq Babbler as well as most of the world population of Grey Hypocollus (Maltby, 1994; Scott 1995).

Previously abundant, mammals have been under enormous pressure. Lions were wiped



Fig. 12 - The globally threatened Marbled Teal is known to breed widely in the marshlands.



Fig. 11 - Storks are common migrants to the marshlands.

out soon after the introduction of the rifle in the wake of the First World War. The last lion shot in the area is reported to have been in 1945. Three globally-threatened species of mammals inhabit the marshes. These are the Grey Wolf, the Long-fingered Bat and a sub-species of the Smooth-coated Otter which is endemic to the marshes. Other large animals, notably the Honey Badger, Striped Hyena, Jungle Cat, Goitered Gazelle and Indian Crested Porcupine have been reported in the marsh area. All had become rare by the 1980s and are now thought to be locally extinct. Previously, the most common mammal in the marshes was the Wild Boar, which posed a major threat to the Marsh dwellers' crops and was their main enemy (Fig. 9). Their numbers have also been in drastic decline. Other frequently-sighted mammals include the Small Indian Mongoose, the Asiatic Jackal and the Red Fox. Common reptiles in the marshes include the Caspian Terrapin, a soft-shell turtle, and a variety of snakes. The Desert Monitor, previously common in desert regions bordering the marshes, has been over-hunted and is now rare (Maltby, 1994).

A rich fish fauna lives in the marshlands.

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

Table 2 - Highly Threatened Species of the Marshlands

(Source: Banister, 1994; Maltby, 1994; Scott, 1995)

Many of the fish are of economic and scientific importance. In 1990, the FAO estimated that 60% of Iraq's inland fish catch of 23,500 tons was caught in the marshes. Fish from the carp family Cyprinidae are dominant in the marshlands. They are of special interest in scientific circles due to their importance in the study of evolution. At least one barbel species, the Gunther (*Barbus sharpeyi*) known locally as *bunni* is endemic to the marshlands and is of high commercial value. A number of species are known to spawn mainly in the marshes



Fig. 13 - 'He (Merodach-Baladan, King of Babylon) fled like a bird to the swampland' and 'I (Sennacherib, King of Assyria) sent my warriors into the midst of the swamps ... and they searched for five days'. But the King of Babylon could not be found. (703 B.C.) (Roux, 1993)

including the endemic giant catfish (*Silurus glanis* and *S. triostegus*), the Hilsa shad (*Tenualosa ilisha*) and a pomphret (*Pampus argenteus*). A wide range of marine fishes migrate upstream via the Shatt al-Arab, including the occasional shark. Of major commercial importance is the seasonal migration of penaeid shrimp (*Metapenaeus affinis*) between the Persian Gulf and nursery grounds in the marshlands (Banister, 1994).

3.5 Archaeological Sites

Rich with historical legacy, the wetlands are the locale in which Sumerian civilisation flourished, later to be succeeded by Akkadia, Babylonia, Assyria and Chaldea (Fig. 13 and 14). On its shores, the legendary Epic of Gilgamesh was enacted. It is also an area of major significance in the history of the three monotheistic religions: Christianity, Islam and Judaism. Biblical scholars regard it as the likely site of the legendary “Garden of Eden”, the “Great Flood” and the birthplace of the patriarch Abraham. Shrines of prophets and venerated religious figures engrave its landscape. World-renowned archaeological sites on the fringes of the marshes include Ur, Uruk, Eridu, Larsa, Lagash and Nina. Little archaeological exploration has been carried out inside the marshes themselves. Mounds,



Fig. 14 - Relief showing life in the marshlands in ancient times.

known as *tells*, rising above marsh waters are believed to be sites of ancient cities. Notable amongst these are the sites of Agar, Qubab, Ishan, Azizah, Dibin and Waqaf (Roux, 1993). Wholesale changes in the region’s land cover, associated with drainage engineering works, military activity and oil exploration, have seriously jeopardised a critical area of great archaeological interest.

4 Marshland Drainage and Its Impacts

4.1 Drainage Works

Gaining a certain mastery over the waters of the Tigris and Euphrates through irrigation canals and flood protection, was a vital factor in the settlement of lower Mesopotamia over 5,000 years ago. No specific plans, however, had been made to drain the marshlands until in the second half of the twentieth century. Initially, surveys commissioned by the Ottoman Empire to restore irrigation development in Iraq had raised the question of the marshlands (Willcocks 1911, 1913). This was followed in 1951 by a study prepared for Iraq's Irrigation Development Commission by British engineer Fred Haigh, now widely considered as providing the framework for the reclamation of the marshlands (Pearce, 1993). Closer examination of the report's recommendations, however, reveal that the main objective of this study was not to drain the marshlands *per se* but to deal with soil salinisation, (which historically was and remains Mesopotamia's main agricultural problem). In order to limit land degradation, Haigh proposed to build a surface and sub-surface drainage network to draw saline return waters from irrigated agricultural lands in the interfluvial region. The logic of this proposal is technically sound, as irrigation agriculture without drainage is clearly

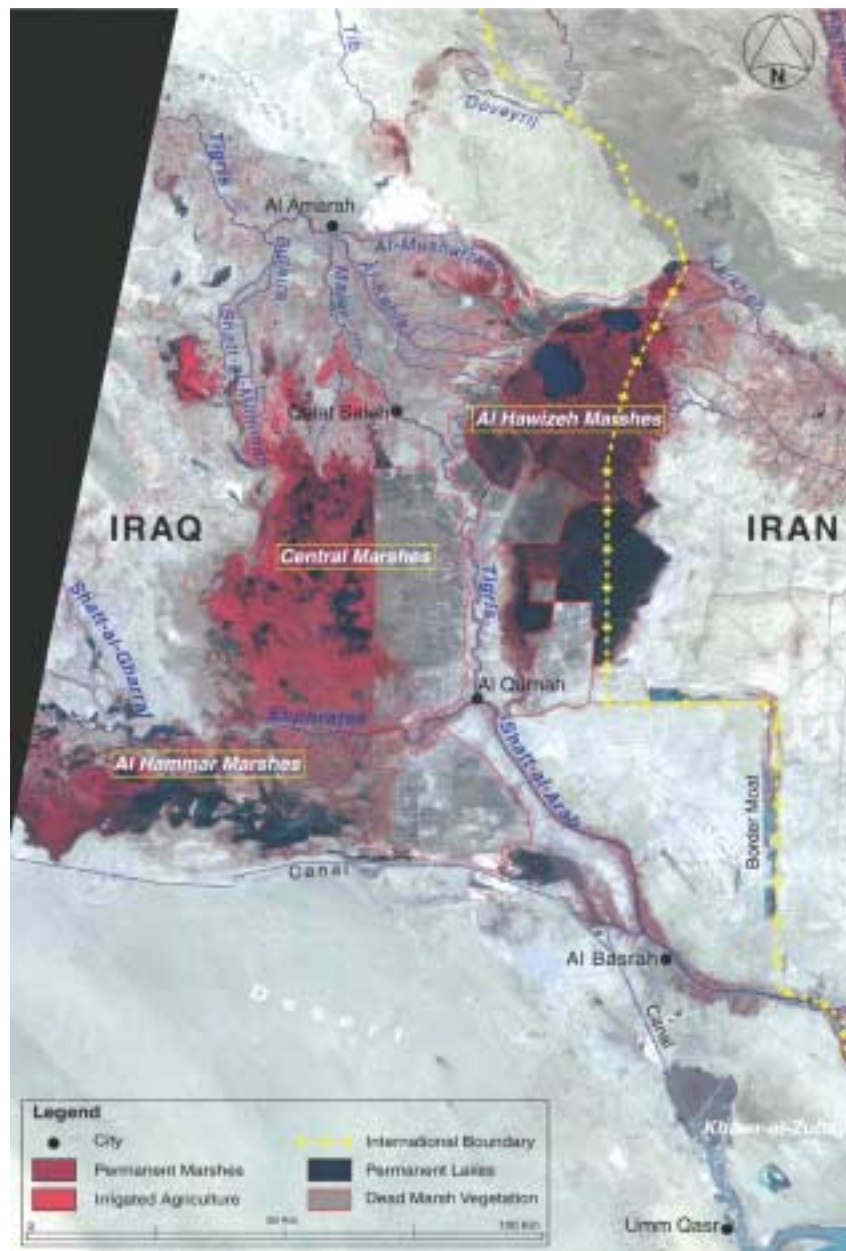


Fig. 15 - The marshlands in 1990 following the aftermath of the Iran-Iraq war. A large eastern swath of the Central and Al Hammar marshes as well as the northwestern and southern fringes of the Al Hawizeh marshes (red outline) had dried out by then as a result of the construction of causeways to ease military transport in an otherwise difficult terrain. (Mosaic of two Landsat 5 false-colour, near-infrared images, Multi-Spectral Scanner (MSS) Bands 4, 2 and 1, taken on 7 September 1990).

unsustainable. Despite the reduction in water discharge, drainage works also stood to inadvertently benefit the marshes by preventing the entry of poor-quality residual waters. Nonetheless, the study also made preliminary suggestions on controlling the lower Tigris distributaries via regulators and diverting their

supplies from the Central and Al Hawizeh Marshes, and “to escape the whole [flow] to the sea”. However, no specific engineering plans were developed to drain the marshlands (Irrigation Development Commission, 1951).

Work on a Main Outfall Drain (MOD) to remove the saline drainage waters, later known variously as the Third River and Saddam River, started in 1953. Construction of the MOD, however, was done in several stages and implemented on an ad-hoc and piecemeal basis. As construction of the MOD progressed in the 1970’s and 1980’s, the focus gradually shifted from building an irrigation drainage system to marshland reclamation. Concrete engineering proposals were developed to drain the marshlands proper (Nippon Koei, 1972). On the Euphrates this was to be achieved by diverting Euphrates flow from Al Hammar marshes and

flushing it out directly into the Persian Gulf. While drainage of the Central and Al Hawizeh marshes was to be accomplished by capturing the flow of the lower Tigris distributaries into a massive complex of canals which would channel their waters to the Persian Gulf via the Shatt al-Arab. These works, however, remained on the drawing board during the Iran-Iraq war (1980-88) and the marshlands remained relatively intact up to the mid-1980s. The transboundary Al Hawizeh marshes were in fact disrupted more by military activity than drainage plans, as it became transformed into a frontline combat zone during the Iran-Iraq war (Fig. 15) (Scott, 1995).

Following the end of the second Gulf War in February 1991 and the ensuing civil unrest in southern Iraq, a massive hydro-engineering programme was launched to drain the



Map 6 - Drainage schemes in southern Iraq.



Fig. 16 - Diversion of Euphrates waters downstream of Al Nasiriyah by the twin canals of the 'Third River' and 'Mother of Battles River'. (Landsat 7 true colour image derived by merging of panchromatic ETM Band 8 with Bands 7, 4 and 2, taken on 4 May 2000).

marshlands. After approximately nine months of round-the-clock shifts, the Iraqi government officially inaugurated the opening of Saddam River on 7 December 1992. Flowing for 565 kilometres from Mahmudiyah, 20 km southeast of Baghdad, the drainage canal collects return flows from irrigated lands in the central interfluvium of the Mesopotamian plain (Map 6) (The Economist, 1992). Running down the right bank of the Shatt-al-Gharraf, the canal intersects the Euphrates ten kilometres southeast of Al Nasiriyah, where it burrows beneath the riverbed in three large inverted siphon pipes (Fig. 16). It then skirts around the southwestern edge of the Al Hammar Marshes. Passing through the desert for 60 km between raised embankments, it then cuts through the southeastern section of the marsh where it joins the Shatt-al-Basrah canal before emptying

into the Persian Gulf at Umm Qasr via the Khawr-al-Zubair (Fig. 21). It should be noted that the Government of Iraq has always maintained that the drainage canals have been implemented as part of its irrigation works or to facilitate exploitation of untapped petroleum reserves (Europa, 1999, Ministry of Foreign Affairs, n.d.). Indeed, up to this stage, engineering designs were generally in line with original plans to remove the polluted drainage waters. Near to where the canal flows under the Euphrates, however, a dam was built to divert water

from the river's main channel into the drainage canal itself. Furthermore, along the southern bank of the Euphrates River between the dam and Al Qurnah, a continuous embankment stretching for 70 km was raised to prevent overflow from the Central Marshes into the Al Hammar Marshes. Diking and diversion of Euphrates waters into the drainage canal, originally intended solely for saline irrigation waters, greatly accelerated the drying out of the Al Hammar Marshes. Moreover, building of these drainage works coincided with the impoundment of Turkey's Ataturk Dam, which had reduced Euphrates flow to an all-time low.

Water influx into the marshlands was further reduced through the diversion of Euphrates water into Al Sulaybiyat depression, located upstream and to the west of Al Hammar marshes (Map 6). Departing five km west of Al

Samawah, the 55 km-long Al Qadissiyah River was completed in mid-1993. It channels the waters of the Shatt al-Atshan, a branch of the Euphrates River, into the depression creating a large flooded lake (Iraq Ministry of Foreign Affairs, n.d.). The Landsat 2000 image shows the artificial lake to have completely dried out, but the canal continues to empty its water into the depression. This was followed by the construction of another major water diversion scheme called the “Mother of Battles River” (Umm-al-Maarik). Work on this canal started in July 1993 and was rapidly completed in a six-month period, and officially inaugurated on 23 April 1994 (Iraq Ministry of Information, 1994). Beginning 2.5 km to the west from where the MOD is siphoned under the Euphrates near Al Nasiryah, the canal runs parallel to the MOD for a distance of 108 km and is between 65-92 meters wide (Fig. 16). It finally discharges into the remaining southeastern portion of the embanked Al Hammar lake. Finally, in December 1997, Iraq inaugurated a new canal called “Fidelity to the Leader” (Wafaa lil-Qaid) (BBC, 1997). Ninety kilometres long, this canal carries water from the MOD to the south of the city of Al Basrah, reducing influx in

the last remaining water body in the southeastern Al Hammar area.

Intensive work to drain the Central marshes was simultaneously underway in 1992. A large eastern swath of the marshes had already partially dried out by 1990 as a result of the construction of causeways to facilitate transport of armoured units during the Iran-Iraq war. Initially, control structures such as locks and sluice gates were constructed to manage water flows in the Tigris distributaries feeding the marshes. Earth embankments, ranging from six to 18 kilometres in length, were subsequently created on the banks of the seven main Tigris distributaries to prevent overtopping. These include the Adel and Wadiyah, which branch off from the Majar Al-Kabir, the Keffah and

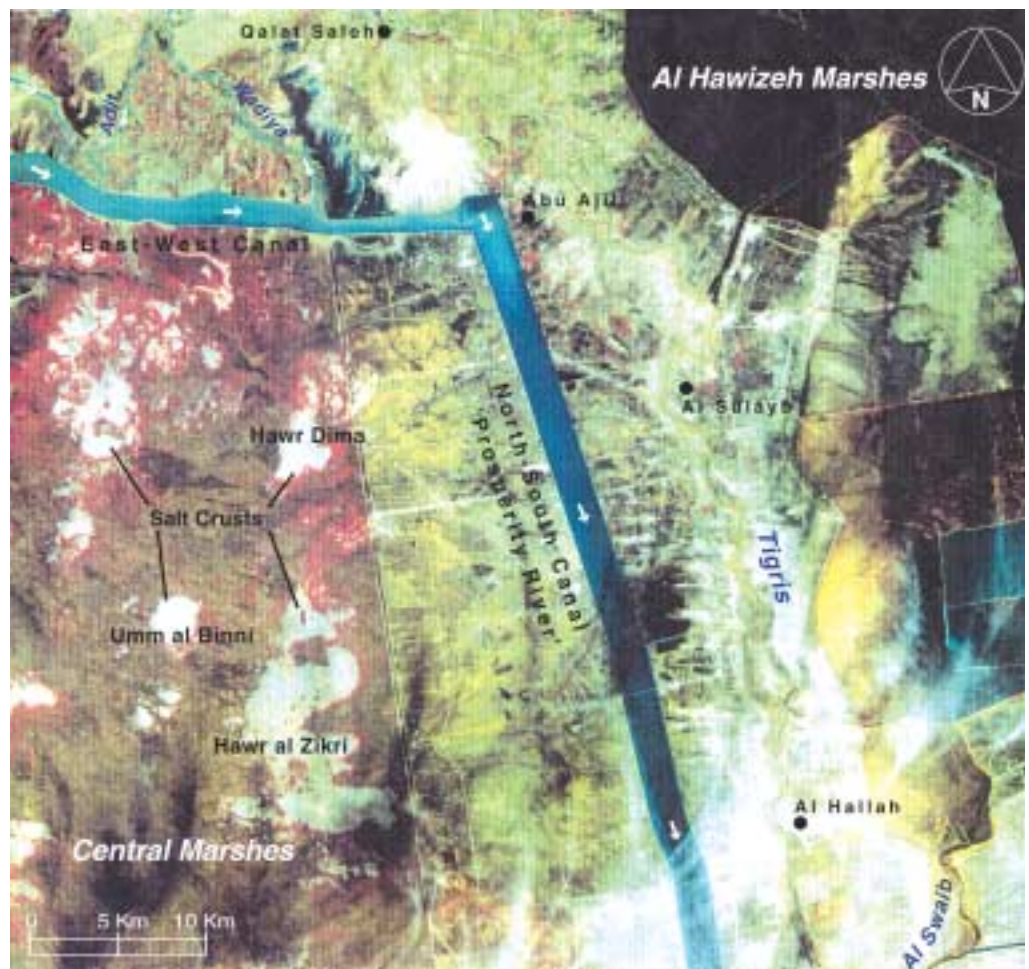


Fig. 17 - Clearly visible in this SPOT image recorded in December 1993 is the 2-km wide and 50 km long ‘Prosperity River’ which captures the waters of Tigris distributaries and channels them across the marshes to the Euphrates near its junction with the Tigris at Al Qurnah.

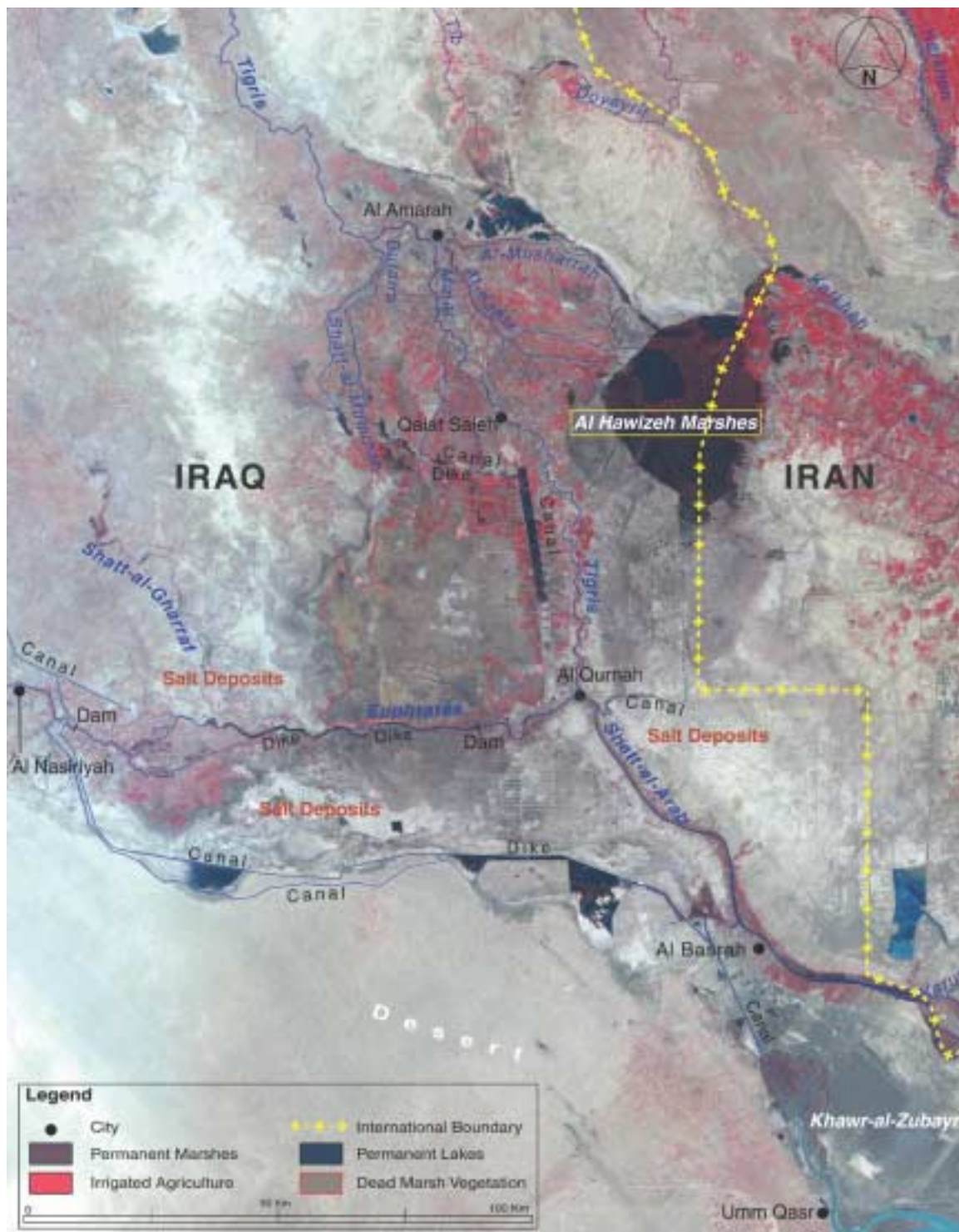


Fig. 18 - In this Landsat 7 Enhanced Thematic Mapper (ETM) mosaic taken in 2000, most of the Central Marshes appear as olive to grayish-brown patches (red outline) indicating low vegetation on moist to dry ground. The very light to grey patches are bare areas with no vegetation and may actually be salt evaporites of former lakes. (Mosaic of four Landsat 7 false-colour, near-infrared images, ETM Bands 4, 3 and 2, taken on 26 March and 4 May 2000).

Charamkhiya of the Shatt-al-Mu'minah, and the Masbah, Hadam and Om Jaddi, which receive their waters from the Butaira. In the next stage, the combined flow of these and

other distributaries, numbering around 40, was captured in a 40 km west-east canal located along the northern boundary of the main Central Marshes (Fig. 17 and 18) (Hamid,

1994). Between one and two km wide, the canal channels the flow from the village of Al Jandallah in the west to Abu Ajil in the east, 10 kilometres south of Qalat Saleh. At this point it joins a larger north-south canal - the centrepiece of the drainage scheme - called "Prosperity River" (Nahr al-Izz). Cutting through the Central Marshes, this two kilometre-wide canal runs 50 kilometres south before it discharges into the Euphrates, 6.5 km west of its confluence with the Tigris at the village of Banou Mansour (Fig. 19). Completed in April 1993, these canals which run from west to east and then from north to south effectively act as a massive moat structure preventing any replenishment of the Central Marshes. In addition, the Euphrates had another dam added to the west of its intersection with "Prosperity River" preventing any backflow into the marshes (Pearce, 1993). Finally, the "Crown of Battles River" (Tajj al-Maarik) played an important role in diverting Tigris waters from above the Central Marshes, which were discharged in the Al Hawizeh Marshes (see below).

Satellite images show that to accelerate their desiccation, both the Al Hammar and Central Marshes were intensively partitioned into polders using dikes. Canals some 20-30 km long were then built to drain the land (Fig. 20). The canals further divided the polders into smaller blocks and the remaining standing water was left to evaporate. Most of the reclaimed lands as depicted in the 2000 image of Landsat have remained barren since the works were completed in 1993/94, and there is little sign of new cultivation.

In 1993/94, the third major marshland domain - the transboundary marshes - appeared to have escaped the wholesale changes wrought by the drainage scheme that the other areas were undergoing. Initially, it was thought that this was due to the fact that a considerable amount of Al Hawizeh's water supply originated from the Karkheh River,



Fig. 19 - In 2000, the lower stem of the North-South Canal had largely dried-up leaving a narrow connecting canal to the Euphrates. (Landsat 7 false-colour image derived by merging of panchromatic ETM Band 8 with Bands 4, 3 and 2, taken on 26 March 2000).

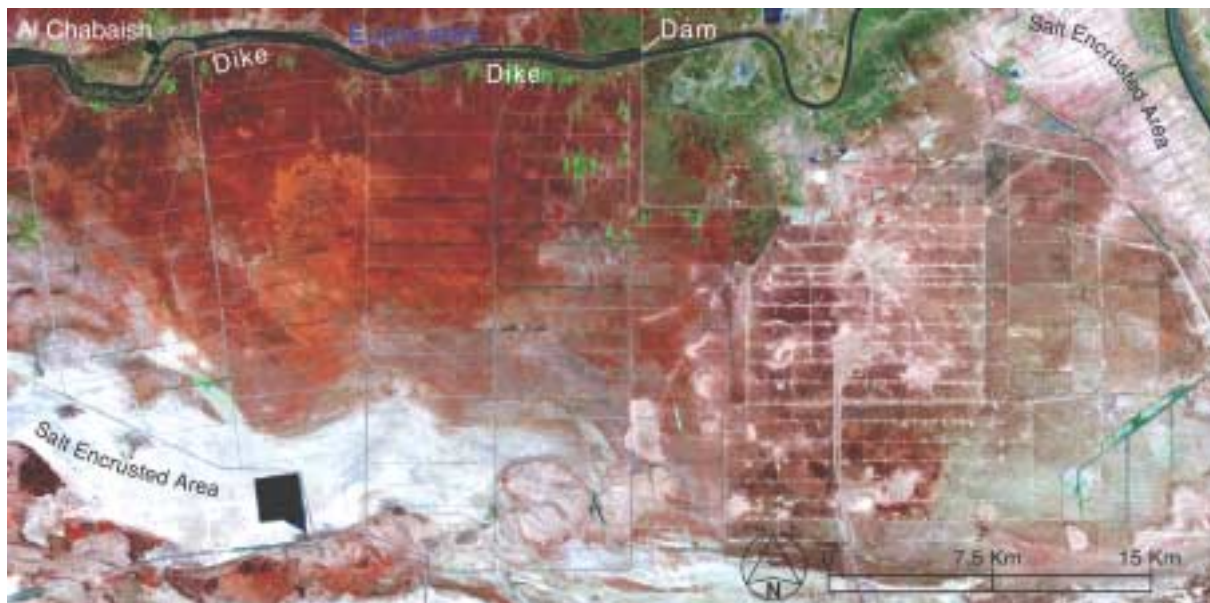


Fig. 20 - Landsat 2000 imagery reveals the Al Hammar marshes to have been intensively partitioned into polders, extension of work underway since 1984/85. Canals and dikes further divide the polders into smaller blocks so that remaining water is drained quickly or left to evaporate, leaving large tracts salt encrusted. (Landsat 7 true colour image derived by merging of panchromatic ETM Band 8 with Bands 7, 4 and 2, taken on 26 March 2000).

located wholly in Iran, and which had not as yet been subject to any major water control projects. But the real scale of the transformation that the Al Hawizeh Marshes were actually to experience in the mid-1990s was initially overshadowed by the temporary influx of additional water from the “Crown of Battles River”. This 42 km-long canal, located 4.5 km north of Al Kumayt, diverts Tigris waters from above the Central Marshes and discharges its flow into the Al Chubaisah Marsh complex. From this point, the waters finally filter through into the Al Hawizeh Marshes via an interconnecting marsh strip. The “Crown of Battles River” has been connected to another longer canal originating some 180 km upstream near Al Kut and running parallel to the Tigris River. This canal starts off by draining the waters of the Shuwaijah Marshes and continues along the east bank of the Tigris, collecting return waters from irrigated lands. It is most likely for this reason that the Al Hawizeh Marshes were reported in 1993 to have initially experienced a slight increase in the size of its permanent lake area (Maltby, 1994).

By 1994, however, the Al Hawizeh Marshes were showing signs of rapid dessication. The two main Tigris distributaries replenishing the marshes, the Al Musharrah and Al Kahla, were canalised at their lower stretches, forcing them to discharge deeper into the marshes. Embankments were constructed to keep the marshes back. This in turn led to the drying out of the northwestern shores, which had traditionally been an important rice cultivation area. Further south, a 17 km long by 500m-wide canal was built to withdraw the waters of the Al Hawizeh Marshes and release them back into the lower Tigris near the village of Kassarah. The size of the Al Hawizeh Marsh was further constrained by the construction of dikes along the length of its perimeters. Multiple north-south and east-west drainage canals, some 500 meters wide and 30 km long, have also been built through the marshes. All these canals flow south, channelling the marsh waters to the Shatt al-Arab via the Swaib River, six km south of the Tigris-Euphrates confluence. Large tracts of the Al Hawizeh have been empoldered into parcels so that the remaining water can be drained more quickly or left to evaporate.

In early 2000, Iran started to impound its largest reservoir dam on the Karkheh, the other main watercourse supplying the Al Hawizeh Marshes. The Karkheh Dam was officially inaugurated in April 2001. It has a gross reservoir capacity of 7.8 billion m³ and is intended to irrigate 320,000 ha of land in the Khuzestan plains. Increased irrigation at this scale is bound to significantly reduce water influx into the remaining portion of the marshes (Fig. 18). Irrigation return waters, which may be highly saline, will also affect the quality of the waters entering the marshes. The northeastern shores of the marshlands in Iran were showing signs of retreat in the Landsat 2000 image, and the southeastern section along the Iran-Iraq border had completely dried out (Fig. 18). Designs to transport water from the Karkheh Dam to Kuwait, if implemented, will put even greater strain on Al Hawizeh's dwindling water supply.

4.2 The Impacts

The scale and speed of land cover change in the Mesopotamian marshlands have been extraordinary, probably comparable only to the deforestation rates of Amazonia and the desiccation of the Aral Sea. The cumulative impacts of dam construction upstream and intensive drainage schemes in and around the marshlands have been devastating. In less than a decade, one of the world's largest and most significant wetland ecosystems has completely collapsed. The March 2000 images provided by Landsat 7 are unequivocal as to the extent of land cover change. On the ground, the once-extensive marshlands no longer exist. Only minor and fragmented parcels remain. The Central and Al

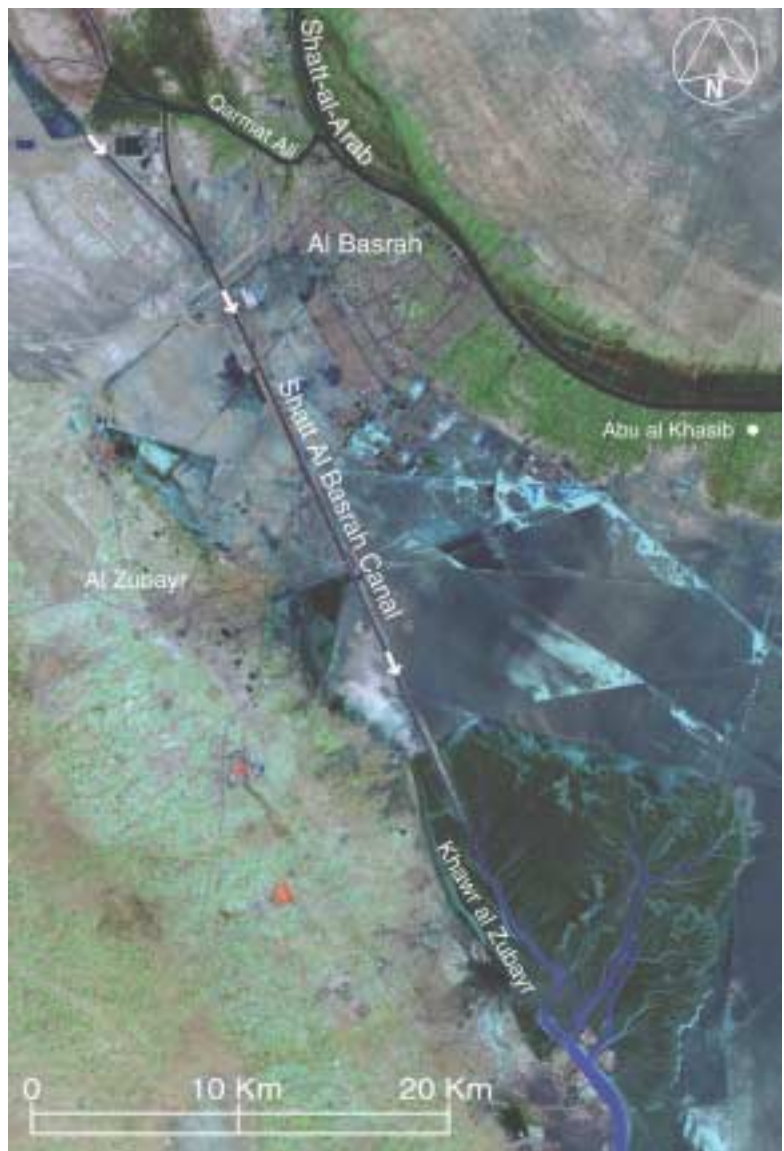
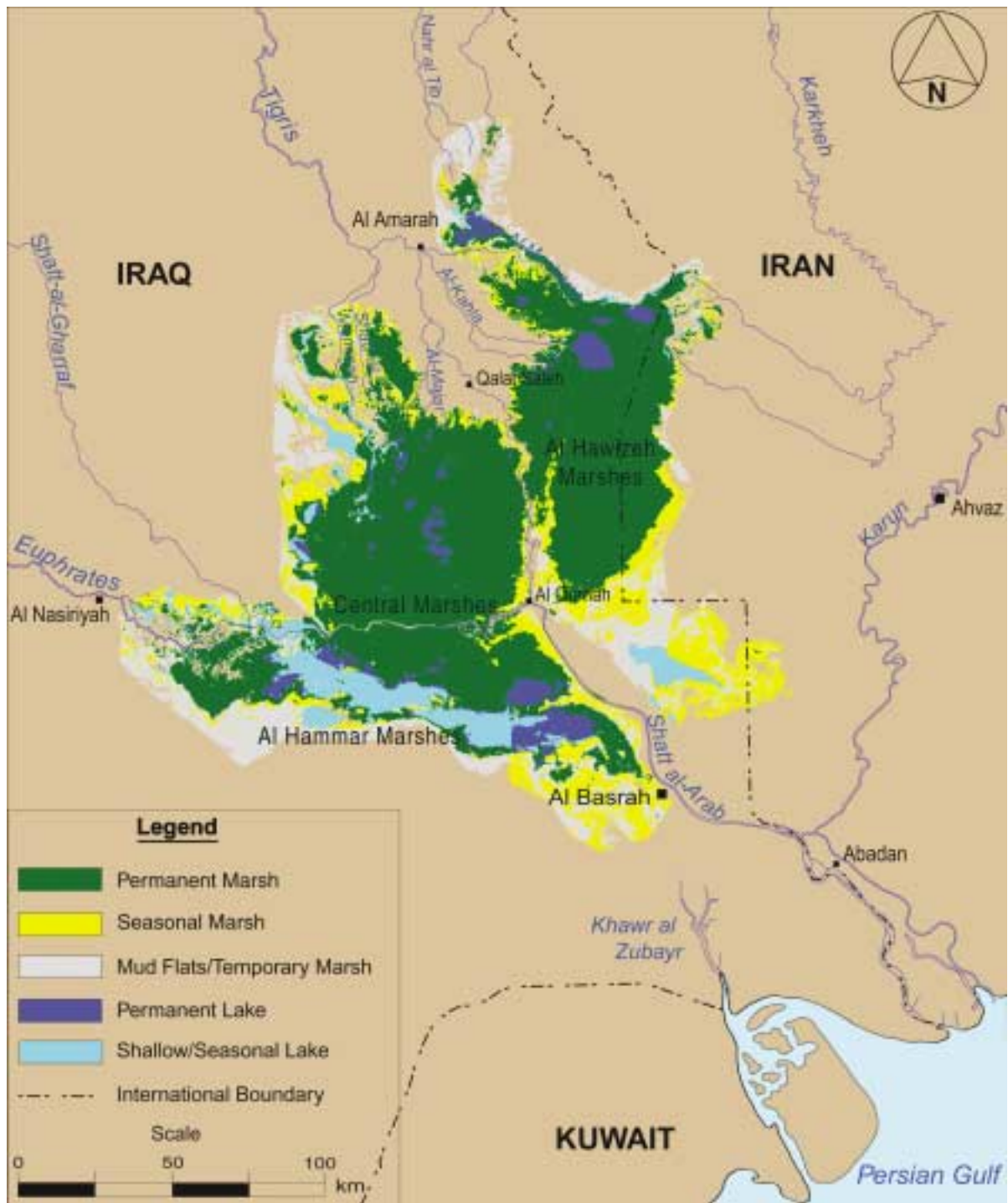


Fig. 21 - The Shatt Al Basrah Canal transports the combined flow of the 'Third River' and the 'Mother of Battles River' and 'Fidelity to the Leader Canal' into the Khawr al Zubayr which empties into the Persian Gulf. (Landsat 7 true colour image derived by merging of panchromatic ETM Band 8 with Bands 7, 4 and 2, taken on 26 March 2000).

Hammar Marshes are now dry land. The former permanent lakes of the Central Marshes (Al Zikri, Umm Al Binni, etc.) have dried up; leaving behind vast stretches of salt crusts. Al Hammar, formerly the largest Lake in the lower Euphrates, has also been completely drained and is now covered with evaporites. Most of the transboundary Al Hawizeh Marsh in Iraq has been transformed into barren land. Only a small northern section remains and its shorelines are in steady retreat. The



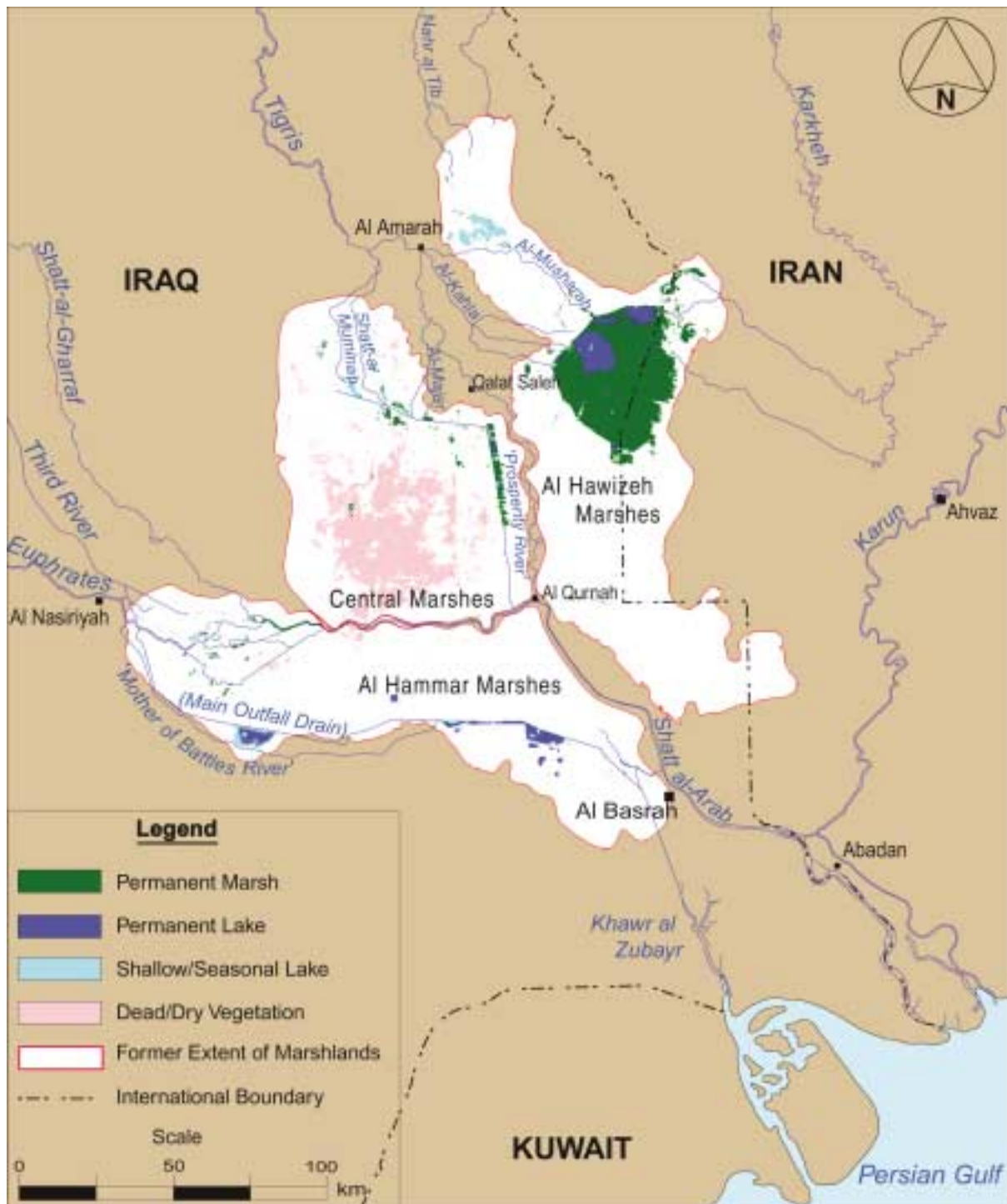
Map 7 - Mesopotamian Marshlands: Land Cover 1973 - 76.

Mesopotamian marshlands have effectively been relegated to the history books, a landscape of the past.

4.2.1 Habitat Loss

Comparative analysis of Landsat imagery from 1973-76 and 2000 enabled a quantified assessment to be made of the areal changes in

marshland habitat extent. The statistics derived from the analysis should not be taken as definitive figures, since the results could not be verified with ground-based measurements. Particular difficulty was also experienced in delineating complex ecotonal zones separating marshland types, and the marshland fringe from surrounding desert. The results, however,



Map 8 - Mesopotamian Marshlands: Land Cover 2000

do provide a reliable indication of the overall magnitude of environmental change. Moreover, the calculations presented are conservative since they have not included the highly variable seasonal and temporarily flooded marshlands, which comprised an important proportion of the original marshland ecosystem.

Generalised classification of marshland land cover in 1973-76 and 2000 are shown in maps 7 and 8. The principal aim has been to highlight changes in the area of water and vegetation. A summary of the findings is provided in Table 3. In total at least 7,600 km² of primary wetlands (excluding the seasonal and temporary flooded

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

Table 3 - Changes in Surface Area of Mesopotamian Marshlands, 1973-76 – 2000 (in km²)

areas) disappeared between 1973 and 2000. Most of the change, however, occurred between 1991 and 1995. The most seriously affected are the Central and Al Hammar Marshes. Of the original 3,121 km² domain of the Central Marshes in 1973, only 98 km² or 3 % remained in 2000. Moreover, most of this residue is actually water and reeds growing in the drainage canals. Al Hammar has been reduced to 6% of its original extent. Again, the remaining area is largely concentrated around the canals and does not constitute a genuine

part of the original wetland system. Al Hawizeh has been subject to a relatively less drastic reduction in its surface area. Nonetheless, it has also decreased by 2,000 km², leaving in place only a third of the original coverage. In 1973, the Iranian extension of Al Hawizeh - where it is known as Hawr Al Azim - accounted for 21% of its total area (Table 4). As a result of extensive drainage in Iraq, however, Hawr Al Azim's proportion increased and in 2000 comprised 29% of the remaining Al Hawizeh Marshes. Nevertheless, it is important to note

Hawr Al Azim	1973-76	2000	2000 as % of 73-76
Permanent Marshes	622.8	295.6	47.5
Permanent Lakes	3.0	1.0	33.0
Seasonal/Shallow Lakes	15.4	0.3	2.0
Total	641.2	296.9	46.3

Table 4 - Changes in the Surface Area of Hawr Al Azim, 1973-76 – 2000 (in km²)



Fig. 22 - Marsh Arabs fleeing the devastation of their homeland in 1993: hastily built reed shanties straddle the four kilometre causeway leading out of the Iraqi marshlands to the frontier post of Himmet in Iran.

that Hawr Al Azim has equally undergone a significant net reduction in area. It is now less than half of its 1973 size. The shoreline of Hawr Al Hawizeh/Al Azim has been in steady retreat during the last decade. Unless urgent remedial action is taken, desiccation of the last remaining vestige of the Mesopotamian marshlands is likely to continue unabated. Indeed, it is likely to accelerate as a result of substantial water retention by the Karkheh Dam and plans to transfer water from its reservoir to Kuwait.

Finally, in light of the fact that the Tigris-Euphrates drainage basin is the largest river system draining into the Persian Gulf, reduced discharge and changes in river flow patterns and quality will have an important impact not only on inland freshwater ecosystems but also on the marine environment in the northwestern Gulf. As the marshlands filtering role has ceased and with the Third River discharging polluted agricultural drainage directly into

Khawr al-Zubair, seawater salinity has dropped around Warbah Island at the Iraq-Kuwait border and its quality degraded with potentially harmful impacts on regional fish resources (ROPME, 2000).

4.2.2 Refugees

As the marshlands began to rapidly dry out in the early 1990s, the Marsh Arabs were forced to flee (Fig. 22). In addition to the engineering works, their homeland became one of the main areas of fighting that engulfed southern Iraq in

1991-93. Numerous marsh villages were encircled, attacked and burnt-down. Marsh waters were also reported to have been poisoned with chemicals (Human Rights Watch, 1993, 1994; United Nations, 1993, 1994, 1999; Wood 1993). Of the 95,000 southern Iraqis who sought refuge in Iran since the end of the Gulf War in 1991, an estimated 40,000 are Marsh Arabs (Fig. 23). The fate of those



Fig. 23 - Approximately 40,000 Marsh Arabs are living in refugee camps in Khuzestan province, southwestern Iran.



Fig. 24 - This sub-species of the endemic smooth-coated otter is now considered extinct.

who stayed inside Iraq remains poorly documented, but an estimated 200,000 - 250,000 are considered to be internally displaced (AMAR ICF, 2001; UNHCR, 1996).

Although exact figures may be disputed, it is clear that the estimated half-million strong population inhabiting the marshlands have been uprooted and displaced. With the marshlands gone, the social and economic livelihood of the Marsh Arabs has fallen apart. Essentially now a refugee population, this unique human community and a 5,000 year-old way of life has also been flushed away by the drainage scheme. Given that the flight of the Marsh Arabs was triggered by massive environmental deterioration, there is a strong case for them to be considered as “environmental refugees”. These were defined in a UNEP commissioned study “as those who had to leave their habitat, temporarily or

permanently, because of a potential environmental hazard or disruption in their life-supporting ecosystems” (El Hinnawi, 1985).

4.2.3 Wildlife Decline and Extinction

The loss of the marshlands has had a catastrophic impact on wildlife and biodiversity. These go beyond Iraq’s borders and are of regional and international importance. Wildlife experts concur that destruction of the wetlands would almost certainly lead to the global extinction of the endemic smooth coated otter sub-species (Fig. 24), the Bandicoot Rat and the endemic Babel, *Barbus sharpeyi*, as they were wholly dependent on this unique habitat for their existence. It would also have caused the disappearance in the Middle East of the African

Darter and the Sacred Ibis, and the extinction in Iraq of the Pygmy Cormorant and Goliath Heron (Scott and Evans, 1994).

In light of their importance as a staging and wintering area for migratory birds on the Western Siberia-Caspian-Nile flyway, the effects of marshland desiccation is being felt across thousands of miles from the Arctic to southern Africa. An estimated 66 species of birds that occurred in the marshlands in internationally significant numbers are at risk. The global populations of the Iraq Babbler and the Basrah Reed Warbler and the regional population of the Dalmatian Pelican are likely to crash and may be wiped out as a result. It is estimated that the world populations of Harrison’s Gerbil, an endemic subspecies of the Little Grebe and the Marbled Teal may have declined by 50%. In addition, major declines in the regional populations of the Eastern White Pelican

(*Pelecanus onocrotalus*, 30-60%), Purple Heron (*Ardea purpurea*, >10%), Little Bittern (*Ixobrychus minutus*, >10%), Glossy Ibis (*Plegadis falcinellus*, >10%), Tufted Duck (*Aythya fuligula*, >20%), Marsh Harrier (*Circus aeruginosus*, >10%), Purple Gallinule (*Porphyrio porphyrio* >50%) and Coot (*Fulica atra* 10-20%) are expected (Scott and Evans, 1994).

The marshes are connected to the Persian Gulf hydrologically via the Shatt al-Arab, which acts as a conduit for a wide range of migratory aquatic species. Of major commercial importance is the seasonal migration of penaeid shrimp between the Persian Gulf and nursery grounds in the marshlands. It is estimated that up to 40% of Kuwait's shrimp catch originates from the marshes. The drying out of the marshlands is therefore likely to have had an important impact on coastal fisheries in the northern Persian Gulf, with potentially serious economic consequences. The marshes wide range of cyprinid fish species, which are of special scientific interest, have also been severely affected (Banister et al, 1994).

4.2.4 Regional Climate Change

Rapid desiccation of over 9,000 km² of wetlands and lakes is bound to have significant ramifications on the regional micro-climate. As the moderating role of the wetlands is eliminated, evapotranspiration and humidity rates will sharply decrease. Rainfall patterns will

be modified. Temperatures will invariably rise, particularly during the hot and long summers. Strong and dry winds reaching temperatures of over 40°C, previously broken by the reed beds, will blow unhindered (Maltby, 1994). With salt crusts and dry marshland soils exposed, wind-blown dust laced with various impurities will considerably increase, affecting thousands of square kilometres well beyond Iraq's borders. Ecosystem degradation at such a grand scale may have serious drawbacks on human health, ranging from the effects of water scarcity and pollution to increased exposure to thermal extremes and potentially toxic dust storms blowing off salt pans and dried marsh bed. Furthermore, the fragile arable lands surrounding the former marshlands are likely to suffer from land degradation and desertification, caused by wind erosion and sand encroachment from the dried marsh bed and surrounding deserts.

Notwithstanding the obvious differences between the two situations, it is possible that health problems comparable to those emanating from the drying out of the Aral Sea (such as respiratory illnesses, cancers and increased infant mortality, made worse by heavy use of toxic pesticides) may also arise as a result of marshland desiccation. Potential human health repercussions stemming from the transformation of marshland ecology therefore need to be taken into consideration.

5 Conclusions

Construction of large dams on the Tigris and Euphrates in the last half of the twentieth century has led to a decisive change in the regime and water supply of the twin rivers. The usable storage capacity of existing dams in the basin considerably exceeds the annual total discharge of both rivers. In addition, at least 20 more dams are planned or are currently under construction. One major impact of such massive water storage capacity is that it has considerably reduced water supply and eliminated the floodwaters which nourished wetland ecosystems in the lower basin. The cumulative impact of the dams therefore played an important role in reducing the marshlands' spatial extent. Some hydrological experts have postulated that the long-term effects of water retention by dams may alone have led to the disappearance of the marshland ecosystem. Wetland fertility and ecosystem processes have also been negatively affected by saline return waters from recently commissioned irrigation schemes, and sediment and nutrient retention by dams.

The accelerated scale and speed of marshland disappearance, however, was mainly driven by massive drainage works undertaken

in the wake of civil unrest following the second Gulf War in 1991. It is also noteworthy that the implementation of drainage engineering works in Iraq was to an important extent made only physically possible as a result of reduced flow from upstream impoundments. Analysis of satellite imagery has shown that the marshland ecosystem had collapsed by 2000. Only a small area of the transboundary Hawr Al Hawizeh/Al Azim remains, which is itself under high risk of disappearing due to upstream activities, including the recently inaugurated Karkheh Dam in Iran and associated water transfer designs to Kuwait, and the planned Ilisu Dam in Turkey. The impact of marshland desiccation and the discharge of polluted agricultural effluent via drainage works on the marine environment in the northwestern Persian Gulf are also likely to be significant.

The destruction of the vast Mesopotamian marshlands, a region of global importance for biodiversity and home of the Marsh Arabs, will go down in history along with other human-engineered changes such as the desiccation of the Aral Sea and the deforestation of Amazonia, as one of the Earth's major and most thoughtless environmental disasters.

6 Recommendations

The following recommendations provide a broad framework and some key elements that ought to be taken into consideration to arrest environmental degradation and rehabilitate the Mesopotamian marshlands. As the marshlands are an integral part of an international river system, implementation of any future restoration initiative hinges not only on remedial actions within Iraq, but equally on the cooperation of all riparian states. The international community has a key role to play in facilitating an agreement(s) between riparian countries by catalysing constructive dialogue within a structured framework, and endowing the whole process with greater objectivity and transparency. The urgency of the situation cannot be overemphasised, as with the passage of time, it will become increasingly difficult to flush the extensive tracts of salt crusts and revive the dried marsh bed. Meanwhile, priority should be given to conservation of the remaining transboundary Hawr Al Hawizeh/Al Azim marshes (6.6), and to partial restitution activities where possible. The recommendations therefore include basin-wide measures (6.1 & 6.2) and more specific actions targeted at the marshlands (6.3 – 6.7).

6.1 International Agreement(s) on the Sharing of Tigris and Euphrates Waters

Negotiations involving all the riparian countries and supported by international facilitation need to be initiated with the aim of establishing an international agreement(s) on the sharing of Tigris and Euphrates waters. This calls for setting a new threshold for long-term water sharing and integrated management of the Tigris-Euphrates drainage basin. Determination of water allocation quotas should not be solely a function of development needs, but requires an “ecosystem approach” aimed at maintaining river flows at levels that sustain all forms of life and the ecological viability of the river system,

particularly that of the marshlands. A similar water-sharing agreement(s) needs to be reached between Iran and Iraq regarding the Karkheh and Karun rivers and other Tigris tributaries. To underpin this process, UNEP proposes to carry out a comprehensive scientific assessment of the Tigris-Euphrates basin in collaboration with riparian countries and regional organisations.

6.2 Mitigating the Impacts of Dams on Downstream Ecosystems

As most of the dams on the Tigris and Euphrates have been built, opportunities to mitigate their cumulative impacts on ecosystems and biodiversity are relatively limited. The main option available is to use environmental flow requirements, which includes managed flood releases, to recreate a semblance of the natural distribution and timing of stream flow. Another alternative for environmental restoration, which has been increasingly used by a number of countries, is to decommission large dams. For planned dams on the Tigris, including the Ilisu Dam, higher standards of environmental performance are required. These include anticipating and avoiding impacts by carrying out environmental impact assessments (EIA), considering alternative projects, optimal siting and size of dams and incorporating environmental flow needs in the dam design. The policy guidelines recently established by the World Commission on Dams (WCD, 2000) provide a “new framework for decision-making”, which if acted upon by dam developers and funders should considerably reduce their negative impacts. Compliance with international treaties, particularly the United Nations Convention on the Law of the Non-navigational Uses of International Watercourses (1997), is also necessary before commissioning dam projects.

6.3 Re-establishing the Flood Regime

Underpinning any rehabilitation programme of the Mesopotamian marshlands will be a basin-wide water management plan designed to reinstate significant large-scale flooding in the Mesopotamian delta. Specifically, this calls for the development of a hydrodynamic model of the Tigris-Euphrates river system and its inland delta, based on sound hydrological and ecological data. Such a model is necessary for the elaboration of re-inundation plans and for the identification of priority target areas for restoration. In the preliminary stages, pilot programmes need to be undertaken in order to evaluate their ecological, economic, and social feasibility, as well as avoid unforeseen negative consequences of proposed remedial measures.

6.4 Protecting Water Quality

The quality of waters entering the marshlands has a critical bearing on the type of flora and fauna it is capable of supporting. Saline irrigation waters compounded with urban and industrial effluent would therefore have a major negative influence on any rehabilitation plans. Within Iraq, salt concentrations in the lower Tigris and Euphrates are considerably augmented by influxes from the Tharthar and Habbaniyah/Razaza reservoirs due to their calcareous soils and high evapotranspiration rates. Remedial actions to control salinity levels and prevent polluted waters from entering the marshlands are therefore pre-requisite steps for restoration.

With large amounts of the sediment load of the Tigris and Euphrates and their associated tributaries (including the Karkheh in Iran) trapped behind multiple dams, the fertility of waters nourishing the marshlands has inevitably decreased. Reduced sediment loads will also have untold impacts on the natural evolution of the inland marshland delta. A rehabilitation programme would therefore need to consider the significance of

sediment retention by engineering structures and propose necessary remedial measures.

6.5 Re-evaluating the Role of River Engineering Works

Regulation of water flow through upstream dam construction has effectively eliminated the seasonal flooding cycle driving the ecological dynamics of the marshlands. In view of the fact that several of the engineering structures built in Iraq in the 1950s were originally intended for flood protection purposes, there is a logical need to review whether their role has been rendered redundant by the recent dams built in Turkey and northern Iraq. In particular, the utility of the massive off-river water storage reservoirs of the Tharthar and Habbaniyah/Razaza needs to be re-evaluated and due consideration given to the modification of their future roles.

Inside the marshlands, diversion canals, embankments, sluices, locks, dikes, polders and other hydraulic works should be modified or removed as necessary to ensure adequate water release into the marshlands. A comprehensive EIA of the drainage works and associated agricultural projects needs to be undertaken, and balanced allocation of competing water demands within Iraq made.

6.6 Designation of Protected Areas

As the last remaining vestige of the Mesopotamian marshlands and a very important sanctuary for endangered wildlife and migratory birds, the importance of initiating immediate conservation measures by both Iran and Iraq to protect the transboundary Hawr Al Hawizeh/Al Azim cannot be overstated. Possible options include establishment of a mechanism for integrated marshland management between Iran and Iraq such as a transboundary 'peace park', designation as a Ramsar Convention or World Heritage site, and/or as a UNESCO Man and Biosphere (MAB) or national reserve(s).

Experience has shown that for conservation programmes to be sustainable, their design and implementation need to be made in close cooperation with the local population.

6.7 Assistance and Repatriation of Marsh Arab Refugees

It is estimated that the drying out of the marshlands has displaced 350,000 to 500,000 Marsh Arabs; of whom at least 40,000 have sought refuge in neighbouring Iran, while the rest are internally displaced within Iraq. In parallel with environmental restitution plans, feasibility studies for the repatriation of Marsh Arab refugees and reintegration within a restored marshland environment need to be carried out. In addition, and at the humanitarian level, relief support needs to be provided to Marsh Arab refugees in Iran as well as those displaced within Iraq.

6.8 Data Collection, Monitoring and Long-Term Capacity Building

Detailed studies on the impacts of marshland desiccation on local and regional environmental conditions and wildlife need to be carried out. A long-term monitoring programme based on regular field data collection, remote sensing imagery and aerial photographic surveys should be developed and implemented. In addition, the capacities of

environmental administrations in Iraq and Iran both at the national and local levels will need to be strengthened, and targeted training on wetland management and restoration provided.

Some related studies that need to be undertaken include:

- assessment of human health impacts of marshland desiccation;
- assessment of the impacts of reduced freshwater flows and seawater intrusion on date palm plantations along the Shatt al-Arab estuary;
- monitoring the effects of marshland desiccation on aquatic species' migrations between the Tigris-Euphrates River system and the Persian Gulf;
- monitoring the impacts of agricultural effluent discharge via drainage works on the marine environment in the northwestern Persian Gulf;
- research into the consequences of marshland drying on the regional climate; and
- investigate contamination of surface waters, groundwater and marshland soils by chemicals and other toxic substances emanating from oil exploration and military conflict.

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Annex 1: Major Dams and Barrages in the Tigris - Euphrates Basin

Euphrates River Basin

Country	Name of Dam	Use	River	Date of Completion	Gross Storage (BCM)	Surface Area (km ²)	HP (MW)	Height (m)
Turkey	Adiyaman	HP	Goksu	Planned	1.887	60	75	90
Turkey	Ataturk	HP, Irrigation	Euphrates	1992	48.70	817	2400	166
Turkey	Birecik	HP, Irrigation	Euphrates	2000	1.22	56.25	672	53
Turkey	Camgazi	Irrigation	Euphrates	1998	0.056	5.55	-	39
Turkey	Derik-Dumulca	Irrigation	Euphrates	1991	0.022	2.23	-	24
Turkey	Hacihidir	Irrigation	Euphrates	1989	0.062	4.4	-	32
Turkey	Hancagiz	Irrigation	Euphrates	1988	0.100	7.50	-	45
Turkey	Kahta	HP	Kahta	Planned	1.887	100	-	125
Turkey	Karakaya	HP	Euphrates	1987	9.58	268	1800	158
Turkey	Karkamis	HP, Flood Control	Euphrates	1999	0.157	28.4	189	21.2
Turkey	Kayacik	Irrigation	Euphrates	UC	0.116	2.91	-	45
Turkey	Keban	HP	Euphrates	1975	31	675	1330	163
Syria	Baath	HP, Irrigation, Flow Regulation	Euphrates	1988	0.09	27.15	75	-
Syria	Tabaqa	HP, Irrigation	Euphrates	1975	11.7	610	800	60
Syria	Tishrine	HP	Euphrates	1999	1.9	166	630	40
Syria	Upper Khabur ¹	Irrigation	Khabur	1992	0.988	1.37	-	-
Iraq	Al Hindiyah Barrage	Flow Diversion	Euphrates	1918, rebuilt 1989	-	-	-	-
Iraq	Al Qadisiyah ²	HP, Irrigation	Euphrates	1984	8.2	500	660	57
Iraq	Fallujah Barrage	Irrigation	Euphrates	1985	-	-	-	-
Iraq	Baghdadi	Flow Regulation	Euphrates	Planned	-	-	-	-
Iraq	Ramadi-Habbaniyah ³	Flood Protection	Euphrates	1948	3.3	426	-	-
Iraq	Ramadi-Razaza ⁴	Flood Protection	Euphrates	1951	26	1850	-	-

HP: Hydropower

UC: Under Construction

¹ Also called the Great Khabur, the project is made up of three dams: Al-Khabur (Basil Al-Assad), West Al-Hasakah (8 March Dam), and East Al-Hasakah (7 April Dam). ² Formerly called Haditha dam. ³ Barrage diverting flows into natural depression via Warrar canal.

⁴ Barrage diverting flows into natural depression via Mujarah canal.

Tigris River Basin

Country	Name of Dam	Use	River	Date of Completion	Gross Storage (BCM)	Surface Area (km ²)	HP (MW)	Height (m)
Turkey	Batman	HP, Irrigation	Tigris	1998	1.175	49.25	198	71.5
Turkey	Cag-Cag	HP	Tigris		-	-	-	-
Turkey	Cizre	HP, Irrigation	Tigris	Planned	0.36	21	240	51.4
Turkey	Devegecidi	Irrigation	Tigris	1972	0.202	32.14	-	32.8
Turkey	Dicle	HP, Irrigation	Tigris	1997	0.595	24	110	75
Turkey	Dipni		Tigris		1.02	46		90
Turkey	Dilimi	Irrigation	Great Zab	UC	0.0591	2.41	-	70
Turkey	Garzan	HP, Irrigation	Tigris	Planned	.983	46	80	113
Turkey	Ilisu	HP	Tigris	Planned	10.41	299.5	1200	138
Turkey	Goksu	Irrigation	Tigris	1991	0.062	3.9	-	46
Turkey	Kralkizi	HP	Tigris	1997	1.919	57.5	90	113
Turkey	Silvan	HP, Irrigation	Tigris	Planned	0.82	164	150	165
Iraq	Al-Adheem	HP, Irrigation	Al-Adheem	1999	1.5			
Iraq	Al-Amarah Barrage	Flow Regulation	Tigris	UC	-	-	-	-
Iraq	Al-Faris ¹	HP, Irrigation	Great Zab	Not Completed	3.30	56	1600	200+
Iraq	Al-Kut Barrage	Flow diversion	Tigris	1939	-	-	-	-
Iraq	Derbendikhan	Irrigation	Diyala	1962	3.0	121	-	128
Iraq	Dibbis	Irrigation	Little Zab	1965	3.0	32	-	15
Iraq	Diyala Barrage	Irrigation	Diyala	1969	-	-	-	12
Iraq	Dokan	Irrigation	Little Zab	1961	6.8	270	-	116
Iraq	Hamrin	Irrigation	Diyala	1980	3.95	440	-	40
Iraq	Saddam ²	HP, Irrigation	Tigris	1985	11.1	371	320	126
Iraq	Samarra-Tharthar ³	Flow diversion	Tigris	1954	72.8	2170	-	-
Iraq	Sennacherib ⁴	Flow Regulation	Tigris		0.5	-	-	-
Iran	Bazoft		Bazoft	Under Design				
Iran	Dez ⁵	HP, Irrigation	Dez	1962	3.460	-	520	203
Iran	Garm-ab		Karkheh	Under Design				
Iran	Karkheh	HP, Irrigation, Flood Control	Karkheh	2001	7.795		400	128
Iran	Karun-1 ⁶	HP, Irrigation	Karun	1977	3.139	54.8	1000	200
Iran	Karun-2	HP	Karun	UC-2005			1000	
Iran	Karun-3	HP, Flood control	Karun	UC – 2001	2.750	2000 (3000)		205
Iran	Karun-4	HP, Flood control	Karun	UC-2006	2.190		1000	222
Iran	Khersan I	HP	Khersan	Under Design	0.520		750	180
Iran	Khersan II	HP	Khersan	Under Design	0.500		500	180
Iran	Khersan III	HP	Khersan	Under Design	0.730		750	165
Iran	Marun	Irrigation, HP	Marun	1998	1.2	25	145	165
Iran	Masdjied-e-Soleiman ⁷	HP, Irrigation	Karun	UC-2001	0.228	1000(2000)		177
Iran	Saz-e-bon		Karkheh	2004			500	
Iran	Shushtar ⁸	HP	Karun	UC – 2005	4.53		2000	180
Iran	Simareh	HP	Karkheh	UC-2004			500	
Iran	Tang-e-mashoreh		Karkheh	Under Design				
Iran	Upper Gotvand	HP	Karun				1000 (2000)	

¹ Formerly called Bekme dam, it is reportedly destroyed. ² Formerly called Aski Mosul dam. ³ Barrage diverting flows into natural depression via canal. ⁴ Formerly called Badush dam. ⁵ Formerly known as the Mohammed Reza Shah Pahlavi Dam. ⁶ Formerly called Shahid Abbaspur. ⁷ Formerly called Karun-4 (Godar-e-Landar). ⁸ Also known as Gatvand.



Concerted action by Tigris-Euphrates basin countries is urgently required to protect the last vestige of the Mesopotamian marshlands. Landsat 7 true colour image (Bands 7, 4 and 2) of the remaining northeastern section of Hawr Al Hawizeh/Hawr Al Azim marshes straddling the Iran-Iraq border taken on 14 April 2001.

www.unep.org

United Nations Environment Programme

P.O. Box 30552 Nairobi, Kenya

Tel: (254 2) 621234

Fax: (254 2) 623927

E-mail: cpinfo@unep.org

web: www.unep.org

