The mountain oasis of Chebika, southwest Tunisia.

Source: Lansbricae/Flickr.com

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Chapter 2 Transboundary Environmental Issues

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Though the nature of regional or transboundary environmental issues has changed in recent years, transboundary issues are not new to the Arab region. Disputes over resources such as water and land have been a source of local and regional conflict for centuries. The term transboundary refers to the movement of physical and biological resources, or of impacts associated with these resources, across political borders. With almost fifty shared borders among Arab and non-Arab countries, the potential for transboundary movements and impacts is high. To complicate matters, some of these countries have not agreed on the demarcated boundary lines of their land and marine borders.

The most pressing transboundary environmental issue in the Arab region is shared water resources. The major shared water basins in the region include the Jordan River, Nile River and the Tigris-Euphrates. Increased demands for water have been driven largely by the explosive growth in population in the Arab region and increases in food production; in 1980, the population of the Arab region was 172 million—by 2015, the population is expected to reach 385 million. Other factors such as improved living standards and climate change exacerbate the water scarcity in the region. In this semi-arid to arid environment, water requirements are met mostly by groundwater, the majority of which are mined from non-renewable aquifers. The annual extraction of groundwater is far in excess of natural replenishment; continued exploitation of the major aquifer systems (Nubian Sandstone, North Western Sahara, Saq Aquifer, and Qa Disi Aquifer) has important transboundary implications as the groundwater basins underlie multiple countries.

Though some countries in the region have invested in developing alternative water sources such as desalination and reclaimed wastewater, they are not sufficient to meet expected demand. Nations without the means to invest in these alternative water sources are especially vulnerable to depleting groundwater resources, and the conservation of these water resources is vital to their economic and social well-being.

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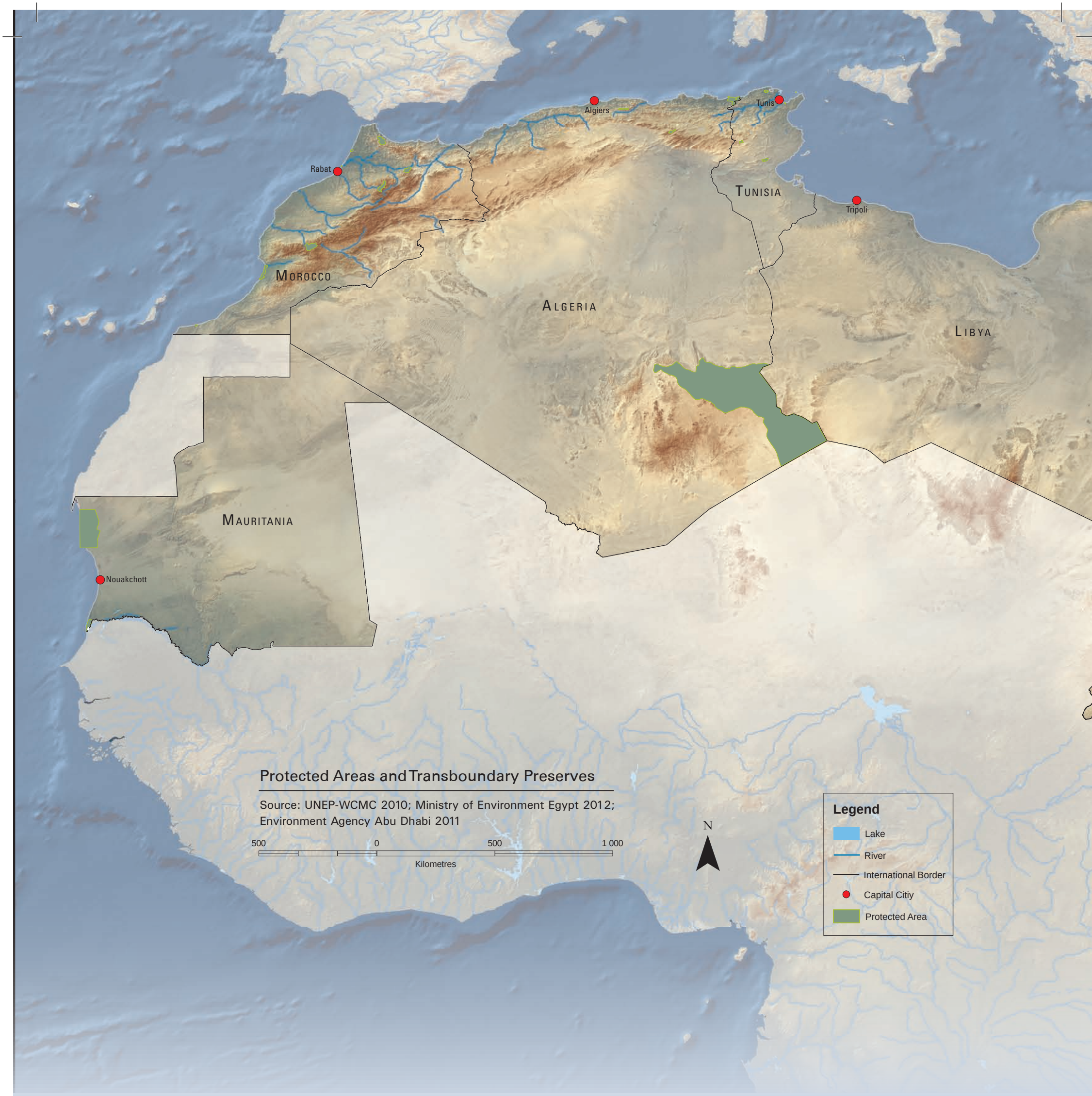

Organizations such as UNESCO have launched programs such as the Internationally Shared (Transboundary) Aquifer Resources Management Project (2000) in order to improve existing knowledge on aquifer systems and formulate common principles for transboundary management of aquifers. Improved data and knowledge about these shared resources will provide governments in the Arab region with the ability to develop common strategies for the sustainable use of this resource. Though water shortages are the driving force for security concerns in the region, other transboundary issues are considered in this chapter and include: deteriorating water quality, coastal and marine pollution, air pollution, human migration due to land and water degradations and scarcity, desertification, environmental deteriorations and associated conflicts. Increased desertification and land degradation in the Arab region places already limited arable lands in the region at further risk (only 14.5 per cent of the total land area is arable and only 29 per cent of this land is cultivated), which transfers across borders in the form of food insecurity and human migration.

Human migration in response to environmental degradation or conflict puts

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added pressure on the receiving community or country. Foremost among these populations are the Palestinian refugees from 1948 and 1967, Gulf War returnees from Kuwait in 1991, refugees from Lebanon's civil war, and more recently, from Iraq. The League of Arab States recognizes that a unified approach to many of the scarcity and security issues is needed; during the recent 22nd League of Arab States Summit (March 2010), countries reiterated their commitment to protecting pan-Arab national security and adopting active policies for addressing climate change and preserving the environment. A unified approach to addressing resources scarcity and environmental deteriorations is crucial as they can lead to economic decline, decreased agricultural production, movements of people across borders, and threaten the security and sovereignty of a nation. Though these conditions can lead to conflict, they also provide opportunities among countries for cooperation and management. Recognition of the need for instituting formal agreements and developing an integrated approach to natural resources sustainable use and management among Arab governments is the first step toward addressing transboundary environmental challenges.

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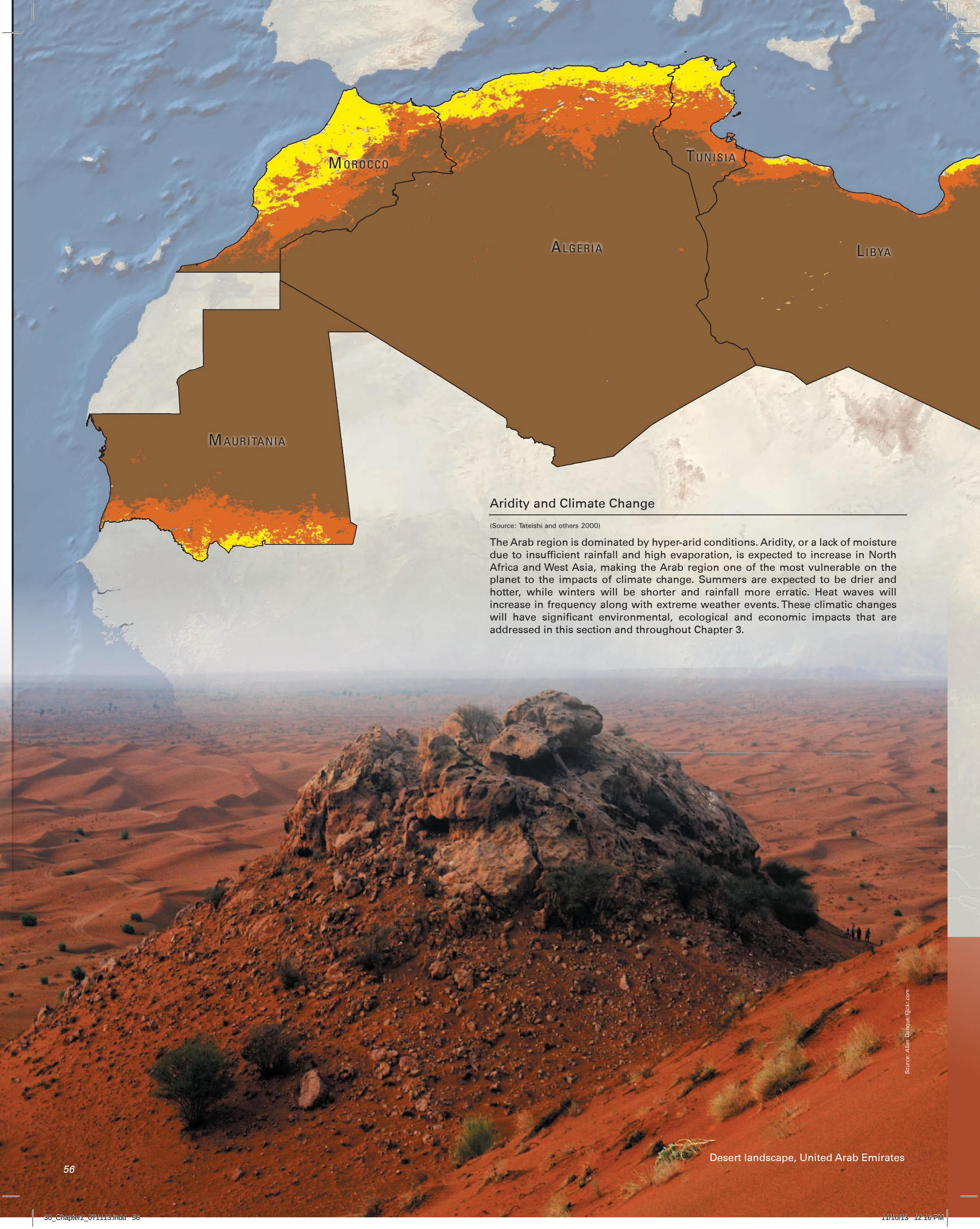

Aridity and Climate Change

(Source: Tateishi and others 2000)

The Arab region is dominated by hyper-arid conditions. Aridity, or a lack of moisture due to insufficient rainfall and high evaporation, is expected to increase in North Africa and West Asia, making the Arab region one of the most vulnerable on the planet to the impacts of climate change. Summers are expected to be drier and hotter, while winters will be shorter and rainfall more erratic. Heat waves will increase in frequency along with extreme weather events. These climatic changes will have significant environmental, ecological and economic impacts that are addressed in this section and throughout Chapter 3.

Source: Allan Donque/Flickr.com

Desert landscape, United Arab Emirates

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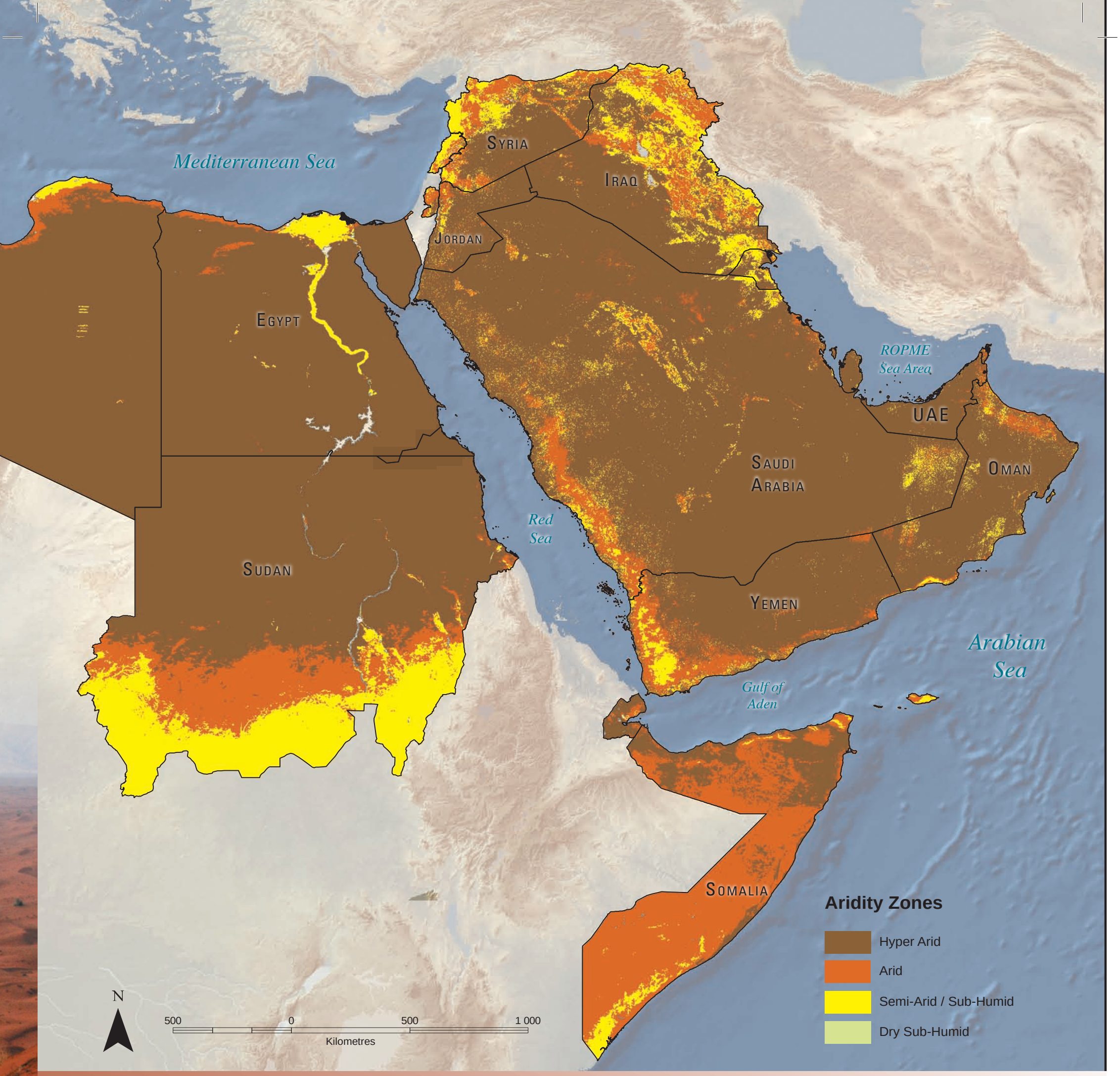

2.1 Global Challenges

Climate Change

> ...today, climate change is already responsible for forcing some fifty million additional people to go hungry and driving over ten million additional people into extreme poverty (Global Humanitarian Forum 2009)

The ramifications of climate change on the Arab region will be severe given the region's already arid climate and scarce water resources. The major impacts of climate change on Arab countries will be rising temperatures, lowered precipitation and sea-level rise. Global temperatures rose during the 20th century by 0.74°C and surface temperatures are projected to increase an additional 1.4 to 5.8°C by 2100 (IPCC 2007). Temperatures in the Arab region are expected to face an increase of 2.0 to 4.4°C by the end of this century. Higher temperatures will exacerbate desertification, increase the incidence and intensity of droughts, heat waves and forest fires, and increase weather variability, causing extreme weather events. Higher temperatures will also increase water scarcity in the region, with per capita water availability predicted to fall by half by 2050, causing acute water shortages.

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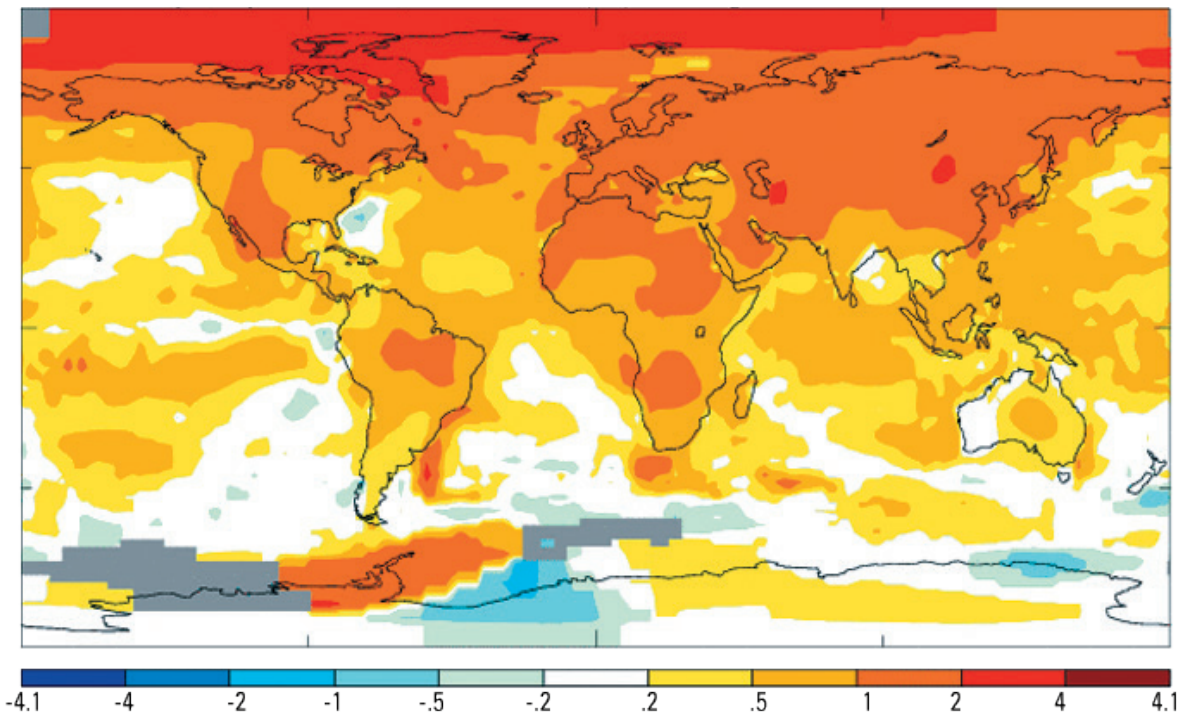
The region's biodiversity is expected to be another casualty of global warming—a 2°C increase in temperature could cause up to 40 per cent of all species in Arab countries to become extinct (AFED 2009). Natural ecosystems especially at risk due to climate change include the coastal mountain ranges of the Red Sea, the cedar forests of Lebanon and Syria, mangroves in the ROPME Sea Area, reed marshes in Iraq, the mountain ranges in Yemen and Oman and all the major river systems (AFED 2009). These areas provide niche habitats and contain unique species assemblages that are restricted in scope and are already at the margin of their ecological tolerances. Rainfall patterns are also predicted to shift with global climate change with a projected decrease in the Arab region of between 0 and 20 per cent. Reduced rainfall coupled with higher temperatures may decrease water flows in the Euphrates and Jordan rivers by 30 and 80 per cent, respectively, by the end of this century (IPCC 2007) - the Fertile Crescent lands (Iraq, Syria, Lebanon, Jordan and the Occupied Palestinian Territories), which depend upon these vital surface waters, will lose fertility due to lack of water and soil erosion. Most of the Arab region's freshwater resources are used for irrigation - lowered precipitation and higher temperatures will exacerbate the pressures on food and animal production in the region.

Higher temperatures will also cause sea level rise of between 0.5 to 4 m, resulting in huge losses in coastal zones that support many of the population centres, agricultural areas and economic centres. A one metre sea level rise could cause the loss of 12 to 15 per cent of agricultural lands in the Nile Delta region alone, and reduce agricultural productivity of the entire Arab region by 20 per cent. The most serious impacts of sea level rise are expected in Egypt, Tunisia, Morocco, Djibouti, Algeria, Kuwait, Qatar, Bahrain and the UAE - even at the optimistic low sea level rise scenario of 0.5 m, low-lying areas will be inundated and inhabitants in cities such as Alexandria, Egypt will be displaced. Djibouti's population is already regularly buffeted by tropical storms from the Indian Ocean, which are expected to increase in frequency and intensity. With 7 per cent of the population living less than 5 m above sea level, Djibouti will be increasingly vulnerable to inland flooding. Qatar, on the ROPME Sea Area, is also extremely vulnerable to rises in sea level, with 18 per cent of its land area and 14 per cent of its population less than 5 m above sea level. Similarly, 10 per cent of Bahrain, or 74 km^2 of the small 741 km^2 island nation may be inundated (Al-Jeneid and others 2007).

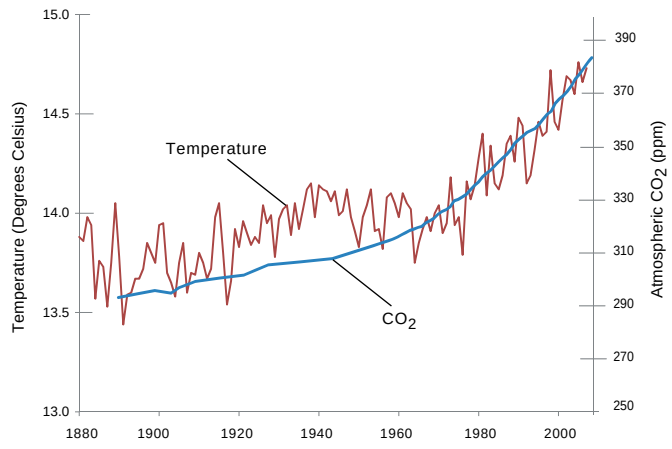
Climate change will increase competition for many resources within and across borders, and cause displacement of populations, increasing the risk of conflict in the region. Though most Arab nations have ratified relevant conventions and signed significant protocols on climate change, urgent measures need to be implemented that include information acquisition, public awareness, and defining impacts that can be developed into effective policies (AFED 2009). Increasing the Arab region's preparedness through activation of the United Nations Framework Convention on Climate Change (UNFCCC) 'Adaptation Fund' is one of several approaches that governments are taking, using funds to implement adaptation projects and programs. Yemen is implementing the Pilot Program for Climate Resilience (PPCR) as part of a World Bank program to fund developing countries to prepare national-level strategic programs for climate resilience and build capacity for implementing them.

Examples of extreme weather conditions related to climate change: forest fires in Lebanon and flooding in Oman.

Annual Change (degrees Celsius) 1970-2009



Map sources and parameters: NASA GISS 2007; GHCN_GISS_HR2SST_1200km_Trnd1212_1970_2009



Average Global Temperature and Atmospheric Carbon Dioxide Concentrations, 1880-2007. The relationship between global temperature and atmospheric carbon dioxide concentrations since the beginning of the Industrial Revolution in 1880 until 2007. As CO_2 levels rise, temperatures also increase. The accumulation of CO_2 and other Green House Gases (GHG) contribute to global warming.

Source: NASA GISS 2007; NOAA/ESRL 2010

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In 2007, the Council of Arab Ministers Responsible for the Environment adopted the Arab Ministerial Declaration on Climate Change in recognition of the region's vulnerability and need to include climate issues in all sectors of sustainable development policy as well as adopt national and regional climate action plans (Hamid 2009). The region's most urgent issue is water management and the need to improve efficiency and implement sustainable practices—water reform that is planned as part of a more holistic set of economic changes that include agriculture, industrial development, tourism, accountability and public finance, will be more effective (World Bank 2007). The mitigation measures and adaptation that will be necessary as we collectively face changed conditions on the planet can be turned into opportunities-- managing scarce natural resources, developing renewable energy, managing coastal areas, preventing air and water pollution, and ensuring efficient use of water and energy and sustainable food production. The World Bank, United Nations and regional organizations such as the Arab Forum for Environment and Development (AFED) are developing strategies and approaches for addressing the impacts of climate change on Arab countries and encouraging concrete action, mitigation and adaptation to enhance the region's resilience to climate change.

Small Island Developing States- The Case of the Comoros

More than one-third of the world's population (2.8 thousand million) is physically vulnerable to climate change, and inhabit areas of the world that are prone to floods, storms, droughts and sea-level rise (Maplecroft 2009). Small Island Developing States (SIDS) are among the most vulnerable to climate change—the Comoros Islands, situated between Mozambique and Madagascar in the Indian Ocean, are no exception. In the Comoros, pressures on natural resources are already high and there is limited capacity to adapt to the impacts of changes in climate due to poor land quality, low crop production, low yields, water stress and a growing population. Beaches on the Comoros Islands are eroding due to increased wave intensity and abnormal tidal ranges (UNEP 2005a). A 1 m rise in sea-level in the Comoros would cause 7.34 km^2 of low-lying coastal areas to be flooded (UNFCCC 2002). Sea-level rise will also result in migration and displacement of inhabitants along the coastal zones (home to over 40 per cent of the country's population), loss of livelihoods, increased water-related diseases, and loss of coastal lands, agricultural areas, groundwater resources (due to seawater intrusion into groundwater systems) and biodiversity (UNFCCC 2005).

Source: Islas Comores/Flickr.com

Source: UNEP/GRID and others 2000

Impact of sea level rise in the Nile Delta, Egypt

The Nile Delta is formed where the Nile River empties into the eastern Mediterranean Sea. It is the most important agricultural region of Egypt and is also one of the most densely populated places on Earth, with 50 million people and a density of 1 545 inhabitants per square kilometre. The delta's 270 km-long coastline lies only 0 to 1 m above sea-level in places and is lined with lagoons and sand belts. The 1 to 10 km-wide coastal sand belts, shaped by discharge of the Rosetta and Damietta branches of the Nile, are eroding and will be further compromised by sea-level rise. These belts provide essential protection of lagoons and low-lying reclaimed lands. Rising sea-levels will inundate large areas of valuable agricultural lands in the delta—a sea-level rise of 0.5 m will inundate the coastal cities of Alexandria, Damietta and Port Said, and a rise of only a few metres will threaten El Mansura, El Mahalla el Kubra, Damanhur, Tanta, Kafr el-Sheikh, Shirbin, Burg el Arab and El Qantara Shark. Important industry and shipping facilities in the delta will also be threatened. Sea-level rise will also impact water quality and affect fisheries in the lagoons, which comprise one-third of Egypt's fish catches. Groundwater salination and impacts to recreational tourism along Egypt's coasts are also expected. These maps show areas of the Nile Delta that would be inundated under different sea-level rise scenarios (0.5 and 1.0 m) and the effects.

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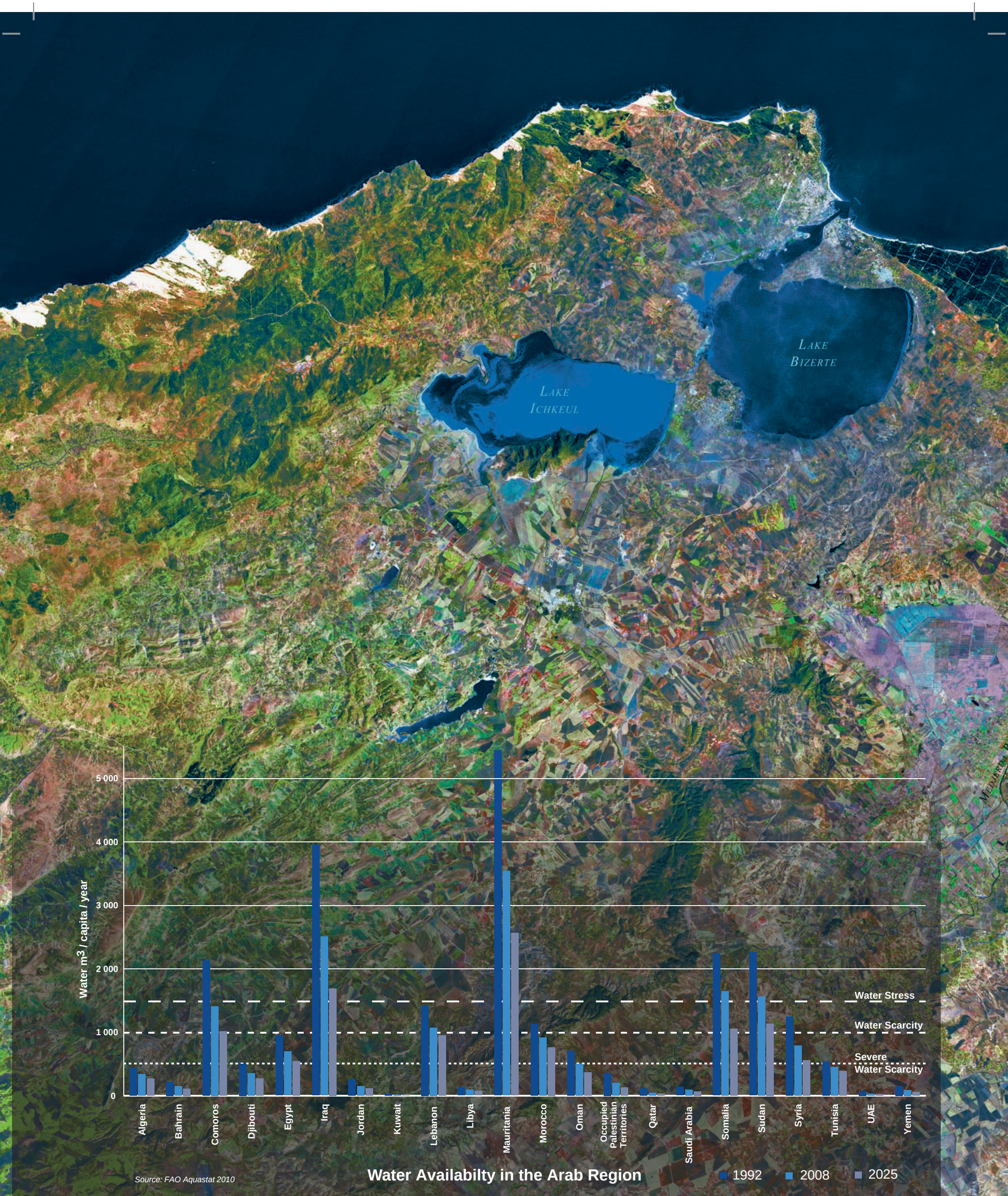

Source: FAO Aquastat 2010

Water Availabilty in the Arab Region

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2.2 Water

Water Resources and Pollution

The Arab region is one of the most water scarce regions of the world; of the 22 Arab League nations, 8 have the lowest water availability per capita in the world. The water availability graph below shows the extent of water stress and water scarcity in the region; for all countries, the amount of available water per capita is decreasing. By 2025, Mauritania and Iraq will be the only countries in the Arab region that are not water stressed or water scarce. Water scarcity in the region is exacerbated by high water demand; the water-poor GCC countries have some of the higher per capita water use in the world. Access to shared freshwater resources has historically been a source of conflict in the region but has also provided opportunities for cooperation.

Source: Landsat TM Mosaic

This vivid Landsat satellite image, derived from data collected over several months in 2001, uses a collection of approximately 7 461 high-quality images to create a seamless mosaic that centres on the North African country of Tunisia. The image focuses specifically on Tunisia's northern coastal plains along the Mediterranean Sea and the country's capital city of Tunis. This data set was derived from a NASA remote-sensing device. Surface observations were collected and combined every eight days (to compensate for clouds that can block the sensor's view) to produce a high-resolution image of the Earth's surface. This image displays extensive agricultural lands in the northern valleys around Lake Ichkeul and Lake Bizerte and around Tunis (shown in different shades of green), where the Medjerda River flows out of the Atlas Mountains. Northern Tunisia and the Medjerda River Basin produce almost all of the country's agriculture, which is dominated by livestock, trees (olive, almond, and fig), vegetables and cereals; this region is experiencing an intensification of agriculture and the amount of irrigated area is increasing rapidly (Bouraoui and others 2005). The Medjerda River, a vital water source for the entire country, is being contaminated with industrial and agricultural pollutants as well as heavy metals and arsenic from mining activities in northwest Tunisia and mining districts in Algeria (Jdid and others 1999). Lake Ichkeul, a freshwater lake that provides important habitat for many migrating birds, is threatened by dams on rivers that feed the lake, increased salinity and agricultural encroachment of its marshlands.

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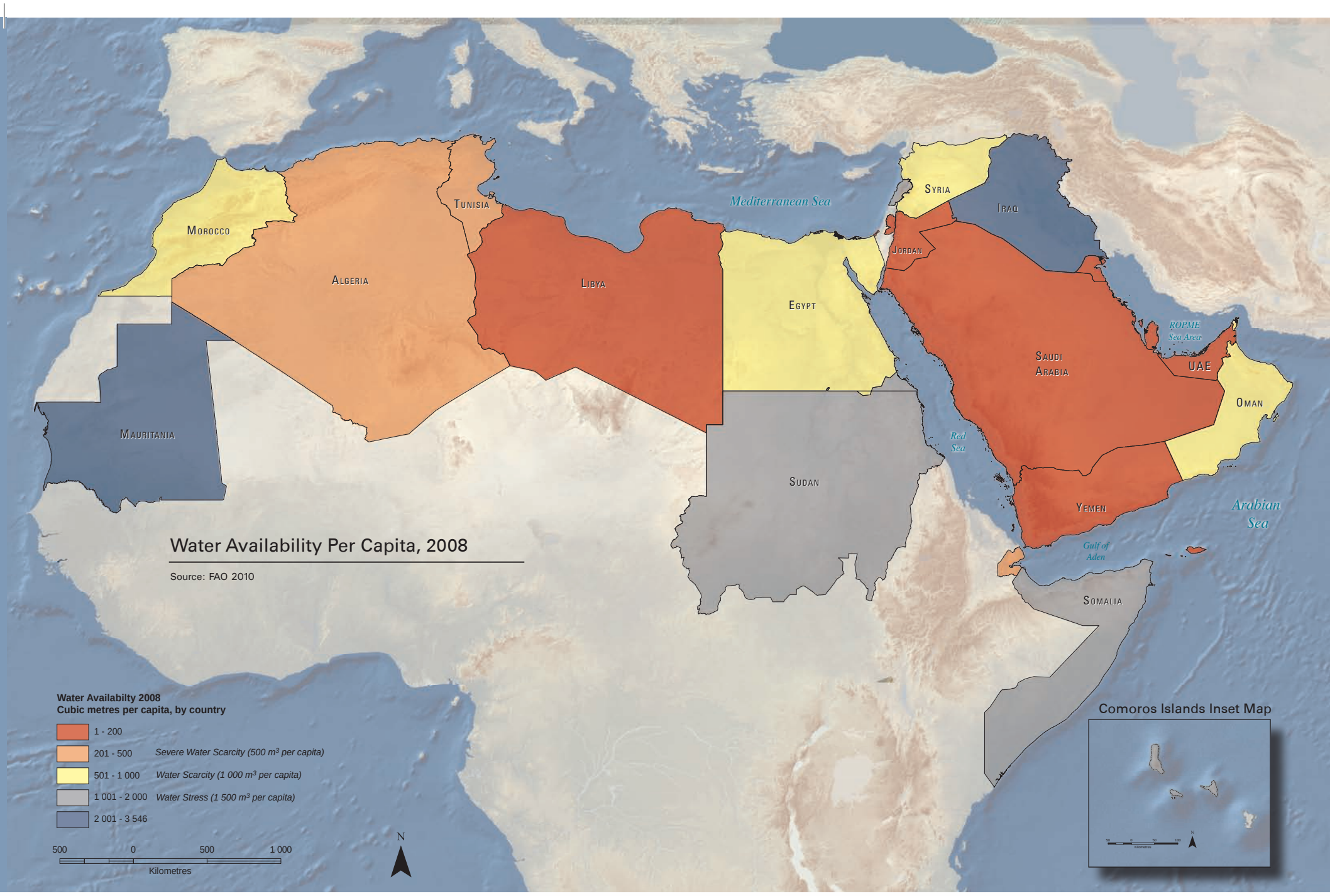

Water Resources

The Arab region encompasses six major river basins that originate outside of the region; the Jordan, Nile, Euphrates and Tigris, Juba-Shebeli, Senegal and the Asi-Orontes. The overall water resources of these rivers constitute about 66 per cent of the total freshwater resources in the Arab region (ACSAD 2008)—the dependency ratio of renewable freshwater originating from outside Syria, Mauritania, Iraq and Egypt is above 70 per cent (UNEP/GRID 2009). (The dependency ratio is a good indicator of where tension and conflict over water-sharing and use can occur; generally, the higher the dependency ratio, the higher the potential for conflict.) Syria, Iraq and Egypt, which are the main agricultural producers in the Arab region, depend heavily on waters from the Euphrates, Tigris and Nile rivers. In Syria, the major irrigated areas are located within the shared river basins of the Asi-Orontes, Euphrates and Nahr el Kabir Janoubi. Any future conflict that interrupts the free flow of these rivers could severely undermine the livelihood of farmers as well as the economic stability of these countries.

The five river basins that are shared among Arab countries include: the Asi-Orontes, Nahr El Kabir Janoubi, Yarmouk (a tributary of the Jordan), Jordan and Medjerda rivers (Tunisia). A majority (82 per cent) of total surface water resources in the Arab region are shared (ACSAD 2008). With respect to groundwater, almost all the major aquifers are shared between the Arab countries and with neighbouring countries. The major aquifers in the region are displayed in the following pages. The sharing of water resources is further complicated by regional disputes, contested borders and land occupation. Foremost among these is the Israeli/Palestinian dispute over West Bank aquifers, and the Syrian/Israeli conflict over the Golan Heights (Israel withdraws about 30 per cent of its water needs from the Golan Heights). Another threat to shared water resources is the overall deterioration in water quality due to lack of adequate sanitation systems and treatment plants, which constitute a threat to human health—almost all the rivers in the region are used as sewage systems without adequate treatment.

Growing water scarcity and the heavy reliance of Arab countries on surface water that originates outside the region, coupled with the lack of treaties for almost all the river basins and groundwater aquifers, presents a significant social, economic and environmental threat to the region. There is a pressing need to finalize treaties and implement integrated approaches to water resources management and planning. Transboundary water disputes are extremely complex and involve issues of sovereignty, individual and collective rights, economic growth and power. Consequently, transboundary water resources management requires an enabling environment that encourages cooperation between affected nations rather than entering into conflict. Strengthening integrated water resources management and improving water governance at the national level would facilitate more effective and efficient water resources management.

In 1995, the former World Bank Vice President Ismail Serageldin claimed

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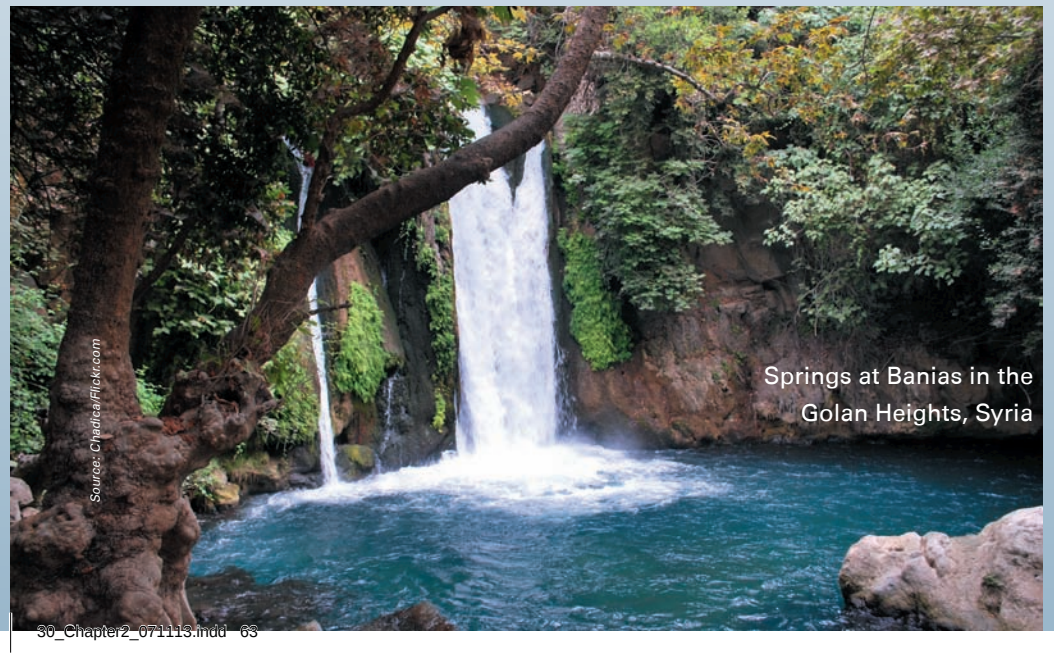
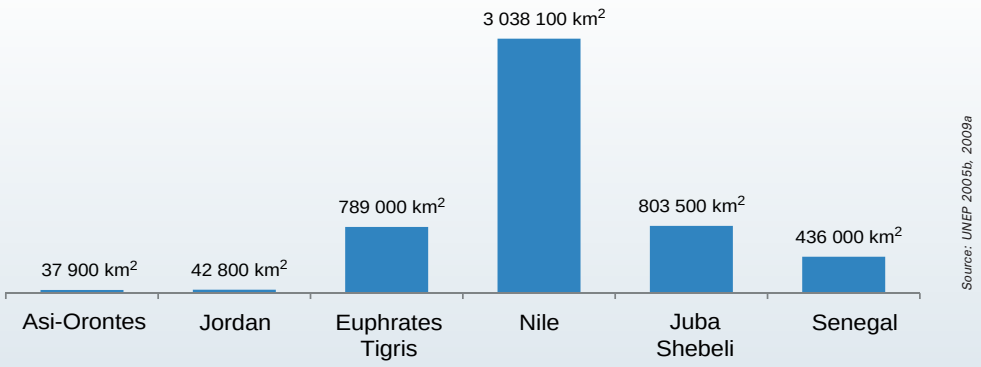
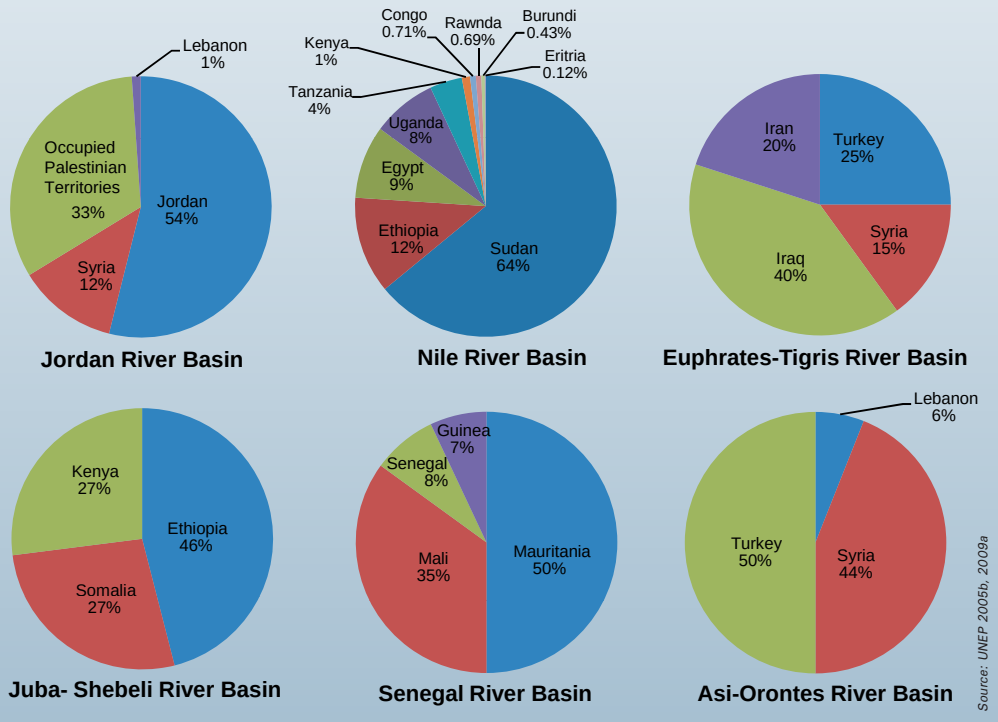
that "the wars of the next century will be about water". Though there are cases where conflicts have arisen over water resources, the need for cooperation among riparian nations to jointly manage their shared water resources provides an opportunity to build trust and prevent conflict. In fact, a 2003 study found that of the international water incidences in transboundary basins, a majority favoured cooperation (1 228), while 507 resulted in conflict (Wolf and others 2003). Within nations, the potential for conflict by water users can also arise—nowhere is this more apparent than in Yemen, where recent clashes over water shortages have resulted in a number of deaths. Seventy to eighty per cent of rural conflicts in Yemen are attributed to water and less than half of the rural population has access to an adequate supply of water (Kasinof 2009). With limited rainfall, quickly depleting underground water supplies, continued drought and inefficient agricultural practices, the civil unrest associated with water shortages can be expected to continue in Yemen.



Springs at Banias in the Golan Heights, Syria



Comparison of total area (sq. km) of the six major river basins in the Arab region



Percentage of river basin area within countries for the six major river basins in the Arab region. Significant area of the river basins originate outside of Arab countries.

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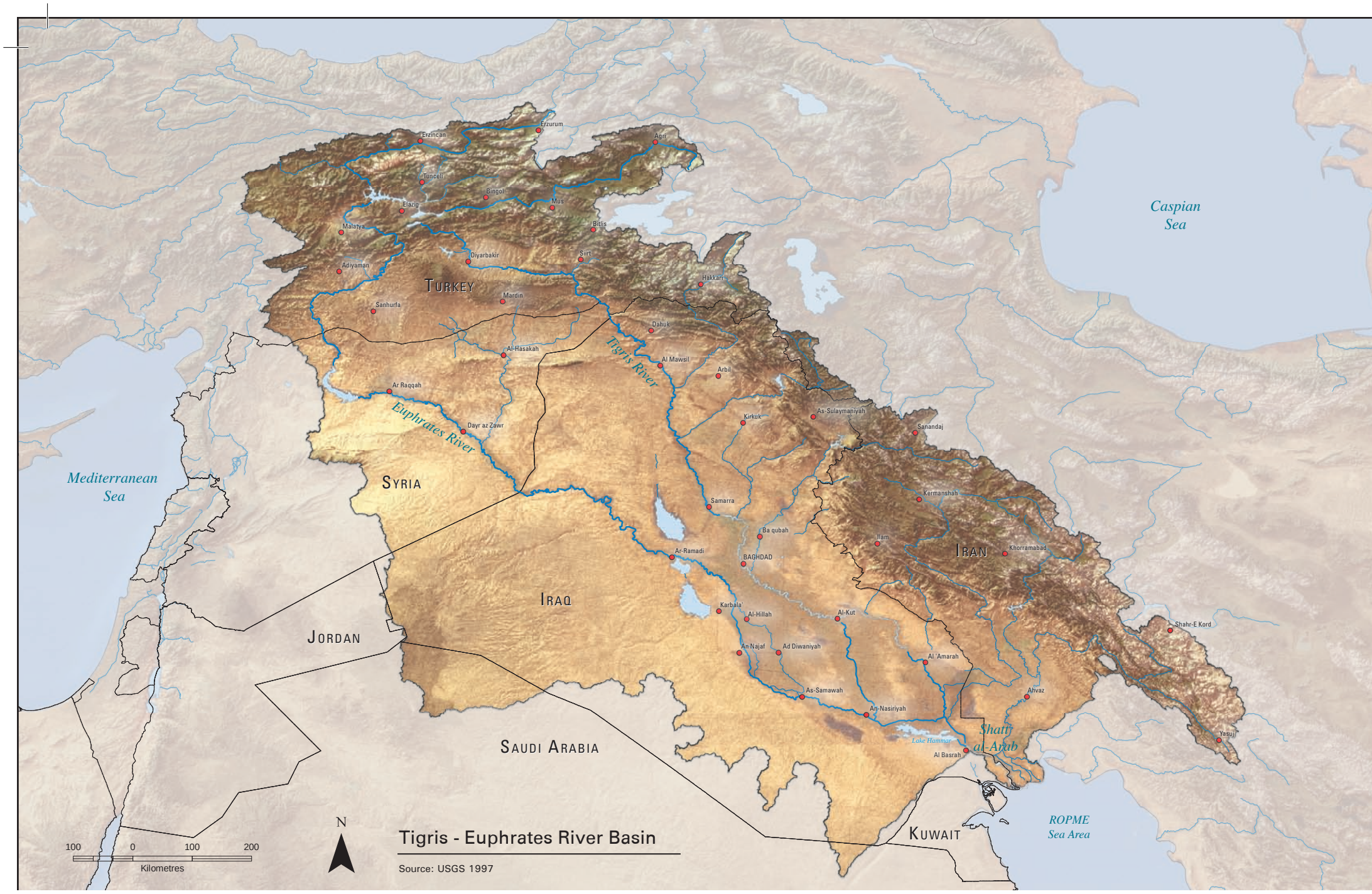

Tigris - Euphrates River Basin

Source: USGS 1997

Euphrates River Basin

With a length of 2 700 km, the Euphrates River is the longest river in southwest Asia, running through Turkey, Syria and Iraq. Turkey contributes almost 98 per cent of the water carried by the Euphrates River. The two Syrian tributaries, the Khabur and the Balikh, also have their catchments in Turkey. The average annual flow across the Turkish-Syrian border is about 29.8 BCM (UNEP 2009a). No other tributaries flow into the Euphrates after the Khabur, except in Iraq, where some of the Tigris' waters are added to the Euphrates. After entering Iraq, the river runs to the city of Hit and travels 753 km to the delta in the ROPME Sea Area. The Euphrates loses a major portion of its waters to irrigation canals and to Lake Hammar (in Iraq). The Euphrates River catchment area covers about 444 000 km^2 (ACSAD-UNEP 2001).

As a major supplier of surface water for Turkey, Syria and Iraq, the Euphrates River has been a source of continuing conflict among these three countries—the risk of water shortages constitute one of the most strategically important security issues of these nations. Increased damming of the Euphrates for agriculture, hydroelectric power and industrial needs, has significantly reduced the amount of water that flows downstream. Syria and Iraq depend heavily on these waters; Syria obtains approximately 85 per cent of its renewable water supply from the Euphrates-Tigris river systems, while Iraq obtains 100 per cent. Turkey's implementation of the GAP Project, also called the Southeastern Anatolia Project, is the most contentious issue with respect to water-sharing in the basin. The GAP Project is a massive US$32 thousand million hydroelectric and irrigation project that includes the construction of 22 dams and 19 hydroelectric power plants on the Euphrates and Tigris rivers and their tributaries—the scheduled completion has been delayed until 2047. Syria and Iraq are concerned about the substantial reduction in downstream river flows; according to Iraq's Water Resources Ministry, the Ilisu part of the GAP project will reduce the Tigris River waters by 47 per cent per year, depriving the Iraqi city of Mosul of about 50 per cent of its summer water requirements (Daly 2008). Full implementation of the GAP project is expected to withdraw up to 70 per cent of the Euphrates' natural flow. Lack of flow in the Euphrates River will also compromise Syria's ability to irrigate its agricultural lands and produce hydroelectricity (Syria relies on high water levels in Assad Lake to sustain hydroelectric production). The Protocol of 1987 was the first bilateral agreement between Turkey and Syria. In the agreement, Turkey committed to releasing a yearly average base flow of approximately 16 BCM over the Syrian border. Syria and Iraq reached a water-sharing agreement soon thereafter in which 58 per cent of the waters were allocated to Iraq and 42 per cent to Syria. In several instances, Turkey has limited these flows of water, bringing Syria and Turkey to the brink of war. Water quality was not considered in the bilateral agreements, and has become a major concern for Syria and Iraq. Water salinity is increasing, especially along the Syrian-Iraqi border, where it exceeds 1.0 g/l, due largely to irrigation waters. Pollution from upstream pesticide and fertilizer use is also compromising the water quality in the basin (Guner 1997).

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Source: Shay Haas/Flickr.com

Euphrates River

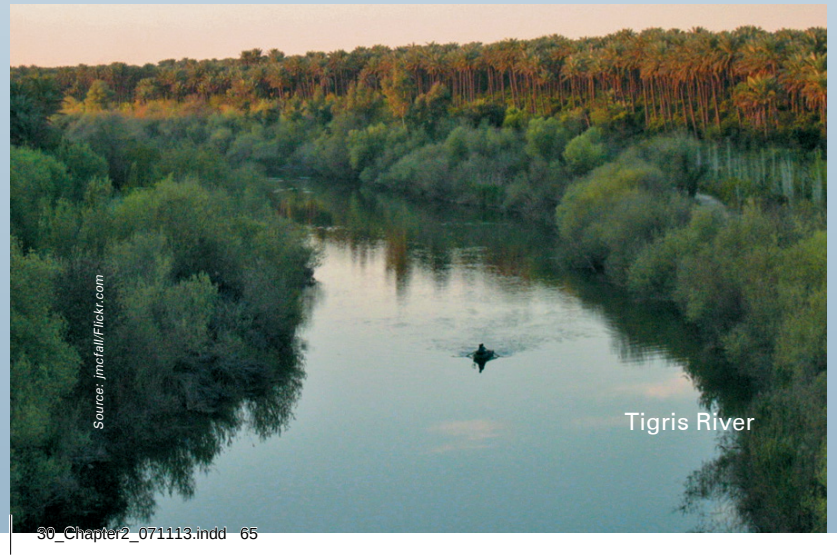
Climate change has emerged as an increasingly challenging threat to water availability in the river basin. Expected global climate change scenarios indicate that catchment areas in Turkey will face a reduction in precipitation of about 20 per cent, an increase in temperature and an increase in evaporation rates (IPCC 2007). These changes will have numerous adverse impacts, particularly on agriculture and water management in the basin.

Tigris River Basin

The Tigris River originates in southeastern Turkey only about 30 km from the headwaters of the Euphrates. The river drains an area of 471 606 km^2 that is shared by four countries (Turkey, Syria, Iraq and Iran). The Tigris flows for 523 km through Turkey before it enters Syria for 44 km, forming the northeastern part of the border between Syria and Turkey, and then flows for 1 418 km in Iraq. The Tigris has four main tributaries: the Upper Zab, which originates in Turkey; the Lower Zab, which originates in Iran; the Diyala, which flows from Iran and Iraq; and Adhaim, which also originates in Iraq. The Adhaim joins the Tigris River about 80 km north of Baghdad, while the Diyala River meets the main stem in Baghdad. The Upper and Lower Zab join the main stem of the river south of Mosul in Iraq (ACSAD-UNEP 2001). The discharge of the Upper and Lower Zab tributaries make up about 50 per cent of the discharge of the Tigris at Baghdad (Beaumont 1998). The majority of the total catchment area of the Tigris River occurs in Iraq (ACSAD-UNEP 2001). The Tigris joins the Euphrates River in southeastern Iraq, where it forms the Shatt al-Arab (the catchment is about 19 000 km^2, and continues 180 km until it empties into the ROPME Sea Area) (Murakami 1995).

Turkey contributes around 52 per cent of the Tigris' flow, with Iraq contributing 48 per cent and Syria contributing none of the flow (Asit 1994). The period of greatest discharge for the Tigris system is from March through May—minimum flow conditions are experienced from August through October. Flow is also variable from year to year. Some of the waters of the Tigris River have been diverted to the Euphrates River through an artificial canal, El Tharthar, and the irregular water flow from the tributaries makes the Tigris a very unstable and unreliable river in terms of annual flow and floods (Kor 1997).

The Tigris has been heavily dammed by Iraq; one of the larger operational dams is the Mosul Dam, which is used in hydropower production, irrigation and flood control. Turkey plans to build extensive hydroelectric projects along the river, as described under the Euphrates River section. The government of Syria is currently evaluating water supply projects. A recent agreement has been signed by Syria and Turkey (and supported by Iraq) that permits Syria to irrigate about 150 000 ha by pumping about 50 m^3 per second from the Tigris River. No agreements have been reached, to date, with Iran for sharing waters that originate in the Lower Zab tributary. With most of the water extracted from the Tigris River being used for irrigation, there is a potentially serious problem with regard to the quality of the irrigation return waters. In general, about 20 per cent of the water that is applied for use in irrigation, drains off the fields and makes its way into adjacent water courses or percolates into the groundwater. These waters carry a variety of chemicals, including pesticides, herbicides and petroleum products.


Source: jmcfall/Flickr.com

Tigris River

Source: Shay Haas/Flickr.com

Euphrates River

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Nile River Basin

The Nile River is the longest river in the world with a length of 6 850 km and a catchment area of 3 007 000 km^2, which covers approximately 10 per cent of the African continent. The water of the Nile comes principally from two sources: the Equatorial Plateau and the Ethiopian Highlands, both of which receive large amounts of rain. The Nile River Basin is shared by ten riparian countries and consists of two sub-basins: the White Nile and the Blue Nile, which converge in Sudan and feed into Egypt as a single river. Almost 200 km before discharging into the Mediterranean Sea, the river bifurcates and its branches encompass the Nile Delta, where the majority of Egypt's population and agricultural lands are located (see the Egypt section in Chapter 3).

Egypt and Sudan are extremely dependent upon waters from the Nile and have the highest dependency ratios of all Nile Basin countries, at 97 per cent and 77 per cent respectively. Given that most of their water resources originate outside of their borders, Egypt and Sudan are extremely vulnerable to any upstream changes in water management and use. The Nile provides the basis of agricultural development for Egypt and northern Sudan, as such, the Nile River is integral to those populations' livelihoods and food security. Egypt's construction of the Aswan High Dam, completed in 1970, impounded a reservoir, Lake Nasser, which has a gross capacity of 169 BCM and yields waters for irrigation and power generation. The dam also impounds floodwaters to the Nile Delta, which has resulted in the gradual decrease in the fertility of these agricultural lands. To compensate, Egypt applies an estimated 1 million tons of artificial fertilizers to substitute for the 40 million tons of silt that were formerly deposited annually by the enriching floodwaters of the Nile. Other impacts to water quality in the Nile are discussed in Chapter 3 and include increased salinity downstream and heavy inputs of untreated wastewater and industrial wastes (Brown and others 2003).

Basin-wide cooperation among the riparian countries began in the 1950s. A 1959 treaty between Egypt and Sudan secured 55.5 BCM of water per year for Egypt (at the Sudanese border), and 18 BCM per year for Sudan, along with 10 BCM annually for seepage and evaporation. Cooperation among riparian countries is crucial as the region faces continued drought, growing populations, desertification and land degradation, pollution increases, and the effects of climate change. These factors will intensify the reliance and competition for the Nile's resources. The Nile Basin Initiative (NBI) was established in 1999 by the ten riparian countries to achieve sustainable socio-economic development through the equitable utilization of the Nile Basin waters—many cooperative projects have been undertaken in the past 20 years in recognition of the need to adequately and efficiently manage the water resources of the Nile River.

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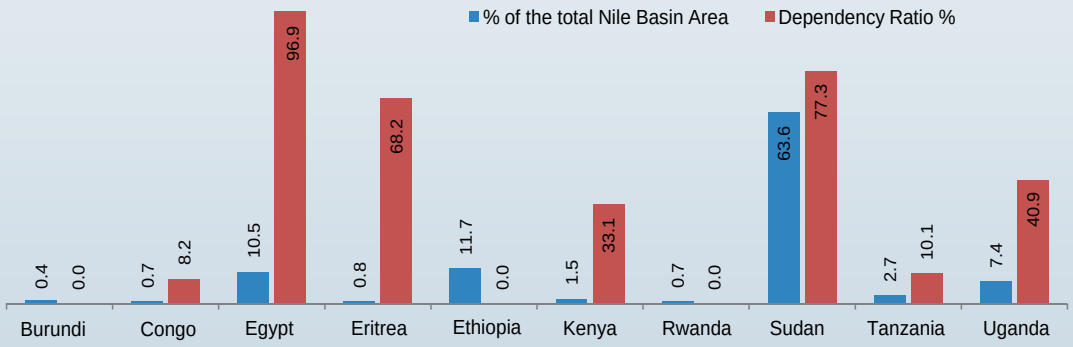
Asi-Orontes River Basin

The Asi-Orontes River Basin is shared among Lebanon, Syria and Turkey and covers approximately 37 900 km^2 (Wolf and others 1999) of which 6 per cent is in Lebanon, 44 per cent is in Syria and 50 per cent is in Turkey (UNEP 2009a). The Orontes River originates in Lebanon, and then courses through Syria from south to north and then into Turkey where its empties into the Mediterranean Sea. The Orontes River and its tributaries collect runoff from the highlands and plateaus located on both sides of the rift valley. The average annual flow is estimated at 2 400 MCM, equivalent to about 80 m^3/s with a minimum and maximum discharge of 10 and 400 m^3/s respectively (FAO 2006a).

A 1994 bilateral treaty between Lebanon and Syria allocates water use and provides for the construction of a dam on the Orontes in Lebanon that allocates 80 MCM to Lebanon (provided the flow of the river does not drop below 400 MCM) to irrigate 6 600 ha. If the water flow drops below 400 MCM, the Lebanese share is reduced by 20 per cent; essentially the risk of drought is borne by Lebanon (ESCWA 2001). Water quality is managed by a joint technical committee. On the lower parts of the river, concentrations of ammonia, suspended solids and biological oxygen demand (BOD) exceed allowable limits, likely due to heavy inputs of chemical fertilizers and insecticides as well as solid waste. An agreement between Syria and Turkey was finalized in 2001 to cooperate on technical issues and identify joint future projects. Recently, the two countries agreed to construct a dam to share water and hydropower.



Country Area Percentage of the Nile River Basin and Water Dependency Ratios

Source: FAO 1995 and 1997 in UNEP/GRID 2000

Source: Hovic/Flickr.com

Asi-Orontes River, Syria

Source: Michael Gwyther-Jones/Flickr.com

Nile River, Egypt

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Arab Region Aquifers

Source: UNESCO-IHP and others 2008

Aquifers in the Arab Region

Underground reserves of water are a life-supporting resource for the Arab region, which has little rainfall and limited surface waters. A number of transboundary aquifers underlie the region that provide vital freshwater for agriculture, industry and domestic uses. Globally, aquifers contain almost 96 per cent of the Earth's freshwater. Most of this water is used for irrigation (65 per cent), while 25 per cent supplies drinking water needs and 10 per cent is for industry. In the Arab region, groundwater supplies are relied upon heavily—the GCC countries, as well as the Occupied Palestinian Territories and Jordan rely on groundwater for the bulk of their water needs. To meet growing demands for water, wells continue to be dug and groundwater extracted, depleting these mostly non-renewable resources. The importance of shared water governance to prevent pollution and over-exploitation of aquifers is being recognized in the Arab region, which contains some of the largest transboundary aquifers in the world.

QaDisi Aquifer

The QaDisi Aquifer is a large aquifer underlying southern Jordan and northern Saudi Arabia. Water from the aquifer is abstracted by both countries; however, Saudi Arabia uses substantially more water (650 MCM per year), mostly for irrigation purposes. Jordan abstracts approximately 75 MCM per year for irrigation and to supply the coastal town of Aqaba. Plans to convey groundwater to Jordan's capital of Amman 300 km away have further complicated the relationship between the two countries over use of the fossil water, and sparked fears of a "pumping race" between the countries. The tension over allocations of groundwater from the QaDisi Aquifer is a prime example of the need for bi-lateral cooperation in the region.

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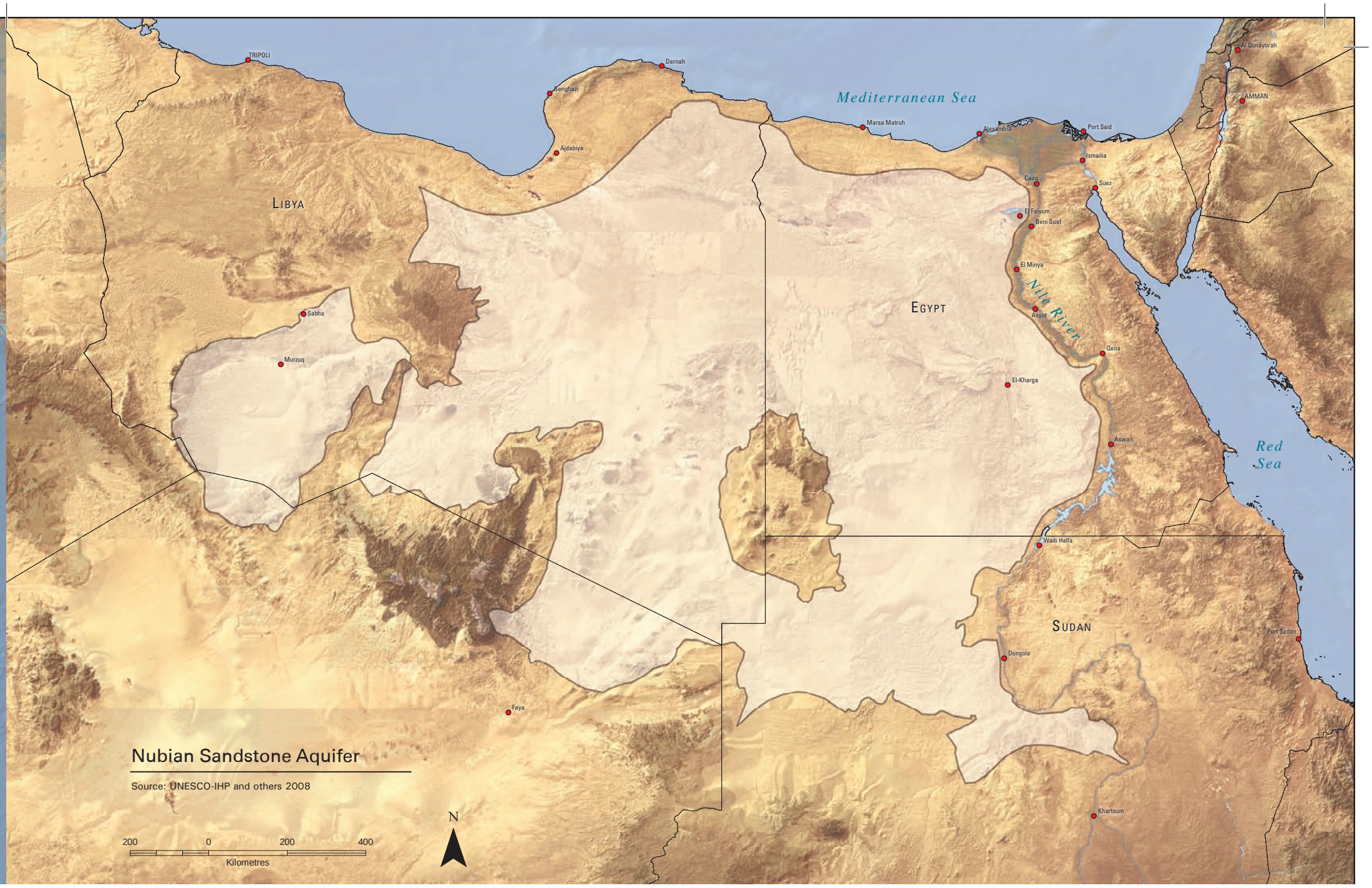
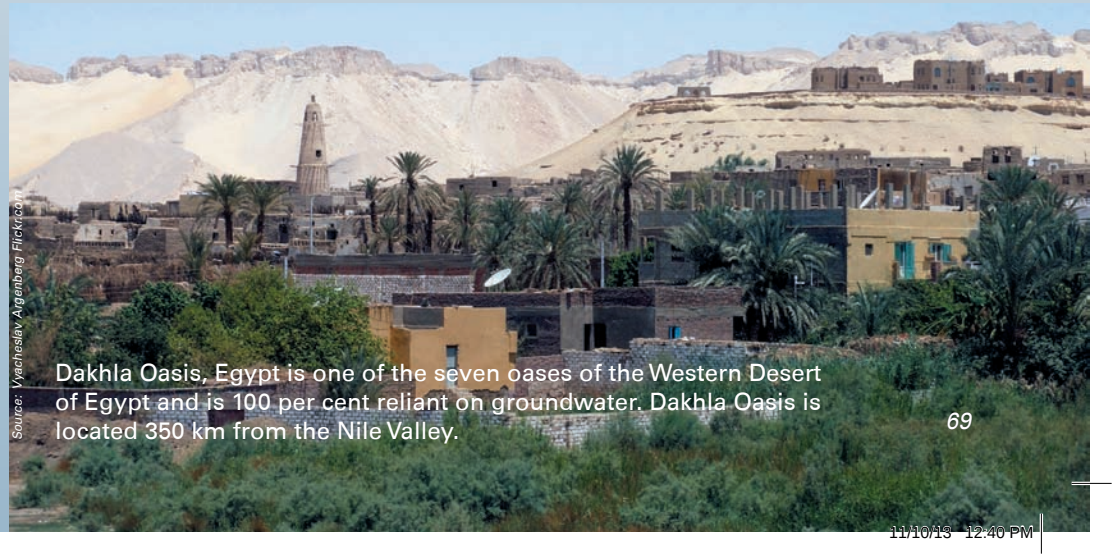


Nubian Sandstone Aquifer

The Nubian Sandstone Aquifer System is a transboundary aquifer that underlies Chad, Egypt, Libya and Sudan. It covers approximately 2.2 million km^2 and contains fossil water that is estimated to be 35 000 years old. The demands on the use of this non-renewable groundwater are considerable and continue to increase with population growth, food demands and economic growth; in some areas, such as the Dakhla Oasis in the Western Desert of Egypt, the aquifer water is the only available water resource. Over-exploitation of the aquifer is occurring at a large scale and continues to increase every year. In the past 40 years, over 40 BCM of water has been extracted from the system in Libya and Egypt. This has produced a maximum drawdown of about 60 m. Most of the groundwater is used for agriculture in Libya and Egypt (UNESCO 2006). To more effectively manage the use of this groundwater over time (the life of the aquifer is estimated to be between 20 and 200 years), it is important to assess the aquifer storage capacity and to calculate the amount of groundwater that can be used by the four sharing countries (UNESCO 2006; CEDARE 2002).

Cooperation among Chad, Egypt, Libya and Sudan began in the 1970s when a regional project was initiated by UNESCO –UNDP to study the aquifer. The most comprehensive project to date was implemented by the Center for Environment and Development for the Arab Region and Europe (CEDARE), whereby a joint committee from the four countries cooperatively supervises the management of the groundwater system. In response to the growing pressures on the Nubian aquifer, the IAEA/UNDP/GEF Nubian Project was launched in July 2006. This project developed a new regional model of the Nubian aquifer to provide a greater understanding of the groundwater system and the transboundary issues and impacts. The model is three-dimensional and treats the entire aquifer system as a single homogenous unit but allows future modification as more data become available. This regional model provides the ability to forecast future scenarios and forms the basis on which shared data collection and decision-making strategies can be devised across the four Nubian countries.

One of the major projects based on the exploitation of this non-renewable aquifer is the Great Man-Made River Project in the southern desert of Libya. It is touted as the largest water project in the world, with more than 4 000 km of pipe to convey over 6 MCM/day or 2 100 million MCM/yr of water for agricultural purposes to meet domestic demands in Libya's coastal cities. Additional information about this massive project is provided in the Libya section of Chapter 3.



Source: Vyacheslav Argenberg Flickr.com

Dakhla Oasis, Egypt is one of the seven oases of the Western Desert of Egypt and is 100 per cent reliant on groundwater. Dakhla Oasis is located 350 km from the Nile Valley.

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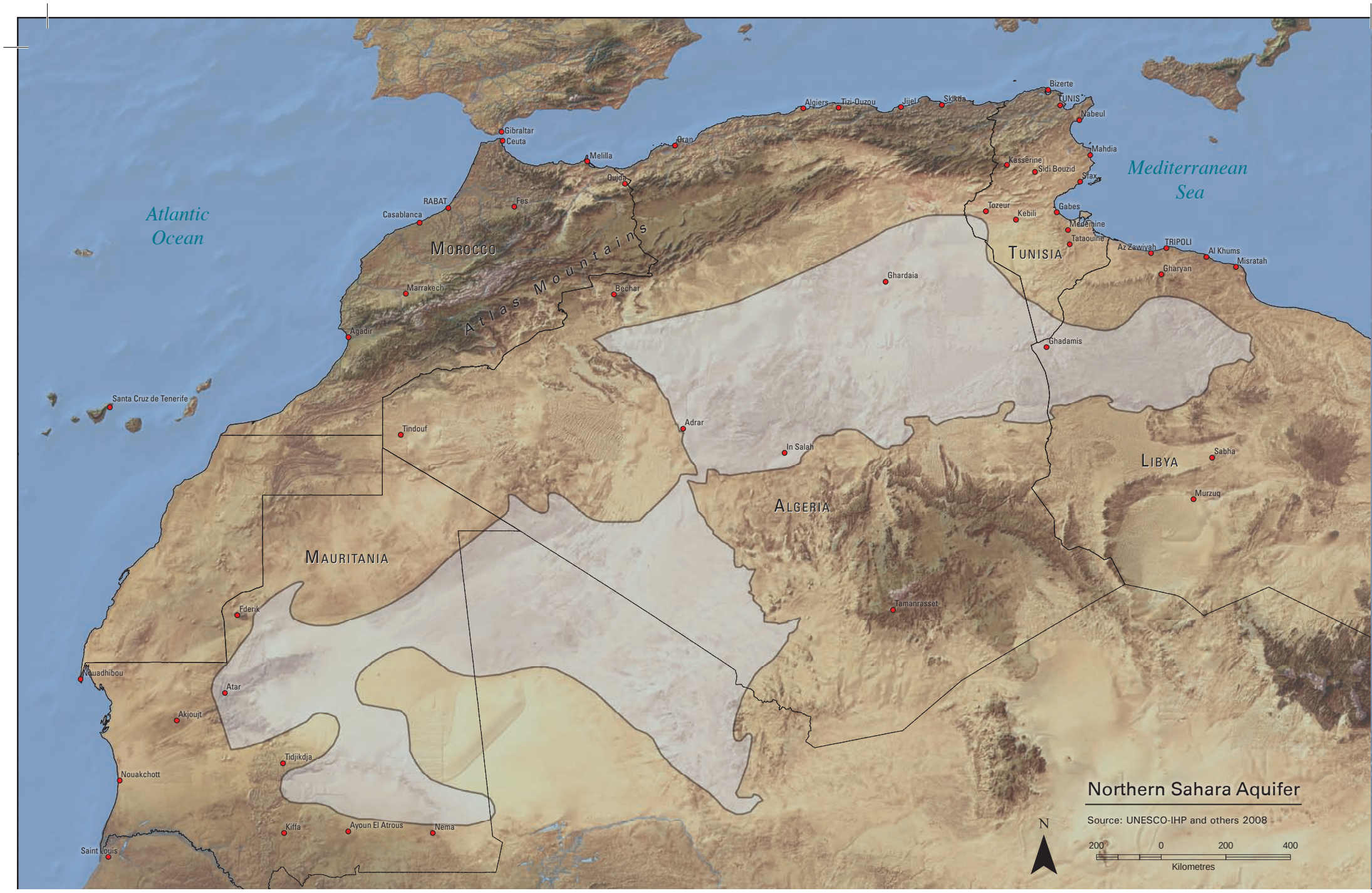

Northern Sahara Aquifer

Source: UNESCO-IHP and others 2008

North Sahara Aquifer System

The Northern Sahara Aquifer System contains a considerable amount of non-renewable water reserves that are shared by Algeria, Libya and Tunisia. The aquifer covers an area of more than one million square kilometres, 69 per cent of which is in Algeria, 23 per cent in Libya and 8 per cent in Tunisia. During the past 50 years, the total annual abstraction rate from the Northern Sahara Aquifer increased from 0.6 MCM to 2.5 BCM. Much of the water use occurs in Algeria with 1.3 BCM per year; Tunisia and Libya abstract 0.55 and 0.33 respectively. Increased reliance on the aquifer to meet growing demands has created a deterioration of the water quality (high salinity), decreased artesian flow, and drying up of wells.

Groundwater mismanagement and overuse, mostly for irrigation purposes, has also led to the deterioration of the fragile oasis ecosystems in the region due to soil salinization and lowered groundwater levels. In 1999, Algeria, Libya and Tunisia began joint studies that were implemented by the Sahara and Sahel Observatory to improve the hydrogeological knowledge of the aquifer, develop an information system and mathematical model and initiate a mechanism for consultation. As a result of this project, there is now 50 years (1950 to 2000) worth of historical data on groundwater levels, water salinity and exploitation. The main output of this project includes the ability to predict the capacity of the system to supply appreciable quantities of water while minimizing risks to the water resource. It is crucial that this resource be jointly managed and that data and information be exchanged among the three countries in order to formulate common policies and strategies.

Pumping groundwater from a well in the Northern Sahara

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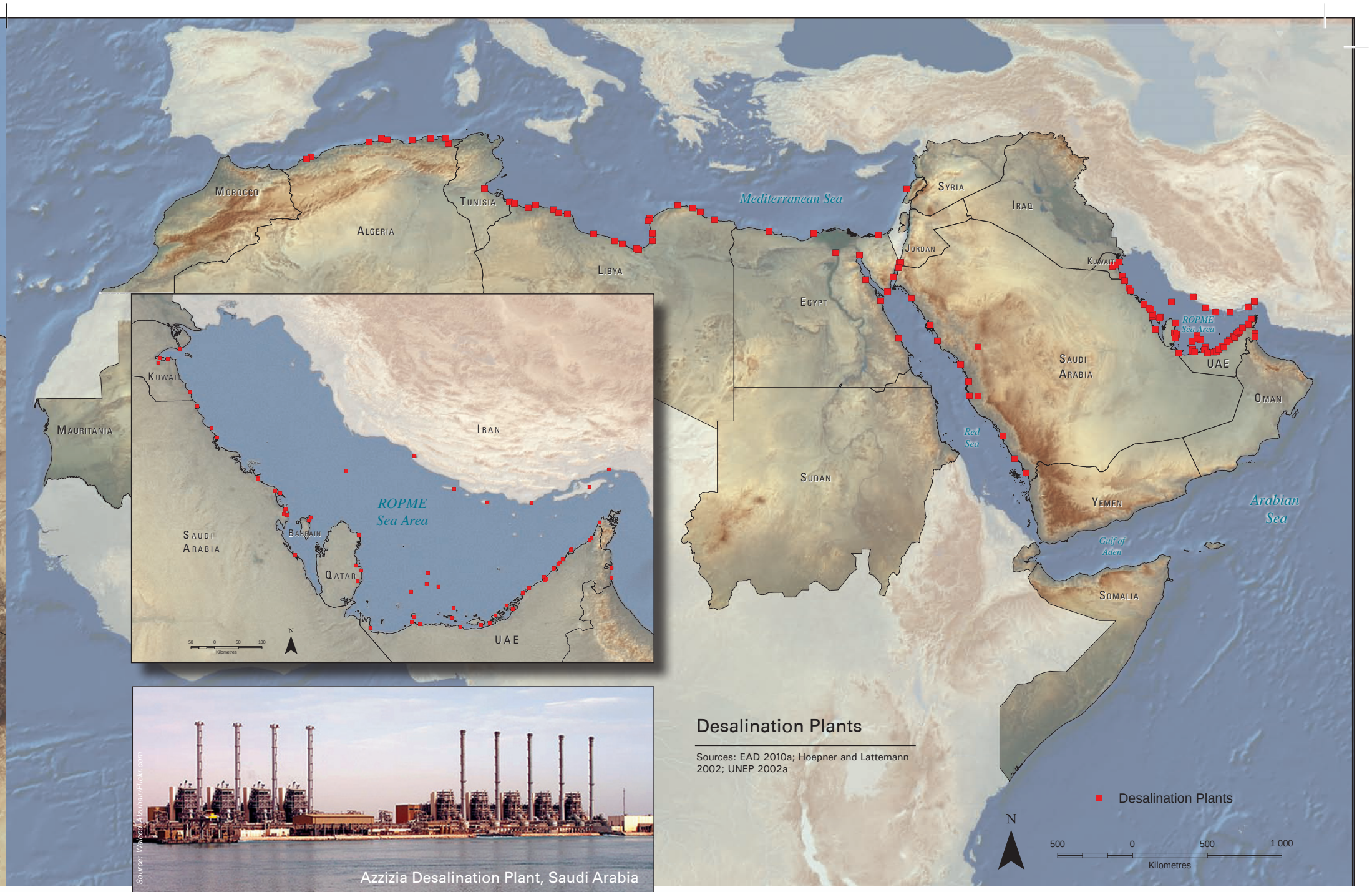
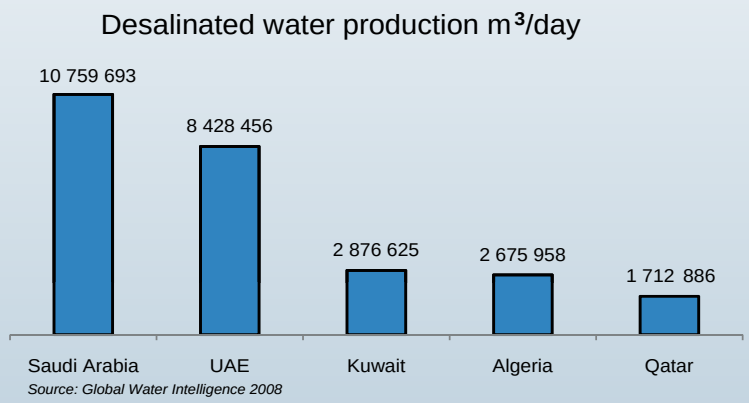


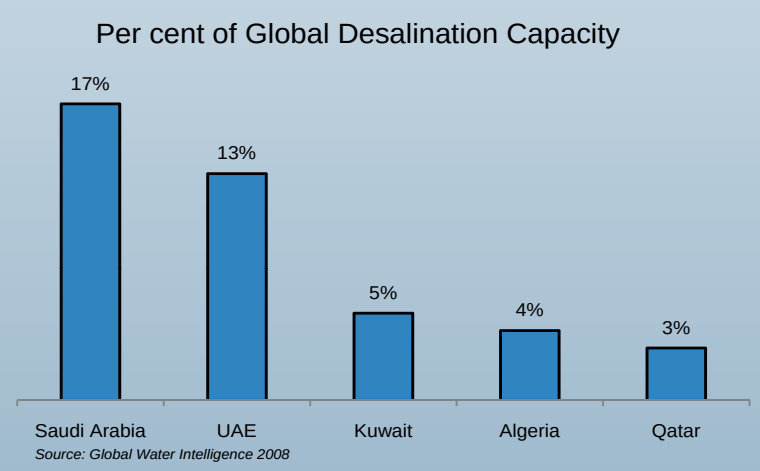
Azzizia Desalination Plant, Saudi Arabia

Desalination

The severe limitations on water resources availability in the Arab region has forced many countries to seek non-conventional water resources in the form of desalinated water and to a lesser extent, treated wastewater. Though these sources overall cover only a small portion of the domestic and industrial water demand, they provide essential supplies of water. Desalination, or the process of converting seawater into freshwater, is practiced widely in the Arab region; the West Asia countries use about 70 per cent of worldwide desalinated water capacity, while North Africa (mainly Libya and Algeria) uses about 6 per cent. Saudi Arabia, the UAE, Kuwait, Algeria and Qatar are the top producers of desalinated water in the region; Saudi Arabia has 17 per cent of the world's desalination capacity, UAE has 13 per cent and Kuwait has 5 per cent (Global Water Intelligence 2008).

Desalination capacity has increased substantially in the past few decades; in 1999 capacity in the Arab region stood at over 12.5 MCM per day, of which 90 per cent was in the GCC countries. The environmental impacts associated with desalination have not been thoroughly studied to date; however, the widespread practice of disposing the salt concentrate that remains after desalination into rivers or the sea has transboundary implications. Nowhere is this more apparent than in the ROPME Sea Area where desalination plants are a major source of pollution, discharging about 1 000 m^3 per second of wastewater into the sea. The wastewater elevates the salinity levels and temperatures in the sea, and also contains chemical pollutants that impact the marine environment (Lattemann and Hopner 2008). A recent study suggests that desalination capacity in the Arab region will need to increase by 2.7 MCM per day every year to meet the rising demand for water in the region (FSRS 2009). The by-products of producing this alternative water resource have transboundary environmental implications that require joint planning, coordination and management.





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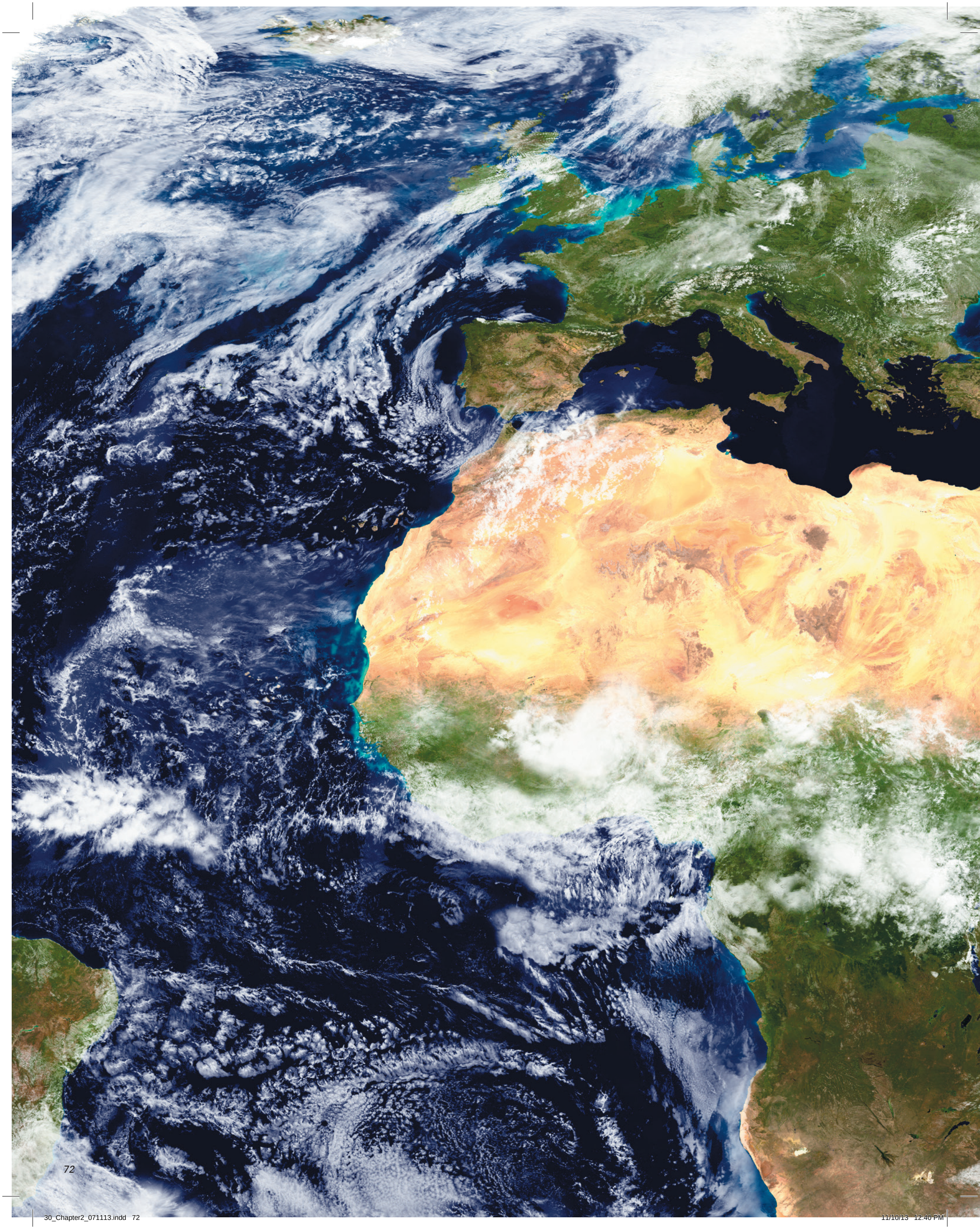

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2.3 Atmosphere

Air Pollution, and Weather Patterns

Air pollution in the Arab region has become an increasingly important environmental issue, especially in the region's mega-cities. Natural components of air pollution, such as dust storms and sandstorms are discussed here along with human influenced components such as increased levels of carbon dioxide.

Use of weather forecasting, and unprecedented satellite imagery to observe, track and predict movements of air, sand and dust storms, ocean currents and other types of environmental information have become widespread. This spectacular true-colour image of the West Asia/North Africa region, which shows prevailing weather and air movements, was created using a collection of satellite-based observations from a single remote sensing device (NASA's MODIS). The land and coastal ocean portions of these images are based on surface observations collected from June through September 2001 and composited every eight days to compensate for clouds that might block the sensor's view.

Source : NASA MODIS

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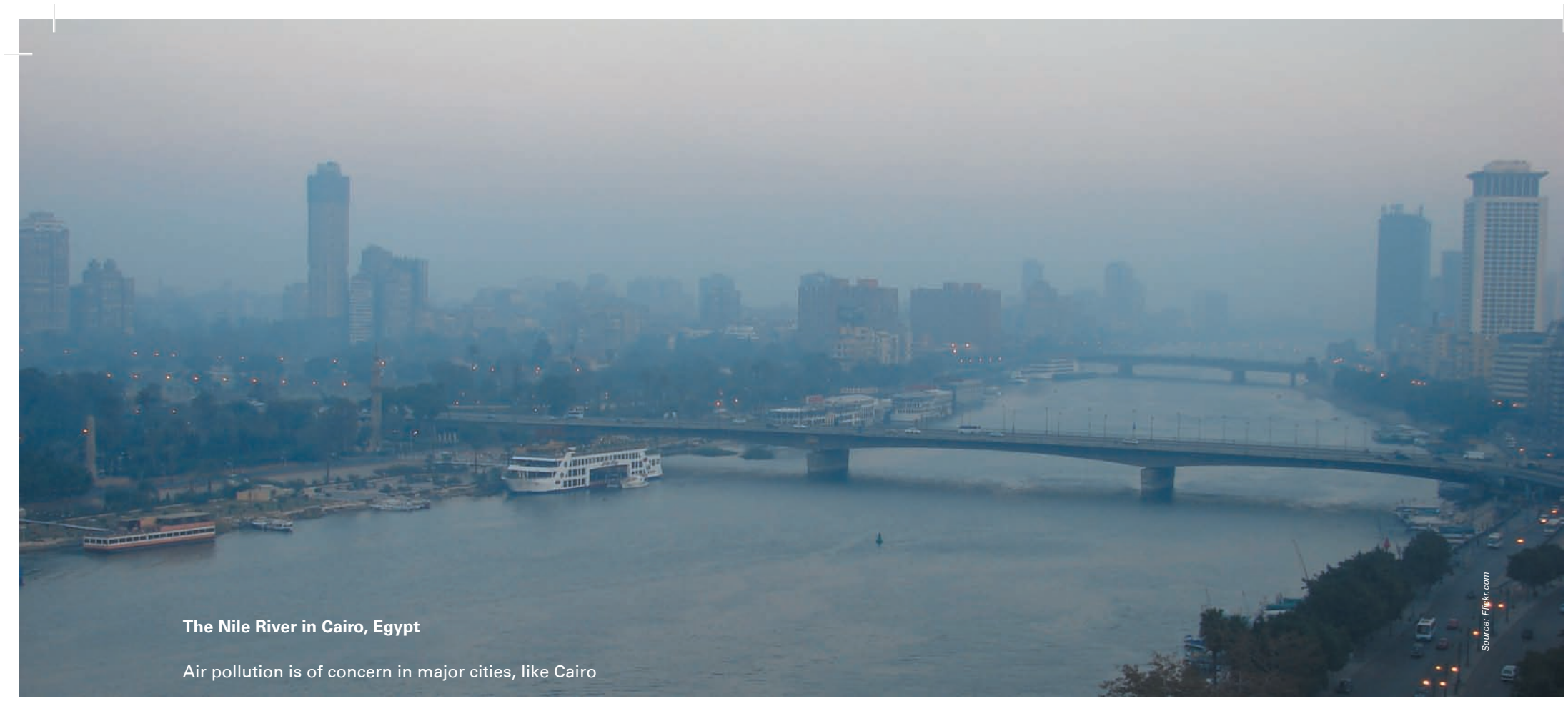

The Nile River in Cairo, Egypt

Air pollution is of concern in major cities, like Cairo

Air Pollution

Air pollutants of concern are those found in the troposphere, the lowest layer of the Earth's atmosphere that extends up to 17 km above the Earth's surface. Major air pollutants include particulate matter (PM), oxides of sulphur (SO_X), oxides of nitrogen (NO_X), carbon monoxide (CO), carbon dioxide (CO_2), volatile organic compounds (VOC) and lead. Some of these primary pollutants react together or with water in the atmosphere to produce secondary pollutants such as ground level ozone, acid rain, fog, and smog that have harmful health effects and impact regional temperatures, precipitation and agriculture (UNEP 2002b).

Air quality and atmospheric pollution have become increasingly important environmental issues, particularly in urban areas, in the Arab region. Emissions associated with oil and gas (exploration, processing, reformulating and shipping), the transportation sector, and energy-intensive industries (power generation, water desalination, petrochemicals, fertilizers, steel, aluminium and cement) are of particular concern. Vehicular emissions are the main source of air pollution in the Arab region; air quality is also aggravated by seasonal sand and dust storms, which are capable of carrying pollutants long distances (ESCWA 2006).

Data on air quality and emissions in the Arab region are lacking and either do not exist in some countries or are in the process of being developed, such as in the UAE, Egypt, Tunisia and Lebanon (AFED 2008). The health-related and environmental costs of poor air quality are prompting governments in the region to adopt policies and enact legislation to reduce emissions. Given the ability of harmful pollutants to travel great distances, transboundary air pollution is also becoming an increasing concern, forcing nations to engage in cooperative actions to increase understanding about the impacts of transboundary air pollution and develop effective pollution control strategies. Harmful air pollutants such as soot particles and nitrogen oxides from vehicle exhaust, agricultural pesticides, mercury from coal-fired power plants, as well as dust blown off deserts and eroded croplands may drift aloft for up to several months and are the main transboundary pollutants of concern (NRC 2009).

Cities such as Sana'a, Dubai, Cairo, Beirut, Baghdad and Manama suffer from high concentrations of air pollutants that far exceed World Health Organization (WHO) guidelines (UNEP-GEO 2006; WHO 2009). Urban air pollution is mostly attributed to energy and industrial production and vehicular emissions—most of the air pollution in urban centres is due to poor vehicle maintenance, aged cars, low quality fuel and poor traffic management (Selim 2004). In fact, 90 per cent of total emissions of carbon monoxide in Arab countries are due to transportation activities (ESCWA 2006). Many Arab countries have phased out the use of lead, lowered sulphur levels in fuels (though they remain high compared to other regions) and adopted cleaner vehicle technologies; however, Algeria, Egypt, Tunisia, Iraq and Yemen still use both leaded and unleaded fuel for their motor fleets (UNEP 2010). Many Arab countries are working with the UNEP's "Partnership for Clean Fuels and Vehicles" program, which aims to alleviate the growing scale of urban air pollution in Arab cities caused by vehicles. In Bahrain, for example, a diesel retrofit program was implemented to reduce emissions from diesel engines (specifically sulphur dioxides), one of the major sources of pollution in Manama.

Some cities (Kuwait City, Abu Dhabi) have adopted the Air Quality Index (AQI) to report daily air quality, focusing specifically on concentrations of ground-level ozone, particulate matter, carbon monoxide, sulphur dioxide and nitrogen dioxide, which pose some of the greatest threats to human health.

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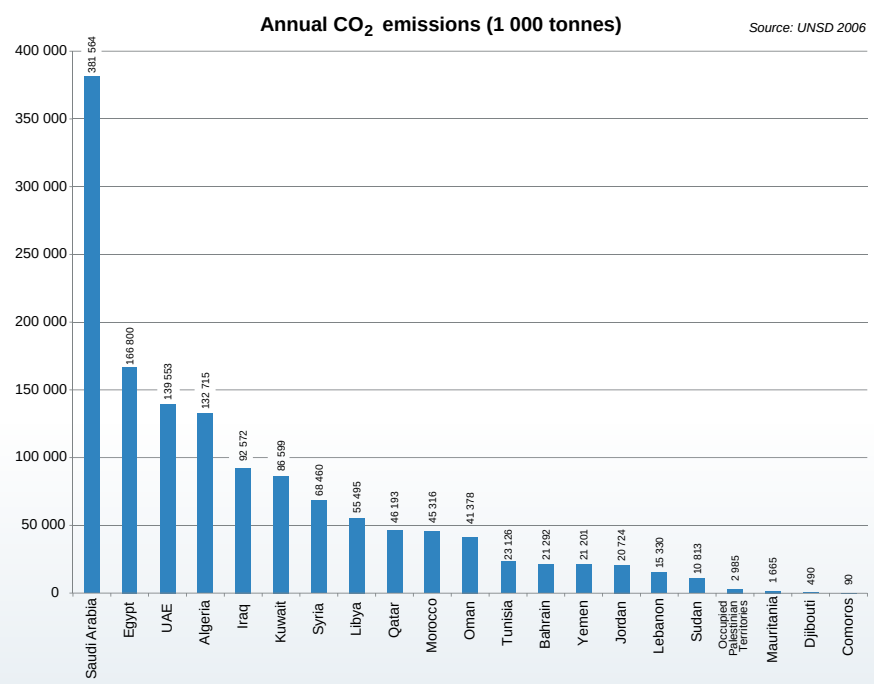
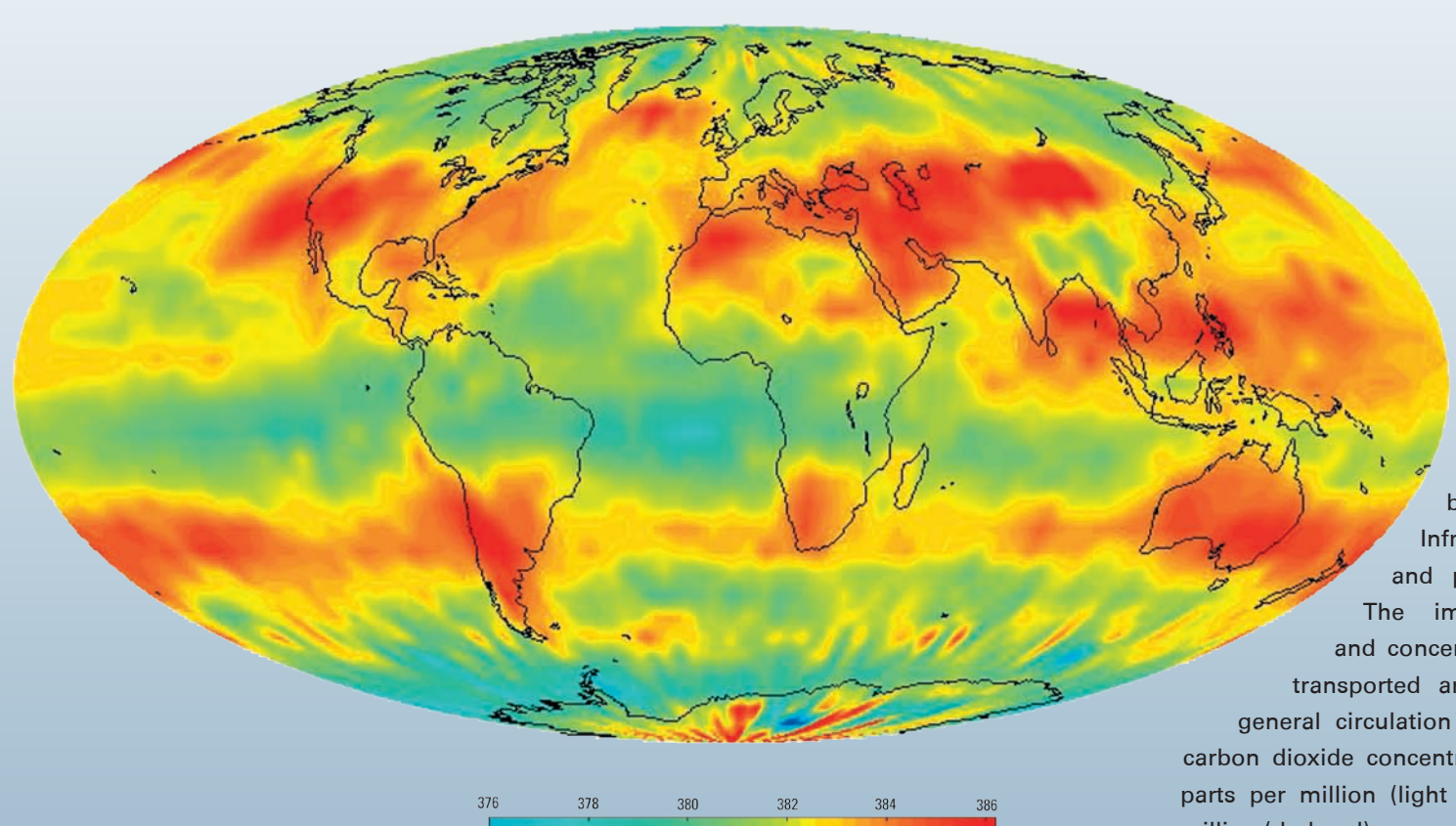
Other technologies such as remote sensing are also being used, though to a limited extent, to monitor and quantify transboundary air pollution, detect and track sand and dust storms and forest fires. Use of new technologies in the industrial sector are adding filters to the smokestack of plants to reduce emitting of air pollutants. In the UAE, the city of Dubai initiated an on-the-road vehicle emission measurement survey using remote sensing as a way to formulate strategies to control vehicle emissions (Dubai Municipality 2010).

Forest fires also contribute significantly to poor air quality in the region. The incidence of forest fires, which are mostly human-caused, has increased markedly, especially in countries bordering the Mediterranean. These fires turn large areas into degraded scrubland, cause widespread erosion and loss of human life and property, and cause atmospheric disturbances, emitting large amounts of PM, CO, VOC and NO_X into the atmosphere. These pollutants impact air quality and contribute to global warming.

A majority of CO_2 emissions in the region are generated as a by-product of the combustion of fossil fuels (oil, coal and natural gas) for energy production and transport. All fossil fuels are made up of hydrocarbons that release carbon dioxide when burned. CO_2, a greenhouse gas, contributes to global warming—the top CO_2 emitters in the world (annual emissions) are China, the United States, Russia, India and Japan (UNSD 2006). The contribution of the Arab region to global CO_2 emissions is low (4.7 per cent) (EOAR 2010); however, oil and gas producing countries contribute a larger proportion of emissions than other countries in the region. Pollution levels in many urbanized areas in the Arab region frequently violate particulate standards. Air quality in Greater Cairo is a major concern to the Government of Egypt, particularly with regards to adverse health impacts (EEAA 2011). The Egyptian government is monitoring ambient concentrations of lead and fine particulate matter through a network of monitoring stations throughout the city. The monitoring network has been operational since 1998. Air quality measures a number of parameters, such as PM10, sulphur dioxide, and carbon monoxide. With more than one million vehicles on the streets, mobile emissions are one of the major sources of air pollution in Greater Cairo. Vehicle emissions of fine particulate matter and other pollutants are significant, and the government is currently working towards a tighter control over vehicle emissions (EEAA 2011).

In Syria, daily concentrations of PM10 varied between 115 and 600 $\mu g/m^3$ for most cities—in Damascus, PM10 concentrations were as high as 749 $\mu g/m^3$ in highly congested traffic areas and 333 $\mu g/m^3$ in residential zones (Haffar 2004). Beirut's PM10 concentrations average 166 $\mu g/m^3$ and SO_2 levels of 300 $\mu g/m^3$ have been recorded near major cement factories and power plants; levels of ozone and smog in Beirut also regularly exceed WHO air quality guidelines (Chaaban and Chedid 2003). Algiers, Rabat and Abu Dhabi also experience high levels of PM10, SO_2 and nitrogen dioxide (NO_2), all of which have serious health risks.





Global Carbon Dioxide

This image of global CO_2, from July 2008, was created with data acquired by the Atmospheric Infrared Sounder (AIRS) and produced by JPL/NASA. The image displays patterns and concentrations of CO_2 that are transported around the Earth by the general circulation of the atmosphere. The carbon dioxide concentrations range from 368.2 parts per million (light blue) to 386.2 parts per million (dark red).

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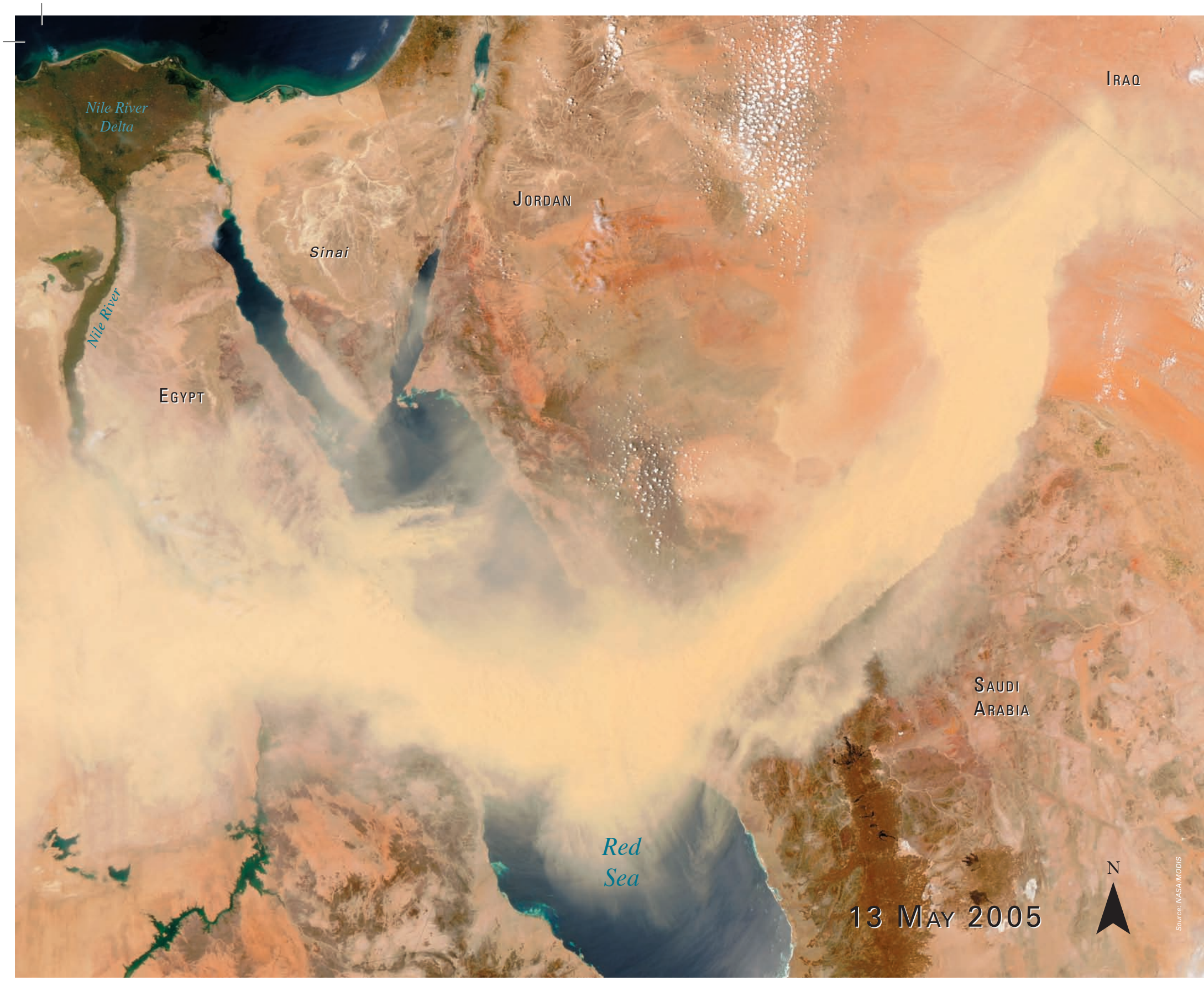

Source: NASA/MODIS

Dust and Sand Storms

Dust and Sand Storms (DSS) are common in arid and semi-arid regions, and arise when wind gusts blow loose sand and dust from a dry surface. The Sahara Desert and the Arabian Peninsula are the main sources of airborne dust and particulates, which can be transported across the entire region and even across the Mediterranean and Atlantic (NASA 2005). The minerals carried by DSS are the main source of nutrients for phytoplankton, the basic food upon which marine life depends; however, they are also hazardous in terms of air quality and can damage vegetation and infrastructure. Those particles, also known as aerosols, can alter the physics of cloud formation and reduce rainfall in the polluted region. Increases in temperature associated with climate change will increase soil fragility, making sand and dust particles more mobile with winds, which are also expected to increase in frequency and severity. The Environment Agency-Abu Dhabi recently expanded its air quality monitoring program to include the measuring of PM2.5 levels (dust and chemicals that are capable of penetrating deep into the lungs); PM2.5 levels are also being assessed to determine how much of the particulates are naturally occurring versus human-caused (EAD 2010b).

Dust and Sand Storms Originating in Iraq

In Iraqi cities, DSS that completely cover populated neighbourhoods are a common occurrence. Land degradation associated with conflict and poor agricultural practices and management has transformed much of the arable land into desert; even the slightest wind movements can pick up dust that can remain airborne for days (ESCWA 2006). This image shows a thick band of dust snaking across the Red Sea between Egypt and Saudi Arabia on 13 May 2005 that originated in Jordan and northern Iraq. The dust impaired visibility, caused health complications and prevented planes from taking off and landing at local airports. These DSS that originate in Jordan and Iraq can extend into Iran, Syria, Saudi Arabia and affect countries to the south, blowing over the Red Sea and into northeast Sudan, southern Egypt, Eritrea and northern Ethiopia. The Nile River (upper left of image) is a ribbon of green with the water flowing northward into a fan-shaped delta before emptying into the Mediterranean Sea (NASA 2005). A ground photo illustrating the immense size of a dust storm in Iraq is shown to the right.

Source: NASA/MODIS

Source: Shannon Arledge

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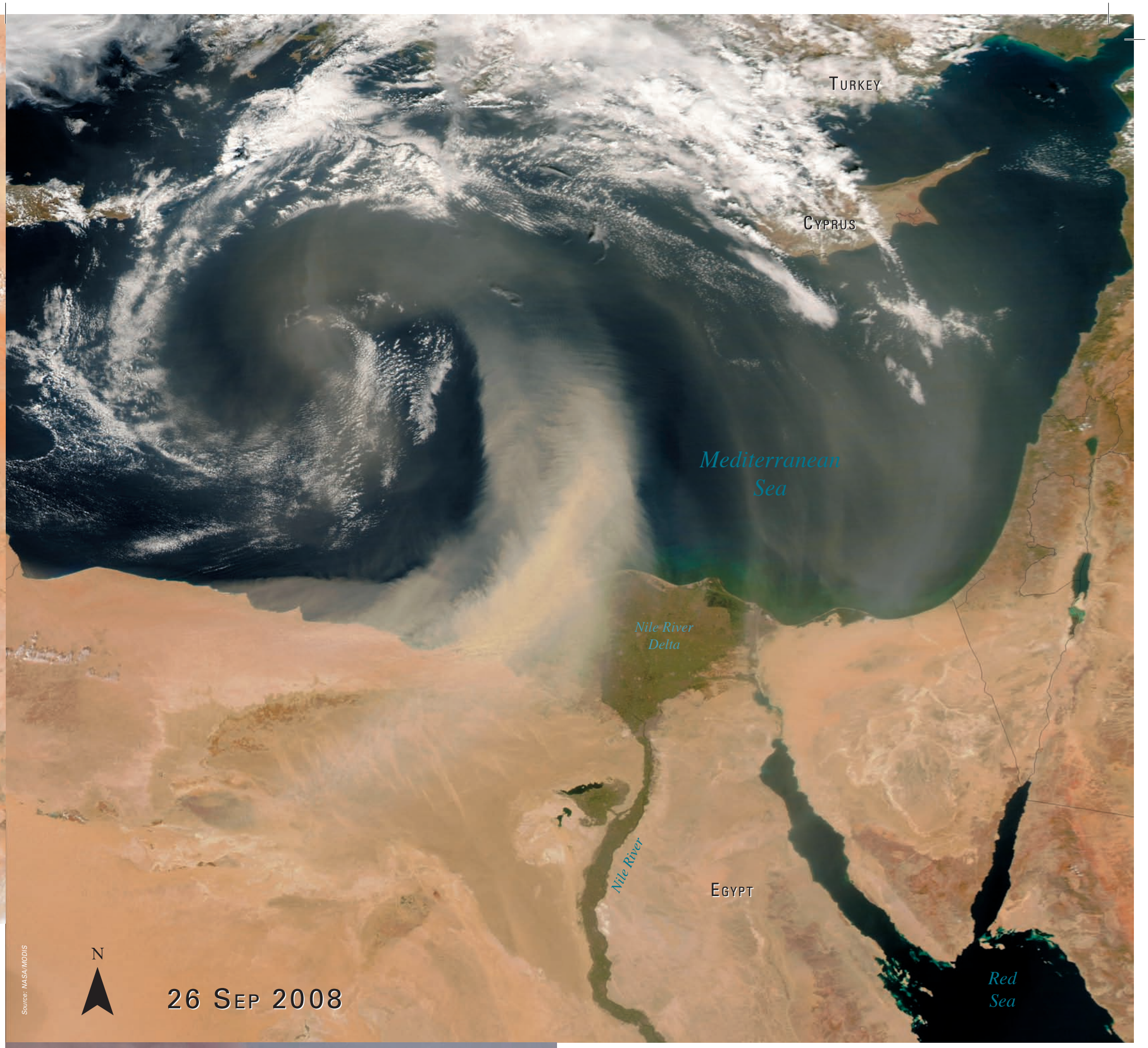

Source: NASA/MODIS

Source: NASA/MODIS

DSS in Al Asad, Iraq on 26 April 2005

Source: Shannon Arledge

Dust and Sand Storms from North Africa to Southern Europe

Frontal wind directions, as shown in the image above, clearly indicate transboundary wind movements from the Arab region to northern Mediterranean countries such as Turkey, Greece, and Italy. These fronts carry dust from the Sahara Desert in Libya and Egypt over thousands of kilometres by convection currents, which form when warmer, lighter air rises and colder, heavier air sinks. The 'simoon' is the dust and sand-laden desert wind of North Africa and Arabia that contributes largely to the atmospheric dust over Europe; evidence of the dust from simoon winds has also been found on the seafloor at considerable distances from shore and as far north as Sweden (Hassan 2004).

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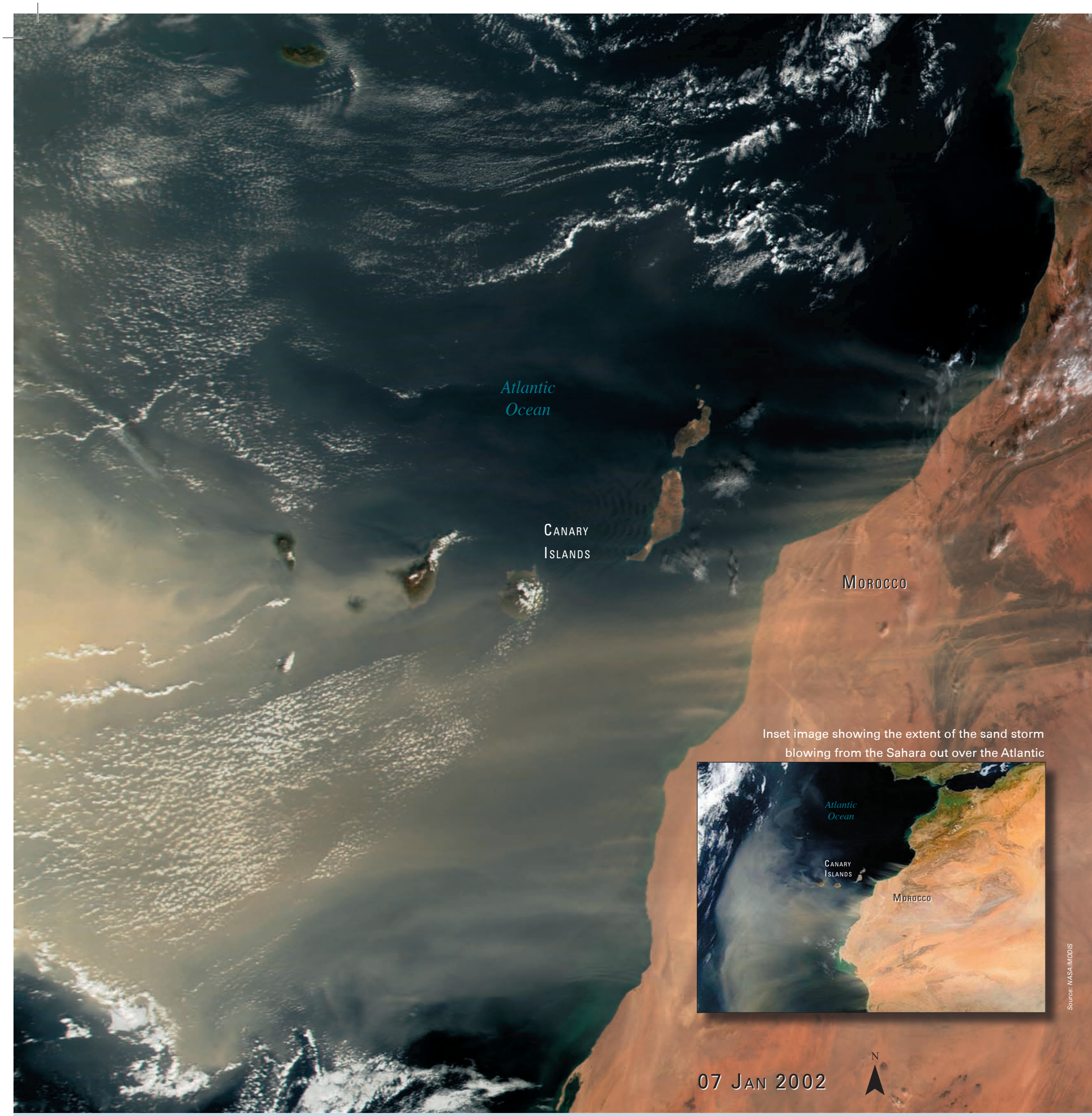

Dust Storms from the Northern African Coast to the Canary Islands

The 'Calima' is an oppressive dust and sand-laden wind that blows from an area of high pressure usually over North Africa and the Sahara Desert. It is driven by south-easterly winds west into the Atlantic and over the Canary Islands, and brings with it extremely hot temperatures, poor visibility and poor air quality that can last from several hours to a week. The Sahara dust is exported across the Atlantic Ocean during these storms, and can blanket areas with dense clouds of dust and sand that extend as far as the Caribbean. The dust carries bacteria and fungi that can harm Caribbean corals but also provides essential soil-building properties for plant growth on the islands. Saharan dust is also believed to play a role in mitigating the Atlantic hurricane season (NASA 2007). This image shows a dust storm from the western regions of Morocco travelling west towards the Canary Islands. A thick pall of sand and dust blew out from the Sahara Desert over the Atlantic Ocean on 7 January 2002, engulfing the Canary Islands in what was one of the worst sand storms ever recorded for the country.

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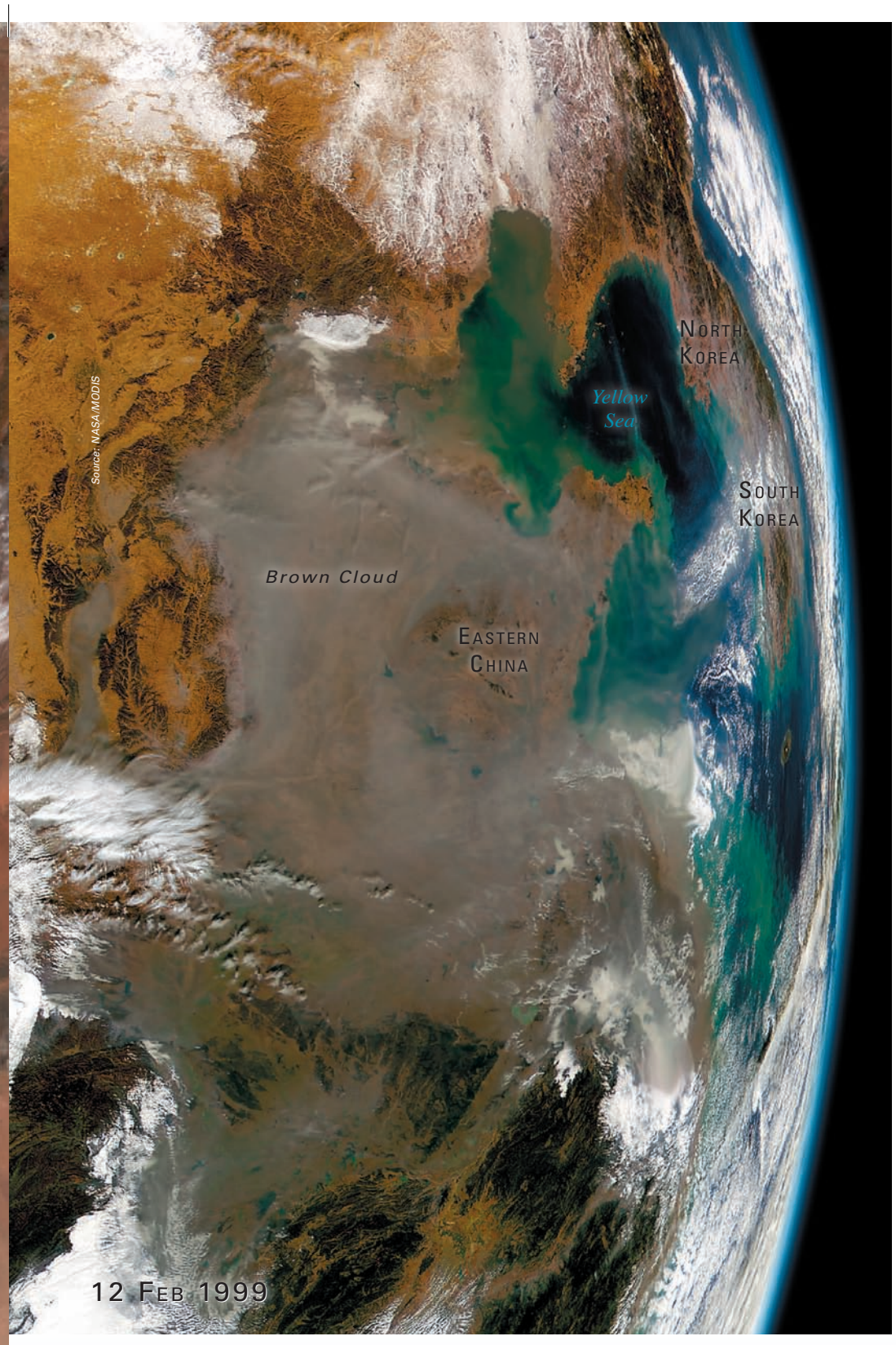


Source: NASA/MODIS

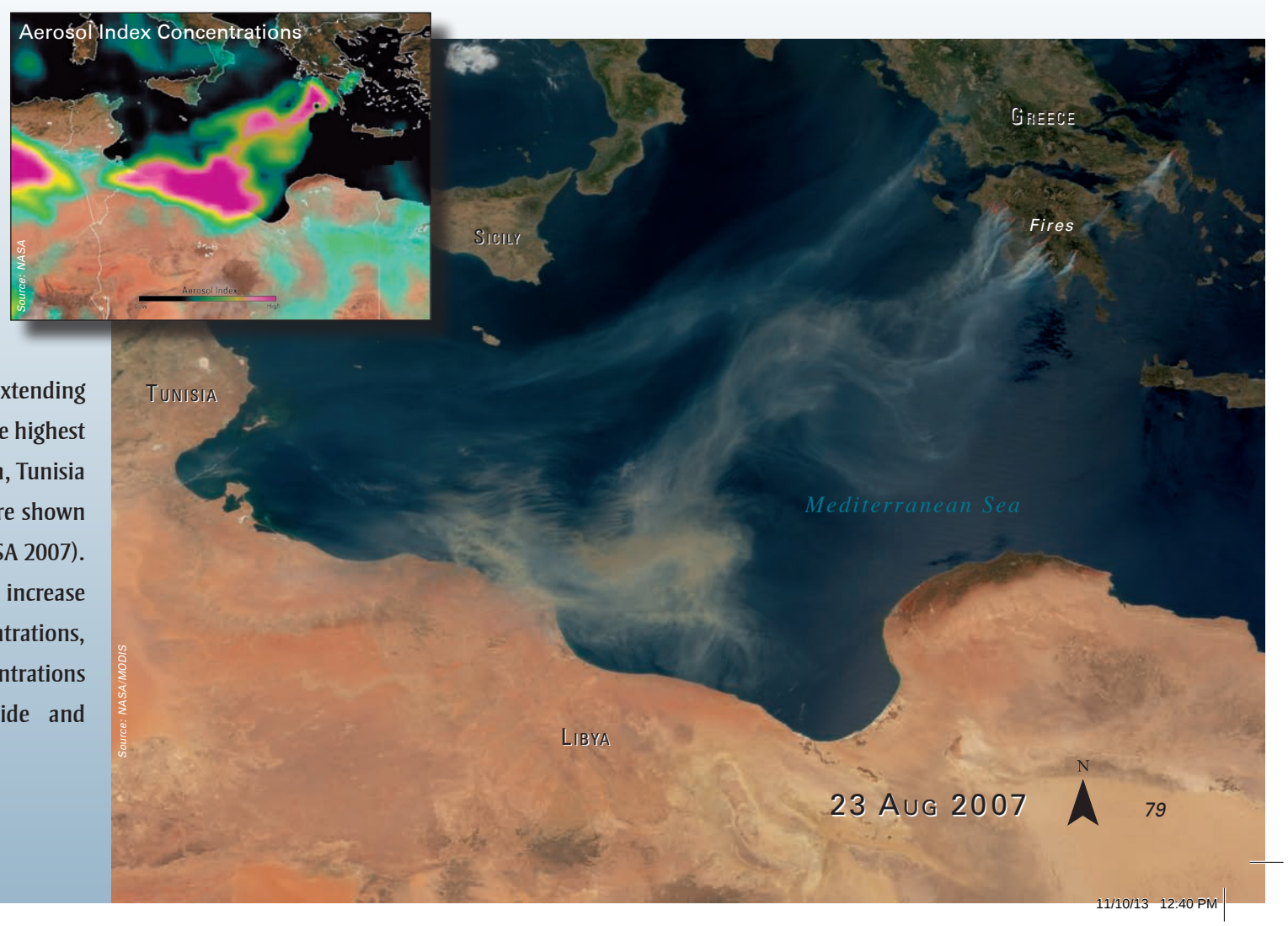
Asian Brown Cloud

The Asian Brown Cloud is a 3 km thick layer of soot and other anthropogenic particles and emissions that is formed during the dry winter monsoon each year between January and April, and stretches from China and the western Pacific Ocean to the Arabian Peninsula. The pollutants are a result of the combustion of fossil fuels, biomass burning and industrial emissions. The cloud is typically composed of sulphates, organic compounds, soot, mineral dust, ammonium, fly ash, and other minor constituents such as potassium and nitrates (UNEP 2002b). The cloud has strong sunlight absorbing capabilities due to its high soot content, which can impact the radiative heating of the atmosphere and land surfaces during January to April, affecting regional temperatures, precipitation, agriculture and health. Reduced heating of the ocean decreases evaporation and precipitation locally or in regions far from the source of the pollution. This brown cloud phenomenon, first observed in 1999 (image at left), epitomizes the effects of transboundary air pollution problems, whereby air pollutants extend beyond their source regions, affecting areas around the world. The brown cloud, which extends up to 3 km in altitude, can disperse rapidly around the globe (Ramanthan and others 2001).

Thirteen mega-cities, including Bangkok, Beijing, Cairo, Dhaka, New Delhi, Tehran, Mumbai and Seoul have been identified as brown cloud hotspots. These hotspots experience surface cooling due to reduced sunlight, which disrupts the hydrological cycle (increasing problems of water stress) and reduces agricultural productivity (by acid deposition and subsequent plant damage, and reduced photosynthesis). In addition, the impacts to human health are far-reaching, with high incidences of respiratory illness. Other effects include an increase in the frequency and strength of the thermal inversion caused by the cloud that can trap more pollution, exacerbating the air quality problems in these locales.

Smoke and Aerosol Concentrations from wildfires originating in Greece

In late August 2007, deadly wildfires in southern Greece sent thick plumes of smoke and aerosols south over the Mediterranean Sea to the Libyan and Tunisian coasts (image at right). These fires, a result of scorching heat waves, destroyed thousands of acres of forest, olive groves and farmland in Greece. In these images, the active forest fires are red and the smoke plumes are shown extending west—the aerosol index images show the highest aerosol concentrations in pink over Libya, Tunisia and Algeria and lower concentrations are shown in yellow and green (see inset map) (NASA 2007). These wildfire emissions cause an increase in average particulate matter concentrations, organic aerosol mass, and gaseous concentrations of carbon monoxide, nitrogen dioxide and ammonia.



Source: NASA

Source: NASA/MODIS

Source: NASA/MODIS

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The deep blue waters of the Red Sea stand out among the surrounding desert in this true-colour Aqua MODIS image from September 2004. Located in the Great Rift Valley between Africa and Asia, the Red Sea is bounded by the countries of Egypt, Israel, Jordan, Saudi Arabia, Sudan, Yemen, Eritrea, Djibouti, and Somalia. The northern end of the Red Sea is bifurcated by the Sinai Peninsula, creating the Gulf of Suez to the west and the Gulf of Aqaba to the east. At the southern end of the Red Sea, the Dahlak Archipelago is evident, displaying green shallow waters dotted with small islands. Further south, the sea narrows where Yemen on the Arabian Peninsula and Djibouti in the Horn of Africa lie only 30 km apart, connecting the Red Sea to the Gulf of Aden and the Arabian Sea. The Nile River flows north through Egypt and Sudan in the upper left portion of the image.

Source: NASA/MODIS

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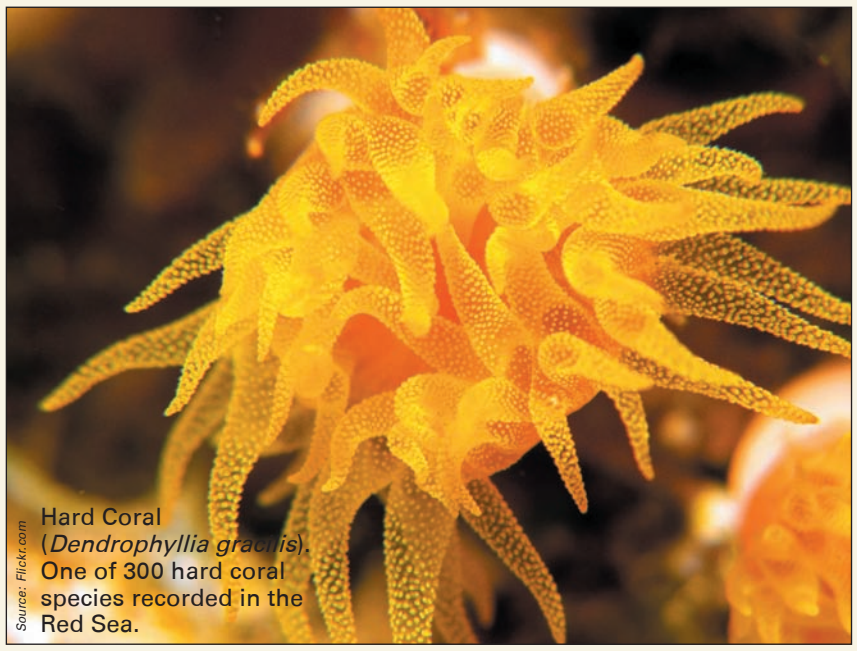
2.4 Seas

Red Sea, Mediterranean and ROPME Sea Area



Hard Coral (*Dendrophyllia gracilis*). One of 300 hard coral species recorded in the Red Sea.

Source: Flickr.com

Despite their remarkable size and resilience, the Earth's oceans and coastal areas face a number of unprecedented threats to their integrity and sustainability. Chief among these are land and sea pollution, over-utilization of marine resources, loss of marine and coastal habitats, and introduction of invasive aquatic species (UNDP/GEF 2004).

Twenty of the 22 League of Arab States countries encompass five of the UNEP Regional Seas Programme areas: the Mediterranean Region, the Red Sea and Gulf of Aden Region, Eastern Africa Region, the ROPME Sea Area and Western Africa Region. These regional seas are experiencing impacts from rapid coastal development and degradation of the marine and coastal environments. The UNEP Regional Seas Programme was created to conserve marine and coastal environments through organizing regional activities and initiatives. Some of the Arab League countries share more than one region; for example, Egypt's coastlines include the Mediterranean and the Red seas, and Saudi Arabia's coastlines extend along the Red Sea and the ROPME Sea Area.

Transboundary Issues and Analysis

Transboundary issues often present challenges that can lead to conflict but can also promote cooperation. In recent years, environmental and resource issues have become the most prominent transboundary issues (Lonergan and others 1997). Most of the Arab countries recognize the nature and challenges of transboundary marine issues and have considered the Transboundary Diagnostic Analysis (TDA) approach within a regional context (for example the Mediterranean, Red Sea and Gulf of Aden regions).

Corals and Anthias shoaling over Jackson Reef in the Red Sea

Source: Matt Kieffer, Flickr.com

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TDA is a scientific and technical assessment of an international waters area that prioritizes and quantifies the environmental issues and establishes their immediate, intermediate and fundamental (root) causes (UNEP/MAP/MED POL 2005). The process of formulating a TDA and a Strategic Action Programme (SAP) has provided an integrated approach and structured framework for the coastal countries bordering these two regions.

Shared TDA issues of the Marine Environment of the Arab Region

The major transboundary coastal and marine issues in the Mediterranean, Red Sea and Gulf of Aden, and ROPME Sea Areas include: overfishing, loss of biodiversity and ecosystems, invasive species, sea and land-based pollution (including oil spills) and eutrophication. Data on the transboundary movements of hazardous wastes and other pollutants in and through these regions are scattered and often lacking.

Source: Flickr.com

Overfishing

The Mediterranean Region

The yield of fisheries is generally low in the Mediterranean Sea compared to other Seas and oceans, probably due to lower primary productivity. Approximately 1.5 million tonnes of fish are caught in the Mediterranean Sea each year (WWF 2004); the catch for the Mashreq countries during 2000 was 80 915 tonnes (Benoit and Comeau 2005). Fisheries resources in the Mediterranean have long been overexploited and there are clear indications that catch size and quality have declined, often dramatically; some species have disappeared entirely from commercial catches. Overfishing, driven by demand and rising prices, is increasing competition for the same fish resources and stocks and destroying their natural habitats. Destructive fishing practices have also contributed to reduced fish stocks; between 1980 and 1992, the number of trawl nets increased by 137 and 170 per cent in Algeria and Morocco, respectively (Benoit and Comeau 2005).

The Red Sea and Gulf of Aden

The Red Sea and Gulf of Aden are recognized globally for their great diversity of marine environments and the abundance of unique species. The status of fisheries in some nations of the Red Sea and Gulf of Aden region is unknown due to lack of stock assessments and incomplete fisheries statistics. However, it is known that the fisheries resources in the Red Sea and Gulf of Aden are exploited locally and by foreign fleets. In addition, illegal fishing in the region by vessels operating outside their natural waters is commonplace. Overfishing has caused declines in catches of finfish, lobster and scombrids, and cuttlefish stocks have completely collapsed (PERSGA 2009). The shark resources in the region are heavily fished (much of it used to fuel the shark fin markets of East Asia), especially in Sudan, Djibouti, Yemen and Somalia (PERSGA 2004). Fisheries are also overexploited in Egypt, Sudan and Yemen.

The ROPME Sea Area

Fish species diversity is generally lower in the ROPME Sea Area, and the fisheries sector only plays a minor role in the economies of bordering countries (Bahrain, Iraq, Kuwait, Qatar, Oman and UAE). The ROPME Sea Area is suffering the impacts of haphazard coastal developments, physical alterations, destruction of habitats, sedimentation, high salinity and extremes of temperature that are impacting the fisheries. These activities eliminate the nursery areas for commercially important species of fin and shellfish. Bottom trawling has severely destroyed benthic communities and substantially reduced commercial fish populations over the past 10 to 20 years. Kuwait's total fish landings in 2007 were less than half their peak 1995 level. Probable reasons include overfishing, nursery ground destruction, and reduced discharge of the Shatt Al-Arab River (Sheppard and others 2010).

Fisheries transboundary aspects

Fisheries issues are transboundary because of the presence of highly migratory stocks and extensive shared stocks; the environmental impacts and other socio-economic aspects are also transboundary. For example, the fragmentation of the Mediterranean area by so many Exclusive Economic Zones (EEZ) bordering each other virtually assures that many stocks are transboundary and/or shared. Fisheries activities cause mortality of endangered species (such as sea turtles and some dolphins), destroy benthic habitats due to dredging (such as seagrass beds and possible coralline hard bottoms), and have ecologically-harmful by-catch (UNEP/MAP/MED POL 2005). International cooperation, compromise, consensus and concerted action are needed for the sustainable exploitation of marine resources and protection of the vulnerable Mediterranean environment.

Source: Paul Fenwick.Flickr.com

Shark laid out for sale at market. Overexploitation of some marine species is causing significant ecosystem changes.

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Segrass habitats are vital to many marine species, and are a threatened habitat globally.

Photo: Jayhem/Flickr.com

Marine Ecosystem Types

Marine ecosystems cover 70 per cent of the Earth's surface and are home to a variety of habitats that range from productive coastal areas to deep ocean floor. The predominant marine ecosystems of the Arab region include tropical communities that consist of coral reefs and mangrove forests, as well as seagrasses and intertidal systems (rocky, sandy and muddy shores). These marine ecosystems are some of the most biologically productive and diverse in the world and are essential to human survival and well-being.

Coral Reefs

Coral reefs occur in shallow tropical waters where sunlight can reach reef-building corals on solid surfaces and stable sediments. Of the 284 300 km^2 of reef area in the world, 18 660 km^2, or about 7 per cent, occur in waters of 13 Arab countries (none are in the Mediterranean Sea) (Spalding and others 2001). Saudi Arabia and Egypt's Red Sea waters have the highest reef area in the Arab region, with 6 660 and 3 800 km^2, respectively. The Socotra archipelago of Yemen, however, boasts the richest site for reefs in the region, with 253 stony coral species. Coral reefs are highly vulnerable to anthropogenic stresses and a changing climate - 60 per cent of these habitats were assessed as at risk primarily due to coastal development, overfishing and the threat of oil spills (WRI 1998).

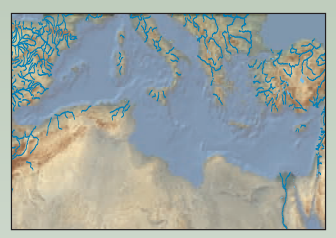
Seagrass Communities

Seagrasses consist of submerged aquatic vegetation whose biomass provides food, habitat and nursery areas for many marine species. In the Mediterranean, seagrass meadows produce more than 80 per cent of the annual fish yield in the sea; they also stabilize the seashore and maintain water quality, mostly through oxygen production (WWF n.d.). Seagrasses abound in the ROPME Sea Area and provide the main diet of the endangered dugong. In the Red Sea, seagrasses are fairly widespread along the coast, especially in the shallow waters of the southern coast.

Mangrove Forests

Mangroves grow in waterlogged and saline soils of the intertidal zone. They play an important ecological role in coastal areas, preventing soil erosion and providing habitat for fish, crustaceans and birds. They are scattered along the Red Sea coast and ROPME Sea Area.

Information on the Coastal and Marine Environment of the Arab States



Region	Countries	Coastal & Shelf Extension & Area		
		Coastline km	Cont. shelf km^2	Territorial Sea km^2
MED Region	Algeria	1 557+	9 688	27 863
	Egypt	2 450+	50 060 (Med+RS)	82 048 (Med+RS)
	Lebanon	294+	1 169	4 702
	Lybia	2 025+	63 595	38 131
	Morocco	2 008+	70 365	37 481
	Syria	212+	852	3 866
	Tunisia	1 927+	65 347	36 773
PERSGA Red Sea & Gulf of Aden Region	Djibouti	443**	3 406	4 853
	Egypt	1 800**	X	X
	Jordan	27**	82	87
	Saudi Arabia	1 840**	95 580 (RS+G)	95 580 (RS+G)
	Somalia	3 898**	40 392	68 849
	Sudan	2 245**	15 861	32 645
	Yemen	3 149**	65 341	82 359
ROPME Sea Area (Data for Arab Countries of the ROPME Sea Area)	Bahrain	255***	7 967	4 006
	Iraq	105***	1 034	716
	Kuwait	756***	6 526	5 362
	Oman	3 165***	46 670	51 821
	Qatar	909***	31 156	11 373
	Saudi Arabia	790***	95 580 (RS+G)	95 580 (RS+G)
	UAE	735***	51 394	30 962
Other Regions	Mauritania	1 268	28 370	19 455
	Comoros	469	1 426	12 684

Source: El-Sayed (2008) X - No Data Available

Main source: World Resource Institute. Earth trends: The Environmental Information Portal (2006)

*EEAA (2006) **PERSGA (1998) *** ROPME (2003)

Blue fish shoaling over Bedouin Moon, Red Sea

Source: Matt Kieffer/Flickr.com

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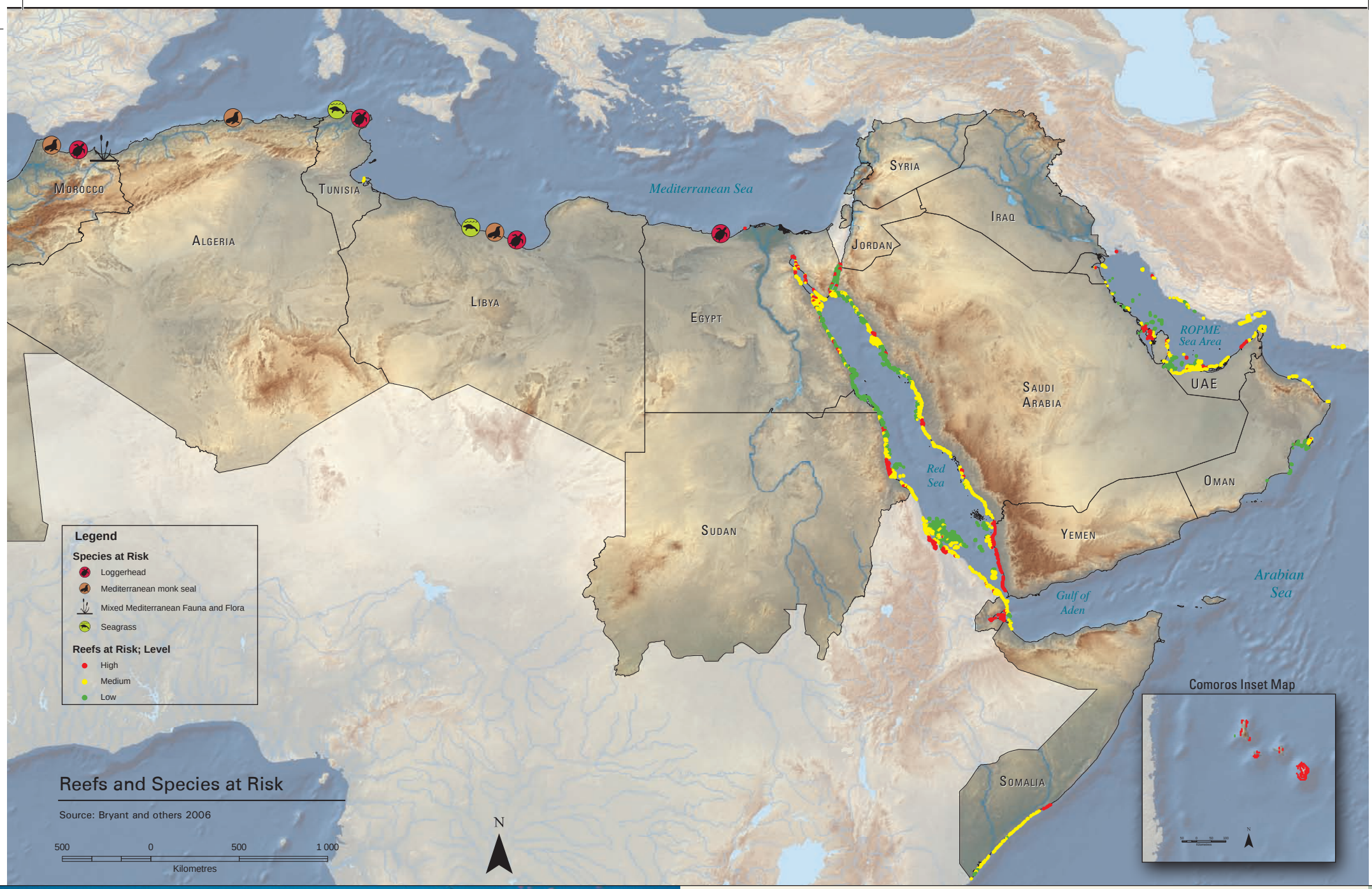

Lost and discarded fishing nets entangle live coral and tear them away from their bases

Source: Tim Sheerman-Chase/Flickr.com

Loss of Ecosystems and Biodiversity

The Mediterranean Region

The Mediterranean Sea contains 8 to 9 per cent of the world's known marine species in an area that constitutes less than 1 per cent of the world's oceans. Due to the threats posed (as described in Chapter 1), the Mediterranean Sea remains a global biodiversity hotspot. Species at risk in the Mediterranean include the Loggerhead turtle and monk seal. The map above shows areas of risk for those species along the southern coast.

The Red Sea and Gulf of Aden

The Red Sea and Gulf of Aden contain only about 8 per cent of the world's mapped coral reefs, almost two-thirds of which are at risk because of pollution and activities associated with coral reef areas (UNEP GEO 2000). Intertidal and nearshore subtidal habitats (including coral reefs) have been lost or degraded as a result of coastal and industrial development. Mangroves have been harvested for use in construction and for firewood; mangroves are also degraded due to grazing by camels in Yemen, Sudan, Djibouti and Somalia.

The ROPME Sea Area

Although the ROPME Sea Area is a stressed environment with high temperatures and low species richness, it contains a high level of biodiversity. As an example, the taxonomic distinctness of algae is exceptionally high in the ROPME Sea Area, at least for certain sub-regions of the sea (Saudi Arabia, Bahrain and Kuwait) (Sheppard and others 2010).

Loss of Ecosystem & Biodiversity - Transboundary Aspects

Transboundary issues regarding the degradation of coastal habitats and decline of biodiversity arise because of combinations of the following:

- Marine living resources are often migratory;
- Coastal habitats provide nursery and feeding grounds for migratory species;
- Degradation of coastal habitats contributes to overall decline of regional and global biodiversity; and
- Ecosystems are inherently transboundary in nature (UNEP/MAP/MED POL 2005)

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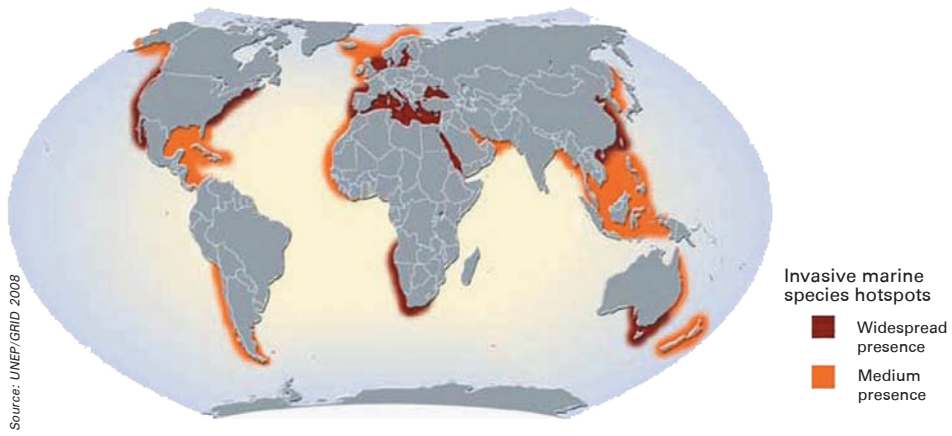
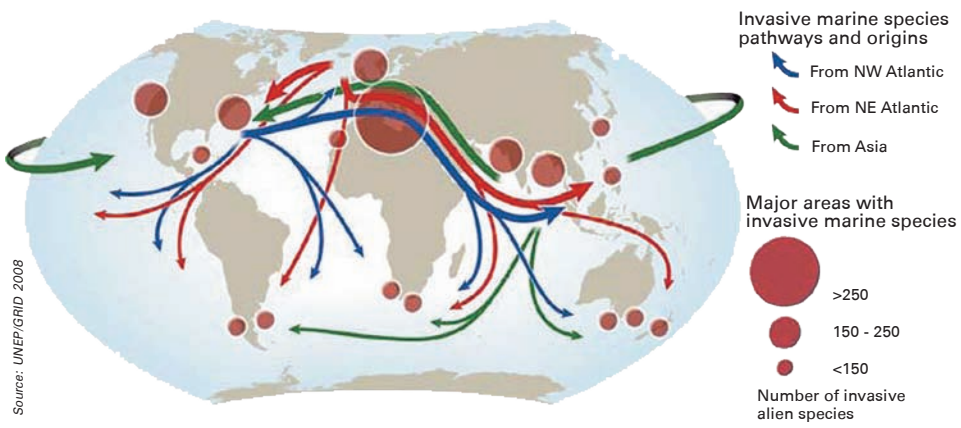


Source: UNEP/GRID 2008

The locations of major problem areas for invasive species infestations or occurrence of exotic species in the marine environment. The impacted areas are subject to high levels of pollution, intensive fishing and bottom trawling, and major shipping routes.



Source: UNEP/GRID 2008

The major pathways and origins of invasive or exotic species infestations in the marine environment. These patterns are concurrent with major shipping routes.

Source: Matt Kieffer/Flickr.com

Infestation of Crown of Thorns (*Acanthaster planci*) on a coral reef

Invasive species

Since the opening of the Suez Canal in 1869, invasive species from the Red Sea (Lessepsian species, either alien or alien invasive species) have become a major component of the Mediterranean ecosystem and have tremendous impacts on the ecology, endangering many local and endemic species. About 300 tropical Indo-Pacific species have become established in the waters of the eastern Mediterranean; more than 70 per cent of the non-indigenous decapods and about 63 per cent of the exotic fish occurring in the Mediterranean are of Indo-Pacific origin introduced into the Mediterranean through the Suez Canal. The Mediterranean region has developed an action plan to address invasive species, and has implemented coordinated measures and efforts to prevent, control and monitor the effects of infestations. The ROPME Sea Area is also vulnerable to invasive species, many of which are introduced by the enormous volume of ballast water from tankers (Sheppard and others 2010). Over 60 Red Sea fish species have entered the eastern Mediterranean via the Suez Canal and are either established or undergoing rapid colonization (Golani 1993; Goren and Galil 2005). These alien fish invasions impact community structure and alter food webs (Goren and Galil 2005). The interactions of invasive species with other stressors, such as global climate change, have long been a concern. A poignant example of how small changes in water temperature can influence invasiveness is the colonization by the lizardfish (*Saurida undosquamis*). After being introduced into the Mediterranean via the Suez Canal, the lizardfish population increased rapidly in the 1950s; its rapid increase was attributed to a rise of 1 to 1.5°C in sea temperature during the winter months of 1955 (Galil 2007). It formed thriving populations in a short amount of time in the eastern Mediterranean, displacing the native hake (*Merluccius merluccius*) and became so abundant that it constituted more than one-fifth of the total fish landings along areas of the Mediterranean coast (Galil 2007).

Invasive species - transboundary aspects

Biotic invasion is one of the five top drivers for global biodiversity loss. The number and severity of outbreaks and infestations of invasive species (species purposefully or accidentally introduced in non-native environments) is growing worldwide, and invasions of marine habitats are now occurring at an alarming rate. Invasive species can change the functions of entire ecosystems. Exotic and invasive species have been identified as a major threat to marine ecosystems, with dramatic effects on biodiversity, biological productivity, habitat structure and fisheries (UNEP-GRID 2008).

Source: Laszlo Ilyas/Flickr.com

Lessepsian species invasion. This brushtooth lizardfish (*Saurida undosquamis*), introduced into the Mediterranean through the Suez Canal, has driven out native fish, become a considerable commercial fish catch and a top predator (Yousif 2003).

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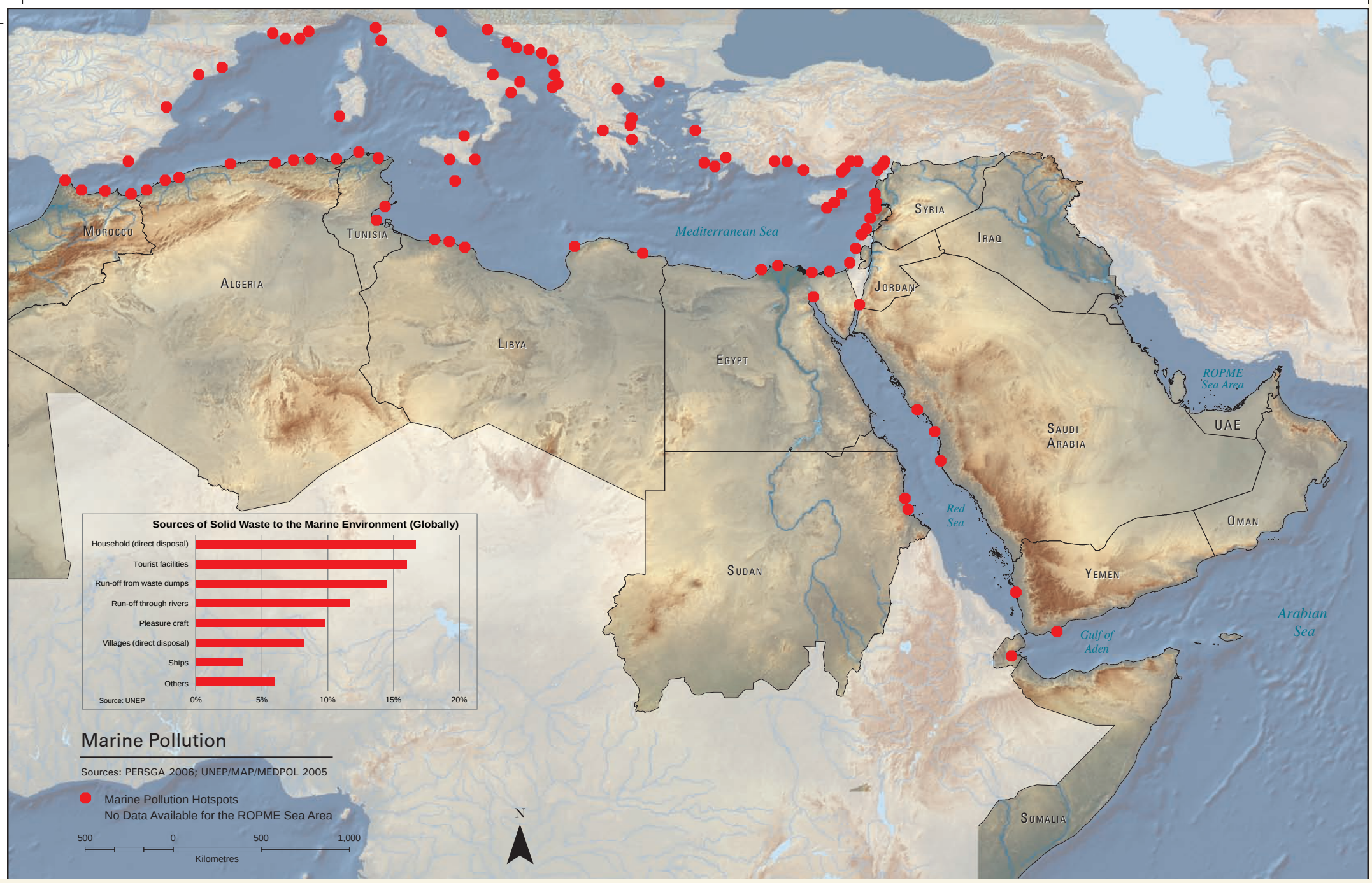

Marine Pollution and Hotspots

The Mediterranean Region

An estimated 150 million people are concentrated along the Mediterranean coastline, 54 million of whom inhabit coastal zones in the eight Arab countries bordering the Mediterranean Sea. Many millions more people descend on the Mediterranean annually as part of a thriving tourism industry. The Mediterranean coastline is also heavily industrialized with hundreds of petrochemical industries, energy installations and chemical and chlorine plants that discharge effluent directly into the sea. Contamination sources in the Mediterranean are largely land-based, consisting mostly of untreated sewage discharge from urban centres, agricultural run-off containing pesticides, nitrates and phosphates, and industrial effluents. The map above displays pollution 'hotspots' or areas where pollution is discharged from domestic, municipal or industrial sources to the marine environment, causing impacts to public health, ecosystems and biodiversity.

Though much of the marine contamination sources are land-based, there is increased oil tanker and other shipping traffic in the Mediterranean. An estimated 220 000 vessels cross the Mediterranean Sea each year – about one-third of the world's total merchant shipping. The Mediterranean is a major route for transporting crude oil — approximately 370 million tonnes of oil are transported annually in the Mediterranean Sea, with around 250 to 300 oil tankers crossing the sea every day. The most important oil traffic lane (90 per cent of total oil tanker traffic) connects the Suez Canal and the Sidi Kerir terminal of the SUMED pipeline in Egypt with Gibraltar (REMPEC 2002). The Mediterranean receives approximately 18 per cent of global marine oil pollution, which is minor compared to the ROPME Sea Area and the Red Sea (UNEP-GEO 2000); however, the control of transboundary pollutants and management of waste in the Mediterranean is in need of urgent attention. Mediterranean border countries are applying integrated approaches to coastal zone management to address transboundary pollution reduction and coastal biodiversity conservation priorities in hot spots and sensitive areas.

Pollution transboundary aspects

Pollutants often travel great distances through air, sea currents and rivers before their effects can be traced. Environmental pollution can produce adverse impacts locally (or in proximity to the source of the pollution), regionally, nationally and, in certain cases, globally. Air masses and ocean currents follow circulation patterns that can disperse pollutants and contaminants even to the most remote and pristine environments on the planet.

Oil spills are one of the greatest threats to marine environments in these regions. The effects of oil pollution can be far-reaching and pose a threat to the health of ecosystems. Offshore marine life as well as coastal ecosystems, marine birds that feed at sea, and mariculture are all exposed to risk from oil spillages mainly from offshore oil extraction and oil transport.

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The Red Sea and Gulf of Aden

Hotspots and main land-based sources of pollution in the Red Sea and Gulf of Aden Region are shown in the map to the left. Although approximately 7 per cent of the world's sea-borne oil is transported through the region, there have been no major spills (>5 000 tonnes) resulting from shipping accidents. Most spills in this region have been the result of operational discharges, equipment failures and groundings (ITOPF 2003).

In addition to routine operational leaks and spills from oil exploration and production, pollution by oil from tank washing and discharges from passing ships is the most significant form in the Red Sea. Chronic oil pollution, in the form of tar balls arriving on the shorelines, has already been observed in the immediate vicinity of some major Red Sea ports and coastal areas. The coast of Saudi Arabia between Jeddah and Yemen is heavily tarred in places, along with the Gulf of Aden coastline of Yemen, the coasts of Djibouti and the coast near the offshore oil fields of the Gulf of Suez (GIWA 2006).

There are 25 000 to 30 000 ship transits annually through the Red Sea. Oil tankers and other ships constitute another significant source of oil pollution in the southern entrance to the Gulf of Suez (GIWA 2006). Major shipping routes run close to the coral reefs near the ports of Djibouti and Port Sudan, and ships often discharge oily wastes and sewage. Ships also cause physical damage when collisions within the reefs occur.

The ROPME Sea Area

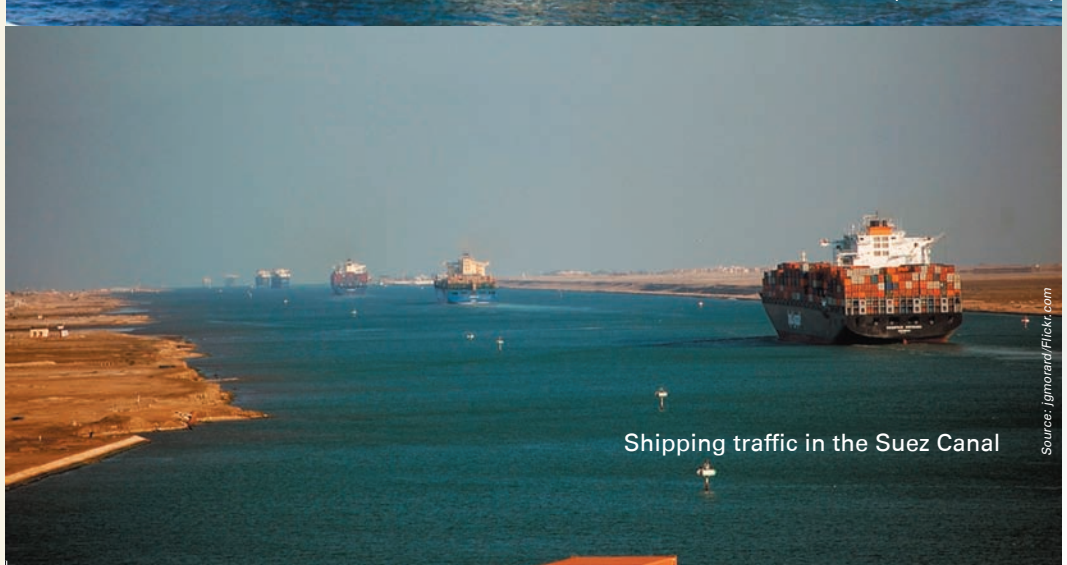
The ROPME Sea Area has some of the greatest pollution risks in the world due to the large number of tanker loading terminals, offshore installations and the high volume of oil tanker traffic. Of the 20 biggest oil spills (greater than 34 000 tonnes) worldwide, 6 were in the ROPME Sea Area (OSIR 2004). The impacts of industrial effluents from petroleum refineries and the petrochemical industry are significant. An estimated two million barrels of oil are spilled annually from ballast discharges, tanker slops and oil and gas platforms (GESAMP 2001). Oil pollution from incidents such as submarine pipeline ruptures also pose a risk to marine ecosystems. In addition, the power plants cause thermal pollution, and the desalination plants, common along the coast of the ROPME Sea Area, release chlorine, brine and thermal loads into the seawater (ROPME 2003).

The ROPME Sea Area has the heaviest traffic of oil tankers. About 25 000 tanker movements sail in and out of the Strait of Hormuz annually and transport about 60 per cent of all the oil carried by ships throughout the world (Sheppard and others 2010). On average, every day about 14 to 15 million barrels of oil loaded on super tankers are transported through the narrow Strait of Hormuz.

Impacts associated with oil traffic include shores heavily contaminated with oil residues and tar balls. About 2 million barrels of oil are spilled annually from the routine discharge of dirty ballast waters and tank washing, partly due to the lack of shore reception facilities. During the Gulf War, over 20 per cent of mangroves on the eastern coast of Saudi Arabia and about 50 per cent of the coral reefs were affected by oil contamination. Hundreds of square kilometres of seagrass beds as well as tidal mud flats were inundated with heavy petroleum products (Sheppard and others 2010).

In 1981, on a voyage from Aqaba to Suez the Loullia ran onto Gordon Reef in the Straits of Tiran, Red Sea

Source: Alex Polezhaev/Flickr.com



Shipping traffic in the Suez Canal

Source: jgmorard/Flickr.com

Navigation Risks in the Red Sea

The Red Sea and Gulf of Aden form part of a major world shipping route that transports about 7 per cent of the global sea-borne oil (PERSGA 2004). Much of the world's crude and refined oil cargoes pass through this region, making it one of the most heavily polluted marine environments. Insufficient and poorly maintained navigational aids and unregulated maritime traffic in many areas of the Red Sea have created high risk zones. These high risk areas include: the southern Red Sea at Bab-al-Mandab and Huneish Archipelago; northern loading points for the Yanbu Petroline in Saudi Arabia; the SUMED pipeline at Ain Sukhna in Egypt; the entrance to the Gulf of Suez and the Suez Canal; and the Straits of Tiran at the entrance to the Gulf of Aqaba. Though no major oil spills (>5 000 tonnes) have occurred to date, a major accident would inflict significant damage to what is considered one of the world's most important marine habitats and species communities. Component 2 of the Regional Organisation for the Conservation of the Environment of the Red Sea and Gulf of Aden's (PERSGA) Strategic Action Programme (SAP) (2004) was designed to promote safety of international shipping and to introduce measures to reduce the impacts of marine pollution. Some of the measures include re-schemed charts of the southern Red Sea to provide better navigational coverage, oil spill prevention and management, traffic separation schemes, and vessel traffic systems.

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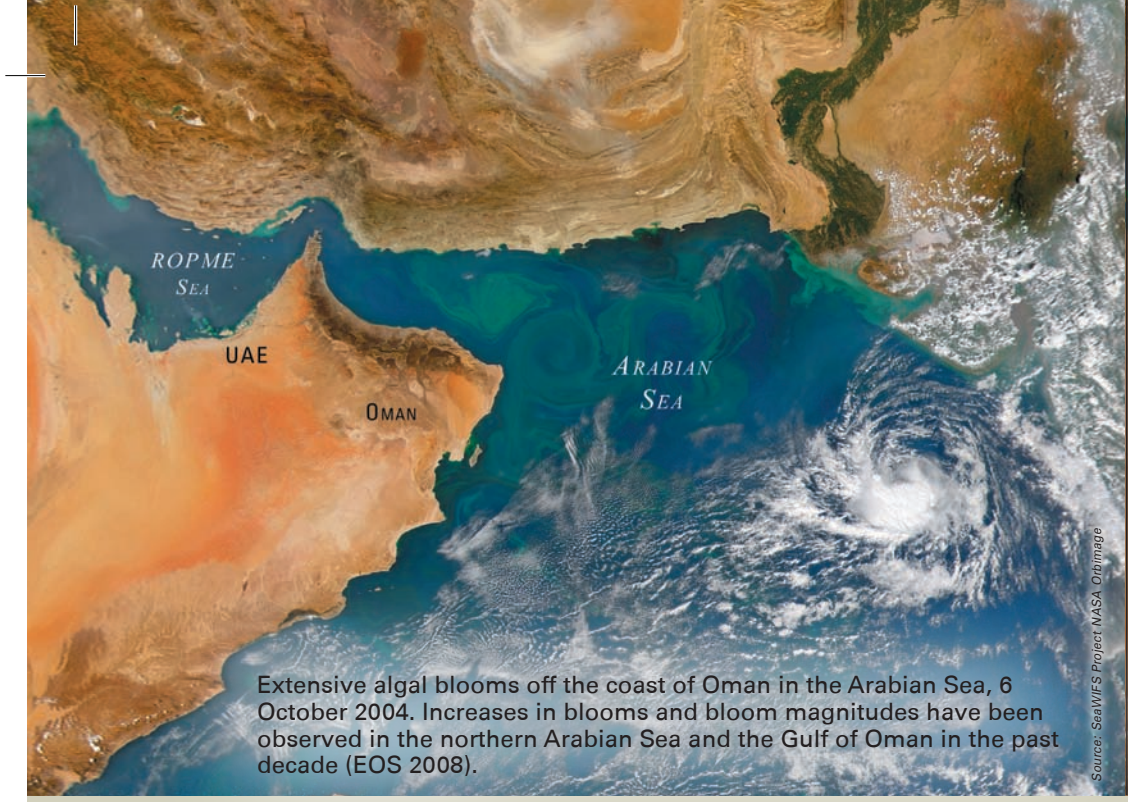
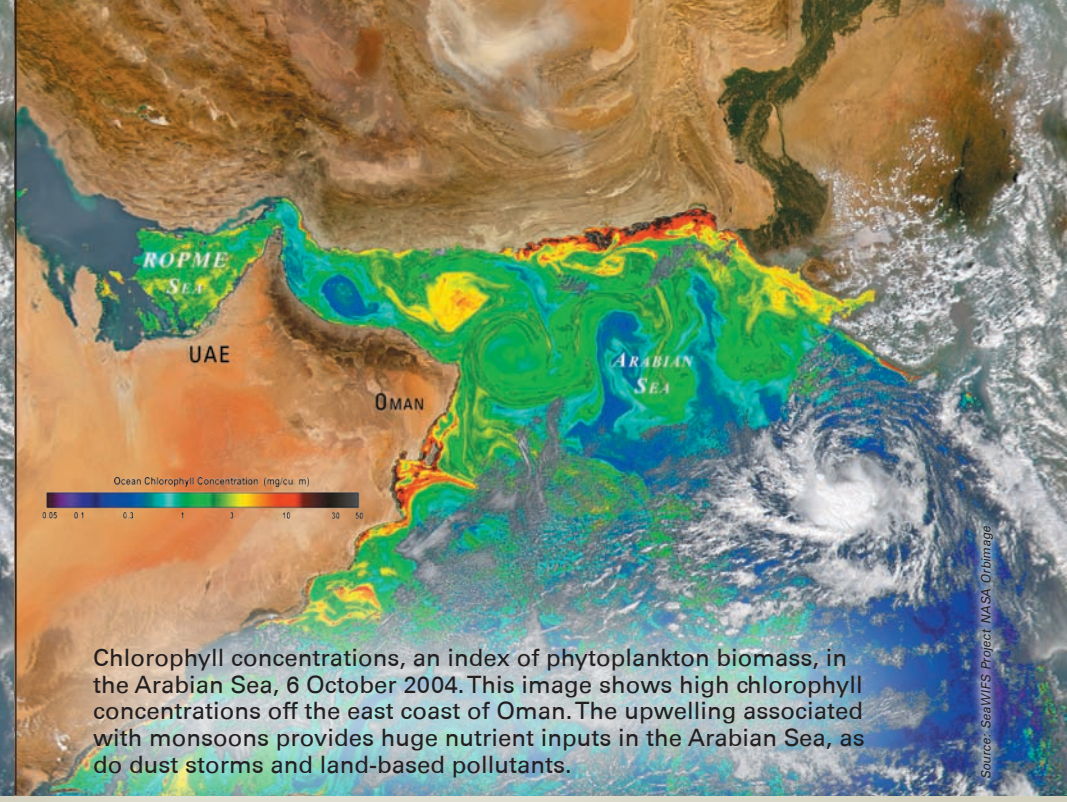


Extensive algal blooms off the coast of Oman in the Arabian Sea, 6 October 2004. Increases in blooms and bloom magnitudes have been observed in the northern Arabian Sea and the Gulf of Oman in the past decade (EOS 2008).

Source: SeaWIFS Project, NASA, Orbimage



Chlorophyll concentrations, an index of phytoplankton biomass, in the Arabian Sea, 6 October 2004. This image shows high chlorophyll concentrations off the east coast of Oman. The upwelling associated with monsoons provides huge nutrient inputs in the Arabian Sea, as do dust storms and land-based pollutants.

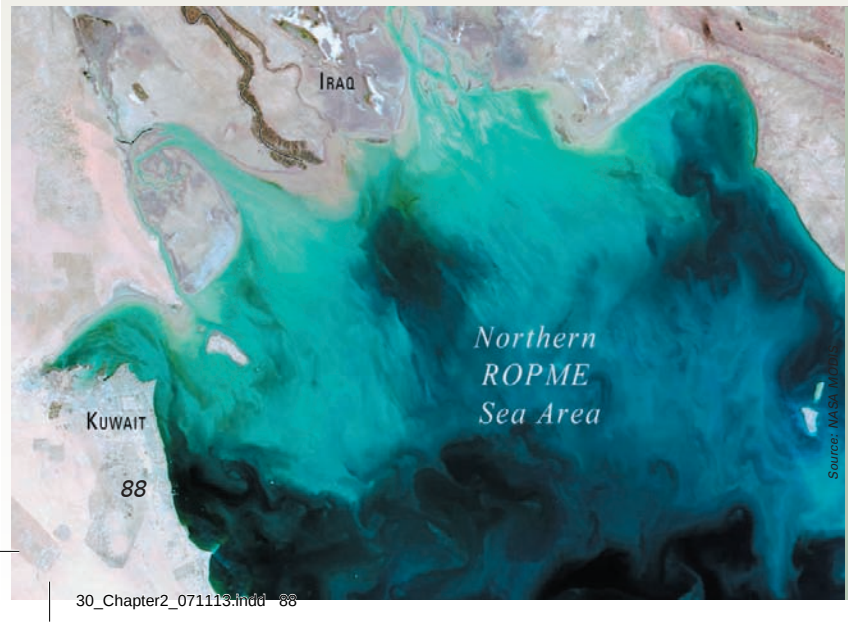
Source: SeaWIFS Project, NASA, Orbimage

Chlorophyll: Key indicator of phytoplankton biomass and eutrophication

Chlorophyll-a, a ubiquitous photosynthetic pigment often associated with other pigments in freshwater and coastal marine phytoplankton, serves as a useful indicator for both the photosynthetic potential and biomass of phytoplankton (Flemer 1969a; Flemer 1969b). Eutrophication occurs when the amount of phytoplankton biomass increases due to the enrichment of waters with nutrients (nitrogen and phosphorus), causing excessive algae blooms – most oxygen from the water system is then used to decompose the algae. Though nutrient enrichment may, in some cases, lead to increased production in commercial fisheries, most of the effects of nutrient enrichment are negative, and result in 'coastal dead zones', which are areas of oxygen deprivation and devoid of life. Currently there are 146 coastal dead zones wordlwide - this number has doubled every decade since 1960 (Larsen 2004); agricultural runoff and municipal wastewater associated with rapid urbanization and growth in populations along the coasts are increasingly to blame. Nutrient over-enrichment interacts synergistically with other human activities, contributing to ever increasing ecosystem degradation (UNEP 2006a).

The Mediterranean Region

Nutrient discharge and eutrophication have been identified as a serious source of environmental degradation in Mediterranean ecosystems due to untreated or partially treated discharges of urban sewage into the sea and leaching from fertilized agricultural areas. An estimated 53 per cent of wastewater discharged remains untreated (UNEP 2004). Areas that are especially impacted include the shallow waters near the Nile Delta and major urban areas such as Sfax, Tunisia (UNEP/MAP/MEDPOL 2005).



Increases in nutrient concentrations and sediments at the outfall of the Shatt-Al-Arab River (at centre) in the northern end of ROPME Sea Area cause phytoplankton blooms- this bloom occurred 29 November 2002. Inputs from untreated sewage, industrial pollutants and oils into Kuwait Bay also increase the seawater nutrient levels.

Source: NASA MODIS

Eutrophication - transboundary aspects

The transboundary aspects of eutrophication relate primarily to its effects on biodiversity. An excess of nutrients in the water gives rise to a complex chain of reactions that disrupt aquatic ecosystems. Under eutrophication, long-living (and slow growing) plants that are important for biodiversity (and support diverse fauna) tend to be outcompeted by fast growing opportunistic species. Among the most serious consequences of eutrophication for biodiversity are algal blooms or red tides. These red tides, caused by several species of microscopic plant-like cells or phytoplankton that produce potent chemical toxins, result in fish kills and contamination of shellfish, and also pose a threat to public health. Bivalve shellfish can accumulate so many toxins that they become toxic to humans. Fish exposed to lower (sublethal) concentrations are also vulnerable to red tides, as they may accumulate toxins in their body.

The Red Sea and Gulf of Aden

Some areas, particularly on the west coast of the Red Sea south of Suez, still receive a considerable load of nutrients and biological oxygen demand (BOD) discharges from domestic sewage. This contributes to eutrophication of the coastal waters around selected population centres, major ports and tourist facilities (Gerges 2002). Oxygen depletion is further exacerbated by dredging and infilling associated with urban expansion, tourism and industrial development, which causes excess sedimentation, which in turn leads to suffocation of benthic communities and ecosystem damage (GESAMP 2001 in UNEP 2006a).

The ROPME Sea Area

Discharges of industrial waste and untreated or partially treated sewage contributes to eutrophication in the ROPME Sea Area. Sewage treatment plants exist in all the countries that border the sea, but the level of treatment varies and the capacity is not sufficient to deal with existing loads. Moderate measurements of chlorophyll-a, ranging from 0.2 to 0.86 mg/m^3, have been reported in the ambient marine environment of the inner ROPME Sea Area (Sheppard and others 2010); values around 0.5 mg/m^3 and greater have been reported from the outer ROPME Sea Area waters. Signs of eutrophication including red tides were observed in Kuwait Bay and in the coastal waters of Muscat (Oman), Dhahran (Saudi Arabia), Abu Dhabi (UAE) and Bahrain (ROPME 2003).

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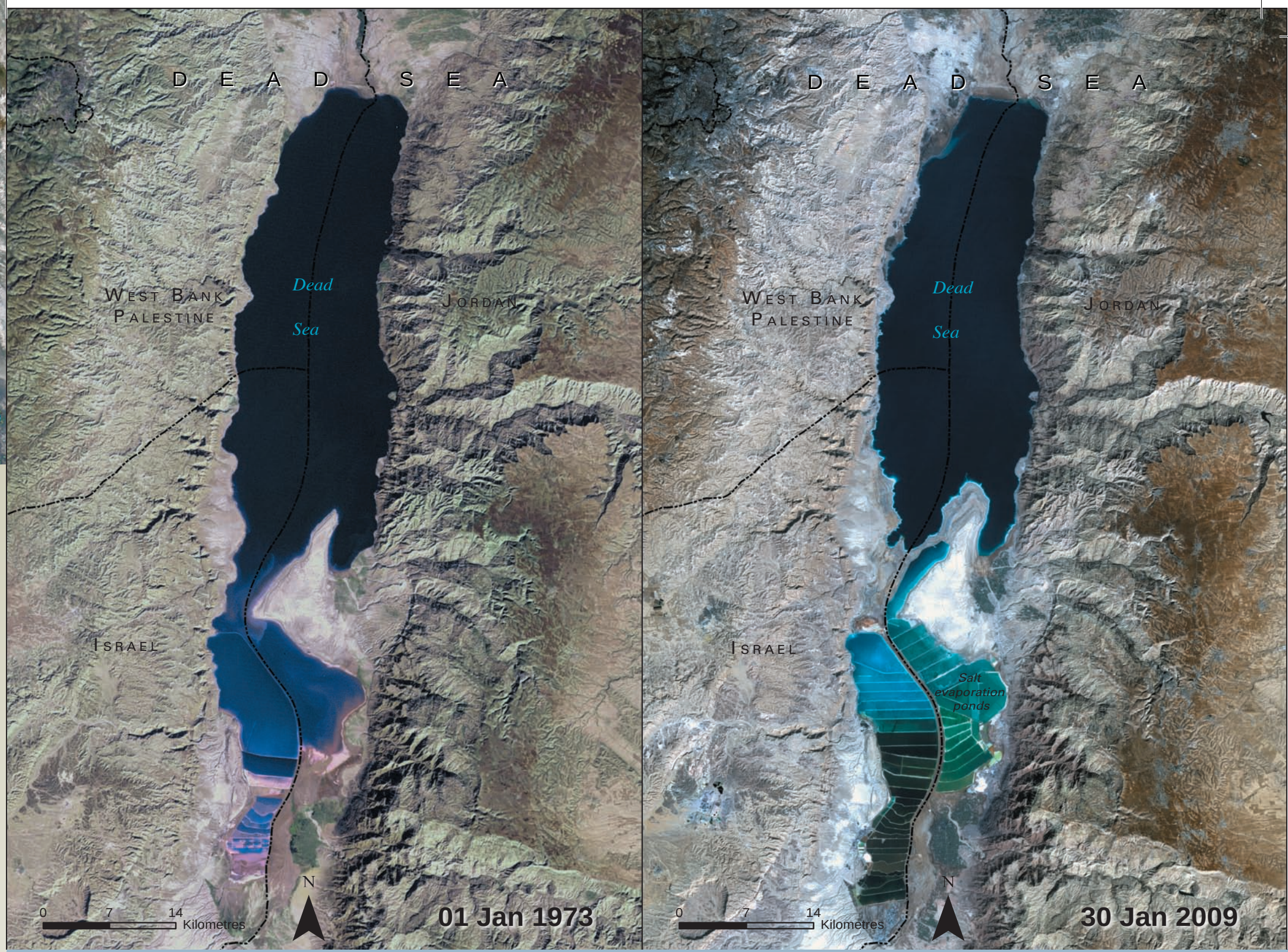

The Dead Sea

The Dead Sea, about 400 m below sea level, is a hypersaline landlocked lake located in the Jordan Rift Valley. The Jordan River is the only major water source flowing into the Dead Sea, although there are small perennial springs that also feed into the sea. The Dead Sea's distinctive chemical composition and fresh/salt water interface have created a unique ecology of international importance. This body of water is rapidly changing, and water levels are dropping due to sharp decreases in inflow from the Jordan River. Excessive abstraction of the river water to meet increased demand in surrounding countries has caused a significant decrease in the Dead Sea's water level. The water level has decreased from 394 m below sea level in the 1960s to 418 m below sea level as of 2006. These levels continue to drop at an alarming pace of 0.8 to 1 m/yr, and the surface area is shrinking accordingly—the Dead Sea's surface area has been reduced by one-third, and currently covers 637 km^2 (World Bank 2009). The impacts of this declining water level and surface area include loss of freshwater springs, river bed erosion, and creation of thousands of sinkholes, or underground craters.

Infrastructural, institutional and demand management solutions have been proposed to prevent continued degradation of the Dead Sea and develop additional water resources. Foremost among these is the Red Sea-Dead Sea Water Conveyance Concept; this would convey seawater in a canal from the Red Sea into the Dead Sea while generating hydroelectric power for use in desalination. This would arrest the rapidly declining water levels in the sea and allow water to accumulate over time to feasible levels (World Bank 2009). Opponents of the canal propose that allowing the Jordan River to flow unimpeded into the Dead Sea would be a more effective restoration tool; other concerns related to the conveyance project include the changes to the Dead Sea's unique water chemistry due to inputs of Red Sea water, the introduction of invasive species, and the disproportionate benefits to certain riparian countries due to already established border and water rights. Addressing the problem of overexploitation of ground and surface waters is essential to curbing the tremendous ecological damage to this internationally significant site. The need for effective water governance for the Jordan River and Dead Sea basin has been recognized. The countries of Israel, Jordan and the Occupied Palestinian Territories are promoting the canal project to coordinate efforts to recharge the Dead Sea; however, addressing water demand in the region is an essential part of a comprehensive conservation strategy. These images show the dramatic decrease in surface area of the Dead Sea from 1973 to 2009, as well as extensive development of salt evaporation ponds at the south end of the sea. These ponds produce sodium chloride and potassium salts.

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Source Jonas Hansel/Flickr.com

Hebron, West Bank. Protective wire mesh protects shoppers in the alleyways of the bazaar from rocks, bottles and trash being thrown down from settlements above.

The once flourishing bazaars of central Hebron, one of the West Bank's largest cities, are now blocked with barbed wire or mesh fencing. Since establishment of a Jewish settlement in the heart of the city in 1979, the economy of this dynamic urban centre has been in decline. To protect the hundreds of settlers, the Israeli military enforces drastic security measures that severely restrict Palestinian movement in areas surrounding the settlement and have driven Palestinians out of their home (UNISPAL 2007).

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2.5 Conflict

Contention, Strife and Human Migration

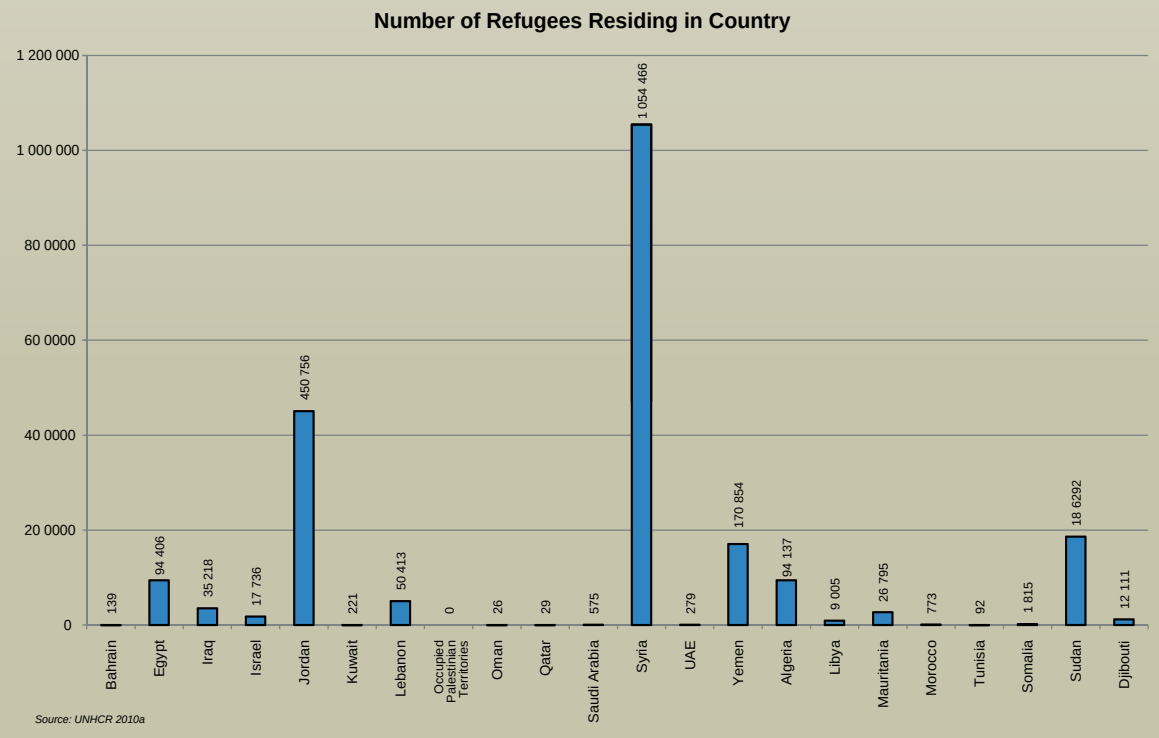
Migration is one of the defining global issues of the early 21st century, with more people on the move today than at any other point in human history—almost 214 million people live outside their birthplace today, which is equivalent to about 3 per cent of the world population. Sixteen million of these migrants are refugees (UN 2009). The current annual growth rate of international migrants worldwide is about 2.9 per cent (International Organization for Migration [IOM] 2010), which is substantial when compared to the world population growth rate of 1.2 per cent in 2009 (PRB 2009). Human migration can be internal (Internally Displaced Persons [IDPs]) or external (refugees and labour migrants), and can be triggered by armed conflict, environmental degradation, or the need to better economic opportunities.

The Arab region, which is home to 5 per cent of the global population, exhibits some of the highest migration rates in the world. Continued conflict and growing scarcity of resources in the region, coupled with climate change, will likely increase the rate of migration. Countries in the Horn of Africa are among those most affected due to poverty, conflict and limited access to resources such as fertile land and water (UNHCR 2010a). Much of the conflict is centred in the arid and semi-arid regions of the Horn of Africa, where pastoralists and agriculturalists have to share resources under deteriorating climatic conditions and resource capacities.

Displacement in the countries of West Asia is mostly fueled by armed conflict, such as in Iraq, the Occupied Palestinian Territories and Yemen. For example, out of a population of 4 million in Lebanon, 400 000 are Palestinian refugees (UNRWA 2008); Syria's population of 18 million includes 1.2 million Iraqi refugees and 560 000 Palestinian refugees (UNHCR 2009a). Jordan is an extreme example of an Arab country affected by mass migration due to regional conflicts - migrants account for more than half of the country's population of 5.7 million, with approximately two million registered Palestinians and an estimated half million Iraqis (UNHCR 2009b). The case of Jordan is all the more acute because it has one of the lowest annual per capita water resources in the world at 153 m^3 (UNDP 2009).

Armed conflict is not only political in nature; in the past 60 years, at least 40 per cent of intra-state conflicts were linked to natural resources (UNEP 2009b). Although environmental factors are rarely the sole source of conflict, potential for violence, and thus displacement, is expected to rise with demographic pressures, economic hardship, growing demand for resources, and climate change. Extreme weather events such as storms, droughts and floods have significantly increased in the past 30 years, causing the displacement of 20 million people in 2008; during that same year, 4.6 million people were internally displaced due to conflict and violence (IOM 2010). The Arab region generates and hosts a large number of refugees and displaced people, estimated at 9.6 million (UNHCR 2010a). As the world's increasing population puts further pressure on already strained resources, environmental migrants are becoming more commonplace. It is estimated that by 2050, 25 to 1 000 million persons will be displaced internally or across borders due to climate change (IOM 2010). These refugees, in turn, place an additional burden on existing resources, causing further environmental degradation and bolstering a vicious cycle of conflict-displacement-and environmental degradation.

Ongoing conflict in Western Sahara, along with desertification, are prompting migrations of the local population. Once composed primarily of grasslands, the Sahel is facing increased desertification due to extreme weather conditions such as drought and flooding. Communities are heavily dependent on natural resources, which renders them highly vulnerable to environmental changes (IOM 2008). As of 2009, 125 000 people in the western part of Morocco were receiving food rations from the World Food Program (WFP 2009).



Refugees in west Darfur, Sudan

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Photo: Yesil Sevenler/Flickr.com

Photo: Yesil Sevenler/Flickr.com

As a result of the Israeli bombing of the Jiyyeh power plant in Lebanon on 27 July 2006 a massive oil spill near Jbeil is evident, causing widespread environmental consequences. The coastline of Lebanon was heavily polluted by oil as a result of the bombing.

Source: NASA / MODIS Images

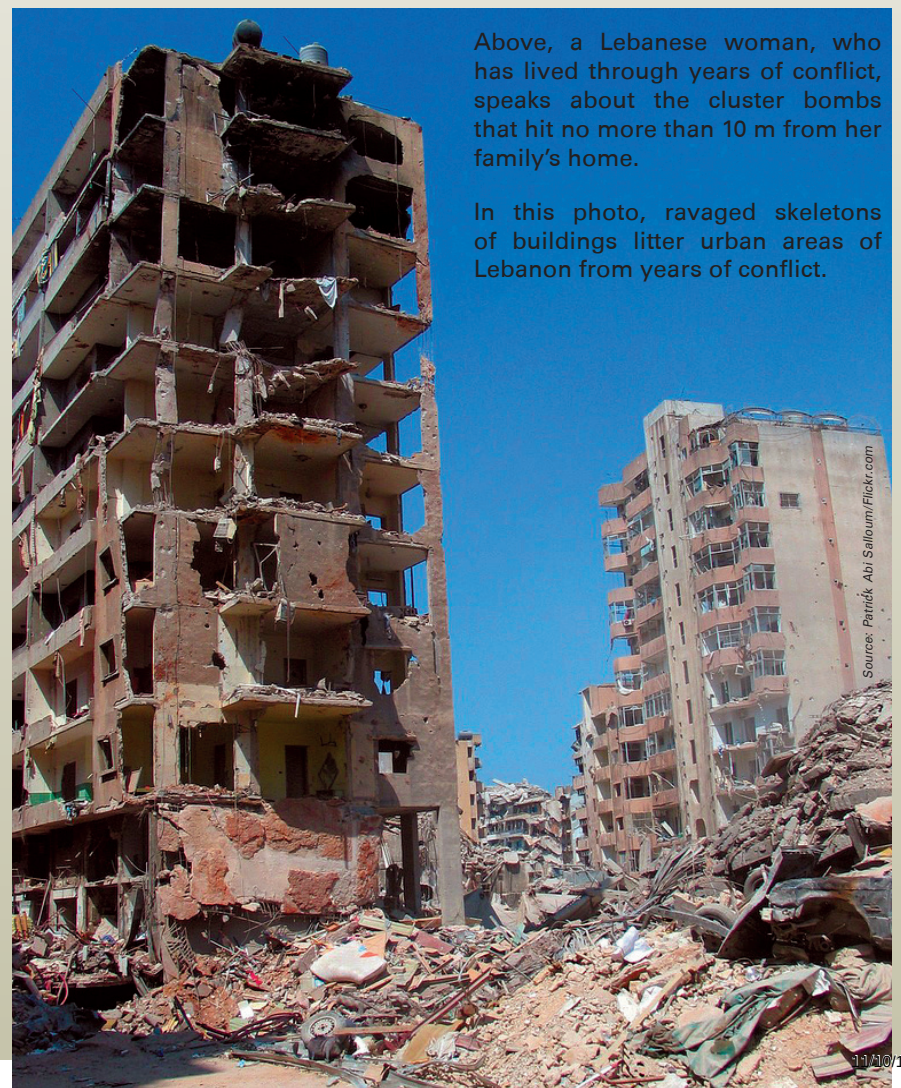
Conflict and displacement: Lebanon

Continuous conflict in Lebanon (1975 to 1990 civil war, Israel's 18-year occupation of southern Lebanon, July 2006 Israeli war on Lebanon and the 2007 Nahr el Bared conflict and consequent destruction of the Palestinian refugee camp) has left hundreds of thousands of people dead and over a million displaced. Conflict has also caused mass emigration out of the country. An estimated 28 per cent of the population was displaced due to the civil war and 949 villages were affected, of which 174 were totally or partially destroyed. The vast majority – over 85 per cent –were displaced from Mount Lebanon or the southern region. Subsequent Israeli conflicts left approximately 200 000 Lebanese displaced. Palestinian refugees, already displaced from their home country, were further uprooted during the "War of the Camps" in 1985.

Although most of the displacement was temporary, many people resettled indefinitely in Dahia, the southern suburbs of Beirut. As of 2006, nearly 17 000 Lebanese were still displaced by the civil war. The 2006 Israeli conflict destroyed and damaged civilian infrastructure, and forced an estimated one million people to flee their homes (90 per cent had returned home within less than a week of the ceasefire) (UNEP 2007a). Environmental impacts of the 2006 conflict were widespread. Oil contamination from bombings was one of the more severe environmental consequences of the conflict. According to the UNEP Post-Conflict Environmental Assessment "The environmental impact of the conflict was brought to the fore by the bombing of fuel storage tanks at the Jiyeh thermal power plant ... which resulted in some 10 000 to 15 000 tons of heavy fuel oil spilling into the sea, affecting approximately 150 km of Lebanese coastline, as well as part of Syria's coast" (UNEP 2007a).

Source: United Nations Photo Flickr.com

Above, a Lebanese woman, who has lived through years of conflict, speaks about the cluster bombs that hit no more than 10 m from her family's home.


Source: Patrick Abi Salloum/Flickr.com

In this photo, ravaged skeletons of buildings litter urban areas of Lebanon from years of conflict.

A Lebanese boy who lost his house in Harat Houreyk (a southern suburb of Beirut) as a result of conflict in the country.

Source: Farfahinne/Flickr.com

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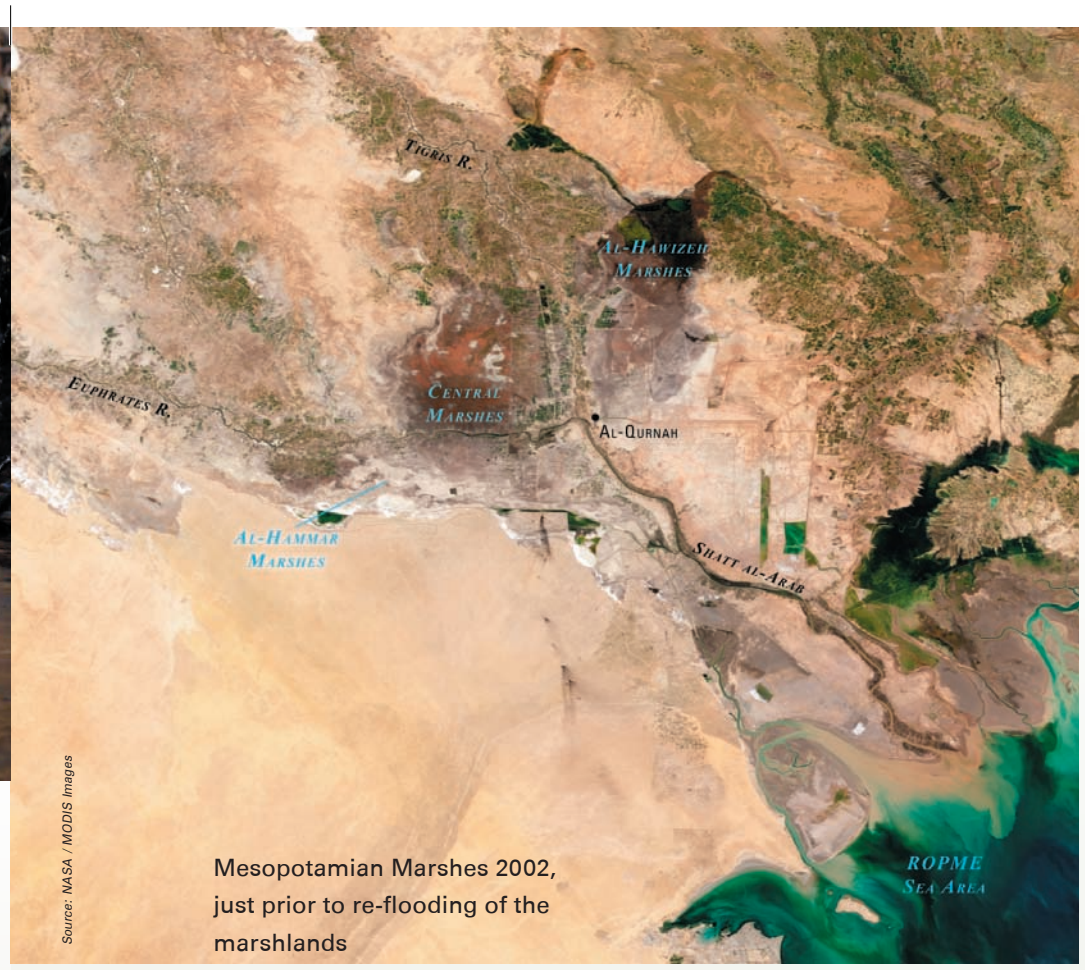
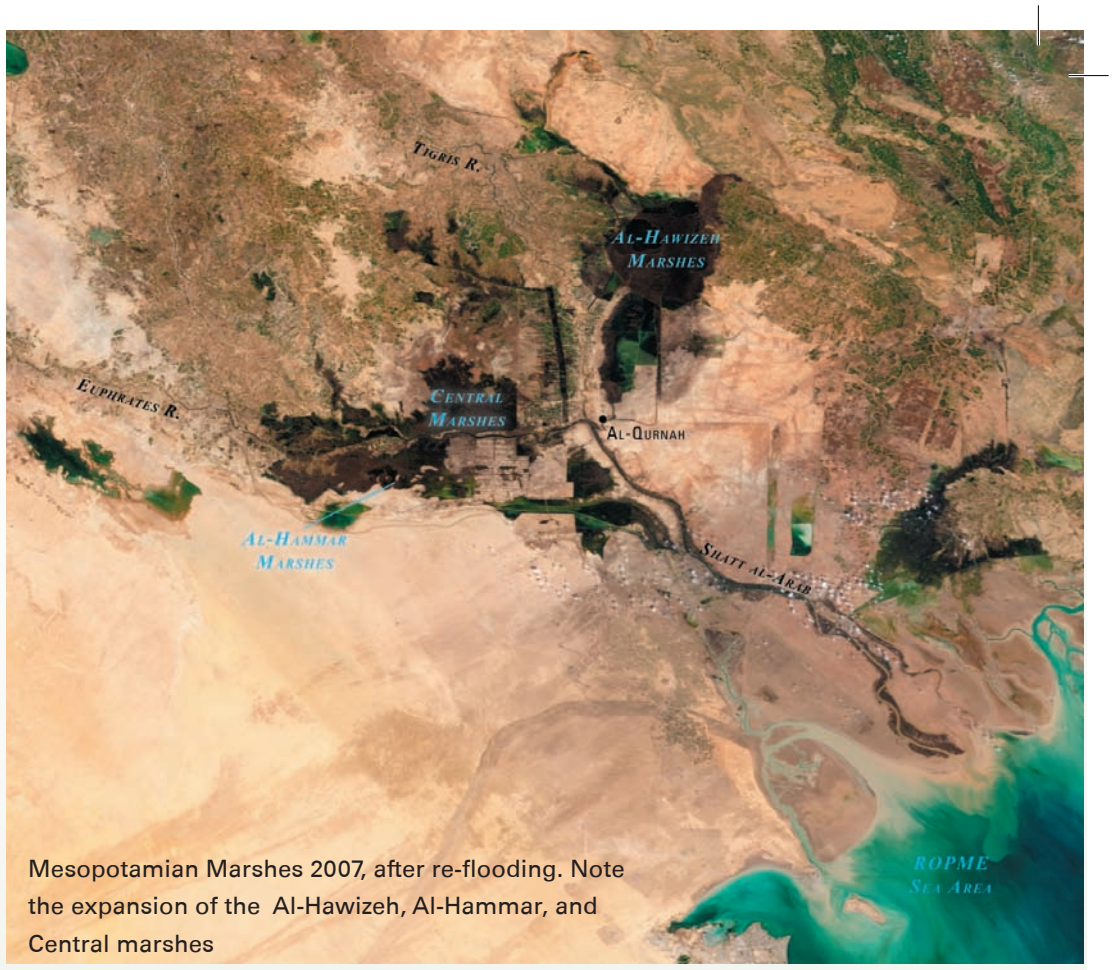


Source: NASA / MODIS Images

Mesopotamian Marshes 2002, just prior to re-flooding of the marshlands



Mesopotamian Marshes 2007, after re-flooding. Note the expansion of the Al-Hawizeh, Al-Hammar, and Central marshes

Source: cadepinkng.Flickr.com

Iraq war refugees

Iraq

The war in Iraq has caused massive internal and external displacement since 2003. By January 2009, 2.7 million Iraqis were internally displaced and about 2 million others were refugees in neighbouring countries such as Jordan and Syria (UNHCR 2010a). In the past, years of sanctions also caused a severe brain drain - beginning in 2003, where an estimated 40 per cent of Iraq's professionals fled the country and many others were persecuted or killed by militias. Between 2005 and 2007, school enrolment dropped by 45 per cent due to lack of teachers and fear of kidnapping (UN News Centre 2007).

Although the overall security situation is somewhat improving, mass returns have not taken place yet due to continued violence; in 2009, only 6 per cent or 167 000 IDPs returned to their homes, while only 37 000 refugees returned to Iraq (UNHCR 2010b). Also, Iraqis remaining in their place of origin are vulnerable due to the ongoing violence and continue to face a deteriorating standard of living, lack of infrastructure, movement restrictions, high unemployment and loss of work opportunities (UNHCR 2010a).

Mesopotamian Marshes

The Mesopotamian marshlands of southern Iraq, which consist of wetlands, open water, tall reedbeds, desert shrubs and grasses as well as inundated mudflats (UNEP 2003), have sustained the way of life of the Marsh Arabs for thousands of years. These marsh peoples live in reed dwellings floating on water and make their living out of raising buffalo, fishing, agriculture, and manufacturing reed baskets and furniture. Almost 90 per cent of the marsh area was lost due to upstream damming and massive drainage works in southern Iraq by the previous Iraqi regime during the 1990s (UNEP 2003)—the surface area shrunk from an estimated 20 000 km^2 to 400 km^2 in 2000 (UNEP 2007b). The demise of the marshlands, and the forced expulsion of the indigenous population in the 1980s, caused the displacement of up to 300 000 Marsh Arabs inside and outside Iraq (Reliefweb 2003). In 2003, a mere 40 000 of the once 500 000 marsh inhabitants remained, or 8 per cent of the original population (Reliefweb 2003).

After the collapse of the Saddam regime in 2003, local communities started to open floodgates and destroy earthen dikes and dams, releasing water back into the marshes. By March 2004, almost 20 per cent of the original marshland area had been restored (UNEP 2007b). In July 2004, UNEP launched the first phase of a long-term project to restore the marshlands, provide clean drinking water and sanitation for 22 000 Marsh Arabs and train Iraqis in wetland management and restoration (UNEP 2004). According to the Iraqi Marshlands Observation System (IMOS), 58 per cent of the marshlands have recovered to their original extent (UNEP 2006b). Timely and adequate water flows must be maintained to ensure the recovery of this dynamic and unique ecosystem, which requires coordinated basin-wide management of the Tigris and Euphrates rivers.

Source: Salim Vaji Flickr.com

Iraqi Marsh Arab

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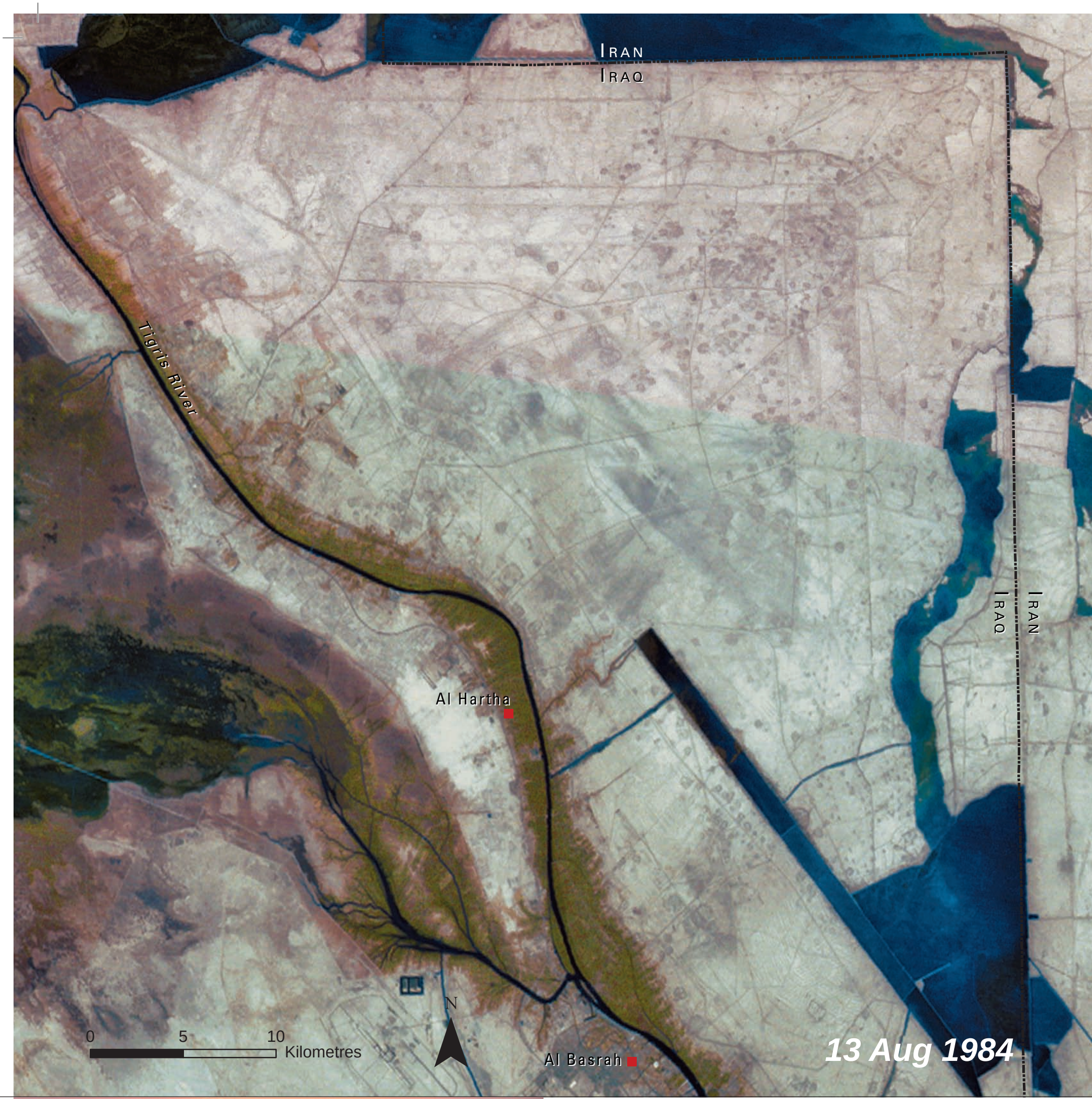

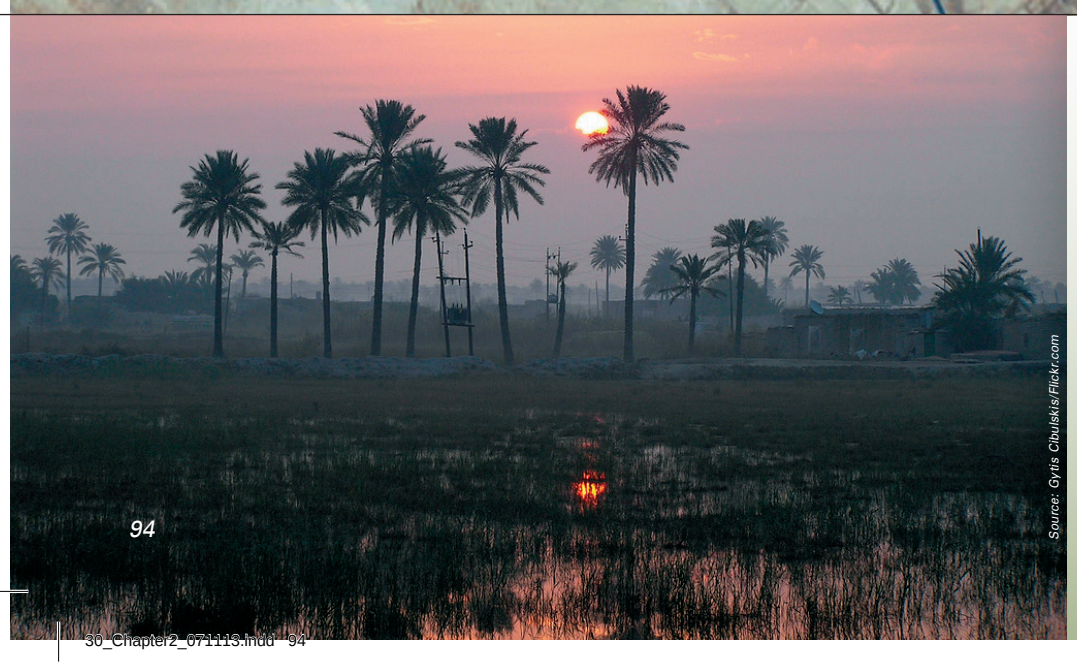
Source: Gytis Cibulskis/Flickr.com

Conflict and Environmental Degradation: Iraq

In an area north of the city of Al-Basrah, Iraq, which borders Iran, marshlands were drained and walled off. This strategic place has been used as a staging area for military exercises and battles, and is littered with minefields and gun emplacements.

The image on the left is from 13 August 1984 and displays the Tigris river, palm plantations and agriculture along the river, areas of open water and marshlands. Some landscape impacts are evident in the staging area in the 1984 image.

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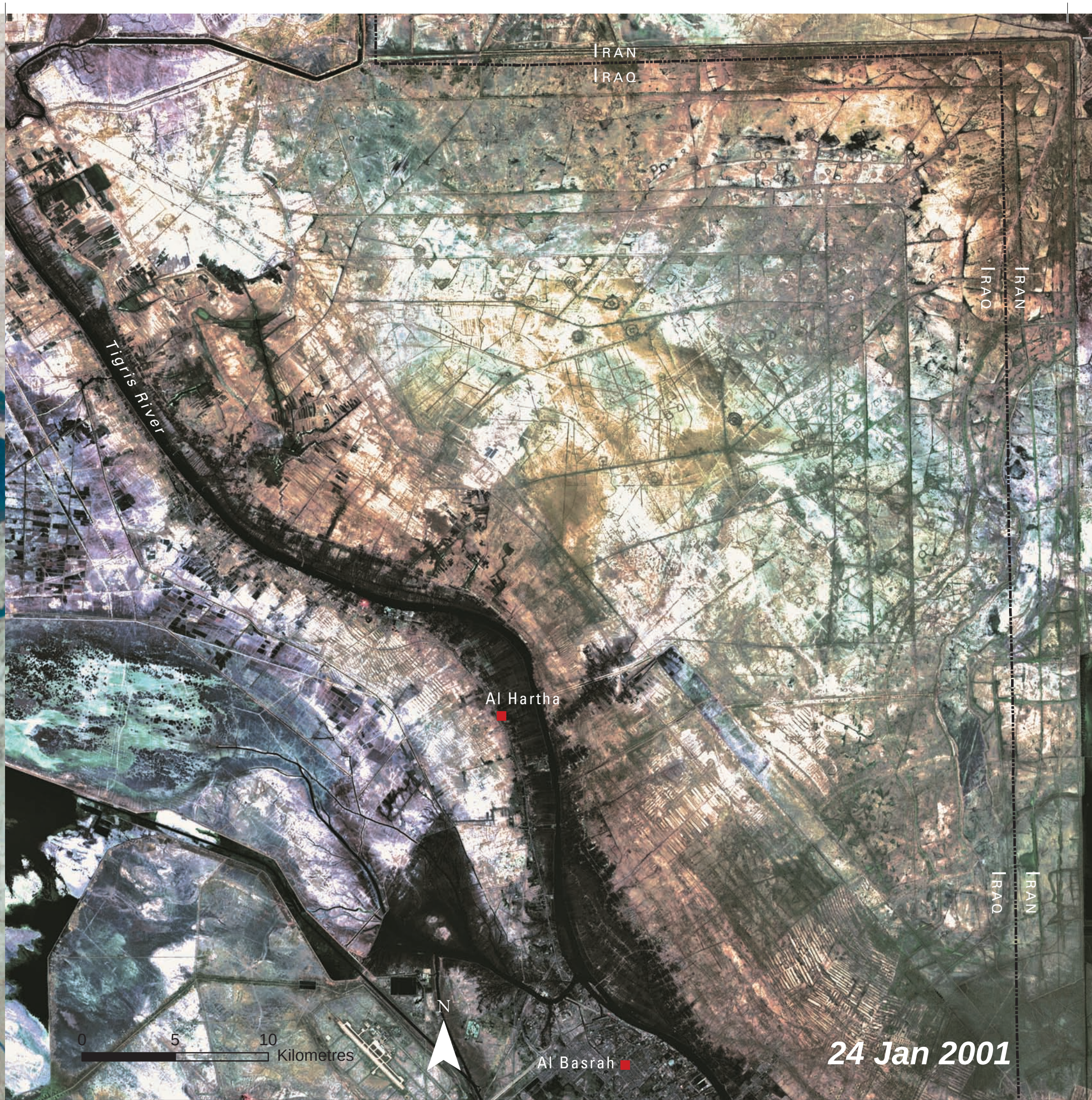

The image on the right was acquired by Landsat 7's Enhanced Thematic Mapper plus (ETM+) sensor on 24 January 2001. This is a false-color composite image made using near-infrared, red, and green wavelengths. The image has also been sharpened using the sensor's panchromatic band. This image displays the vast impacts from military operation and conflicts, and the total environmental devastation of the area. Marshlands and open water are completely drained and the agricultural zones are fallow. The landscape has been shattered by use as a conflict zone.

Source: DVIDSHUB/Flickr.com

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Wadi Al Batin

Abdaly Farms

IRAQ

K U W A I T

Wadi Al Batin

KUWAIT CITY

ROPME Sea Area

SAUDI ARABIA

Wafra Farms

New green plant cover within fenced protection area near Al Abdaly Farms in the north of Kuwait

Source: eMSK /EPA /Kuwait

0 10 20 40 Kilometres

N

22 Feb 1986

KUWAIT-IRAQ AND KUWAIT-SAUDI ARABIA GREEN BORDERS:

REMARKABLE ENVIRONMENTAL CHANGE AND ENHANCEMENT

The most apparent and visible evidence of desertification is the loss of vegetation cover and its insufficient protection against soil erosion. Loss of plant cover entails loss of biodiversity and the failure to withstand habitat deterioration or desertification. Successfully stemming the spread of desertification can be achieved through national policies that allow resource conservation to be an integral part of national endeavours that protect and utilize natural resources sustainably. The Kuwait-Iraq Separation Border Zone (a demilitarized zone), imposed by the UN Security Council in 1991 after the Iraq war, runs 190 km along the border and extends 10 km into Iraq and 5 km into Kuwait. Comparing the image pairs shows that within this fenced and protected area, the change in green cover is clearly evident. Similarly, the fenced border areas between Kuwait and Saudi Arabia, and the fenced oil fields in Kuwait have also shown a remarkable increase

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Wadi Al Batin

Abdaly Farms

IRAQ

K U W A I T

Sabah Al-Ahmad Nature Reserve

KUWAIT CITY

Al-Jahra Reserve

Wadi Al Batin

ROPME Sea Area

SAUDI ARABIA

Wafra Farms

New vegetation in Sabah Al-Ahmad Nature Reserve

Source: eMISK/EPA/Kuwait

0 10 20 40 Kilometres

N

Mar 2010

in green plant cover and demonstrate the power of land use protection from grazing and anthropogenic pressures. Removal of the perturbations has contributed positively to the growth of plant cover and resource conservation. In the past twenty years, the Government of Kuwait has adopted and established twelve protected areas and nature reserves around the country. Another ten protected areas have been proposed, in addition to over eight restricted areas for specific reasons, which includes fenced oil fields and buffer regions around international borders. The 5 km-wide fenced area along Kuwait's northern and north-western borders (established in 1991) was later declared by the Government of Kuwait as a nature reserve to protect wildlife and biodiversity. The combined area (12 adopted protected areas plus 8 fenced areas) in Kuwait is 26.76 per cent of the total country area; over 4 769 square kilometres. These change pair images clearly demonstrate the positive effects that restriction and resource protection have on the landscape by capturing the dramatic increase of green vegetation cover.

Waterhole in Sabah Al-Ahmad Nature Reserve

Source: eMISK/EPA/Kuwait

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Source: John Jobby Flickr.com

Israel's separation wall has become the most visible manifestation of the Israeli military occupation in Palestine

Separation Wall

Occupied Palestinian Territory

In November 1947, the UN General Assembly partitioned historical Palestine into Arab and Jewish states. In the war that followed, more than 700 000 people lost their homes. In 1976, the war between Israel, Egypt, Jordan and Syria resulted in the occupation of the West Bank, Gaza, and the Golan Heights, which also displaced hundreds of thousands of people. Today, almost 1.4 million Palestinian refugees, more than one-third of the total Palestinian population, live in 58 camps in the Occupied Palestinian Territories, Lebanon, Syria and Jordan (UNRWA 2009).

In June 2002, Israel began building a "separation wall" within the West Bank as an asserted security measure. The wall, with a planned length of over 700 km (almost half of which was complete by 2010) separates the West Bank from Israel. It restricts freedom of movement and access of Palestinians, often making it difficult for inhabitants to conduct their daily routines. The wall has also interrupted agricultural activities in the Occupied Palestinian Territories, which contribute 12 per cent of the GDP (World Bank 2009). Agriculture, which uses two-thirds of water resources in the Occupied Palestinian Territories, has been gradually deteriorating since the start of the occupation due to over-extraction of groundwater resources and deteriorated water networks; construction of the wall has isolated 10 per cent of agricultural lands in the West Bank (World Bank 2009), and further restricted Palestinian access to their lands (especially olive groves), a large part of which fall outside the wall extent (Negotiations Affairs Department 2004). The wall has also cut off farmers from their domestic and agricultural wells, further limiting access to water resources. As a result, Palestinian abstractions from the three aquifers in the West Bank have declined from 138 MCM in 1999 to 113 MCM in 2007 (World Bank 2009).

Source: Magne Hagesæter/Flickr.com

Graffiti on the separation wall

Israeli control over resources also impacts water quality; over-extraction of Israeli wells has alarmingly decreased the water table in Palestinian wells, thus increasing salinity (World Bank 2009). Water quality is further exacerbated by land pollution sources, specifically solid waste dumpsites and wastewater treatment plants operating beyond their design capacity. In 2007, a collapsed sewage pond in northern Gaza (Beit Lahia) flooded an entire village and killed four Palestinians – the pond and treatment plant were designed to serve 50 000 people but instead serve 190 000 (UNEP 2009b).

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Internally displaced women carrying water in Sudan

Source: Rita Willaert/Flickr.com

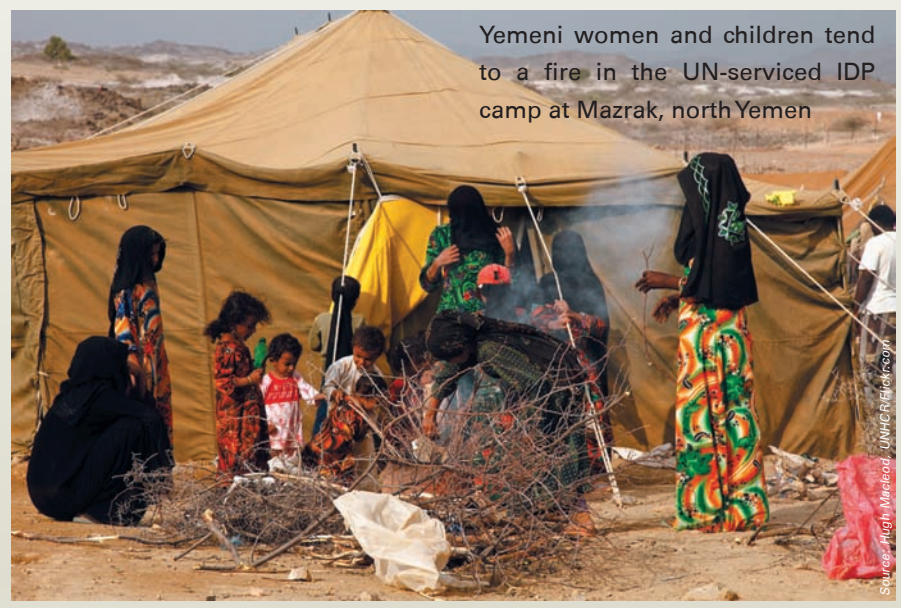
Conflict and displacement: Yemen

Yemen is one of the poorest countries in the world, with high unemployment, severe droughts and food shortages. Ongoing conflict in the country over the past several years has caused massive displacement, particularly along the border with Saudi Arabia where over 150 000 people have been displaced from the Sa'ada governorate since the start of the latest conflict in 2009 (UNHCR 2010a). As of January 2009, the number of IDPs in Yemen was estimated at 100 000, while up to 800 000 people are indirectly affected by the conflict, including communities hosting the refugees. The country also hosts more than 140 000 migrants (as of January 2009), mainly from Somalia, but also from Iraq and Ethiopia (UNHCR 2010a). Abandonment of farmlands in the north due to conflict and drought has led to widespread land degradation.

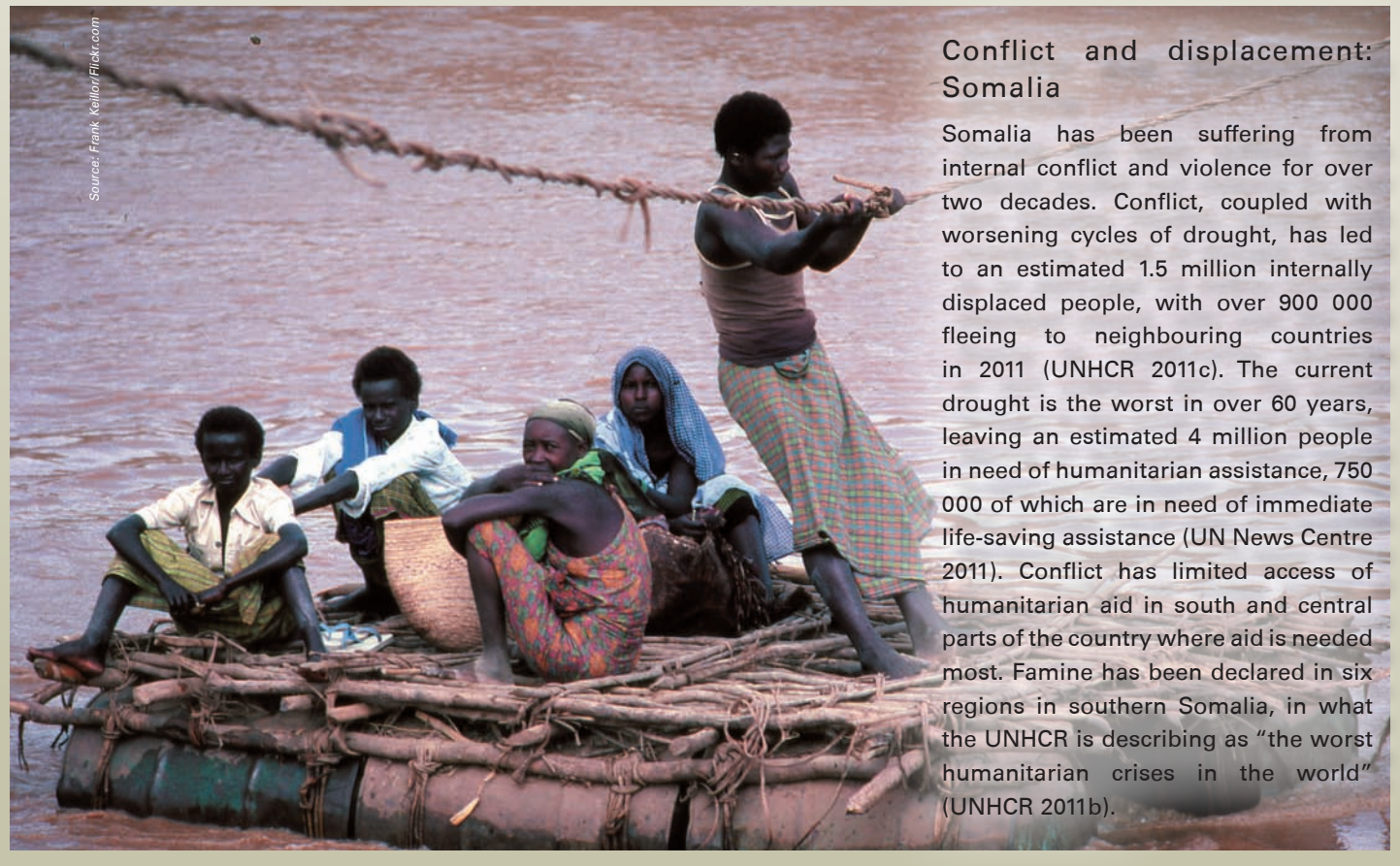
Conflict and displacement: Sudan

Sudan has the largest number of IDPs and international refugees in the world, partly due to long-term violent conflicts that include: the first civil war between the north and south (1955-1972); the oil-fueled second civil war (1983-2005), mostly in the south; and the Darfur conflict (1970-1994), which resumed in 2003. The Darfur conflict alone has caused the displacement of upwards of 2.6 million people, and an influx of 250 000 refugees into Chad, which has transboundary environmental consequences (UNHCR 2010a).

Conflict between the north and south in Sudan is largely due to competition over oil reserves, water and agricultural lands (UNEP 2007c). These areas of the country exhibit extreme differences in terms of climate and natural resources—the south is equatorial, has more water and is more fertile, while the north is mostly desert. Deforestation and a decline in precipitation over the past 30 years has caused nomads and pastoralists in North Darfur to move south, leading to violent competition with the residing farming communities over scarce water resources and agricultural land (UNEP 2007c).

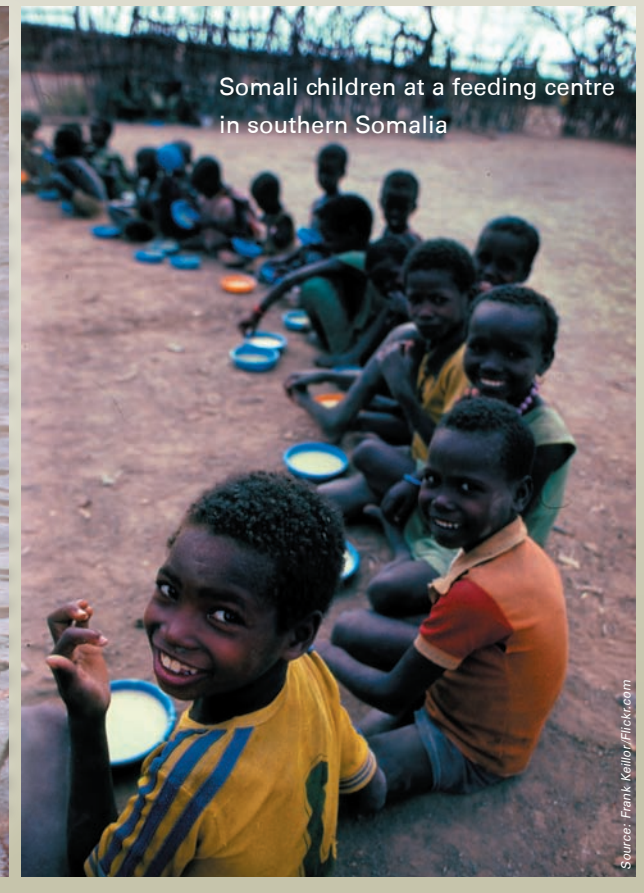

Yemeni women and children tend to a fire in the UN-serviced IDP camp at Mazrak, north Yemen

Source: Hugh Macleod/UNHCR/Flickr.com


Source: Frank Kellor/Flickr.com

Conflict and displacement: Somalia

Somalia has been suffering from internal conflict and violence for over two decades. Conflict, coupled with worsening cycles of drought, has led to an estimated 1.5 million internally displaced people, with over 900 000 fleeing to neighbouring countries in 2011 (UNHCR 2011c). The current drought is the worst in over 60 years, leaving an estimated 4 million people in need of humanitarian assistance, 750 000 of which are in need of immediate life-saving assistance (UN News Centre 2011). Conflict has limited access of humanitarian aid in south and central parts of the country where aid is needed most. Famine has been declared in six regions in southern Somalia, in what the UNHCR is describing as "the worst humanitarian crises in the world" (UNHCR 2011b).


Somali children at a feeding centre in southern Somalia

Source: Frank Kellor/Flickr.com

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