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Chapter 5: Challenges and Opportunities — Change, Development, and Conservation

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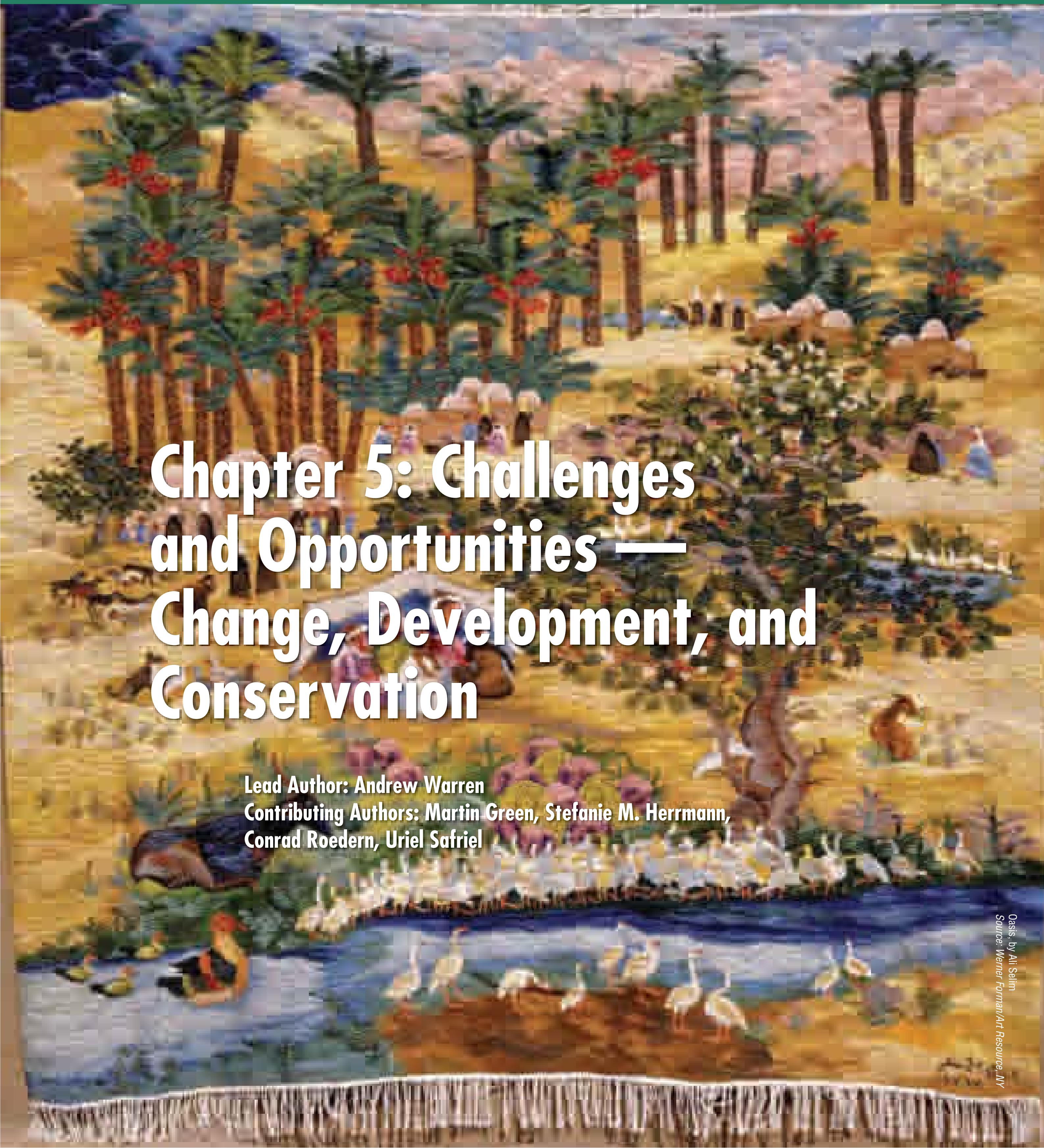


Oasis, by Ali Selim
Source: Werner Forman/Art Resource, NY

This chapter explores the challenges and opportunities for deserts in the coming decades. It is about what might happen, what could happen, and what should happen in deserts. It is an emotional progression: from anxiety about the future, through excitement about its possibilities, to anger when the environment, especially its beauty, is threatened.

The Forces of Change

POPULATION

Population in deserts will change, but unevenly. Few people, mostly pastoralist nomads, live in the great spaces of the desert. Even if the high birth rates often described for some nomad groups were true, the additional numbers would be few. Much larger mining and drilling communities will also have little overall impact. They consist, and will continue to consist, disproportionately of young, short-stay men, whose numbers fluctuate with the price of minerals. In Leonora, an old mining town in Western Australia, over 60 per cent of the population is still male, a century after its foundation.

Rural groups living along the great rivers will have more impact. Scattered, long-established, smaller oases have the same demographic dynamics, but smaller numbers. The World Economic and Social Survey (UNDESA 2005) predicts a steady decline in fertility in these populations, but also overall natural growth for some years. In Egypt, for example, the number of 25–28 year-old men will grow from 3.6 million in 2005 to peak at 3.8 million in 2025, before dwindling. This will put increasing demands on resources, particularly water, and may lead to dissatisfaction with unemployment. But the production of so much potential labour has a more positive implication, because labour is desperately needed in the industrialized world: in Italy, the number of 2–28 year-old males has already peaked and will have halved by 2025; an extreme, but characteristic case. Labour-seeking industries may be attracted to these growing desert populations, but because the greatest demand for labour is in the service sector, more of the surplus will gravitate to the industrialized world, and this will boost a counter-flow of remittances. In Pakistan, remittances peaked in 1982–83, when they contributed 75 per cent to the overall balance of trade (Amjad 1986). In 2002, remittances to the developing world were already US$67 billion, against government and bank lending of US$14 billion (Islam 2003).

Two further groups will have much greater impact. Both have grown and will grow quickly, but by immigration, not by natural increase. The smaller of these two groups is rapidly growing, and uses resources at a high per-capita rate. This group consists of retired migrants to the desert, and inhabits principally parts of the U.S. southwest (Figure 5.1). Growing numbers now also live in the United Arab Emirates (Figure 5.2). Very many more people live in cities like Lima, Cairo, Baghdad, Riyadh, Karachi, Kashgar (Kashi), Urumqi and Yarkand, all with populations of over five million. All have grown and will continue to grow quickly, and all attract many more men than women. Some depend on the production of oases (Cairo and the western Chinese cities); others are supplied from further afield. All consume large quantities of water, although all also pass on large quantities of re-usable water.

INVESTMENT AND CAPITAL

Investment (of a more formal kind than remittances) has a less certain trajectory. Inward investment was the strongest driver of change in deserts in

Figure 5.1: Palm Springs

Palm Springs, California, is where over 30 per cent of the population was over 60 years old in the year 2000. Their profligate use for water for gardens and golf courses is vividly picked out by the red (“false-colour”), which shows photosynthetically active vegetation. The un-irrigated desert is a dull blue-grey.

Source: Advanced Spaceborne Thermal Emission and Reflection Radiometer — ASTER

Figure 5.2: Burj Al Arab

The Burj Al Arab Hotel, Dubai: very high-class desert tourism.

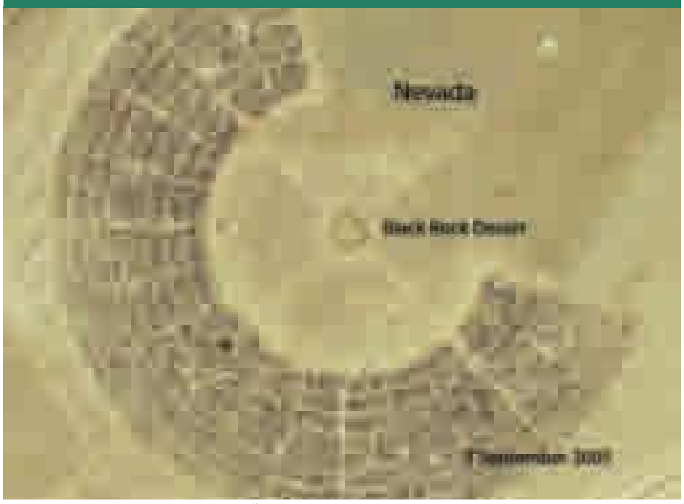
Source: Jumeirah Hotels website, http://www.jumeirah.com/

the recent past. Most went to the extraction of oil, gas, iron, uranium, phosphates, nitrates, and copper, among other minerals. Even if no new reserves of oil are discovered, deserts contain a high percentage of global reserves, and this implies continued investment, if at a lower rate. Rising prices may maintain the income from older investments. Investment in gas is newer, and will probably increase. Iron ore contributes 40 per cent of Mauritania's export income; desert Western Australia contributed 16 per cent of the world's production of iron in 2003. Both will probably maintain their position, although iron prices fluctuate wildly. One-third of known recoverable global reserves of uranium are in Australia, but none of its desert reserves is currently mined. Namibia has about six per cent of known global recoverable reserves, and the Namibian mine is the only desert uranium mine currently in production. A global move to nuclear electricity generation would encourage the reopening of other reserves, as in Kazakhstan, Niger, and northern Chad (over which Chad and Libya went to war in 1987). North Africa (largely its deserts) holds about one-third of world reserves of phosphate.

Desert tourism, another source of investment, has grown quickly. Four million tourists visit Morocco and five million reach Tunisia each year. They contributed six per cent to Tunisian gross domestic product in 1999, and employed over 300 000 people. Desert destinations in both countries outperformed their coasts. There was a 161 per cent increase in tourism to Egypt in 2005. Dubai claims to be the world's fastest growing tourist destination; 100 000 British people have bought homes there, and it is aiming at 15 million tourist visits a year. Baja California is booming. More gambling is said to take place in deserts than in any other global environment. The upward trends may continue in some places, although some markets must be nearing saturation. If the past is a guide, the pattern of development will be patchy.

The steady growth in short trips, as to the U.S. deserts, is less likely to falter. They attract less investment, and probably generate less income, but involve more people. An estimated 800 000 people a year, and as many as 80 000 on a single weekend, already visit the Algodones Dunes in California, many to go dune buggying. The "Burning Man", a week-long cultural festival with international draw, is held annually on the playa of the Black Rock Desert in Nevada (Figure 5.3).

Figure 5.3: The "Burning Man" ceremony, 2005



The Burning Man ceremony is an "annual experiment in temporary community dedicated to radical self-expression and radical self-reliance" held in the Black Rock Desert about 120 miles north of Reno, Nevada.

Source: IKONOS image taken on 3 September 2005; available at http://www.spaceimaging.com/gallery/ on 12 January 2006

Large, cheap sites, which are superabundant in deserts, are a further source of investment (generally by the state). It is not only these qualities that attract this investment: it is also distance from prying eyes and air-borne attack, and freedom from planning objections. All this allows deserts to be used for purposes that would be difficult or even unimaginable in other regions; the first nuclear bomb was tested at La Jornada del Muerto in New Mexico in 1945; the

Figure 5.4: Desert launch centre in China

Chinese astronauts blasted into orbit from this desert site on 11 October 2005

Source: IKONOS image taken on 6 October 2005, available at http://www.space imaging.com/gallery/ on 10 January 2006

U.S. plans to store nuclear waste in about 600 square kilometres of Yucca Mountain, Nevada. The French tested their nuclear bombs at Reggane in the Sahara and the British at Woomera in the Australian desert (a reserved area of about 127 000 km^2), where Australian nuclear waste is now stored. Later came Lop Nur in the Chinese desert (about 100 000 km^2), the Kharan Desert in western Pakistan, and Pokhran in desert India. Military training takes place in the Mojave Desert, the Omani Desert and the Negev Desert in Israel. Russia, China, Japan, and the United States have space-flight installations in the desert (Figure 5.4). Low-cost space in the California deserts is used to park huge numbers of unused aeroplanes. There are prisons in many deserts; Woomera is used to hold refugees, and the European Union is said to be planning a holding station for refugees in the North African desert. These intrusions import many people into deserts, generate considerable income, and help to upgrade infrastructure, but have large environmental footprints, particularly with respect to water. In an insecure and competitive world, this kind of investment will continue, even grow.

GLOBALIZATION

Globalization may continue to be faster in deserts than elsewhere (Box 5.1), but it is also countered by rising oil prices, increasingly restricted migration, nationalism, and cultural separation. In some

Box 5.1: A short history of globalization in deserts

Globalization is nothing new in deserts. Linguistic uniformity, one of its key features, was established hundreds of years ago in the Old World deserts (Diamond 1997), largely because of political unification (a second key ingredient) as under Darius, Alexander, Genghis Khan, Timur and the Muslim Caliphates. Urbanization, yet another key ingredient, was a product, some believe, of the need to organize irrigation (Wittfogel 1957). The Tehuacán Valley, in central Mexico, was a cradle of New World urbanization (Plunket and Urunuela 2005). Traffic between Old World desert cities thoroughly globalized the cameleers, traders and camp followers on the Old Silk Road. They must have rolled their eyes up at globally renowned works in medicine (Al-Samarkandi), astronomy (Qadi Zada), humour (Nasr Ud Din), and poetry (Omar Khayyam), to say nothing of the silks, porcelain and musks that came from beyond the deserts. The Garamantes, who carried goods across the Sahara to the Romans, built impressive Romanesque cities deep in the Libyan Desert (Mattingly and others 2002). The Bedouin of Sinai and northern Arabia controlled yet another route between civilizations, and have been constantly re-globalized, as recently when they adopted satellite phones to play the stock market (Lancaster 1981).

Globalization reached more distant deserts, in Australia and southern Africa, in the era of railways, telegraph lines, radio networks and metalled roads. When international capital financed the exploitation of the vast reservoirs of oil beneath some deserts, some Bedouin were suddenly transformed into some of the richest, biggest-spending and best-travelled people on earth. The impacts of globalization were not all benign, for many desert people have suffered war, suppression and famine precipitated by global conflict. The recent wars in the Chadian, Angolan, Afghan and Iraqi deserts are examples (Figure). Even in desert regions far from apparent conflict, indigenous minority groups, such as the Tuareg and Sahraouis, are affected by increased militarization (Keenan 2005).

Globalization: A Russian-made rocket launcher abandoned in the desert during the proxy war between Chad and Libya (1987.

Source: Charlie Bristow

senses, the deserts are less globalized now than half a century ago: most were once colonial, few now are. Deserts on the tourist maps of the 1970s, as in Algeria, Sudan, Afghanistan and Iran, are now less accessible, although others like Central Asia, have re-opened. The balance of oil investment is also shifting away from deserts. The impact of globalization, where it happens, will be benign here and malign there, as before. The benign impacts include freedom to seek work, attract tourists, and benefit from medical advances and new ideas.

Inequity is a malign outcome of globalization, although it has many other roots. The outlook for equity is murky, and this should prompt concern: inequity is a powerful force for change, perhaps now expressing itself through terrorism. It is true that some remittances are invested constructively back home, as in dry parts of Kenya (Tiffen and others 1993), but remittances are unreliable, and after all, depend on inequity. Globalization counters equity in many other ways. The rich use their gains from globalization to buy off political and economic processes and remove autonomy from the poor. The overall balance between the negatives and the positives in globalization, even its strength, is debatable (Hirst and Thompson 1999).

CLIMATE CHANGE

Climate is another changing input into the equation, if a more dispassionate one. It has the potential to seriously threaten water supply, the most critical of desert resources. Climate could change at two scales. On a long time-scale, climate has and could again change without human intervention. The paleoclimatic record shows that radical change has happened within a decade (or even more quickly). The Akkadian civilization in Iraq and the Indus Valley civilization in Pakistan were brought down by sudden climatic change about 4 000 years ago (Staubwasser 2003). Only 6 000 years ago, Lake Chad, the northern basin of which is now in a literally howling desert, was a freshwater lake bigger than the present Caspian Sea (Drake and Bristow 2006).

Faster climate change is already happening and most climatologists believe that its acceleration is inevitable, whatever the cause, and almost whatever the response: it may be too late to intervene to change the trajectory of the next few decades (IPCC 2001). Temperatures, and with them evaporation (and hence aridity), will almost certainly rise further, which may or may not be compensated by increased rainfall. The deserts whose own climate is most vulnerable to change are in southern Africa. Projections for decreases in run-off in southern African rivers are of the order of 10–30 per cent (Milly and others 2005). Deserts that will most certainly suffer (and perhaps badly) are those that get their water from alpine meltwater (see Chapters 3 and 6). Climate change could adversely affect human health, both through rising temperatures or through increases in rainfall, or its variability. The virulence of plant or domestic animal pathogens may increase, or crop yield could decrease (say after drought), leading to malnutrition. Some climatic effects are well proven, as in the correlation between ENSO events and plague and hantavirus pulmonary syndrome in the U.S. Southwest; child diarrhoea in Lima; and the effects of increased ozone levels in urban areas, brought on by higher temperatures (Patz and others 2005).

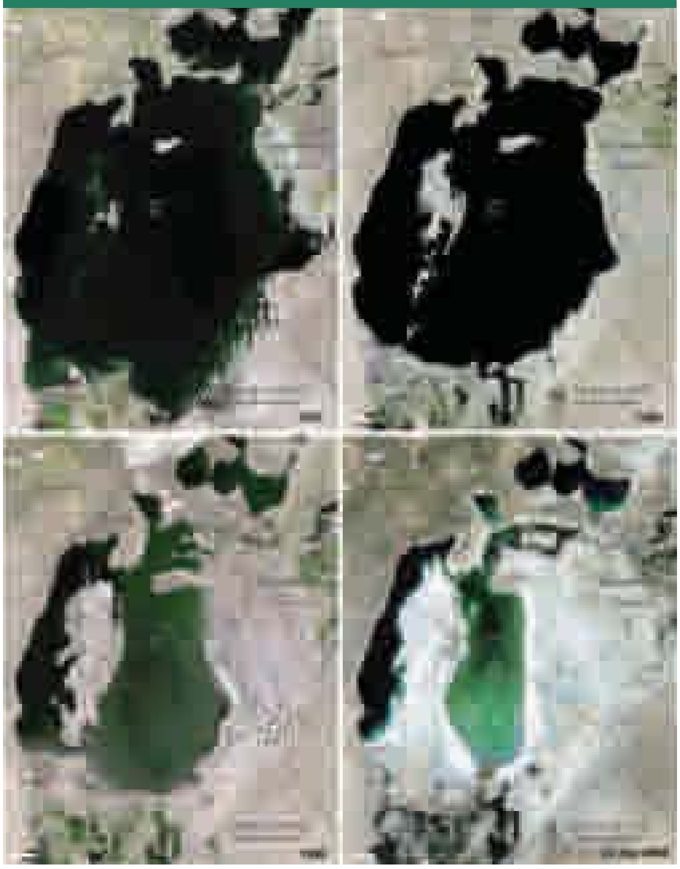
ENERGY

Costs of energy, many believe, can only rise. Petrol prices rose to almost unprecedented heights in the U.S. in 2005, and despite a brief fall in early 2006, the trend is upward. The price of natural gas was a major political issue in Europe in the winter of 2005–6, and most commentators expect natural gas prices to rise further. The costs of aviation fuel are threatening the financial viability of many airline companies. Although some deserts command large reserves of oil and gas, most do not. Dearer energy will affect them all, but in different measure. In deserts, where the relation between the price of energy and that of water is close, more expensive energy will restrain many development schemes. The costs of solar and wind energy may be lower in deserts than in some other places, but even so, they do not yet compete well with fossil fuels, except in a few sites, and their cost-trajectory is uncertain, especially if cheap fossil energy is not available to build the necessary facilities. The costs of travel seem bound to rise, so that tourism may suffer (among many other things), although rising travel costs are claimed not yet to have had an effect in the U.S.

RESTORATION

The costs of cleaning up the mistakes of the past have been rising and are likely to continue to do so. There have been many of these mistakes, some of them discussed elsewhere in this chapter. The reclamation of salinized land, and the revival of economies that once depended on that land, already consume large sums, and could consume much more. By far the best-known case has been the Aral Sea basin (Figure 5.5), which will take decades to restore (if it is ever achieved). The existing recovery programme will only save one basin of the former sea, and reduce only a proportion of the dust that damages health (Kingsford and others 2005).

Figure 5.5: The vanishing Aral Sea



The Aral Sea began to contract after a large proportion of the water in the two main feeder rivers was diverted to irrigated cotton in the 1960s and 1970s. By 1987, its level had fallen 14 m; its salt concentration had doubled from about 10 grams per litre in 1961 to 40 grams per litre in 1994; 20 of the 24 native fish species had been lost and there was a virtual end of commercial fishery; dust storms became toxic with salts and agricultural pesticides; 97 per cent of women in the surrounding area are now anaemic; life expectancy is significantly lower than in surrounding areas. The rescue effort includes the re-engineering of the Syr Darya River delta in the north, which will retain water in the northern basin, but desiccate the South Aral Sea, perhaps within 15 years.

Source: Kingsford and others 2005; image: UNEP/GRID, Sioux Falls

The Aral is not unique. "Salinization and waterlogging have affected 8.5 million ha or 64 per cent of the total arable land in Iraq; […] 20–30 per cent of irrigated land has been abandoned due to salinization" (UNEP 2002). In the Tarim River basin of China, more than 12 000 square kilometres of land was salinized between the 1960s and 1990s (Feng and others 2005). In both countries, degradation is expanding. Because salinization slowly and incrementally affects yield well before it precipitates complete failure, the problem may take years to become apparent to anyone but the local farmers. Collapse of the whole may then be sudden. This is what is said to have happened in Iraq, 3 000 years ago, where the legacy of salinized soils is almost as great today as it was then (Jacobsen and Adams 1958). Dealing with accumulated salt may take centuries, if not millennia.

The prospect of wars over water (Bulloch 1993) has not materialized. Countries that compete for water, like India and Pakistan, have kept strictly to their agreement about sharing water (in their case, the Indus Waters Treaty), even if they have resorted to war over other things. Perhaps water is too important to fight over (Alam 2002). This is not to say that water is not a source of local conflict, as it has been recently in Cochabamba in Bolivia, and continues to be in Israel and Palestine. Reclamation may not, then, be violent, but it will not be cheap. Communities and economies will need to be relocated; national and regional economies have to be adjusted — some of them for the better in the long-term, if we believe Reisner (1986); more will have to be spent on supplying water, and on international treaty obligations. Dust, as from the Aral Sea and the Owens Lake in California, has to be controlled. Sedimenting reservoirs have to be managed more carefully and on a longer-term basis.

Collapse

Accounts of the collapse of the Iraqi and Indus Valley (above) and other desert collapses, such as that of the irrigation system in Chaco Canyon in Arizona in the 12th century (Diamond 2005), show that collapse is a common hazard in deserts. This is largely because desert economies depend so utterly on water. In ancient water-supply systems, withdrawal or degradation usually brought collapse. Vulnerability may now be reduced, but it is not eliminated, as the Aral crisis shows.

CULTURAL CHANGE

In a history of the Grand Canyon, Stephen Pyne (1998) traced a progression of different aesthetics: indifference among the early Spanish explorers; revulsion at a wasteland among the first potential settlers; incomprehension of a huge depression, when landscape taste had discovered mountains; wonder at its geological history, following the discoveries of John Wesley Powell; the American sublime. Each desert has had a similar history of changing tastes, and each will continue to experience this kind of fundamental change.

The Challenges and Opportunities of Development

This section is about what could happen. Technological and organizational changes could bring large gains, but a lesson should be learnt from the short review of dreams about deserts in the past: many promises come to nothing (Box 5.2).

WATER

Water has always been and will continue to be crucial to the development of deserts. But opinions about water development have changed. Fifty years ago there was immense faith in engineers and in state investment to support them (in the western, socialist, oil-rich, and Third World countries alike). But this faith closed planners' ears to warnings about the long-term impacts and real costs of water projects (Reisner 1986). Today, this legacy considerably constrains opportunities in three ways. First, the need to clean up the consequences, as discussed; second, the need to extricate policy from the past and to construct better policy for the future; and third, the depleted and degraded state of whatever water remains.

Building more dams and drilling for more groundwater still tempt the policy-maker, and in many cases the temptation is undeniable. The ongoing debate in Pakistan about a proposal for a dam at Kalabagh on the Indus system illustrates the problems of this course. The water in the Indus and its tributaries is already thoroughly utilized; demand for water is rising with population and modest increases in prosperity; thus the distribution of water is increasingly controversial. The huge dams that were built with foreign aid after the signing of the Indus Waters Treaty in 1960, as at Tarbela (on the Indus itself) and Mangla (on the Jhelum), are filling with sediment (Tate and Farquharson 2000). The first dams took the best sites, leaving sites that are less than optimal. Large, impounded reservoirs lose large amounts of water by evaporation. Dam-building requires huge investment, with questionable long-term returns, and no guarantee that the water they save will not lead, as the water from earlier dams did, to salinization. Climate change will probably decrease the flow of the snow- and ice-fed rivers that are Pakistan's main sources of water.

A high proportion of desert river water is already used. The Colorado River in the USA, the Nile and the Mesopotamian rivers are now nearly completely utilized. Siltation of reservoirs happens worldwide; in the next few decades, sediment may clog the outlets of the Glen Canyon dam (inaugurated only in 1963) on the Colorado River in the U.S.; some NGOs are already calling for its decommissioning. Almost all the sediment in the Colorado and the Nile is retained; the figure is 60–80 per cent in the Tigris-Euphrates system (Vörösmarty and others 2003). The time between the completion of large dams and the point where siltation threatens to close them is running at about 30 to 40 years. If so, many more will soon be threatened.

Returns on investment from water schemes are debatable. In the Central Valley of California, state subsidies on water, in one case, and at one time, amounted to about $217 per acre per year, for land that yielded crops with a value of only $290. The crop was cotton, a highly water-consumptive crop, in national surplus and grown more cheaply in other parts of the USA, let alone elsewhere in the world (Reisner 1986). Of course, dams yield more than water, particularly hydroelectric power and recreation, and these must always feature in cost-benefit analyses, but all of these benefits are threatened by siltation, an almost inevitable

Box 5.2: Desert dreams

Deserts, to those who do not know them, are blank slates. To the desert fathers of the early Christian church, the blank slate was to be filled with God (Figure 1). Imperialists saw something else on the blank slate: somewhere to plot the straight frontiers of their new political entities. Other Europeans and North Americans — scientists and others — had nightmares about the environmental decay they thought they saw in deserts, and used the desert as an object lesson in environmental management (for example, Percy Shelly's "Ozymandias", published in 1818, Peter Kropotkin 1914; Hedin 1931, Lowdermilk 1943).

Figure 1. The search for God in the desert. The Santa Katarina Monastery, at the foot of Mount Sinai in Egypt.

Source: Andrew Warren

Dreams then turned environmental and technological. The dream of deserts reclaimed by planting trees, prompted President Roosevelt to propose a 260 X3 000 km greenbelt across the Great Plains (Zon 1935). Edward Stebbing (1938) dreamt of one across Africa. Much later, the Japanese dreamt of a greenbelt in the northern Sahel (Rognon 1991). More technological dreamers proposed to paint kilometre-scale squares of desert black: dark surfaces would be hotter than light ones; the heat would lift the air; this would encourage rain (Glantz 1977). This idea was less successful than the notion of cloud seeding to bolster rainfall, but it too came to little (Silverman 2003).

Figure 2. Desert dreams: Like ghost-witnesses of a glorious past, only a few dead palms remain from an old deserted golf course near the coast of the Salton Sea, in California. The place was abandoned when the waters of the Salton became saline from the accumulation of agricultural drainage.

Source: Michael Field

The dream of diverting water to reclaim the deserts came true in many places, yet it turned to a nightmare in some, like the Aral Sea. More elaborate dreams were never realized: the Amazon taken in a pipe beneath the Atlantic to West Africa; the Congo pumped over the hill towards Lake Chad; the Zambezi to the Kalahari; the Ob and the Yenisey from Siberia to the deserts of Central Asia (a project that has again been dusted off); the Alaskan rivers to the southwestern United States (another dream that cannot be shaken off). In another dream, seawater was channelled into desert depressions, to test whether this would enhance rainfall. The Chott Djerid in Tunisia, an early target, proved to be above sea level, but the Qattara depression in Egypt was indeed below sea level, and is still the object of these dreams. This kind of dream meets three kinds of waking reality: vast investment; poor support in science; and a history of disaster among earlier dreamers (Glantz 1977; Figure 2).

Dreamers of water beneath the sands were spurred on by the discovery of the Great Artesian Basin in Australia, and of deep groundwaters in the Algerian Sahara in the late nineteenth century. In Libya the dream may have been realized. Even pessimists give the Great Man-Made River in Libya, the first phase of which was completed in 1991, a century of function; optimists claim five centuries. But its aquifer, like almost all desert aquifers, has only a limited life. The deeper water is thought to be 200 000 to 1 200 000 years old, and the water held at depths of less than 600 m below the surface is about 160 000 years old. The water in the Great Artesian Basin is 225 000 to 400 000 years old. Most desert aquifers are smaller, and most are rapidly retreating under heavy pumping. The main aquifer in Shiyang in northwestern China also contains water that is largely "fossil", and is being depleted rapidly (Ma and others 2005). Moreover, many desert aquifers, like the Great Artesian Basin, contain highly mineralized water, quite unsuitable for irrigation. As Saudi wells are pumped ever lower, more and more mineralised water is brought up. Depleting aquifers in coastal areas allows in seawater, which has now penetrated 20 km inland in Libyan coastal aquifers (Allan 2005).

consequence of dam-building. There are many other examples in which the underpricing of water, or the non-collection of fees for water (for whatever reason) has encouraged profligate use, which in turn may accelerate salinization and waterlogging (Ray and Williams 1999). Many of these stories would have applied to Australian water management in the past, but there has now been radical reform aimed at the more effective and less environmentally-damaging use of water (Turral and others 2005).

Groundwater, with some exceptions (Box 5.2), also has problems. Saudi Arabia's trajectory on groundwater illustrates some of these. The city of

Riyadh is close to a large supply of groundwater, yet the government chose to sell this water cheaply for agriculture (to promote food security), and to supply the people of Riyadh with desalinated water pumped up from the ROPME Sea Area, at much greater cost. As in the history of desert water development in the USA, the cheapness of the water allowed Saudi farmers to grow highly water-consumptive crops and even livestock (Figure 5.6; Allan 2005).

Water supply can be improved only by combining technology and management. Some technologies (Box 5.3) may make a great impact locally (as for new hotels or isolated settlements), and could play a greater part in this role. Some are only feasible at large expense and high consumption of energy. A small number, like the desalinisation of brackish water, are both cheap and widely applicable. Better policy will depend on learning the lessons of the many twentieth-century water policies that squandered rather than conserved water. Given the escalating water crisis in many deserts, caused not least by the old policies, better policy is urgent.

Figure 5.7: Kata Tjuta

Kata Tjuta National Park, 450 km southwest of Alice Springs, Australia. The main attraction, Uluru, is the vast quartzite rock in the centre of the image. It is an Aboriginal sacred site and Australia's most famous natural landmark.

Source: IKONOS satellite image available at http://www.spaceimaging.com/gallery/ on 2 December 2005

Figure 5.6: Non-renewable use of water

The expansion of centre-pivot irrigation systems in Saudi Arabia, where diminishing supplies of groundwater are being used to grow very water-consumptive crops, while Riyadh is supplied by desalinated water pumped up from the ROPME Sea Area. Some of the water in the aquifer is as much as 20 000 years old and therefore non-renewable.

Source: UNEP/GRID, Sioux Falls

TOURISM

Tourism (Figure 5.7) is another opportunity for development, but investment in tourism is risky. The risks are illustrated by the recent history of tourism in Chad and Niger. They have uniquely attractive deserts, but civil war throttled tourism in both in the 1980s and early 1990s, and the rebound, if any, has been from a low base (Hosni 1999). Chadian tourism is under retreat from unrest again in early 2006. And even if there has been growth, it can falter: visits to Namibia fell appreciably in 2004, perhaps because of recession in parts of Europe, perhaps because of reports of rising crime in Namibia itself. Tourist numbers fell significantly in Mexico, Chile and Peru after 11 September 2001. Distance is not, yet, an obstacle: large numbers of Europeans, North Americans, Japanese, and now Chinese and Indian tourists still visit distant deserts (like the Namib, the Atacama, Uluru, Oman and Dubai), but energy prices threaten all these flows. Terrorism and recession are other, inevitable threats.

Box 5.3: Water technologies for deserts

Water technology is continuously improving: there have been advances in the systems for building dams and pipelines in saline conditions (which are common in deserts), as demonstrated recently in the construction of the Great Man-Made River in Libya (Hurley and Blake 2002), for lining canals, greater water-use efficiency and so on. Irrigation efficiency has been increased with drip irrigation and microsprinklers, which achieve water use efficiencies of 95 per cent, compared to efficiencies of 60 per cent or less in flood irrigation (Vickers, cited in Gleick 2001). Desalinisation of water is now mostly by reverse osmosis, but to desalinate seawater in this way costs about eight times that of getting water from conventional supplies (in wet climates). Even if costs fell, they would soon meet the rising costs of energy, of which desalination is very consumptive. In December 1995, the 11 066 desalinization plants in the world had the potential to produce 7.4 billion cubic metres per year, a mere 0.2 per cent of world water use. However, the physics of reverse osmosis mean that costs fall rapidly as the salinity of the input decreases. To desalinate brackish water may need only 0.02–0.10 US cents per cubic metre of treated water; this makes the process much more competitive (Gleick 1998). Treating and reusing wastewater is already practiced in some regions and has great potential. In Israel, 70 per cent of municipal wastewater is treated and reused for irrigation. In California, golf courses and crops are now irrigated, and aquifers are recharged, with recycled wastewater. Windhoek uses recycled wastewater to supplement municipal water supply (Martindale, cited in Gleick 2001).

"Alternative" methods of enhancing the supply of water include fog harvesting in cool-current coastal deserts (Figure). In Cape Province in South Africa, most fog occurs below the 200 m contour. The highest rates of water collection from this fog are over 2 litres per square metre of collecting surface per day (Olivier 2002). Wilder proposals include the towing of icebergs or large bags of freshwater to desert coasts, filling oil tankers with water for their return journeys from the wet world, and the direct use of seawater for irrigation (D'Amico and others 2004). Given their enormous dependency on energy, these systems are unlikely to water much of the desert.

Fog and fog collectors in Chile. Fog (*camanchaca*) is common on the coast of the Atacama Desert, between, 8ºS and 32ºS, as in some other coastal deserts. The experiment with the fog collectors was to see if they could produce enough water for livestock, afforestation, water supply and wildlife.
Source: Guido Soto and Waldo Canto

Tourism development has other dangers that should be recognised explicitly in policy, such as corruption (of all sorts and at all levels), competition for resources like water, damaged beauty and biological value, temptation for street and organized-crime, flagrant inequity, and litter. Against all that, ecotourism, to which the deserts have much to offer, is said to be the fastest-growing sector of the tourist market, although there are concerns that the label is used to cover activities that damage biodiversity, such as off-road motoring. More carefully defined, monitored and marketed, it has the potential to enhance nature conservation, and to contribute to local incomes (Goodwin 1996).

THE USE OF DESERT SPACE

Space-consuming installations may still bring investment, although decisions are usually taken by national governments, whose fixations with national prestige or perceived vulnerability usually blind them to the interests of desert people or environments. Many large desert voids remain, far from habitation, and contain nothing to interest tourists. Many are remarkably resilient, especially those occupied by sand dunes. Desert dwellers and tourists will undoubtedly raise objections, nonetheless, on the grounds of competition for water, safety, pollution and aesthetics, if not of peace.

Wind and solar energy installations can also make use of cheap space, large inputs of solar energy, some windy sites and the absence of objectors (Box 5.4). Small solar cells, for domestic use and telecommunications, are now quite common in deserts, but only a very small fraction of the touted potential has been harnessed. The best-case scenario would have the deserts becoming the globe's principal suppliers of energy — forgetting for the moment the environmental costs and the destruction of beauty. Against this will be the length of transmission lines and competition from other renewable sources nearer to large centres of population. At the least, it can be confidently predicted that the adoption rate of small solar and wind energy devices will accelerate, especially if the obstacles are overcome: high capital costs; expensive, short-life batteries; inadequate facilities for repair and maintenance.

Agriculture and horticulture are already profitable in many deserts, as in Israel and Tunisia, and have great further potential. If there is water, or better, re-used water, and if it is used effectively, as in greenhouses, or by drip irrigation, the intense solar radiation and seasonal patterns of low-latitude

Box 5.4: Solar and wind energy

Renewables (including solar and wind energy) provided only 0.5 per cent of world energy consumption in 2004 (Smalley 2005), but with the decline in the production of fossil fuel, renewables will have to be more productive. Their cost has been steadily decreasing and solar energy might become competitive with gas in about 2025 (GAC 2005). Renewables might supply one-third to one-half of global energy by 2050 (Shell International 2001). Deserts in general have the highest levels of solar input in the terrestrial world (cloudiness and dustiness reduce radiation in some). They also have cheap and plentiful space, far from people. Figure 1 shows the area that would be required if photovoltaic cells (converting sunlight directly into electricity) were the only suppliers to a range of markets.

Figure 1. The Sahara with the sizes of "solar farms" necessary to supply the whole world (largest square 800 X 800 km), Europe (320 X 320 km) and Germany (180 X 180 km, smallest square).

Source: Ludwig Bölkow Foundation, with thanks also to Conrad Roedern

Solar energy is very unlikely to be deployed on sites as large as in the figure, but some moderately large projects are in progress: Los Angeles may soon get electricity from a 1 800 ha site near Victorville in the Mojave Desert. 50 MW capacity might be installed by 2008. A task force of the International Energy Agency believes the optimum size to be yet smaller (about 5 MW; Kurokawa 2003). The northern Sahara is a good place to start pilot projects of this size, because it is already connected to the European electricity network (Cova and Kerviskadic 2005).

The greatest attraction of solar energy is that it can be captured in small installations, close to where it will be used, and free of centralized control (and malfunction). In these situations costs are already competitive: an estimate for the installation of a solar hybrid system (including subsidies for energy efficiency measures) at Tsumkwe in north-eastern Namibia is US$2.1 million, whereas merely to install a power line to the site would cost US$6.5 million (Conrad Roedern, personal communication). The major element in the operating cost of these small systems is the replacement of batteries, but they can be expected to operate for 25 years before replacement. An attractive use of solar power is for small water pumps, but once installed, maintenance of such vital services becomes critical (Hamidat and others 2003).

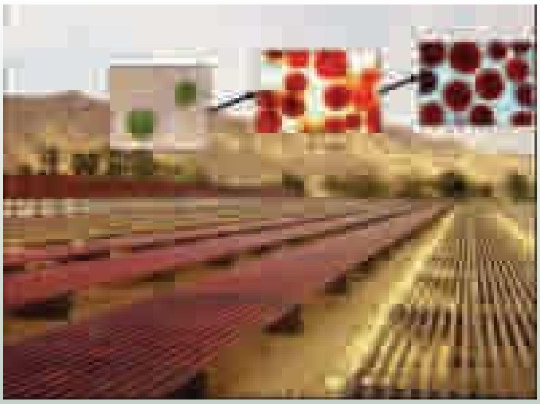
Figure 2. Wind Farm in the San Gorgonio Pass, California.

Source: Space Imaging's IKONOS satellite, http://www.spaceimaging.com/gallery/ioweek/archive/05-02-07/index.htm, 14 September 2003

For wind energy, deserts have little advantage over other sites (particularly coasts), except as regards cheap space, and more freedom from aesthetic objections. As with solar energy, lengthy power connections are a disadvantage. Desert winds are strongest where the wind is funnelled through mountain passes, such as the Tehachapi Pass in the Californian desert, where there is already a large wind farm (5 000 turbines, generating 1.3 billion kilowatt-hours of electricity per year, Figure 2); there are others in the San Gorgonio and Altamount Passes nearby, all quite close to a large market in southern California.

Box 5.5: Aquaculture in deserts

Aquaculture is a fast-growing food production system, and most of it is happening in developing countries (FAO 2000). Surprisingly, aquaculture thrives in deserts, like the Negev and Arizona (Kolkovsky and others 2003). Deserts offer many advantages. The amount of water invested in harvested fish is less than in the production of a vegetable crop. In a vegetable crop most of the water added goes in transpiration and evaporation; fish do not transpire and do not require light for the production process, so that their containers can be covered to minimize evaporation. Many aquaculture crops are far more tolerant of, even thrive in, water that is too saline for most cultivated crops, and many geothermal waters are both warm enough and contain the right salts for fish. The dangers in aquaculture, especially of nutrient-rich effluents and pesticides, are easily controlled.



Algal culture in transparent tubes at Kibbutz Ketura in the hyper-arid southern Negev Desert, Israel. The organism is *Haematococcus*. The pigment it produces is Astaxantin.

Source: Rachel Guy

Aquaculture produces many valuable products: edible fish, ornamental fish, edible shrimps (and other crustaceans), and algae for nutritional, pharmaceutical, or industrial use. Micro-algae, which photosynthesize, fare even better than fish and crustaceans in the drylands (Figure). They thrive in transparent tubes, which allow them to make use of the desert light. They rapidly reproduce and provide nutrition, vitamins, antioxidants and pigments. Micro-algal aquaculture can be integrated with fish aquaculture, because the larval stages of many fish species consume micro-algae. They can even substitute for fishmeal in neighbouring aquaculture systems.

The expertise and investment to start an aquaculture venture are not great. The system evolved in developing dryland countries, with low levels of investment. In Egypt, aquaculture is thousands of years old, and in Chad, people have cultivated the micro-alga *Spirulina* for their own consumption for centuries.

deserts allow them to produce when higher latitude agriculture is not productive. Aquaculture can also flourish (Box 5.5.). Another resource is wild (and newly domesticated) desert plants (Box 5.6).

Conservation and Sustainable Use

This section discusses what should happen in future desert development. It examines the conservation of soil, biodiversity, and beauty, but another general warning is necessary for those who think such an ideal is easy to achieve. Deserts are one of the last major scientific frontiers, and it can be argued that more is spent on researching the polar environment than on the more biologically-rich global desert. We do not yet know enough about the environment to be confident in prescriptions for conservation.

EROSION

Most erosion in deserts is beyond feasible control. Some of the huge areas of bare rock, steep bouldery slopes, sand dunes and pebble-covered plains barely change from year to year; others

Figure 5.8: Millet field in arid Sudan

Jebel Gehaniya, 10 km east of Kagmar in arid North Kordofan, Sudan. The arrows point to a tree that occurs in both pictures. The landscape after a very dry year (1984 in the upper image) is contrasted with the remains of a crop from a much wetter year (1989 in the lower image).

Source: Lennart Olsson

Box 5.6: Harvesting desert plants

Wild desert plants are useful for many more purposes, and for many of which are less destructive than grazing, browsing or firewood. A re-examination of some ancient systems of exploiting them has led to some commercial successes, and the deserts of Mexico are a great case study for this. Wild chilies (*Capsicum* spp.), and wild oregano (*Lippia* spp.) are gathered for food and sold in Mexican and U.S. markets; wild yuccas and agaves for fibre; and plants like *Euphorbia antisyphillitica* in the Chihuahuan Desert, for waxes. Mesquite (*Prosopis* spp.) can produce 1 000 kg/ha of edible and nutritious pods (Felger and Nabhan 1980). Cacti, columnar cacti in particular, have edible, tasty, and nutritious fruits with high-quality sugars. The fruits of *Opuntia* spp., the prickly pear, are widely consumed from wild and cultivated plants. The species also yields edible cladodes (stem-pads), which are harvested in Mexico, and some are exported. The leaves of a desert aromatic, the Baja Californian damiana (*Turnera diffusa*) are now actively and sustainably harvested to make a sweet liqueur that has a growing demand. Perhaps the biggest success story is mezcal, a liquor that is distilled from pit-roasted wild agaves. Some mezcal is the drink of connoisseurs who have graduated from tequila (from the boiled stem of another, cultivated agave). There is potential for much more.

Another valuable trait in desert plants is efficient water use. The efficient tepary bean (*Phaseolus acutifolius*) has been passed over in favour of less water-efficient crops (such as the commercial cultivars of *Phaseolus vulgaris*), but the tepary has enormous potential. Indigenous mechanisms like these have the potential to produce crops for much more water-efficient agriculture. There is a long list of possible candidates for new water-efficient crops (Felger and Nabhan 1980).

Searching for distinctive germplasm takes this quest into another dimension. Germplasm that encodes adaptations to desert conditions is of particular interest to plant breeders (to produce crop varieties better adapted to the desert), and to pharmacologists, who search for biologically-active secondary compounds. The search can be helped by studies in ethnobotany, but, promising as this search may be, little seems yet to have been found — perhaps because the pharmaceutical industry is secretive in their searches.

In the Mezquital Valley of the Mexican Central Plateau, a woman combs the fibre of the lechuguilla (*Agave lecheguilla*), a desert plant, on the spines of a barrel cactus (*Ferocactus*), known locally as *biznaga*. The fibers have been previously tinted with a crimson dye derived from cochineal (*Dactylopius coccus*), a scale insect that thrives in prickly-pear cacti of the genus *Opuntia*.
Source: Fulvio Eccardi

In many desert countries, the marketing of wild products is still a major economic activity. A colourful mixture of natural herbs and manufactured products is displayed for sale in a souk, Marakesh.
Source: Peter Tarr

erode, sometimes quickly, but the processes are seldom accelerated by human agency. In some agricultural systems, like run-off agriculture, erosion is actually welcomed (Evenari and others 1971). Rain-fed agriculture is only possible on the desert margins, and here too there is an equivocal message about erosion. Farmers in the northern Kordofan province of Sudan can produce crops from sandy soils in arid areas, but only in wet years (Figure 5.8). The sandy soils are easy to cultivate with hoes (usually the only ground-preparing tool available) and have good water-holding and water-yielding characteristics. The sandy fields may suffer wind erosion in dry periods, but many of the sands are deep enough to withstand millennia of erosion before they become unproductive. There are many such soils in arid areas. Few farmers can be convinced that erosion of these soils should be controlled, and anyway have inadequate labour to invest in it (Warren and others 2001).

Erosion, of course, is what produces the sediment that silts reservoirs. Some of it comes from high, tectonically active mountains, like the Himalayas, as in the case of the Tarbela and Mangla dams. Here, the natural rate of erosion on slopes and in river channels vastly exceeds the erosion caused by people; conserving agricultural soils would make little impact (Ives and Messerli 1989). In the U.S. Southwest, desert areas feed some of the sediment that is filling reservoirs like Lake Powell (behind the Glen Canyon Dam), and here too it appears that soil conservation would have little impact. Fifty years ago the consensus of scientific opinion was that overgrazing had exacerbated erosion in the Southwest, and if this were true, it might have been controllable. Some 30 years ago the consensus shifted to the belief that most erosion occurred in years with intense summer rains. These wet years have now been linked to El Niño cycles (Hunt and Wu 2004). Moreover, it appears that erosion rates in parts of Arizona are unaffected by vegetation cover in the short-term (Ritchie and others 2005). A more effective way of managing sediment in reservoirs is to build small sediment-holding dams upstream of the main dams (Catella and others 2005). Small dams beneath the water could hold back siltation from the outlets of the main dams (as proposed for the Tarbela and Glen Canyon dams). Although effective in the short-term, neither of these systems will give more than temporary relief.

Dust is the most significant natural output from the deserts (see Chapter 3 and Uno and others 2005). Should/could it be controlled? Control would be barely feasible for the quite natural processes that create about 90 per cent of dust in areas like northern Chad (Figure 5.9) or western China (Zhang and others 2003). Moreover, control, in the unlikely event that it succeeded, would interfere with the role of dust as a global fertilizer, as in the agro-ecosystems and forests of West Africa, the forests of the northeastern Amazon basin, the forests of Hawaii, and, most critically, the oceans, where the supply of iron-rich desert dust regulates biological productivity and may thus help to control global CO_2 (Dutkiewicz and others 2006).

Dust from agricultural operations can be a severe and expensive nuisance, but seldom in deserts.

Figure 5.9: Dust storm over Lake Chad

A large dust storm in April 2004 streaming from the northern basin of the now-dry Lake Mega-Chad, the dustiest place on Earth (Giles 2005). If irrigated plantations were chosen as a method to control the dust (the most common method), water would have to be brought 400 km from the nearest available perennial supply in the present Lake Chad (at the bottom of the image) to the origin of this dust storm. Other dust-generating deserts are also far from water supplies off sufficient size to control them.

Source: http://earthobservatory.nasa.gov/

In deserts, dust is a real pollutant downwind of desiccated lakes, such as the Aral Sea and Owens Lake in California, and here control is feasible and desirable. It is a taller order to ask for the control of military manoeuvres in the desert, like those that created large clouds of dust in the desert war in North Africa in the 1940s and the two Gulf Wars.

MANAGING IRRIGATION

Irrigated soils are a much higher priority for conservation. In most large irrigation schemes, water from rivers, wells or qanats is fed by gravity to low-lying sites. The soils in these sites are vulnerable to salinization, because the added water raises the water-table within them. When the soil water nears the surface, some is drawn up further by capillarity and the salts it carries are concentrated by evaporation on the surface, where they reduce yields, ultimately to very low levels (Figure 5.10). Waterlogging also damages crops. In large schemes, where settlers are unaccustomed to irrigation, or where planners have ignored warnings about salinization, large areas have gone out of production.

In low-intensity irrigation, as in Iraq in the 3rd millennium BCE, salinity was kept at bay by fallowing the land. During the fallow, weeds and natural drainage drew down the water-table. In

Figure 5.10: Salinization of desert soils

A Sindhi cowherd minding his cattle as they graze on a former rice field, which now has strongly salinised and infertile soil (white salt is at the surface). What was a productive field can now only support salt-tolerant wild species, like tamarisk.
Source: Andrew Warren

second millennium BCE Iraq, a centralized state replaced the ancient system with irrigation from a large canal. Salinity accumulated and steadily reduced yields (Jacobsen and Adams 1958). In intensive modern systems, where water is added to three or more crops a year, the best strategy to manage salinization and waterlogging is to maintain drainage through the soil, and to add enough water to carry away the salts. The bigger the scheme, the more expensive are the necessary drainage pipes, ditches, or tube-wells for lowering the water-table, and the canals to take salty water to the sea or to reservoirs where it can evaporate. Complementary strategies include using brackish water to irrigate salt-tolerant crops, and blending saline with fresh water, but there are dangers in both.

RIVERS, WETLANDS AND LAKES

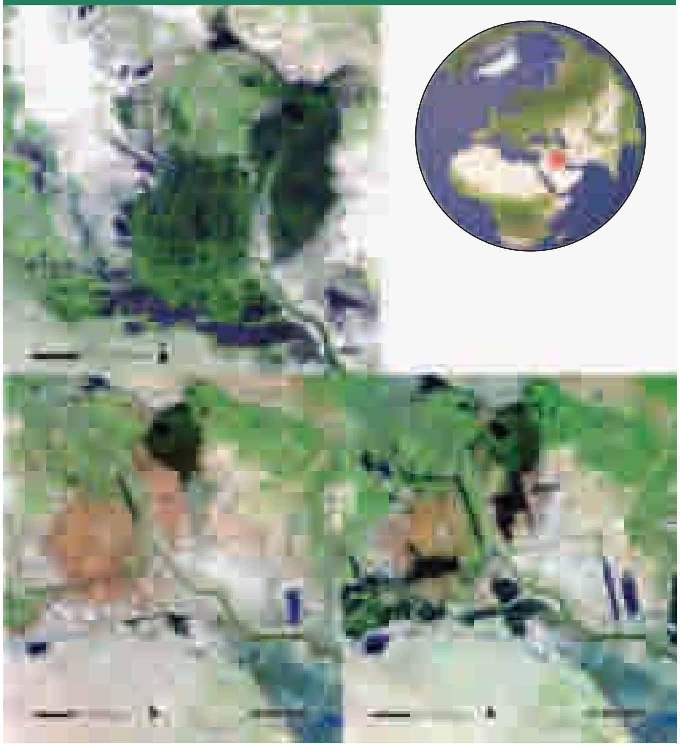
Rivers

Wet desert environments are biologically the richest places in the desert. The richest of all are the perennial rivers. Ephemeral rivers have value, and although they profoundly affect the lives of the communities and wildlife that live near them (Jacobson and others 1995), their value and vulnerability are small compared to those of the perennial rivers, the good management and conservation of which is of utmost importance.

The most difficult issue in conserving the biological value of perennial rivers is the assurance of flow. Some, like the Tarim River, were desiccated by irrigation decades ago; most of the others have been progressively depleted. But the mere suggestion that water should be left for wildlife is risible to most managers of irrigation schemes. The second, closely linked issue is the quality of the water, and in this, the interests of conservationists and farmers come closer together. The main contaminant is "return flow": water returning to the river from irrigated fields. Return flow is always more saline than the water taken from the river in the first place. Saline return flow increases problems for downstream farmers, as when it flows from the Punjab and Sindh in Pakistan. In the Colorado River in the U.S., salinity was a minor problem in the 1960s; by the 1980s, nearly 40 per cent of its salinity came from return flow (Law and Hornsby 1982). The issue is international on the Colorado River (and on the Rio Grande that flows between Texas and Mexico), because the U.S. and Mexico agreed, in 1974, that the salinity of cross-boundary rivers should be kept below a threshold, but the salinity of water that flows to Mexico is, even so, above that threshold. The U.S. Congress, long ago, allocated US$1 billion to the problem (Reisner 1986); a desalination plant at Yuma (cost US$256 million) opened in 1992, but closed eight months later, partly because of high running costs. Hopes of a reopening are now being raised. In China, the maximum annual salinity in the upper reaches of the Tarim River rose from 1.3 grams per litre in 1960, to 4.0 in 1981–1984, and to 7.8 in 1998, as it was increasingly supplemented by return flow (Feng and others 2005). Salinity damages the ecology of perennial rivers and their floodplains. In the southwestern United States, the salt cedar, an alien, salt-tolerant tree, has invaded hundreds of thousands of hectares of alluvial plains, altering their avian and invertebrate ecology. Attempts at control have met with mixed results (Shafroth and others 2005). Return flow may also carry residues of agricultural chemicals and toxic trace elements.

Dams themselves severely interfere with the ecology of the perennial rivers. They deprive rivers of sediment, and thus depleted, most rivers excavate their channels, and this isolates and desiccates their former floodplains. When silt-deprivation is added to the replacement of cyclical floods and low flows by the more constant flow from a dam, other problems appear. After the closure of the Glen Canyon dam on the Colorado River, riffles (where the river flows shallowly over stones) expanded at the expense of pools and this favoured fish that spawned in gravel over those that did not (Magirl and others 2005). The combined effect also discourages lateral migration of the channel (as when meanders move), and this interferes with the ecology of the early-successional native cottonwood tree (Tiegs and Pohl 2005). Deep, cold water is released from dams, and this, together with all the other changes, is endangering the humpback chub in the Colorado (Petersen and Paukert 2005). Smoothing out the flow alone has altered the habitat of clams in the Colorado Delta (Cintra-Buenrostro and others 2005). Silt-free rivers create further troubles when they reach the ocean. Silt from the Nile once protected the Mediterranean delta coast from erosion, but after inauguration of the Aswan High Dam, no longer does so (Fanos 1995). Fewer nutrients now enter the Mediterranean, leaving it even more of a marine "desert" (Azov 1991).

Figure 5.11: The shrinking Mesopotamian wetlands



The destruction and slow recovery of the Mesopotamian wetlands in Iraq, fed by the Tigris and the Euphrates Rivers. At one time, the wetlands covered 150 000 to 20 000 km^2. They were still large in 1973, as the image from that year shows. However, they had lost area, even then: the first upstream dams and barrages were built in the 1950s; there are now 32, with eight more under construction and 13 more in planning. Local drainage and water diversion began in 1952. The Saddam regime sanctioned further drainage, and two-thirds of the inflow had been diverted by 1993. The 2000 image shows large brown, drained areas. The wetland once harboured two-thirds of western Asia's waterfowl; few remain. The local species of otter (*Lutra perspicialata maxwelli*), made famous in a lyrical description by Gavin Maxwell (1957) and a native turtle (*Trionix euphraticus*) are among the probable extinctions. The Marsh Arabs lost their distinctive, low-impact, much-photographed lifestyle. Now, the "Eden Project" plans to resuscitate some of the marshlands, but acknowledges that full recovery is unlikely (Kingsford and others 2005, Richardson and others 2005). The image for 2004 shows some progress: an increase in the black (flooded) area.

Source: UNEP/GRID, Sioux Falls

Wetlands

Wetlands have less economic value than perennial rivers, but because their economic development value vastly increases when they are drained, they are under even more pressure. Because wetlands are the resting or roosting places for huge numbers of migratory birds, the most important have been given supposedly strong protection in international agreements, notably the Ramsar Convention of 1971, and the Convention on Biological Diversity (CBD) of 1992; yet this has done little to stem their loss (Lemly and others 2000). Desert wetlands vary hugely in size and vulnerability, and may also change substantially with management and climatic oscillations (Figure 5.11).

Lakes

Most desert lakes are dry, seasonally or for years at a stretch. The smooth surfaces of some are best-known as speed tracks, but not all are smooth. Some of their features, such as the flamingo pools in the huge Salar de Atacama in Chile, or the remarkable wind-propelled rocks at Racetrack Playa in Death Valley (Bacon and others 1996) deserve careful management, but many, like the remoter parts of the vast Salar de Atacama, and Umm-as-Samim in Oman, are protected simply by remoteness and the dangers of travel.

Lakes fed by perennial rivers, like the Aral Sea, are more biologically rich, and more vulnerable. Many have suffered severely. Owens Lake in the upper Mojave dried up in 1926 (except for a few shallow wetlands), drained by an aqueduct to Los Angeles, opened in 1913. The dry, salty lake bed now releases an estimated 900 000 to eight million tonnes of dust a year, the most prolific single source of dust in the U.S. The plume is obvious 40 km downwind (Reheis 1997). Before they were drained, lakes like this seasonally supported millions of birds. Even though saline, Lake Eyre in South Australia — the world's largest ephemeral lake — occasionally supports thousands of waterfowl (Kingsford and Porter 1993). A less well-known set of lakes is probably even more biologically valuable. These are the remote, groundwater-fed lakes, some of them in extreme deserts. A few in Libya and many in China collect in hollows between huge dunes. Others are strange anomalies, like the stairway of fresh and saline lakes at Wanyanga (Ouanyanga) in extremely arid, northernmost Chad (Figure 5.12). Species endemic to isolated water bodies like these, as the desert pupfish of the Sonoran Desert, are vulnerable to extinction and need special attention (Fagan and others 2002).

Rehabilitating wet desert habitats

Given the massive size of the engineering structures that have ruined the ecology of rivers, wetlands and lakes, and the millions of people who now depend on them for water, their complete ecological restoration is unthinkable, at least in the short-term. In this time frame, better management of flow regimes, rerouting of saline return flows to special canals (as has been proposed in several irrigation schemes), and the preservation of a few remnant wetland or lacustrine ecosystems (as is also happening in many places), would alleviate some of the more urgent conservation problems. Desalinization, as may again happen on the Colorado, is too much to hope for on a major scale. In the longer-term, the financial, human, and environmental costs of maintaining huge water-delivery systems may foreclose them. Rivers, wetlands and lakes might again return to their prelapsarian glory, but at huge human cost.

Figure 5.12: Desert lakes, Wanyanga, Chad

The lakes at Wanyanga (Ouanyanga) in northernmost Chad surrounded by hyper-arid desert. Dunes have invaded the depression and separated the lakes. Some of the lakes are fresh, some saline. They are isolated from other open water bodies by hundreds of kilometres of desert.

Source: Google Earth image browser

Two further wet ecosystems, both of high biological value, need rather different forms of conservation. The first is in damp desert "hollows", places to which water gravitates and feeds a shallow water-table or at best a few springs. The second are ecosystems that have been isolated by post-glacial climatic change: the "sky-islands" (see Chapter 1). In some of both, isolation has allowed the evolution of unique species, or sub-species. Unfortunately for conservationists, people (indigenous or exploitative, malevolent or innocent) also gravitate to these places, which then become the sites of intense conflict. Their conservation needs strict restrictions on interference.

DRY DESERT HABITATS

Desert ecosystems in the huge spaces between the wet places vary greatly in biological value. Some of the hyper-arid deserts support little life of any kind, except after rare rainstorms when they are briefly visited by species from surrounding, better-watered deserts. One can travel for hours in parts of southern Libya, Algeria or Peru, eastern Saudi Arabia and central Oman, northern Sudan, Chad, Niger, or northern Chile without seeing a blade of grass or a bush. A daily lizard or gazelle, or at some seasons a migrating bird, comes as a surprise. Some authorities have asked, are they ecosystems at all? Are the connections between species durable enough to class them as fully-interactive systems? (Moore 1978). It is more debatable whether these wildernesses deserve the scarce resources available to conservationists. Perhaps conservationists should concentrate their efforts on the desert's edge, that is, on arid ecosystems interposed between the hyper-arid wildernesses and the savannahs and grasslands. It is in these areas where the harvesting of wild products often offers a valuable economic alternative (Box 5.6), and more generally, where many species have great biological value and are under maximum threat.

Hunting

Indiscriminate hunting is one of the biggest threats to desert biological sustainability, so damaging that if allowed, it would soon eliminate its own *raison d'être*. Hunting may have eliminated the post-glacial mega-fauna of North America, and much later, North Africa and southwest Asia lost most of their large mammals to hunters in Roman times. It is said that on the day on which the Emperor Titus inaugurated the Roman Coliseum, 5 000 wild animals were slaughtered. The more distant African and Asian deserts lost their large mammals after guns became available in colonial times, when they were also infected with the European hunting ethos (Anderson and Grove 1987). In desert Central Asia, the native Przewalski's horse (*Equus caballus przewalskii*), was hunted to extinction in the wild by about 1870. Hunting and competition with domestic camels has reduced the population of the wild Bactrian camel (*Camelus bactrianus ferus*). Przewalski's gazelle (*Procapra przewalskii*) is now isolated to only four local populations around the Qinghai Lake in desert China (Li and Jiang 2002). Hunting continues. Income from trophy hunting in Namibia was estimated in 2003 to be 14 per cent of all tourist earnings (Humavindu and Barnes 2003). Large convoys of air conditioned caravans follow hunters across the deserts of Arabia, Sudan and Kazakhstan. The remaining populations of large mammals, such as various species of gazelle, oryx (*Oryx beisa*), addax (*Addax nasomaculatus*), Arabian tahr (*Hemitragus jayakari*) and the Barbary sheep (*Ammotragus lervia*) are on the brink of extinction. Game bird populations are declining fast, particularly that of the Houbara (*Chlamydotis undulata macqueenii*), which is the choice for hunters with falcons in Arabia and Kazakhstan (Tourenq and others 2005). Most of these endangered species need urgent protection: captive breeding (of oryx as in Oman); reintroduction; restrictive legislation and its enforcement; and so on. Surprisingly (to some) help is coming from the hunters, at least as concerns the Houbara; they have supported captive breeding, radio tracking and other conservation measures in Saudi Arabia and the United Arab Emirates (Bailey and others 1998).

Grazing

Another threat to dry ecosystems may come from pastoralists, but here the argument is not so simple. Pastoralists do indeed use the high nutritive value of arid grasslands in wet seasons. The Fulani in Niger take their cattle to the edge of the desert in the wet season, specifically for this (Penning de Vries and Djeteyé 1982), as do the Kabbabish camel nomads in Sudan (Wilson 1978).

The argument about the damage that grazing might be doing to these ecosystems is unfinished. Some authorities believe that overstocking has removed valuable species, and reduced grazing value. Their evidence includes the replacement of palatable by unpalatable species, particularly the woody shrubs that have invaded many arid areas, as in Arizona (Guo 2004) or in southern Africa (Wiegand and others 2005). Further evidence lies in research into recovery times after intense grazing. In one case, full grass cover only replaced woody scrubland after 20 years of protection (Valone and others 2002). Estimates of recovery times for the Mojave ecosystems range from 50 to 300 years, but in some cases could reach 3 000 years (Lovich and Bainbridge 1999).

The counter-argument depends on the model of these ecosystems as "pulse-response" (see Chapter 1). In seasonal or multi-annual dry periods, the ecosystem is said to be incapable of supporting enough stock to do it any damage in the brief, wet pulses. Only if stock is fed supplements brought in from wetter areas, or is moved back and forth from wet to dry areas (which, it is true, are common practices), is "overgrazing" even possible. Nomadism, this school also argues, is an ideal system for using the patchy effect of rainfall on grazing. Further, especially in the Old World, the character of many arid ecosystems depends on grazing, and because some of the native grazing animals have become domesticated, grazing by them could be vital in maintaining the original ecosystem dynamics. Conservation may then depend more on the choice of grazing intensity and grazing species, than their total exclusion. Finally, some authorities believe that overgrazing is much less of threat in arid climates where forage dynamics are primarily driven by climatic cycles, than in semi-arid or sub-humid climates where grazing is more likely to be the chief control on the availability of forage (Briske and others 2003).

Conservation priorities

Another issue in the conservation of these systems is the choice of priority. If a rare species has priority, like the long-lived desert tortoise in the arid Mojave (*Gopherus agassizii*, a federally-listed, threatened species), complete protection from hunters and graziers may be imperative. If the objective is the conservation of an ecosystem as a whole, there is more room for manoeuvre, but there are problems there too. If there are functioning patches of different size, all the way from micro-ecosystems sheltered by bushes or trees, to patches of many hundreds of square kilometres, what is the optimum size of protected areas to ensure conservation? The fail-safe rule is: as large as possible.

Community-based conservation

A more practical question is also exercising conservationists: should conservation be "expert-led" or "community-based"? (Berkes 2004). Community-based conservation does not always succeed, mainly because development and conservation goals usually conflict, and because the phrase has become too loosely used. But with care, the idea of community conservation should resonate in deserts where people and their grazing animals have been part of the ecosystem for thousands of years, and where there is huge wealth of indigenous knowledge, as Triulzi (2001) describes in Syria.

Beauty

The beauty of deserts, so essential to tourists and residents, is a further priority for conservation. There are at least three conflicting desert aesthetics: desert as wilderness, as challenge, or as scenery. The wilderness-seekers — stereotypically, backpackers, and the well-educated — use deserts to find their "intellectual humility" (Leopold 1949). To them, development and the numbers of visitors need stringent control. The challenge-seekers need technology to achieve their aims (they might be SUV drivers). They want to drive over exciting terrain and may compromise with, even welcome, development. Given the openness of many deserts and their accessibility to motor transport, their activity can be intrusive (Sax 1980). The tourist aesthetic is subdivided many more times: the Wissa Wassef romanticism of the image on the title page of this chapter; the desert fathers (Box 5.2) and/or romantic decay; Marlboro County; walkabout; T.E. Lawrence; Rudolf Valentino; and so on. And tastes change.

These various demands need to be balanced with the needs of people who live and work in the desert, let alone with the demands of people beyond the desert for water or energy. The task is not impossible. Most visitors to the Grand Canyon or Uluru are impressed by the sensitivity with which they are managed under the onslaught of tens of thousands of people in a season, even if a minority complains one way or another. An advantage of some deserts over many other global environments is that they are remarkably resilient. Sand dunes loose the tracks of people or vehicles after a gentle breeze. Bare rock may not register a moderate number of footfalls. But the desert is not everywhere so unforgiving; there are many places where the demands clash, or where trampling, littering, and disturbance do lasting damage. Vehicle tracks in many deserts are visible on satellite images; they may persist for very many years (Belnap and Warren 2002).

All forms of conservation (particularly of biological value and beauty) are best met with some degree of statutory protection, backed by adequate funds. The trajectory of the total desert area under protection is upward, which is encouraging, but it would need to be accompanied by less easily monitored trajectories of community involvement, visitor satisfaction, biological change and funding, to confirm it as a wholly good story.

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