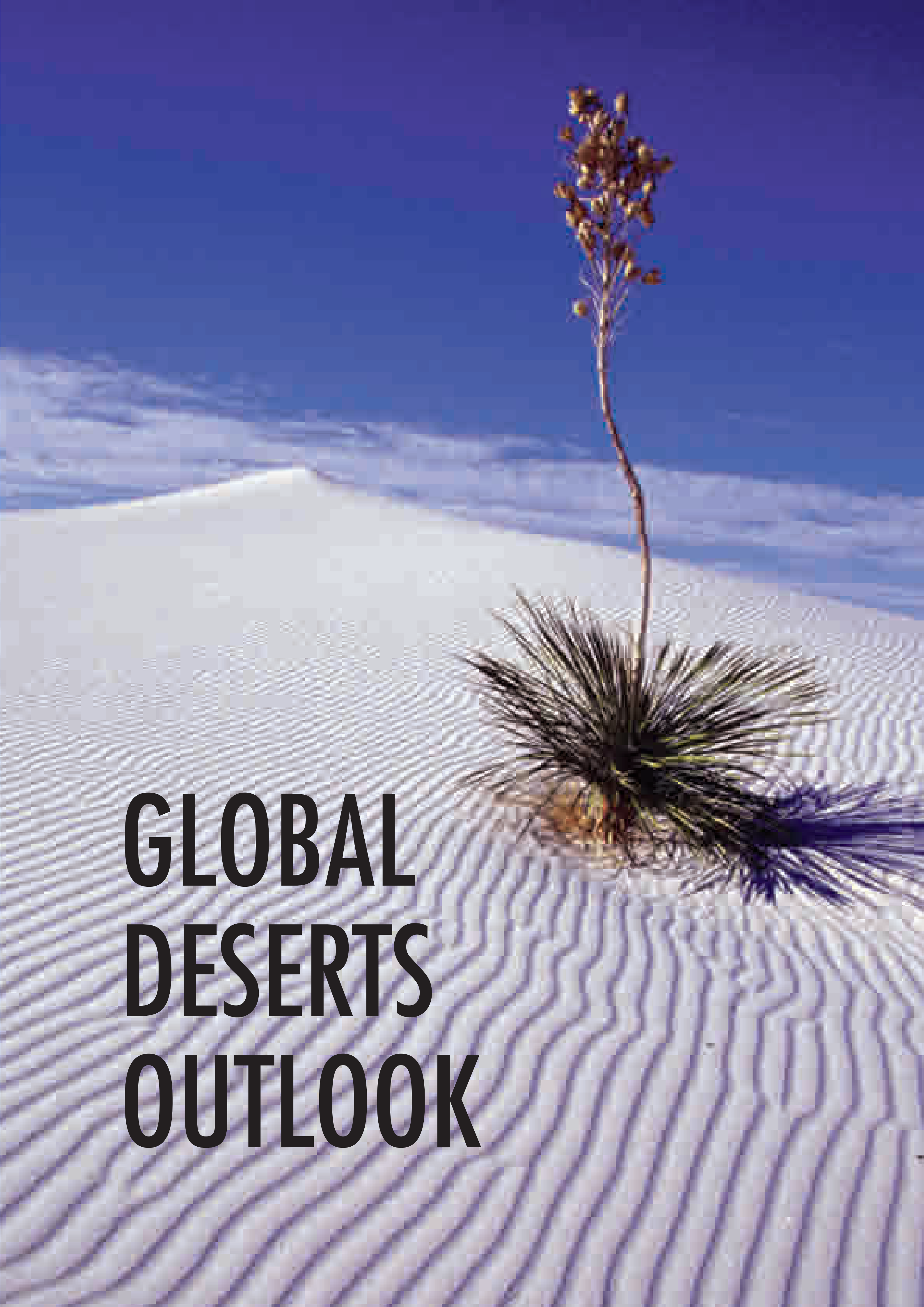
GLOBAL DESERTS OUTLOOK



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Foreword

The world's deserts represent unique ecosystems which support significant plant and animal biodiversity, particularly with respect to adaptations for survival in arid conditions. Various human societies have also been established in deserts throughout history, and today deserts are an important part of the world's natural and cultural heritage. Deserts are also diverse landscapes, contrary to the common notion of vast swathes of endless sand; for example, the FAO-UNEP Land Cover Classification System has identified over seventy classes of desert land cover in Egypt alone.

Desertification – the degradation of drylands due to factors including climatic variations and human activities – is among the most serious environmental challenges facing the world today. Deserts cover a total of over 19 million square kilometres, representing almost 15 per cent of the terrestrial surface of the planet, and are currently home to some 144 million people. At the same time, poverty affects many of the people living in deserts. Moreover, desertification is a truly global problem, affecting areas and populations outside of drylands. Dust from the Gobi and Sahara deserts has, for instance, been linked to respiratory problems in North America and has affected coral reefs in the Caribbean Sea.

It is against this backdrop that the UN General Assembly has declared 2006 to be the International Year of Deserts and Desertification (IYDD). The international community is deeply concerned by desertification, its implications for the achievement of the Millennium Development Goals, and the need to raise further awareness of the issues.

UNEP, as part of its global environmental assessment programme, and as a contribution to IYDD, has undertaken this global assessment of deserts. The *Global Deserts Outlook* represents the first thematic assessment report in UNEP's Global Environment Outlook series. The special focus of this report, in the context of IYDD, will help to raise global public awareness of the state and development potential of the world's deserts. The report draws on various studies and assessments of dryland ecosystems that have yielded valuable new insights into the issues of deserts and desertification, although significant gaps in terms of data and methodologies remain.

The *Global Deserts Outlook* provides a balanced picture of deserts. It shows that they are more than landscapes which are the end result of the process of desertification. The report urges policy-makers to consider the development potential of deserts, and their conservation needs: what are the most appropriate and sustainable livelihoods for people living in desert areas? Although deserts do not have much water, they do have other valuable natural resources that benefit people, such as biological and cultural diversity, and minerals. They also have the potential to attract tourists and generate solar power. The scientific knowledge and engineering skills needed to generate sustainable incomes from desert resources already exist; appropriate actions and equitable sharing of the proceeds need to be determined.

The *Global Deserts Outlook* is a stimulating and informative resource for all those concerned with deserts and desertification, and the sustainable development of dryland environments.

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Executive Summary

DESERTS HARBOUR RICH ECOSYSTEMS

Deserts cut cross our planet along two fringes parallel to the equator, at 25–35° latitude in both the northern and southern hemispheres. The Desert Biome can be defined climatologically as the sum of all the arid and hyper-arid areas of globe; biologically, as the ecoregions that contain plants and animals adapted for survival in arid environments, and, physically, as large contiguous areas with ample extensions of bare soil and low vegetation cover. A map produced by overlaying areas under these three criteria shows a composite definition of the world's deserts, occupying almost one-quarter of the earth's land surface, some 33.7 million square kilometres.

Deserts landscapes are diverse; some are found on a flat shield of ancient crystalline rocks hardened over many millions of years, yielding flat deserts of rock and sand such as the Sahara, while others are the folded product of more recent tectonic movements, and have evolved into crumpled landscapes of rocky mountains emerging from lowland sedimentary plains, as in Central Asia or North America.

Over the last two million years — the Pleistocene period — climatic variations of the earth have transformed the world's deserts, forcing them to shrink during cold glacial periods and expand during the hot interglacials, leading finally to the current warming and aridization trend of the last 5 000 years, from the mid-Holocene to date. Some of the Ice-Age species still survive in arid mountain ranges, or desert "sky-islands", as rare relictual organisms.

Most large deserts are found away from the coasts, in areas where moisture from the oceans rarely reaches. Some deserts, however, are located on the west coasts of continents, such as the Namib in Africa, or the Atacama in Chile, forming coastal fog-deserts whose aridity is the result of cold oceanic currents.

The deserts of the world occur in six global bio-geographical realms:

- The **Afrotropic deserts** are found in the sub-Saharan part of Africa, and in the southern fringe of the Arabian peninsula. Their mean population density is 21 persons per square kilometre, and their human footprint (that is, pressures on the environment resulting from human activities) is relatively high, especially in the Horn of Africa and Madagascar.
- The **Australasian deserts** comprise a series of lowland arid ecoregions in the Australian heartland, covering in total some 3.6 million square kilometres, of which some 9 per cent is under some degree of environmental protection. Hardly inhabited at all, their mean population density is less than 1 person per square kilometre, and show, by far, the lowest human footprint among the global deserts.
- The **Indo-Malay** region harbours only two hot lowland deserts — the Indus Valley and the Thar — covering in total 0.26 million square kilometres, of which some 20 per cent receives some level of legal environmental protection. With a mean density of 151 persons per square kilometre, these are the deserts with the most intense human use in the world.
- The **Nearctic deserts** cover 1.7 million square kilometres in North America, of which 19 per cent is under some level of legal protection. Because of the growth of large urban conglomerates such as Phoenix in the United States, their mean population density is high (44 persons per square kiometre) and their mean human footprint (21) is the second highest of the world's deserts, especially in the Sonoran and Chihuahuan deserts.
- The **Neotropic deserts** in South America cover 1.1 million square kilometres, of which only 6 per cent receives legal protection. Their mean population density is 18 persons per square kiometre, and their mean human footprint (16) is lower than in their North American

counterparts, with most pressure concentrating in the Sechura Desert in the coasts of Peru.

- By far, the **Paleartic realm** concentrates the largest set of deserts in the world, covering a remarkable 16 million square kilometres that total 63 per cent of all deserts on the planet. Their population density is 16 persons per square kilometre, and their mean human footprint (15) is the second lowest on the planet, possibly because of their sheer inaccessibility and extreme aridity. The Sahara, an immense shield-desert, occupies 4.6 million square kilometres, or 10 per cent of the African continent. In sharp contrast with the flat Sahara and Arabian deserts, the deserts of Central Asia present folded mountains with high landscape heterogeneity and enclosed basins, some of which contain large lakes such as the Caspian and Aral Seas.

With summer ground surface temperatures of near 80°C, and only enjoying very ephemeral pulses of rain, species in deserts have evolved remarkable adaptations to harsh conditions, ranging from plants adapted to the fast use of ephemerally-abundant water or to extraordinarily efficient use of scarce water, to behavioural, anatomical, and physiological adaptations in animals. Some species from different deserts show striking resemblances in their appearances despite their differences in phylogenetic origins and biogeographic histories, a phenomenon known as convergent evolution. As a survival strategy, many desert species have symbiotic interactions and cooperate with each other through pollination, fruit dispersal, or by providing protective shade.

True deserts are not the final stage of a process of desertification; they are unique, highly-adapted natural ecosystems, both providing life-supporting services on the planet and supporting human populations in much the same ways as in other ecosystems.

DESERTS ARE THE HOME OF DIVERSE CULTURES AND LIVELIHOODS

Deserts are home to many human populations of the world. Currently around 500 million people live in deserts and desert margins, totalling 8 per cent of the global population. Among the greatest contributions of desert cultures to the world are the three "religions of the Book", Judaism, Christianity and Islam, which have had tremendous impact far beyond their areas of origin.

Humans have learnt to survive in deserts, compensating for their poor morphological and physiological adaptations to desert climates with a panoply of behavioural, cultural and technological adaptations to the dry environments. Traditionally, desert livelihoods were of three types — hunter-gatherers, pastoralists, and farmers. Hunter-gatherer tribes, such as the Topnaar of the Namib, are known for their in-depth knowledge of local food plants and wild animal species. Pastoralism, on the other hand, makes use of domesticated animals, such as camels or goats, to produce products such as milk, leather, and meat. Desert agriculture occurs mostly around oases and desert rivers, which often provide silt and nutrients through flooding cycles.

These ways of life, however, are changing rapidly, from hunter-gatherers to cattle ranchers, and from nomadism and transhumance to tourist-targeted activities. Irreversible damages have been caused in previously good agricultural grounds in deserts by large-scale modern developments, such as dam constructions for water and energy supplies. In recent times, extraction of minerals, use of the vast open spaces for military facilities, energy-intensive urban developments, and tourism, have increasingly changed the ways of life for some desert populations.

Resource use and management in deserts for these developments focuses and depends heavily on water and energy, two key resources. Recent increases in the pace of desert urbanization are the result of the relocation of expansive land developments, mining and power engineering, the growth of transport infrastructure, and improvements in water extraction and supply technologies. The high, or even complete, dependency of large desert cities on imported resources has become economically feasible as they generate sufficient income from their economic activities.

Due to the extremely slow rate of biological activity in deserts, these ecosystems take decades, if not centuries, to recover from even slight damage, such as the tracks left behind by an off-road vehicle on a lichen-covered hill. Moreover, because traditional livelihoods in deserts require large areas, they are particularly vulnerable to political and environmental changes. A good example of this is how the lives of nomadic herders in the Gobi floundered under the changes from Mongolia's transition from a socialist system to a market-driven economy.

DESERTS PLAY AN IMPORTANT ROLE IN THE GLOBAL ENVIRONMENT AND ECONOMY

Deserts interact strongly with the rest of our planet. Global-scale climate change during the 1976–2000 period has shown increased temperatures in nine out of twelve deserts studied. Average projected changes for 2071–2100 show a temperature increase of between one and seven degrees Celsius in all world deserts. Rainfall, on the other hand, could increase or decrease with climate change: while the Gobi Desert in China will most likely receive more rain, the Sahara and Great Basin deserts could become drier. In general, a warmer planet will bring more rainy pulses to winter-rain deserts and more drought pulses to summer-rain deserts. Large desert rivers originate mostly outside deserts, and many could face declining water flow from climate change.

These changes will, undoubtedly, impact the ecology of deserts. For example, nearly half of the bird, mammal and butterfly species in the Chihuahuan Desert are expected to be replaced by other species by 2055. Annual grasses that are prone to wildfire are likely to extend their coverage in some deserts, invading native scrubs and increasing the risk of soil erosion.

Deserts also have strong linkages to non-desert environments. Decreased rainfall in some deserts as a result of climate change will represent increased emissions of cross-boundary dust storms with, literally, far-reaching consequences. Most dust particles in the global atmosphere originate from the deserts of northern Africa (50–70 per cent) and Asia (10–25 per cent). Nutrients carried by desert dust, such as phosphorus and silicon, enhance growth in oceanic phytoplankton by increasing the productivity of some marine ecosystems, and also of nutrient-poor tropical soils, as observed from Saharan dust deposited in the Amazon basin. Desert-generated dust also reduces visibility, interfering with ground and air traffic away from deserts and increases the incidence of respiratory illnesses.

Deserts provide migratory corridors for many species. Non-desert birds on cross-desert migration across the Sahara compete increasingly with the human population of the region for rare oases that cover only two per cent of the area. The desert locust (*Schistocera gregaria*) is normally found in 25 countries of the Sahel and the Arabian Peninsula, but during epidemic outbreaks can spread over up to 65 countries, consuming 100 000 tonnes of vegetation a day, from India to Morocco, and even crossing the Atlantic to the Caribbean and Venezuela.

Deserts have provided trade corridors from times immemorial through which goods and cultures travelled. Water-soluble salts, such as gypsum, borates, table salt, sodium and potassium nitrates have been historically a product of deserts. Evaporite minerals, such as soda, boron, and nitrates, are common in deserts and are not found in other ecosystems. A sizeable share (30–60 per cent) of other minerals and fossil energy used globally is exported from deserts, including bauxite, copper, diamonds, gold, phosphate rock, iron ore, uranium ore, oil, and natural gas.

Because of their warm climate, deserts also export agricultural products, produced under irrigation, to non-desert areas. Agriculture and horticulture are already profitable in many deserts, as in Israel and Tunisia, and have great further potential. A new non-conventional desert export is derived from aquaculture, which paradoxically, can be more efficient in water use than desert plants, and can take advantage of the deserts' mild winter temperatures and low cost of land. Biologically-derived valuable chemicals, produced by micro-algae as well as medicinal plants, are also manufactured in deserts, capitalizing on their high year-round solar radiation, and exported to global markets. Besides the ongoing export of wild plant products from deserts to non-deserts, there is a pharmaceutical potential in desert plants which is yet to be tapped.

The growth of desert cities, clearly evidenced in industrial countries in the mid-twentieth century, has attracted the migration of non-desert people into desert habitats, drawn by new employment opportunities and the availability of cheap housing. In recent years, the influx of tourists to deserts, seeking the dry and sunny climate, has encouraged migration to deserts as well. Finally, in developing countries, specifically in Sub-Saharan Africa, periodic droughts in non-desert drylands draw thousands of rural migrants and nomads to adjacent desert cities in search of food and employment.

Research carried out in deserts has enriched the knowledge of the history of our universe and planet, and of life on earth. Deserts attract scientists of every discipline, ranging from testing grounds for planetary exploration equipment, to research on meteorites (well-preserved due to the slow rate of desert rock weathering), to astronomical observations, and archaeological and geomorphologic studies. Many areas of research benefit from the desert's clean atmosphere, low human disturbance, dry climate, sparse vegetation cover, minimal cloud cover, and thin soils — features that contribute to good preservation conditions and high detectability of scientifically-relevant objects and phenomena.

Our understanding of global processes, the development of much of our modern research, our ability to cope with global environmental change, and the preservation of much of our global heritage depend to a large extent on the way we manage and preserve the world's deserts. What happens in deserts affects every one of us.

DESERTS PRESENT DEEP CHALLENGES FOR SUSTAINABLE

from human impact. When the problem is present, it tends to concentrate on the deserts' edge or on the more humid parts inside the biome, such as oases, and desert mountain sky-islands.

In these more vulnerable portions of the global deserts, however, impacts can be significant. Removal of vegetation cover, especially due to grazing, increases soil loss. Disturbance to the fragile desert surface, by military and recreational activities, leaves long-lasting damages. Mining activities and the remnants of these have contaminated freshwater bodies with high concentrations of heavy metals and chemical substances, as seen in parts of Argentina and Chile. Oil extraction causes air pollution, spills and chronic leakages that affect both surface and subsurface organisms. Irrigated portions of deserts in China, India, and Pakistan face declining yields due to increasing salinity. In China, deterioration of the plant cover in the headwaters region of the Yangtze River has created major flooding problems downstream and massive water erosion in the Loess Plateau. While biodiversity hotspots — the biologically-richest and most endangered terrestrial ecoregions — occupy 12 per cent of deserts, almost exactly the same proportion as for hotspots globally, the proportion of the desert biome with IUCN protected area status is much less (5.5 per cent) than the same figure for all ecoregions (9.9 per cent).

People have responded to these problems by developing and implementing actions at the regional and national levels. For example, in many countries in North Africa, as well as Yemen, there is a wealth of traditional knowledge on soil and water conservation in deserts through sustainable land management practices, including the retention of suspended sediments in terraces. In an effort to