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DESERTIFICATION AND CLIMATE CHANGE

ARE THEY PART OF THE SAME FIGHT?

BERNARD BONNET, JEAN-LUC CHOTTE, PIERRE HIERNAUX,
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Foreword

The term "desertification" was first used in the early twentieth century. Its use spread quickly throughout colonial Africa, reinforced by the powerful image of the encroaching desert. From the outset, the causes of desertification have been linked to climate aridification ("desiccation") and environmental degradation, particularly that related to vegetation cover (deforestation, savannization, etc.) and soil (wind erosion, run-off, loss of fertility, etc.).

It was later mainly associated with poor environmental management by rural populations. This devaluation of rural environmental management techniques continued after countries gained their independence, mainly because the productivity levels of family farming did not meet the productivist and modernist aspirations of the new states. But the 1969–1973 and 1983–1984 droughts tipped the balance once again towards climatic causes – a view that has since gained traction with the impacts of climate change.

The severity of the environmental, social and economic crisis triggered by the droughts of the 1970s and 1980s led to widespread media coverage of the term "desertification", bringing it into the mainstream vernacular alongside "climate change" and "biodiversity".

This book answers questions about the nature of desertification, its geographical extent and its connection to deserts, climate variations and climate change (chapter 1). It also examines the causes of vegetation and soil degradation and the repercussions on ecosystems, biodiversity, water resources and the climate, along with the impact of those repercussions on human societies and the economy (chapter 2). This book also looks at adaptation strategies and methods for combating desertification (chapter 3) and delves into the history of these adaptations and struggles, the mechanisms deployed at local, national and international levels, and the efforts of specialized research and training programmes to tackle the issue (chapter 4).

Throughout the book, readers will see that desertification, and efforts to combat it, must account for the multifaceted complexity of the phenomenon, from its biophysical and socioeconomic aspects to the many stakeholders, scales of study and actions that are involved. Similarly, the spatial and temporal dynamics of causes and solutions are an essential part of the reflection process.

WHAT IS THE NATURE AND EXTENT OF DESERTIFICATION?

DOES DESERTIFICATION ONLY INVOLVE THE EXPANSION OF DESERTS?

Antoine Cornet, Pierre Hiernaux, Hélène Soubelet, Jean-Luc Chotte, Thierry Heulin

Originally, the word "desert" referred to an uninhabited area – in other words, devoid of people. Today, the word has a more climatic and biological meaning: it describes regions with scarce, irregular precipitation and very specific biodiversity made up of a few, highly adapted species, such as limited and sparse vegetation. Deserts are a particular biome mainly characterized by the absence or rarity of its living organisms as well as by the specific climate conditions that make these areas so arid. Desert ecosystems are remarkable examples of the ability of living species to adapt to extreme environmental conditions. The people who live in these areas have developed strong social and cultural innovations in harmony with the environment. Deserts have an internal dynamic tied to the geomorphology and climate. The theory of desert expansion – which suggested that the Sahara was expanding 5.5 km per year – has now been rejected by the entire scientific community, which has conclusively shown that deserts are not advancing significantly. As a biome whose ecological integrity has not been degraded, deserts are not typically considered part of the desertification process.

The term desertification has always been defined in various ways and subject to debate and even controversy. The United Nations Conference on Desertification in 1977 defined it as follows: "Desertification is the diminution or destruction of the biological potential of the land, and can lead ultimately to desert-like conditions. It is an aspect of the widespread deterioration of ecosystems." However, this definition says nothing about the

many causes of land degradation. To address the various debates and controversies on the issue, the United Nations Environment Programme (UNEP) formed a working group in 1991. A new definition recognized the harmful impact of people as the primary cause of desertification: "Desertification is land degradation in arid, semi-arid and dry sub-humid areas (drylands) resulting mainly from adverse human impact." While it involves various processes that lead to a decline in soil quality and vegetation, human activity drives the phenomenon. The concept of "land degradation" encompasses falling yields, declining vegetation cover, the exacerbation of physical mechanisms at the soil surface, the qualitative and quantitative loss of water resources, and soil degradation. But persisting controversies divide the scientific community. For some, desertification refers to an environmental state, i.e. the manifestation of desert conditions and the final stage of land degradation. For others, desertification characterizes the process of soil and vegetation degradation that gradually leads to a loss in productivity, which may or may not be reversible. These diverging definitions stem from differences in how the extent of desertification is assessed as well as in strategies to combat the problem. For instance, should priority be given to restoring degraded areas, or should preventive measures be adopted to reduce or eliminate the causes of desertification? Today, the scientific community considers that desertification, associated with the loss of total productivity and environmental resilience, is not a sudden phenomenon. On the contrary, it occurs at the end of a gradual process marked by different thresholds. It is based on this viewpoint that international bodies have adopted the term *desertification* as being equivalent to land degradation in dry areas. The United Nations Convention to Combat Desertification (UNCCD) has proposed a new definition: desertification means "land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities". These bioclimatic regions are determined based on the ratio of mean annual precipitation to mean annual potential evapotranspiration. The UNEP defines dryland as areas with a ratio of between 0.05 and 0.65. Hyper-arid desert areas (with a ratio of less than 0.05) are excluded.

Desertification has myriad impacts on the environment and on people. At the United Nations Conference on Environment and Development in Rio de Janeiro in 1992, following a call from countries affected by desertification, the international community recognized that the issue is a global environmental problem that requires worldwide mobilization. This was the beginning of the UNCCD.

In general terms, desertification describes complex and interacting mechanisms and processes driven by a set of factors at different scales over space and time. While human activity is recognized as the main factor, the climate context is often considered to be an aggravating or triggering factor, as in the case of the series of dry years in the 1970s and 1980s in the Sahel. The desertification process does not cause ecosystems to become a desert in the ecosystemic sense of the word, but rather in the ecological sense: they experience a loss of biodiversity, functionality and ecosystem services (the area's capacity to produce biomass, retain water, be fertile, etc.).[1] New knowledge about the environments and societies in dryland areas should now be used to further refine the concept of desertification to establish a more nuanced definition of land degradation in dryland areas that accounts for the resilience of the environment and people. Knowledge and political action must converge to move forward.

DOES CLIMATE CHANGE EXACERBATE THE DESERTIFICATION PROCESS?

Pierre Hiernaux, Jean-Luc Chotte, Arona Diédhiou

A global phenomenon of anthropogenic origin

The link between the air temperature at the Earth's surface and the atmosphere dates back to 1824 and the work of French physicist Joseph Fourier. The greenhouse effect was described as early as 1856 by the American scientist Eunice Foote, and the role of carbon dioxide (CO_2) in global warming was suggested by the

1. See chapter 4, "How does desertification affect biodiversity?"

Swedish scientist Svante Arrhenius in 1896. However, measurements of the concentration of atmospheric CO_2 did not begin until the 1950s, and their upward trend was not confirmed until the 1970s. The term "global warming" was used for the first time by the American climate scientist Wallace Broecker in 1975.

The first atmospheric circulation models were then developed, and the Intergovernmental Panel on Climate Change (IPCC) was set up in 1988. The first IPCC reports, published in 1990, provided scientific evidence linking climate change to the greenhouse effect and established human responsibility for global warming. The first world conference on climate change was held in Rio de Janeiro in 1992 and led to the United Nations Framework Convention on Climate Change (UNFCCC).

Climate change is a global phenomenon of anthropogenic origin that must be distinguished from cyclical interannual climate variations (such as El Niño), whose extent increases with the dry conditions that characterize arid, semi-arid and dry sub-humid climates. The rising atmospheric concentrations of greenhouse gases – mainly carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) – is the driving force behind global warming. This warming then alters the general circulation of air masses and ocean currents, causing disturbances in wind patterns, air humidity and precipitation.

While CO_2 levels have increased more or less steadily around the globe, the rise in temperatures varies depending on the region and the season. This rise may be tied to the coldest or warmest seasons, or to daytime or night-time temperatures. In the sub-Saharan Sahel, for example, Françoise Guichard's research has shown that the increase mainly concerns night-time temperatures at the end of the dry season (March to May), which is already the hottest season. However, the rise does not affect temperatures at the start of the dry season (November to February), which are cooler, or the monsoon rainy season (June to September). In Mediterranean climates, it is not only the temperatures during the hottest summer months that rise the most, but also night-time temperatures, leading to more frequent warm nights. In the continental climates of Central

Asia, which are characterized by very wide temperature ranges, Uzbek climatologist Alisher Mirzabaev has observed a greater frequency of extreme events. Rainfall pattern trends affected by climate change also vary between regions. Rainfall is more abundant and more intense in tropical drylands, such as the sub-Saharan Sahel, East Africa, the southern Arabian Peninsula, western India and Pakistan, and northern Australia. However, it is less abundant around the Mediterranean region and in the Middle East, Central Asia, Southern Africa, northern Latin America and north-western Mexico. In any event, it seems that the irregularity and intensity of rainfall events are increasing, making seasonal droughts and floods (or, in some regions, snow and hail) both more frequent and more intense.

The impact of climate change on desertification

The effects of climate change are compounded by those of climate variations that characterize arid, semi-arid and dry sub-humid regions. They include the effects of CO_2 enrichment of the atmosphere, rising temperatures, and changes in wind and rainfall patterns, whose direction and intensity vary from one region to another.

Precipitation

The strong interannual variations in seasonal rainfall that are typical in arid and semi-arid climates have always been factors that promote or exacerbate ecosystem degradation. The droughts of 1972–1973 and 1983–1984 in the Sahel, for example, substantially reduced vegetation cover, which caused wind erosion and, locally, the shifting of dunes that had been stable for decades. Paradoxically, these droughts also prompted or exacerbated water erosion from monsoon rains, causing more incidences of stronger and more intense run-off, which then contributed to an increase in the filling of ponds and worsened flooding and siltation of temporary rivers. These droughts changed the Niger River's regime, adding an early peak known as the "red flood" due to the water's colour. This phenomenon has been called the "Sahelian paradox" (less rainfall but more water in the discharges). These wind and water erosion phenomena are all the more pronounced

locally when they occur on soil that has been disturbed (e.g., ploughed, weeded or trampled by livestock).

CO_2 enrichment of the atmosphere

The CO_2 enrichment of the atmosphere, for which the concentration is currently around 450 ppm (compared with 310 ppm before the 1950s) should accelerate photosynthesis, and thus plant production. Numerous experiments carried out in climatic chambers have confirmed this upturn in production and the efficiency with which plants use water. However, the results also depend on water, nitrogen and phosphorus constraints in the soil, and they differ according to the biochemical pathways of photosynthesis (C3, C4 or CAM, for crassulacean acid metabolism). Since the 1990s, scientists have used experimental systems employing CO_2 enrichment of the air at plot scale (known as free-air carbon enrichment, or FACE, experiments) to test the effect of several concentration levels (often up to 600 ppm), combined with rainfall, temperature, and nitrogen and phosphorus input scenarios, on most crops and in various forest and savannah biomes. Unfortunately, few of these trials – which are extremely costly to run – have been carried out in arid or semi-arid zones. The overall findings confirm the stimulation of photosynthesis and higher water-use efficiency in plants. Some of these experiments are conducted over the long term and offer indications of how vegetation adapts. They show a change in the flora, generally in favour of C3 plants (especially woody species), but this trend may be offset by the concomitant rise in temperature, which favours C4 plants (e.g. maize, sorghum).

Rising temperatures

Rising temperatures are accompanied by an increase in evapotranspiration (which can worsen drought episodes), but their impact on vegetation depends on their timing in relation to plant growth. For example, rising temperatures have little impact in the Sahel, where they occur during the dry season.

Wind and rainfall patterns

The impact of changes in wind and rainfall patterns varies from region to region. The trend towards more rainfall in the Sahel since the 1990s explains the "regreening" observed on satellite imagery, especially the increase in woody plant cover and density. Exceptions to this trend, such as in western Niger, are related to the local intensity of land clearing for farming and urban sprawl. In other regions where climate change is reflected in reduced rainfall, such as the steppe in southern Algeria, we are seeing a decline in vegetation cover, a change in floristic composition towards annual species and an increase in wind erosion and local silting, all exacerbated by rising agricultural and pastoral pressure on resources. In all events, whether rainfall rises or drops, the increasing irregularity of its distribution, combined with its greater intensity, will likely worsen degradation of the biome by intensifying soil erosion, unless the effect of CO_2 enrichment of the air on the vegetation cover suffices to reduce erosion and maintain if not enrich soil organic matter.

WHICH REGIONS AND POPULATIONS ARE AFFECTED BY DESERTIFICATION?

Antoine Cornet

Most continents are affected by desertification. The dry regions threatened by this phenomenon cover 40% of available land, i.e. 5.2 billion out of 13 billion hectares. Some 37% of the world's drylands are in Africa, followed by Asia (33%) and Australia (14%). Affected drylands are also found in the Americas and on the southern fringes of Europe. In terms of land use, 65% of these areas is used as pasture, 25% is farmland and the remaining 10% is allocated to other purposes (forests, urban areas, etc.).

In 2000, dryland areas were home to 35% of the world's population. More than 1.5 billion people live in arid, semi-arid and dry sub-humid regions in over 60 countries. These populations, at least 90% of whom live in developing countries, rank on average far behind the rest of the world on human well-being and

development indices. Aside from those with mineral and oil wealth or providing industrial and service activities, these countries subsist essentially from their natural resources and thus from agricultural, pastoral and forestry activities, most often for domestic consumption. Population growth and persistent drought, as well as climate change in general, are intensifying pressure on these resources and on land. This pressure leads to questions about how societies in dry zones adapt,[2] how quickly they implement and disseminate adaptations, and their capacity to innovate, all of which can jeopardize the local environment, particularly biological diversity, and the very survival of populations.

Under the United Nations Convention to Combat Desertification (UNCCD), the States Parties must voluntarily declare themselves "affected" by desertification. This involves various obligations, including the establishment of national action programmes to combat desertification. Non-affected countries have only one obligation: to report on their cooperation activities every two years and pay their compulsory contribution. France, for example, has declared itself as non-affected. However, climate models unambiguously predict its aridification, which may eventually lead it to declare itself affected. Furthermore, many of the affected countries that are signatories to the UNCCD (196 in 2024) do not have drylands. This relativizes the UNCCD's focus on dryland areas.

Assessments of the true extent of desertification and estimates of the total surface area of drylands affected by desertification around the world vary significantly. The calculation method and the type of land degradation taken into account both influence the estimate. The Global Assessment of Soil Degradation (GLASOD, 1991, Wageningen University), which was based on expert opinions, reckoned that 20% of drylands suffer from soil degradation. Another estimate dating from the early 1990s (International Center for Arid and Semi-Arid Land Studies – ICASALS, Texas Tech University), drawing mainly on metadata, calculated that 70% of drylands are affected by soil and/or

2. See the following question, "Can we adapt to desertification?"

vegetation degradation. A 2003 assessment, based on partially overlapping regional databases and remote sensing data, put the figure of the world's degraded drylands at 10%.

Using the broad concept of biological productivity and degradation of ecosystem services, the study commissioned by the Millennium Ecosystem Assessment (2005) estimated that 10–20% of drylands were already degraded. According to these estimates, the worldwide total area affected by desertification could be between 6 and 12 million square kilometres.

Given the limitations and inherent problems of each of the databases on which this work is based, better evaluation is needed. After 2008, the UNCCD established indicators for assessing the extent and evolution of desertification. It also created a conceptual framework for integrating these indicators and mechanisms for reporting and managing the indicators at national and local levels.

In 2008, the European Environment Agency (EEA) conducted a study on desertification in southern, central and eastern Europe, covering an area of 1.68 million square kilometres. In 2013, the EU's Joint Research Centre published a new version of the World Atlas of Desertification. In 2017, a follow-up study based on the same methodology showed that the area exposed to desertification had grown by 177,000 km^2 (or 10.5%) in under a decade.

The indicators established by the UNCCD were included in target 15.3 of the Sustainable Development Goals (SDGs): combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world. Indicator 15.3.1 used by the United Nations is the proportion of land that is degraded over total land area, expressed as a percentage. Based on a binary quantification (degraded/not degraded), the indicator is calculated using available data for three subindicators that must be validated and reported by national authorities. The subindicators are changes in vegetation cover, land productivity and soil organic carbon.

Based on these indicators, the 2015 baseline figures[3] for several countries and regions are: Africa, 18% of land degraded; Asia, 24%; Europe, 10%; France, 12%; Kenya, 40%. The SDG Global Database includes 136 countries, many of which do not have drylands.

Given that the UNCCD covers only arid, semi-arid and dry sub-humid areas, should we conclude that the definition of desertification as given should evolve within the UNCCD framework? To answer this question we must examine both the scientific and technical aspects as well as the political angles and opportunities within the international debate. Do the particular characteristics and distinct features of drylands mean we should consider land degradation in these areas to be a specific phenomenon to which the term "desertification" should be attributed and differentiated from the very real land degradation in other biomes? The recent recognition of land degradation as an important factor in other conventions (the United Nations Framework Convention on Climate Change and the Convention on Biological Diversity) might justify this extension to the entire phenomenon of land degradation. Amending this definition within the framework of the UNCCD would require opening negotiations on the text, which few parties wish to do given the difficulty of reaching a consensus.

CAN WE ADAPT TO DESERTIFICATION?

Emmanuel Chauvin, Pierre Hiernaux, Christine Raimond

Perceptions of desertification, its causes, extent and effects vary significantly depending on the viewpoints of the stakeholders involved, which in turn stokes controversy.[4] In Africa, the concept of desertification is a colonial construct based on a profound misunderstanding of dryland ecology and the associated rural

3. Sustainable Development Goals Global Database: https://unstats.un.org/sdgs/dataportal

4. See the first five questions in chapter 2.

activity systems. This construct has since been analysed by scientists, but is often employed as is by post-colonial states and international players to justify their environment- and development-related actions. Theories and definitions based on the essentially anthropogenic origin of desertification – and more specifically, blaming the supposedly "bad" agricultural and silvo-pastoral practices of local populations for causing soil degradation (e.g. overexploitation, shifting cultivation, transhumant livestock farming, wildfires) – are stubbornly persistent. They often still guide actions proposed to prevent or remedy the problem (e.g. sedentarization of livestock farming and agropastoral activities, reforestation, and establishing land reserves, which often involves excluding populations and reducing access rights).

Yet the rural and urban societies living in these regions have long since adapted to arid, semi-arid and dry sub-humid climates, often in ways that run counter to the actions suggested by development projects to curb desertification. The ecosystems of these regions have developed as an adaptation to a major seasonal water constraint and very high temperatures, while also offering benefits for vegetation and agriculture, since rainfall occurs during the period when days are longest and temperatures are highest. Spatiotemporal heterogeneity in rainfall distribution, run-off and subsurface run-off, as well as in the mineral fertility of soils (nitrogen and phosphorus availability for plants), explain the considerable differences in the distribution and production of vegetation in landscapes that have also been greatly shaped by human activities (oases, wooded parks, pastures, etc.).

When faced with the scarcity and spatiotemporal variability of resources, societies adapt in many ways. In Africa, adaptations revolve around five principles: extensive resource exploitation; mobility and migration; multi-enterprise farming; multifunctional areas; and regional complementarity between different agroecological zones based on product flows.

The main adaptation is due to the extensive nature of most agricultural, pastoral and forestry activities, and to the mobility of people and products associated with them. Depending on soil conditions and climate fluctuations, farmers grow a wide