

Desertification In The Sahel

Introduction

You read in the chapter on Land Degradation that:

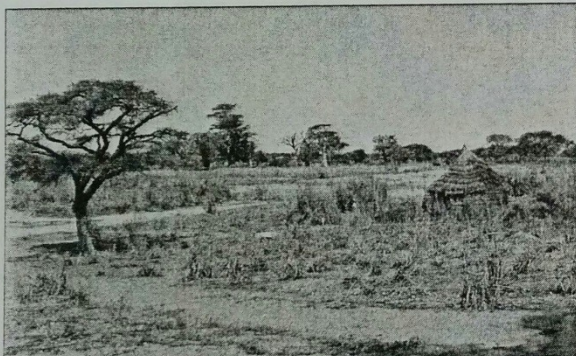
Desertification is the degradation of land in arid, semi-arid, and dry sub-humid areas. It is caused primarily by human activities and climatic variations. Desertification does not refer to the expansion of existing deserts. It occurs because dryland ecosystems, which cover over one third of the world's land area, are extremely vulnerable to over-exploitation and inappropriate land use. Poverty, political instability, deforestation, overgrazing, and bad irrigation practices can all undermine the land's fertility.

From Food and Agricultural Organization web page on [Desertification](#).

You also read that both nature and humans influence desertification. Here we look at one region that has captured the attention of the world for at least the past 40 years— the Sahel of north Africa. Beginning in the 1960s, the area became very dry and hundreds of thousands died of starvation. Was the devastation the result of human misuse of the land, was it the result of natural changes in climate, or was it the result of both? Answers to these questions have not come easily. At first, land use and land degradation were thought to be the primary causes. The United Nations Conference on Desertification focused attention on land use, and led to the emphasis on land degradation as the cause of desertification. Since then, we have found that the issue is more complicated.

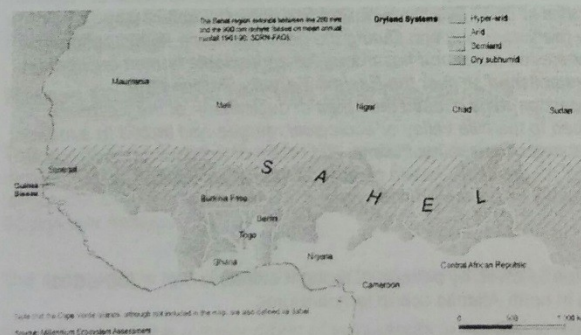
What is the Sahel?

The Sahel is the semi-arid transition region between the Sahara desert to the north and wetter regions of equatorial Africa to the south. It extends from the Atlantic in the west to the Indian ocean in the east. It has high variability of rainfall, and the land consists of stabilized ancient sand seas. It is one of the poorest and most environmentally degraded areas on earth.



Near Wolof village of Ndiagene in Senegal in the Sahel.

From [Ewan Robinson Rural Visit](#) as shown in NASA Earth Observatory article on [Desertification](#).



Map of the sahel in north Africa. Some scientists include Eritrea in the sahel.

From Millennium Ecosystem Assessment report on [Ecosystems and Human Well-Being Desertification Synthesis](#).

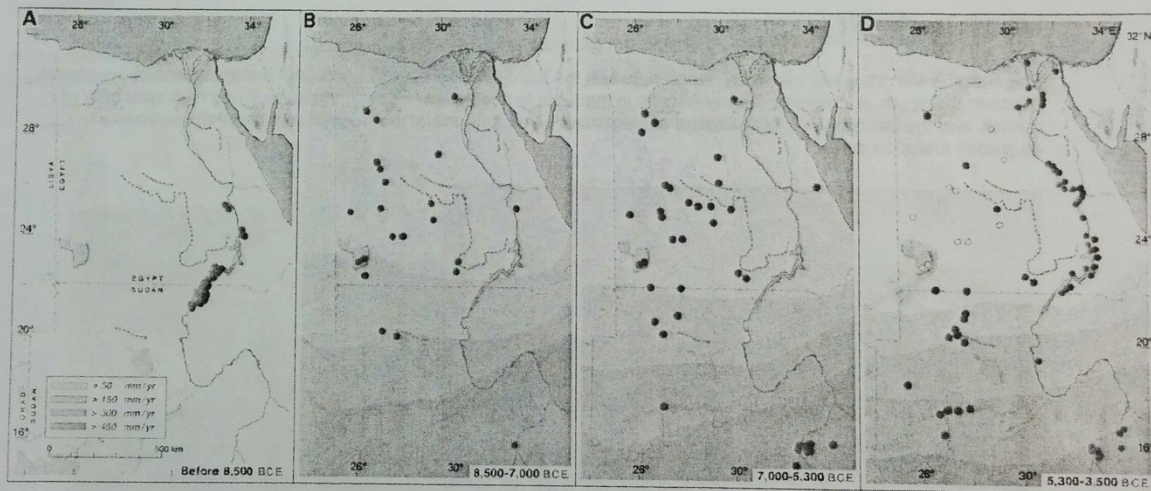
History of Desertification in Sahara and Sahel

Climate of the Sahel and the Sahara has changed greatly over the past 11,000 years since the end of the last ice age. The Sahara has expanded and contracted, changing the course of civilizations.

One of the most striking climate changes of the past 11,000 years caused the abrupt desertification of the Saharan and Arabia regions midway through that period. The resulting loss of the Sahara to agricultural pursuits may be an important reason that civilizations were founded along the valleys of the Nile, the Tigris, and the Euphrates. German scientists, employing a new climate system model, have concluded that this desertification was initiated by subtle changes in the Earth's orbit and strongly amplified by resulting atmospheric and vegetation feedbacks in the subtropics. The timing of this transition was, they report, mainly governed by a global interplay among atmosphere, ocean, sea ice, and vegetation.

From ScienceDaily article on [Sahara's Abrupt Desertification Started By Changes In Earth's Orbit, Accelerated By Atmospheric And Vegetation Feedbacks](#).

The changing climate first attracted people to the Sahara as rainfall increased abruptly throughout the region beginning about 10,500 years ago (8,500 BC) at the end of the Younger Dryas (See [Abrupt Climate Change](#)). Then increasing drought drove them southward into the modern Sahel as the rains became less frequent beginning about 7,200 years ago. By 5,500 years ago (3,500 BC) the Sahara had returned to full desert conditions. It appears that many who left the Sahara settled in the Nile valley about 5,500 years ago, setting the stage for the First Dynasty starting with the reign of King Narmer in 3,000 BC (5,000 years ago).



Climate-controlled occupation in the Eastern Sahara during the main phases of the Holocene. Red dots indicate major occupation areas; white dots indicate isolated settlements in ecological refuges and episodic transhumance. Rainfall zones are delimited by best estimate isohyets on the basis of geological, archaeozoological, and archaeobotanical data. (A) During the Last Glacial Maximum and the terminal Pleistocene (20,000 to 8500 BC), the Saharan desert was void of any settlement outside of the Nile valley and extended about 400 km farther south than it does today. (B) With the abrupt arrival of monsoon rains at 8500 BC, the hyper-arid desert was replaced by savannah-like environments and swiftly inhabited by prehistoric settlers. During the early Holocene humid optimum, the southern Sahara and the Nile valley apparently were too moist and hazardous for appreciable human occupation. (C) After 7000 BC, human settlement became well established all over the Eastern Sahara, fostering the development of cattle pastoralism. (D) Retreating monsoon rains caused the onset of desiccation of the Egyptian Sahara at 5300 BC. Prehistoric populations were forced to the Nile valley or ecological refuges and forced to exodus into the Sudanese Sahara where rainfall and surface water were still sufficient. The return of full desert conditions all over Egypt at about 3500 BC coincided with the initial stages of pharaonic civilization in the Nile valley. Click on the image for a zoom.

From [Kuper and Kröpelin \(2006\)](#).

Since 3,000 BC the Sahel has had periods of more rain followed by periods of drought at intervals of $1,500 \pm 500$ years. The more recent changes are tied to changes in north Atlantic ocean temperatures.

Recent Climate Change and Rainfall

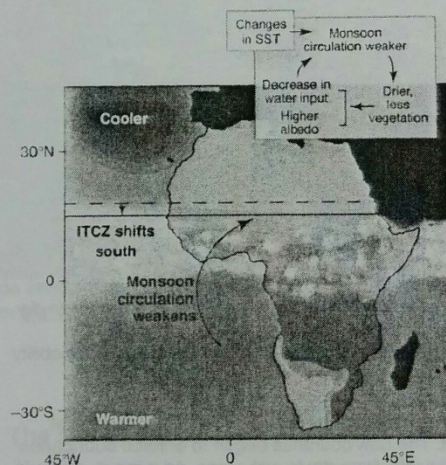
Years of above average rainfall from the 1950s to the 1970s, were followed by drought in the Sahel starting in the late 1960s. The drought has had a devastating impact on this ecologically vulnerable region and was a major impetus in the establishment of the United Nations Convention on Combating Desertification and Drought. Since then, meteorologists, oceanographers, and geographers have sought to understand what caused the drought.

Recent work by meteorologists and oceanographers has shown that much of the recent year-to-year changes in Sahel rainfall are forced by changes in sea-surface temperature in the Gulf of Guinea (on the equator near the prime meridian) and by El Niño in the Pacific. When the gulf is warm, the Intertropical Convergence Zone shifts south away from the Sahel reducing the African monsoon that draws moist air into the Sahel. Longer term changes in rainfall from decade to decade are forced by changes in sea-surface temperature in the western Indian and tropical Atlantic oceans. When these areas are cool, Sahel rainfall increases.

The oceanic forcing of Sahel rainfall is amplified by land-atmosphere feedbacks. As the land dries out, there is less vegetation, less evaporation from the land, and more sunlight is reflected from the land. These processes further weaken the monsoon. This positive feedback also involves land degradation due to human interactions with the land.

Land-atmosphere feedbacks amplifying climate change in the Sahel. Click on image for a zoom.
From Dryland Systems in *Ecosystems and Human Well-Being: Current State and Trends*, part of the Millennium Assessment.

Rains return when the gulf is cooler, and rainfall shifts north watering the Sahel. Evaporation from the land increases, less sunlight is reflected, and the African monsoon strengthens.



Changes in Sahel rainfall are forced by changes in sea-surface temperature in the Gulf of Guinea. The response is amplified by land-atmosphere feedbacks in the Sahel.
From Zeng (2003).

Human Dimensions of Sahel Land Degradation

The drying of the Sahel in the late 20th century caused widespread famine that attracted world-wide attention, including the United Nations Conference on Desertification (UNCOD) in Nairobi, Kenya in 1977, the 1993 Convention to Combat Desertification, the 2006 International Year of the Desert and Desertification, and the Millennium Ecosystem Assessment.

The studies show that climate change strongly influences the Sahel in recent decades, but it is only part of the story:

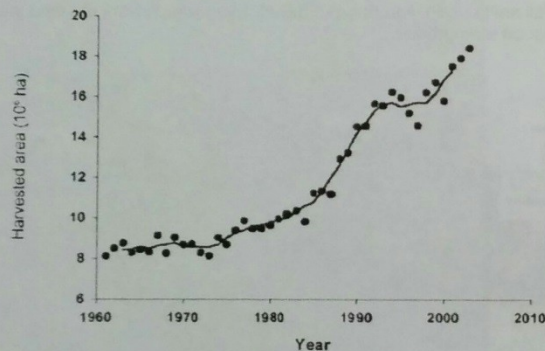
Rainfall variability is a major driver of vulnerability in the Sahel. However, blaming the 'environmental crisis' on low and irregular annual rainfall alone would amount to a sheer oversimplification and misunderstanding of the Sahelian dynamics. Climate is nothing but one element in a complex combination of processes that has made agriculture and livestock farming highly unproductive. Over the last half century, the combined effects of population growth, land

degradation (deforestation, continuous cropping and overgrazing), reduced and erratic rainfall, lack of coherent environmental policies and misplaced development priorities, have contributed to transform a large proportion of the Sahel into barren land, resulting in the deterioration of the soil and water resources.

From United Nations Environmental Programme, World Agroforestry Center. Climate Change and Variability in the Sahel Region: Impacts and Adaptation Strategies in the Agricultural Sector.

The human influences include:

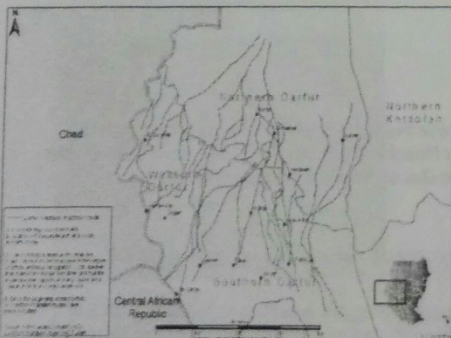
1. Population increase. Population is doubling every 20 years. The growth rate of population (3% per year) exceeds the growth rate of food production (2% per year). The total population is around 260,000,000 people.
2. Poverty. Per capita income varies from \$500/year in Burkina Faso to \$1,000/year in Mali to \$2,000/year in Nigeria. In contrast, the per capita income in France, Germany, and the UK is about \$35,000/year. All are estimates for 2007. The area includes three of the four poorest countries on earth.
3. Over grazing, poor farming methods, and use of trees and vegetation for firewood. Overgrazing and poor agricultural practices lead to soil erosion, further degrading the land.
The traditional Parkland system (integrated crop-tree-livestock systems), which is the predominant land use system and the main provider of food, nutrition, income, and environmental services, is rapidly degrading—woody biodiversity and cover is being lost, and soil fertility is declining from already low levels through exhaustive cropping practices and soil erosion.
From West Africa Drylands Project.



Area devoted to crops in the Sahel since 1960. The need to grow more crops, both for export and for local use, has led to expansion of agriculture into areas poorly suited for crops, leading to land degradation in dry years.

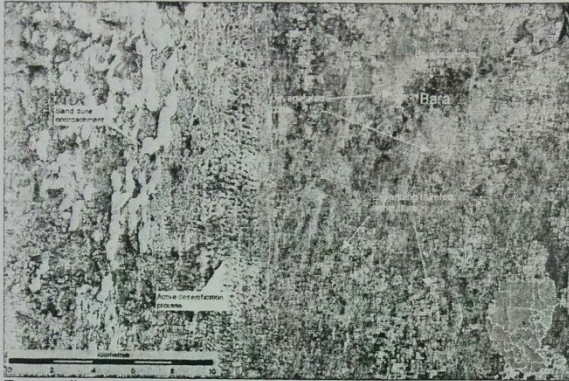
From United Nations Environmental Programme, World Agroforestry Center. Climate Change and Variability in the Sahel Region: Impacts and Adaptation Strategies in the Agricultural Sector.

4. Colonial Influence. The Sahel was divided into countries by European nations. The borders were set by political processes that mostly ignored the local people and their use of the land. The new countries began to enforce boundaries limiting the ability of nomads to move their herds in response to changing rain, from dry to wet areas. As a result, nomads were forced into villages, and in dry years their herds overgrazed the area around villages and cities.



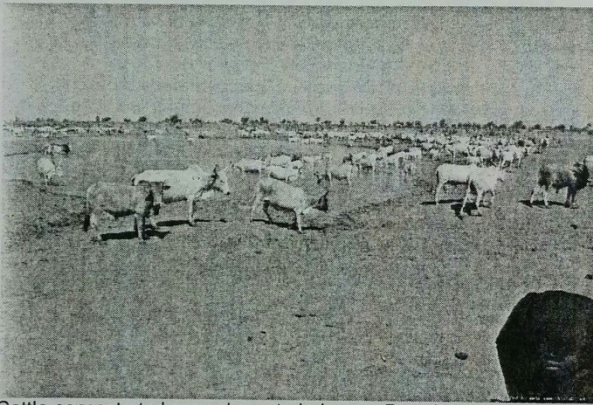
Major historical migration routes used by nomadic herders in the past. Now the borders with Chad and the Central African Republic are closed, and even borders between provinces in the Sudan are closed, and herders must stay within their own province. The closing of the borders causes environmental and political problems. Click on the map for a zoom.

From United Nations Environmental Program.



Desertification in Bara, Sudan due to restrictions on movement of herds of animals. Notice the devegetated areas around Bara. Click on the image for a zoom.

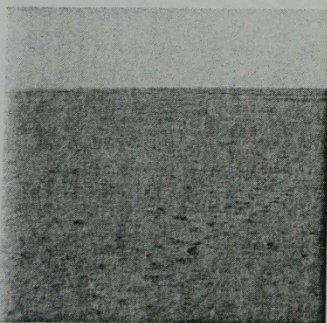
From United Nations Environmental Programme [Natural Disasters and Desertification](#) (a 0.6 MByte pdf file).



Cattle concentrated around a waterhole near Bamako, Mali, Africa. Click on image for a zoom.
From [Manfred Schweda](#).

5. Migration due to political instability and war. Conflicts in Niger, Nigeria, Mali, Darfur, and Eritrea have caused mass migration of people from rural areas to refugee camps to nearby countries.

The End



The end result of land degradation. Completely degraded land in northern Darfur, just outside a large refugee camp.

From United Nations Environmental Programme [Natural Disasters and Desertification](#) (a 0.6 MByte pdf file).

References

Kandji, Serigne Tacko; Verchot, Louis; and Mackensen, Jens. 2006. Climate Change and Variability in the Sahel Region: Impacts and Adaptation Strategies in the Agricultural Sector. United Nations Environmental Programme and World Agroforestry Centre.

Giannini, A., R. Saravanan, and Chang. (2003). Oceanic forcing of Sahel rainfall on interannual to interdecadal time scales. *Science* 302 (5647): 1027–1030.

We present evidence, based on an ensemble of integrations with NSIPP1 (version 1 of the atmospheric general circulation model developed at NASA's Goddard Space Flight Center in the framework of the Seasonal-to-Interannual Prediction Project) forced only by the observed record of sea surface temperature from 1930 to 2000, to suggest that variability of rainfall in the Sahel results from the response of the African summer monsoon to oceanic forcing, amplified by land-atmosphere interaction. The recent drying trend in the semiarid Sahel is attributed to warmer-than-average low-latitude waters around Africa, which, by favoring the establishment of deep convection over the ocean, weaken the continental convergence associated with the monsoon and engender widespread drought from Senegal to Ethiopia.

Reynolds, J. F., D. M. S. Smith, et al. (2007). Global Desertification: Building a Science for Dryland Development. *Science* 316 (5826): 847–851.

In this millennium, global drylands face a myriad of problems that present tough research, management, and policy challenges. Recent advances in dryland development, however, together with the integrative approaches of global change and sustainability science, suggest that concerns about land degradation, poverty, safeguarding biodiversity, and protecting the culture of 2.5 billion people can be confronted with renewed optimism. We review recent lessons about the functioning of dryland ecosystems and the livelihood systems of their human residents and introduce a new synthetic framework, the Drylands Development Paradigm (DDP). The DDP, supported by a growing and well-documented set of tools for policy and management action, helps navigate the inherent complexity of desertification and dryland development, identifying and synthesizing those factors important to research, management, and policy communities.

Zeng, N. (2003). ATMOSPHERIC SCIENCE: Drought in the Sahel. *Science* 302 (5647): 999-1000.