Can Technology Change Africa's Climate?

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Many strategies are proposed to eliminate drought in Africa's dry regions, but better land management would reap surer results.

Each time there is a prolonged, devastating drought on the African continent, new, technologically based quick-fix solutions are offered. Many people continue to believe that technology will resolve many of the environmental problems that plague the inhabitants and governments of Africa.

Although there have been severe droughts in Africa for centuries, a major difference between these earlier droughts and the more recent ones involves technological capabilities. Today, people have the know-how to alter the African landscape in ways that their ancestors could only dream about.

Most weather- and climate-modification schemes have proposed making African land arable again while compensating for the reduced productivity resulting from inadequate land management practices. While some members of the scientific community take a hopeful view of weather- and climate-modification techniques, others question whether schemes that look good in theory will work under real world conditions. Others are extremely skeptical of the potential value for making the African continent increasingly productive.

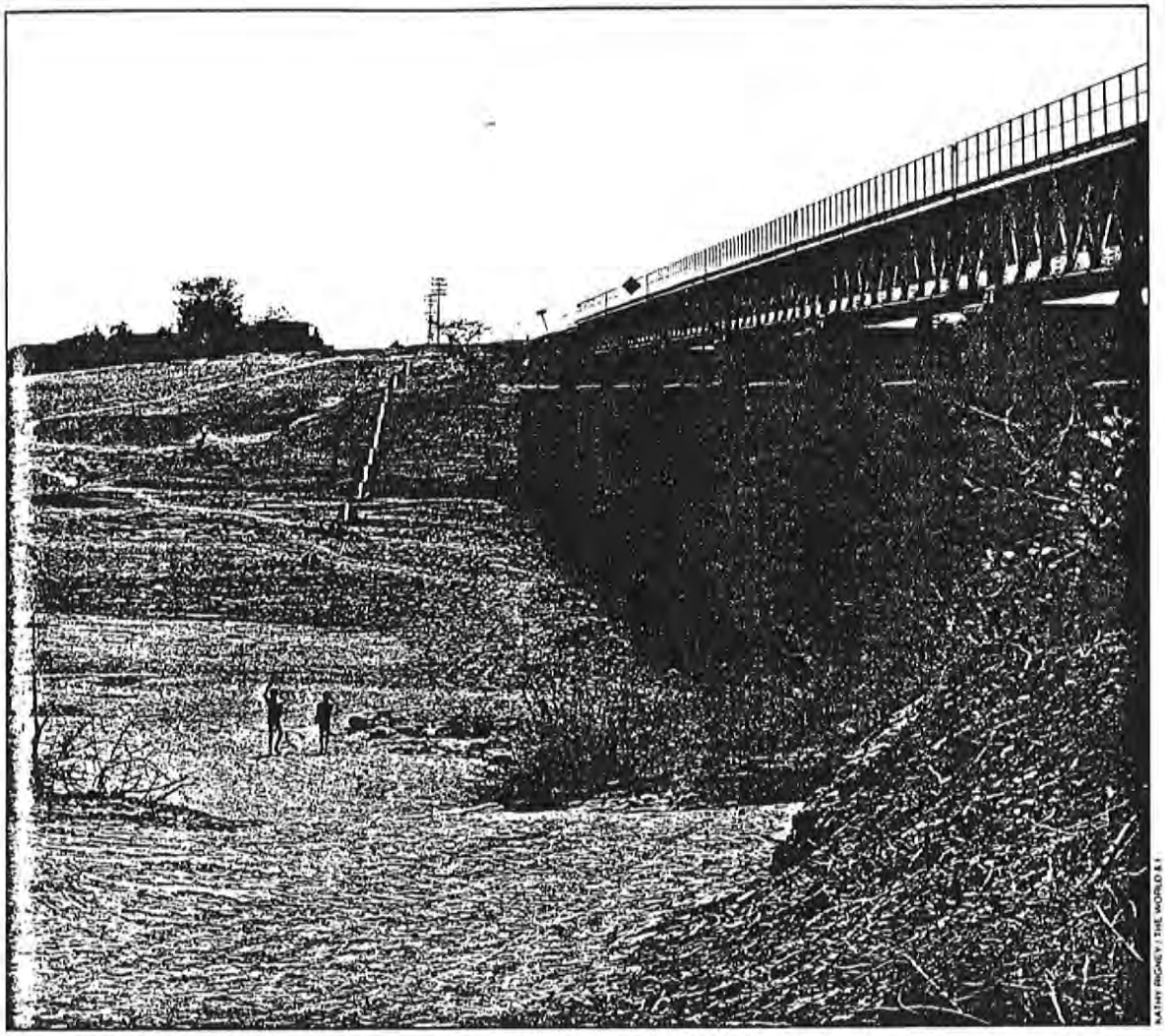
For convenience, weather- and climate-modification schemes relating to arid and semiarid lands in Africa can be divided into three categories: vegetation modification, atmospheric circulation modification, and precipitation modification.

Vegetation modification

Vegetation modification schemes are generally based on the suggestion that there are strong interactions (called feedback mechanisms) between the land's vegetative cover and atmospheric processes. It has been suggested that destruction of forested land has an adverse effect on climate at the regional and local levels. As early as the 1930s, E.B. Stebbing, a British forester, suggested that "deforestation, coupled with overuse of the land through poor land management practices, has led to a drying out of the soils." This, he suggested, led in turn to a slow but sure decline in regional annual rainfall. Stebbing was convinced that as the land deteriorated, woodlands changed to savanna, then to semiarid sahel, and finally into desert.

When Stebbing wrote these comments in the 1930s, he was concerned about the apparent shift southward of the Saharan desert sands at about a half-mile a year. Today, rates of desert encroachment to the south have been estimated at up to 30 miles a year. He spoke of erecting a green barrier—a tree belt across the southern edge of the Sahara that would stop desert sands from shifting onto productive areas; break up the hot, dry winds blowing out of the desert; retain soil moisture, which he expected (through evaporation and transpiration) to produce additional rainfall; and reduce runoff following rainstorms.

After each recent drought in the West African Sahel, there has been a renewed call for a green barrier. In fact, in the 1970s Algeria began construction of such a barrier along the northern edge of the Sahara, from its border with Morocco to its border with Tunisia, in a



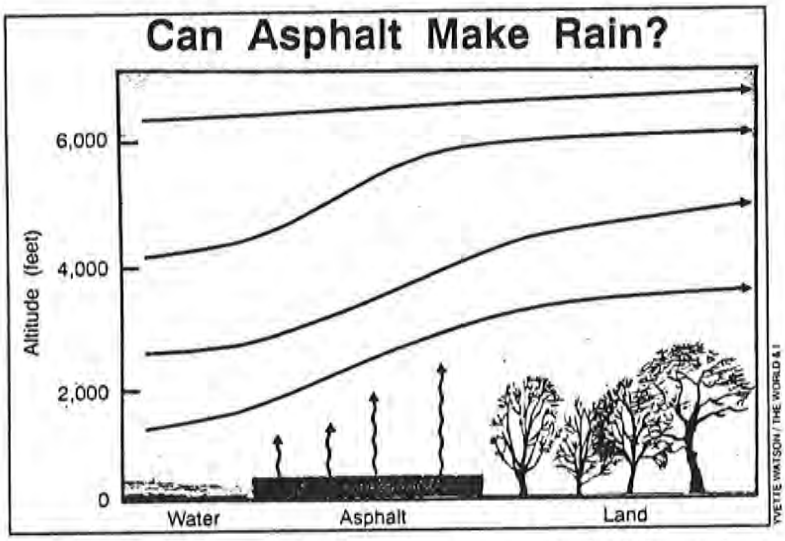
■ Drought has temporarily dried up the Senegal River, which forms part of the border between Senegal and Mali.

strip almost 1,000 miles long. Japan has rejuvenated this concept for the southern fringes of the Sahara, and plans to build a 3,000-mile green wall in the 1990s.

A variation of this scheme relates to the loss of condensation nuclei as a result of overgrazing by livestock. With the permanent removal of vegetation a widespread result of land clearing and overgrazing, *biogenicparticles* (organic matter, as opposed to inorganic dust) are unavailable in the atmosphere to serve as nucleating agents for raindrops. Biogenic particulates are apparently better at providing such nuclei than inorganic ones [see "Biogenic Ice Nuclei," THE WORLD & I, July 1987]. Russell Schnell has suggested, based on his Sahelian research, that the removal of sources of biological matter in the Sahel may have led to the sharp reduction in regional rainfall that plagues the area today.

MIT professor Jules Charney hypothesized that removing vegetation from the Sahel has changed the reflectivity of the earth's surface (its albedo) to such an extent that "any tendency for plant cover to decrease would be reinforced by a decrease in rainfall, and could initiate or perpetuate drought."

These hypotheses about the alteration of the vegetative cover and its impact on rainfall re-



■ **The asphalt island concept. The temperature difference between the asphalt and the surrounding area would lead to vertical movement of moisture-laden air, creating clouds and rain.**

main as controversial to scientific researchers as they are appealing to government decision makers and the few scientists who seek to implement demonstration projects.

Atmospheric circulation modification

This group of modification schemes is designed to alter the physical characteristics of the lowest kilometer or so of the atmosphere. This task can be affected by changes on the land's surface. Three such schemes are creating asphalt islands, introducing carbon-black dust into the atmosphere, and creating large inland bodies of water.

The asphalt island concept is based on the belief that there is considerable moisture in the atmosphere in arid and semiarid zones and that what is lacking is a mechanism to convert that moisture into rainfall. Observations have shown that when mountains lift air masses, rain can be produced. The idea, then, in the absence of a mountain range, is to create "thermal" mountains. By constructing black asphalt strips in desert areas, a mechanism for lifting air masses to produce rainfall would be created. The temperature difference between the paved surface and its unpaved surroundings would lead to vertical movement of a moisture-laden air mass. The rising air mass would create clouds and, ultimately, rainfall.

This technique is designed, at least in theory, to produce an effect similar to that caused by mountain ranges, but its magnitude would be less. Scientists interested in this approach have pointed to existing examples: the "heat island" effect of urban areas, "cloud streets" (cloud trails associated with tropical islands), and forest fires.

The idea of weather- and climate- modification by construction of asphalt islands is based on intuition, theoretical considerations, and analogy. As of today, no country has allowed the paving of its land surfaces with asphalt strips to generate rainfall downwind.

Carbon dust

It was suggested in the 1970s that putting carbon dust directly into the atmosphere would create a heat source within the atmosphere that would lead to atmospheric instability. A variation of the asphalt island concept, the idea was proposed for bringing rainfall to the semiarid parts of northeastern Brazil but was not specifically suggested for the African continent.

Scientists believed that weather modification for an area of 100 to 200 square kilometers would be possible if carbon dust were released directly into the atmosphere above tropical and subtropical coastlines. The carbon would act as an artificial heat source, increasing evaporation from the water surface and promoting extra cloud building over the adjacent land areas. They argued that the carbon-dust heat source would be more efficient than asphalt strips because the

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dust would mix with the air mass that it was heating and would move along with it. They also suggested that the area receiving increased precipitation would be much greater with carbon dust than with asphalt.

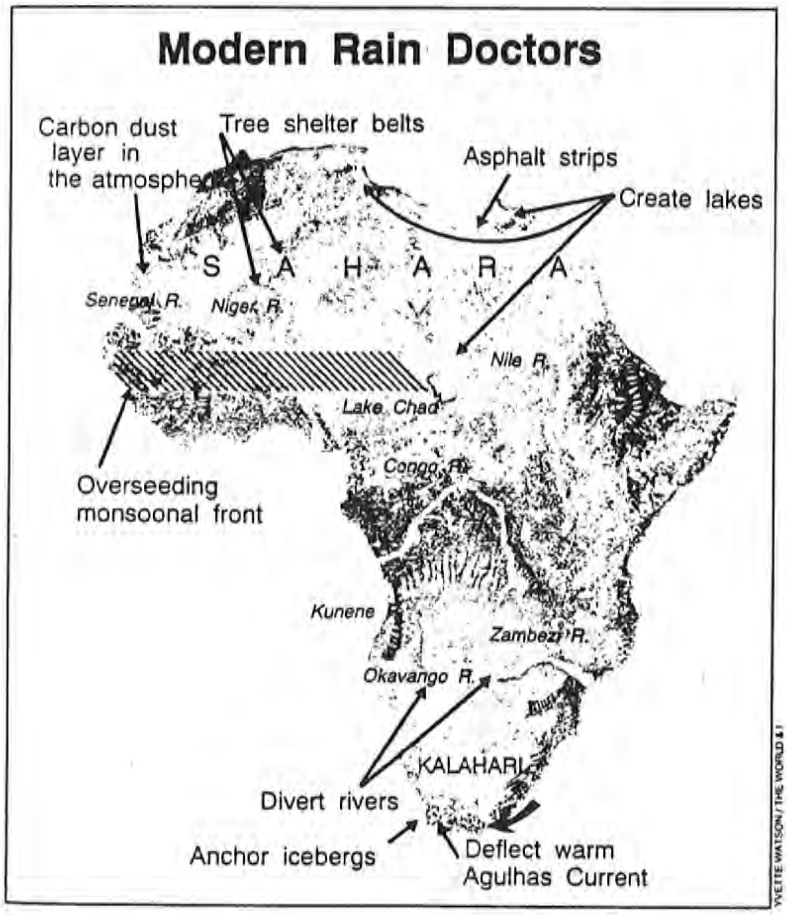
Inland seas

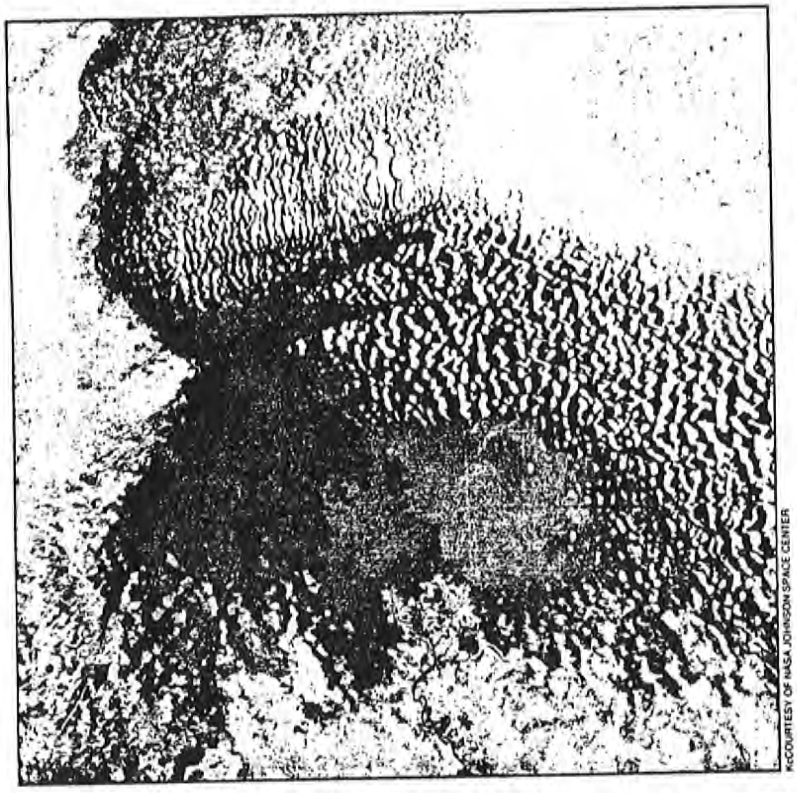
Throughout the twentieth century, authors have called for the creation of inland seas on the African continent. Such seas were supposed to supply the atmosphere with moisture through evaporation, which would then be returned as rainfall in the vicinity of the seas. Such a cycle would (in theory) increase the amount of agricultural land in these otherwise arid and semiarid regions.

Seas could be created by damming or diverting the flow of major rivers into inland drainage basins. Several of these basins are the remnants of ancient drainage basins into which modern rivers no longer flow. Many of these suggestions were designed to improve Africa's agricultural potential and to make an otherwise harsh environment enticing to increased rates of European settlement.

Different basins have been proposed for inland sea projects, such as the Chad Sea. Hermann Sergel, a German engineer, suggested that most of the waters of this sea "would be used to irrigate the Sahara, while the surplus would be channelled into the Mediterranean through an artificially created second Nile."

Similar but relatively more popular schemes have concerned the development of large inland bodies of water in and around the Sahara and Kalahari des-





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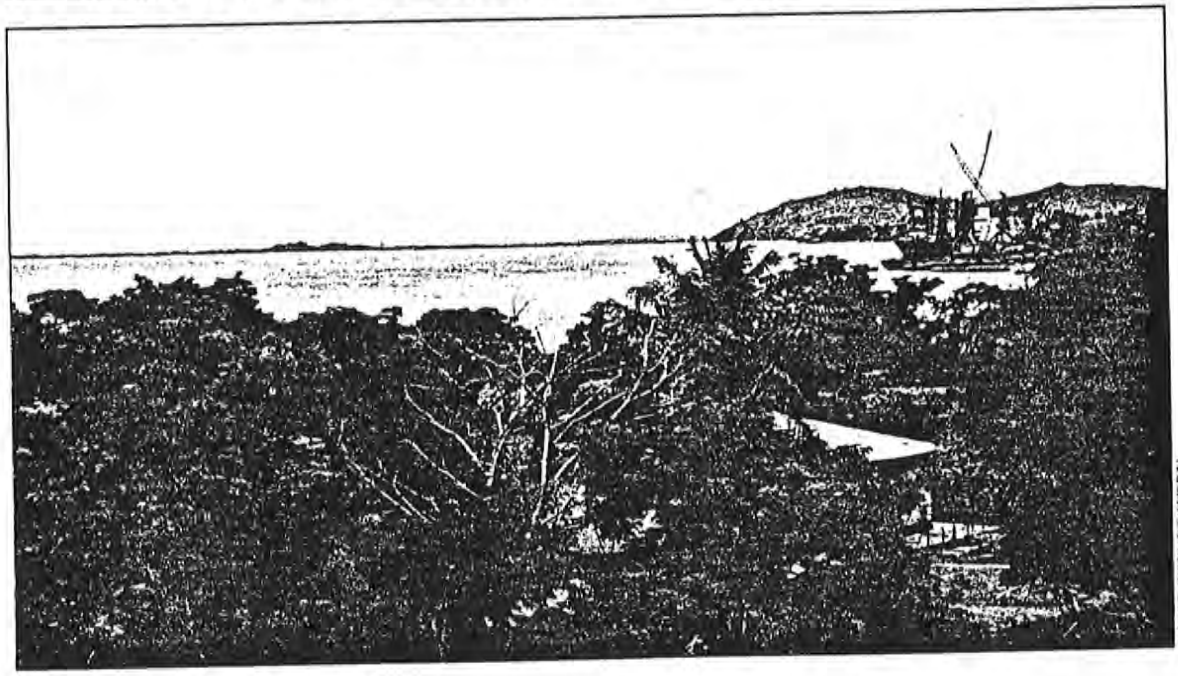
erts. Such strategies, suggested during extended droughts, were known at least as early as the turn of this century. Once each drought ended, however, the inland seas concept was put aside, only to reappear during the next major drought.

Based on the fact that part of the Sahara Desert lies below sea level, some scientists have

■ *Left:* This color infrared photograph of Lake Chad, taken from a space shuttle in March 1990, shows how drought has shrunk the lake. Whereas 20 years ago the lake encompassed most of the pictured area, the lake proper is now confined to a small area in the south. Elsewhere lie marshlands with small ponds impounded between sand dunes.
■ *Below:* The Congo River flows by the port of Bona in Zaire. Some suggest that part of its waters could be diverted to refill the Chad basin, creating a large source of evaporation and rain for the region.



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suggested that constructing a canal through the higher land of the north African coast to the Mediterranean would enable the creation of Saharan seas. In 1912, G.A. Thompson referred in a *Scientific American* article to a French proposal for such an idea, with the hope of creating conditions favorable for European colonization. The theory was that the inland sea would increase atmospheric moisture through evaporation and boost rainfall in the area.

In the mid-1970s, assessments were undertaken in Egypt's Qattara Depression to determine the feasibility of creating an inland sea that would permit hydropower generation. The study suggested that insufficient power would be generated, and the expansive project was never pursued.

Some scientists have challenged the evaporation-precipitation hypothesis, asserting that there is no evidence that precipitation would be enhanced in the area surrounding an inland sea. A mechanism to cause water in the atmosphere to fall as rain (e.g., ascending motion) would still be absent from the region. A computer simulation of the impacts of a hypothetical Lake Sahara done by the Rand Corporation suggested that there would be a very low probability of enhanced precipitation resulting from the creation of the inland body of water.

Rejuvenating Lake Chad

The most recent suggestion concerning compensation for a climate-related reduction in rainfall and river runoff centers on Lake Chad. This lake is a large inland sea in the midst of the West African Sahel at the juncture of four countries—Chad, Nigeria, Cameroon, and Niger.

Lake Chad occupies only a small percentage of the much larger Chad basin. Since the late 1960s, there has been a steady decline in regional rainfall and flow from the rivers that feed the lake. As a result, the surface area of the lake declined sharply, from about 9,700 square miles in 1963 to 1,900 square miles in 1984, and was even further reduced to 970 square miles by 1986. The lake's volume is also greatly affected by year-to-year variations in climate.

In 1990 a French and a Congolese scientist jointly proposed a plan to replenish Lake Chad's waters by diverting river flow from the Congo-Zaire basin to the Chad basin. It has been suggested that Lake Chad could be replenished with only 1 percent of the flow of the Congo River. The transfer might also reduce the risk of flooding that the Congo regularly experiences as a result of excessive stream flow.

Scientists suggest that such a transfer is technologically feasible. However, environmental assessments must be made before the project is undertaken. Issues to be addressed include the following: the water needs in the Chad Basin, the possible effects on regional climatic conditions, and the ecological impact of combining waters from the Congo basin with those of Lake Chad.

The proposal to replenish Lake Chad has only recently been suggested. There has been no critical analysis of this proposal, beyond scientific curiosity about whether the project might benefit the inhabitants of both basins.

The Schwarz scheme

An inland sea for southern Africa was suggested around 1920

■ The Makgadikgadi, a broad inland basin in northern Botswana, was occupied by a great lake at various times before the end of the last glacial age 10,000 years ago. Water from the Okavango River could be diverted to fill this basin, creating the potential for increased rainfall in the area.

by E.H.L. Schwarz. At that time the region he was interested in flooding was under the jurisdiction of Great Britain and South Africa. Schwarz proposed to reestablish an ancient inland drainage basin centering in an area of modern Botswana by diverting the flow of rivers that normally flow out to the ocean back inland. He suggested that one could "obtain sufficient water from the Chobe and Okavango Rivers to fill the Makarikari [Makgadikgadi]. This water, saved from the sea [would] be evaporated, and [would] fall as rain during the next year."

Again, the purpose of this technological fix was to open up otherwise useless land to irrigation. In the early discussions of the scheme, Schwarz stressed the precipitation enhancement aspect, but in later years he shifted to using the water for irrigation. The big question posed by critics of the scheme in the 1920s was whether the "new" precipitation would fall back into the basin from which the evaporation came. Interest in the Schwarz scheme early in the century was sparked by the belief that South Africa was drying out, after a decade of devastating drought at that time.

The region encompassed by the original scheme now contains parts of Angola, Namibia, South Africa, and Botswana. To undertake the creation of a Lake Kalahari would require the cooperation of these states.

Other South African schemes

Other technologically based schemes to bring an assured supply of water to a drought-plagued land include a proposal to deflect the Agulhas Current. Presently, it flows up the eastern coast of South Africa. The suggestion was to divert the current so that it would flow along the normally arid coast of western South Africa. The warm current was expected to bring rainfall to this dry area.

Yet another scheme was to tow icebergs from Antarctica for use as a source of fresh water to South Africa. It was suggested that, in addition to serving as a source of drinking water, "the very humid warm air circulating

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there would be chilled sufficiently to cause increased precipitation over the coastal belt and maybe further inland." As farfetched as this may seem, serious research was undertaken in the late 1970s on towing icebergs to Saudi Arabia for the purposes just cited. The project, however, remains on the drawing board.

Precipitation modification

Perhaps the best known form of weather modification is related to cloud seeding to enhance rainfall or suppress hail. Both of these techniques have been used in Africa. Interest in cloud seeding usually appears during drought—for example, in the early 1970s, in the West African Sahel, and again in response to Morocco's multiyear drought in the early 1980s. While the scientific basis for cloud seeding remains highly controversial, such projects appeal to governments and foreign aid agencies alike because they are not expensive and show the people that their government is trying to bring back the rains.

A variation of cloud seeding was suggested by Norwegian atmospheric scientist Tor Bergeron. He proposed that by overseeding (that is, dispersing too many seeding agents), raindrops would not become heavy enough to fall as rain. If the monsoonal front in coastal West Africa were overseeded, Bergeron argued, the precipitation would fall farther inland in the arid and semiarid regions. Before undertaking a large-scale effort, Bergeron called for a pilot study to test his theory. He hoped that this human intervention would shift the arable land limit further north.

A wiser solution

Africa's food production problems have never been as acute as they are today. While there is much interest in technological intervention to save Africa from environmental devastation, it may be wiser to address the underlying causes of those processes that add to its woes.

It is much cheaper in the long run to train farmers to properly use the land under today's conditions (e.g., increased sedentary farming, reduced fallow time, depleted soil fertility) than to try to reclaim land that has become inhospitable to human settlement. Desertification coupled with increasing demographic pressures foster expansion of human settlement into marginal areas that are increasingly unsuitable for agricultural production or livestock rearing.

It would be wiser to foster improved land management practices than to resort to technological fixes. A misleading feature of drought is that, following such a natural disaster, the human and livestock populations are greatly reduced because of drought-related deaths and spatial displacement; the land's carrying capacity will then be relatively more in balance with the drought-reduced population. What will have changed for the worse, however, will be the rejuvenative capacity of the land.

If inappropriate land-use activities are permitted to continue unaddressed, no single technological solution will be able to save the continent from devastation of its food-producing potential. One must then ask, as Stebbing did in 1935, "How long before the desert supervenes?"■

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