

## Greening the Desert

### How Farmers in Sahel Confound Scientists

*Scientists are catching up with farmers on how local knowledge and cooperation can work miracles.* [Dr. Mae-Wan Ho](#) and *Lim Li Ching*

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### Scientists catch up with reality

For years, many scientists have been making dire predictions of widespread irreversible 'desertification' in the African Sahel. But recent findings have proven them wrong.

Satellite images consistently show an increase in 'greenness' since the 1980s over large areas, confirming evidence on the ground indicating that the Sahel has recovered from the great droughts of the 1980s, and that human factors have played a large role in reclaiming the desert [1].

The African Sahel is a semi-arid grass and shrubland region situated between the Sahara desert in the north and the humid tropical savannas in the south, with a steep north-south gradient in mean annual rainfall. Rainfall is markedly seasonal and variable. A long dry season alternates with a short humid

season during the northern hemisphere summer. The scarcity of rainfall and its variable, unpredictable pattern accentuating from south to north, are the most important factors that shape the Sahel ecosystem. The vegetation cycle closely corresponds to the seasonality in rainfall, with virtually all the plant growth in the humid summer months. Overlying the sharp seasonal contrasts in rainfall are considerable fluctuations from year to year, and from one decade to another.

Although variable rainfall and droughts are seen as normal in arid and semiarid climates, the droughts that struck the Sahel in the late 1960s through to the 1980s were unprecedented in length and severity. Land degradation and famine during the droughts, exacerbated by political instability and unrest, prompted the UN to hold a conference on desertification in 1977. This initiated a debate, still ongoing, on the causes and effects of drought, land degradation and desertification.

There are two opposing camps in the debate. Adherents of the desertification hypothesis hold human activities responsible for 'irreversible' declines in vegetation from 'overuse of resources' and 'human mismanagement'. Skeptics, however, see declines in vegetation as the result of drought, and hence a temporary phenomena, with humans playing only a minor role, if at all.

Some scientists have stressed the high potential of adaptation of the Sahel population to rainfall variability, and they are right.

## Greenness correlates with rainfall

Scientists at the University of Arizona Tucson, University of Maryland Baltimore and NASA Biospheric Sciences Branch Greenbelt in the United States investigated the spatial and temporal patterns of vegetation greenness and rainfall in the African Sahel. For rainfall, they used available meteorological data. For greenness, they used imaging data derived from measurements made by the Advanced Very High Resolution Radiometer instrument on board the National Oceanic and Atmospheric Administration polar-orbiting satellite series. The measure of greenness, Normalized Differential Vegetation Index (NDVI), is the normalized ratio of the near-infrared (NIR) and red spectral reflections:

$$\text{NDVI} = (\text{NIR} - \text{red}) / (\text{NIR} + \text{red})$$

NDVI is sensitive to the presence, density and condition of vegetation and is correlated with the absorbed photosynthetically active radiation and growth in vegetation.

For the period 1982-2003, the overall trend in monthly maximum NDVI is positive over a large portion of the Sahel region, reaching up to 50 percent increase in the average NDVI in parts of Mali, Mauritania and Chad, though averages are not very meaningful in this highly dynamic environment with considerable seasonal fluctuations. This positive trend in NDVI is accompanied by widespread increases in rainfall over the same period of time, with maximum positive slopes in northern Nigeria.

However, from a longer-term perspective, the observed increase in rainfall is merely a return to more or less average conditions that prevailed before the 1960s after an exceptionally dry period, and does not suffice to cancel out the secular downward trend in rainfall across the entire region. The early to mid 1980s saw the peak of desiccation in the Sahel for the century.

Monthly maximum NDVI in the Sahel was found to correlate best with rainfall accumulated over a period 3 months (current plus previous 2 months), which confirmed earlier findings that vegetation greenness in semi-arid environments is more strongly related to soil moisture - a function of rainfall accumulated over a period of time - than to instantaneous rainfall. Correlation coefficients computed for NDVI and rainfall are highly significant for the entire Sahel region ( $P < 0.05$ ) with stronger correlations in the southern Sahel than in the north.

#### Greenness 'hotspots' correlate with human activity

When the main correlation of NDVI to rainfall is subtracted out, there is a residual pattern of NDVI in which large areas are without significant trends (over and above that predicted from the trends in rainfall), and considerable areas of positive residual trends, i.e., areas in which the vegetation has been greening more than explained by rainfall alone. These positive 'hotspots' are found in parts of Senegal, Mauritania, Mali, Niger, the Central Plateau of Burkina Faso and large portions of Chad.

While the greening in the Niger Delta of Mali might be explained by an expansion of irrigation, different explanations must be found for the Central Plateau of Burkina Faso, which had been identified as a prime example of the desertification crisis some 20 years ago. Here, a recovery of vegetation greenness beyond what would be expected from the recovery of rainfall alone might be due to increased investment and improvements in soil and water conservation technique such as contour bunding, in response to the drought crisis experienced by farmers [2].

In Niger, the greening hotspots were observed in Tahoua and Maradi regions, centring around the area of Projet Keita, an extensive rural development programme with a focus on natural resource management and soil and water conservation which began in the early 1980s supported by the FAO and the World Food Programme of the UN as well as the governments of Niger and Italy. Chris Reij, a soil conservationist who has worked in the region for decades, has independently corroborated the farmer-managed natural regeneration in this region of Niger, particularly along the road between Maradi and Dosso.

In Chad, the greening hotspot was found, among other places, in the Chari-Baguirmi region. The West African Pilot Pastoral Programme has managed a few sites there since 1994 to test a participatory approach to holistic rangeland management [3]. Pastoralists have evaluated the outcome as positive.

Areas showing negative trends in the NDVI residuals cover a considerably smaller area of the Sahel [1] and are clustered in northern Nigeria and Sudan, particularly in northern Nigeria. A hypothetical explanation may be human-induced land degradation due to civil strife and conflict. But overall, the ‘negative’ impacts of human activity are relatively insignificant.

### More supporting satellite evidence

Another study of satellite images supported the notion that more plants make more rain [4, 5]. Evidence was found for a positive feedback between vegetation and rainfall at the monthly time scale, and for a vegetation memory operating at the annual time scale. That means greater greenness the previous month tends to increase rainfall a month later, and a green year tends to increase rainfall the next year, as greater plant growth and deeper root systems tap into more ground water for making rain.

This positive interaction between vegetation and rainfall increases the inter-annual variation in rainfall, accounting for as much as 30 percent of the variability in annual precipitation in some regions of the Sahel.

As a commentator stated [4]: “The result adds to the impetus to preserve green spaces in dry regions, in order to help prevent deserts from growing and encroaching on agricultural land.”

## Evidence emerging from the ground

*Evidence of recovery has been coming from the ground since at least the beginning of the present century. Fred Pearce reported in the New Scientist in 2001 on how in Nigeria, Niger, Senegal, Burkina Faso and Kenya, integrated farming, mixed cropping and traditional soil and water conservation methods have been increasing per capita food production several fold, keeping well ahead of population growth [5].*

*The use of sheep manure for fertiliser gave increased yields for farmers in Kano, Nigeria. Planting leguminous crops increased nutrient levels in the soil by fixing nitrogen from the air. Integration of crops and livestock enhances nutrient cycling; legumes and manure return to the soil what crops take out. The Kano region is the most agriculturally productive part of the country, with increased yields of sorghum, millet, cowpeas and groundnuts.*

*A four-year study in eastern Burkina Faso challenged the assumption that land is degrading largely due to human activities [6]. It found that despite declining rainfall since the late 1950s and increasing populations, there was no evidence of land degradation connected to human activities nor a decline in food productivity. Conversely, yields of many crops have risen, and there was no decline of soil fertility over 30 years.*

These farmers did not achieve environmental sustainability through a capital-intensive or high-tech path. In Burkina Faso, the increased yields of sorghum, millet and groundnuts could hardly be attributable to increased external inputs, because these crops received little fertilizer and were cultivated largely with a hand hoe.

The scientists found that farmers have a rich repertoire of soil and water conservation technologies, such as crop sequencing, crop rotation, fallowing, weeding, selective clearing, intercropping, appropriate crop and landrace selection, plant spacing, thinning, mulching, stubble grazing, weeding mounds, paddocking, household refuse application, manure application, crop residue application and compost pits. Mechanical practices include perennial grass strips, stone lines, wood barriers, earth barriers, brick barriers, stalk barriers, stone bunds, earth bunds and living hedges.

Perhaps more important than the practices is the selective way they are used, which vary with different field types, allowing optimal adjustment of limited labour and inputs to the requirements of different crops and soils. If land becomes limited, farmers do not need to invent new management systems; they apply these soil and water conservation practices *more intensively*. Farmers also apply land management practices only when and where needed. Using their knowledge of crops and soils, they treat only the parts of their field that need particular attention at any one time.

High local population densities, far from being a liability, are actually essential for providing the necessary labour to work the land, dig terraces and collect water in ponds for irrigation, and to control weeds, tend fields, feed animals and spread manure [5]. As population densities increase, farmers intensify their cooperation systems, grouping to tend each other's fields at busy periods, lending and borrowing land, livestock and equipment, and swapping seed varieties.

People thus invest heavily in creating and maintaining social networks that share land, labour, seeds, cattle grazing bushland, technologies and cash [6]. These networks enhance the ability of farmers to farm sustainably and efficiently by cooperation and reciprocity. They also allow people to diversify their livelihoods, learn from each other, and minimize risks, thus avoiding poverty traps.

Furthermore, in Maradi district of southern Niger, where repeated droughts have wrought environmental damage, farmers have reversed the damages and reclaimed the desert [5]. This was also true of Machakos (renamed Makueni) district of Kenya. In the 1930s, British colonial scientists had condemned the bare eroding hills of the drought-prone area to environmental oblivion; likewise the local Akamba people were seen as doomed to a miserable poverty-rife existence. The same narrative was consistently reproduced in the 1950s and 1970s. Yet researchers found the hills greener, less eroded and more productive than before, despite a fivefold population increase. The Akamba had responded to the droughts by switching from herding cattle to settled farming, giving them incentive to work the land effectively.

## Niger a haven of trees

In Niger today, millions of trees are flourishing, thanks to poor local farmers. There are at least 3 million tree-covered hectares, not the result of the large-scale planting or other expensive methods often advocated by African politicians and aid groups, but by the efforts of individual farmers themselves. The area is far greener than it was 30 years ago; and these gains have come at a time when the population of Niger has exploded.

How did all this come about? Lydia Polgreen told the story in the *Herald Tribune* [7]. About 20 years ago, farmers like Ibrahim Danjimo realized something had to be done. “We look around, all the trees were far from the village,” he said, “Suddenly, the trees were all gone.”.

Danjima, now in his 40s, has been working the rocky, sandy soil of his tiny village since he was a child. He and other farmers in Guidan Bakoye took a small but radical step of not clearing the saplings from their fields before planting as they had for generations. Instead, they would protect and nurture the saplings, carefully ploughing around them when sowing millet, sorghum, peanuts and beans.

Another change was the way trees were regarded by law. From colonial times, all trees in Niger had been property of the state, which gave farmers little incentive to protect them, and they were chopped for firewood or construction.

Over time, farmers began to regard the trees in their fields as their property, and in recent years, the government has recognized the benefits and allowed individuals to own trees. Farmers make money off trees by selling branches, pods, fruit and bark.

Mahamane Larwanou, a forestry expert at the University of Niamey in Niger's capital, said the revival of trees had transformed rural life. Farmers can sell the branches for money, they can feed the pods as fodder to their animals, sell or eat the leaves and fruits. The tree roots fix the soil in place, preventing it from being carried off with the fierce Sahel winds. The roots also help hold water in the ground rather than letting it run off into gullies that flood villages and destroy crops.

Wrestling subsistence for 13 million people from Niger's fragile ecology is something akin to a puzzle." Larwanou said, "Less than 12 percent of the country's land can be cultivated, and much of that is densely populated. Yet 90 percent of Niger's people live off agriculture, cultivating a semiarid strip along the southern edge of the country."

Farmers practise mostly rain-fed agriculture. The return of trees increases the income of rural farmers, cushioning them against the boom and bust cycle of farming and herding.

Ibrahim Idy, a farmer in Dahirou, a village in the Zinder region, has 20 baobab trees in his fields. Selling the leaves and fruit brings him about \$300 a year in additional income. He has used that to buy a

motorized pump that draws water from his well to irrigate his cabbage and lettuce fields, and sends his children to school. His neighbour, who has fewer baobab trees, cannot send his children to school; instead they have to draw water from the well. In some regions, swaths of land that had fallen out of use are being reclaimed with labour-intensive but inexpensive techniques.

In the village of Koloma Baba, in the Tahoua region just south of the desert's edge, a group of widows has reclaimed fields once thought forever barren. They dug pits in plots of land as hard as asphalt, placed a shovel of manure in each pit and wait for rain. The pits held the water and manure stayed in the soil and regenerated its fertility. In this way, more than 240 000 ha of land have been reclaimed, according to researchers. But it is still a hand to mouth existence, the women produce enough to eat, and disaster is always just one missed rainfall away.

While Niger's experience of greening on a vast scale is unique, smaller tracts of land have been revived in other countries. "It really requires the effort of the whole community," said Larwanou. "If farmer don't take action themselves and the community doesn't support it, farmer-managed regeneration cannot work."

Moussa Bara, the chief of Dansago, a village in the Aguié region where the regeneration has been a huge success, said the village had benefited enormously from the revival of trees. He said not a single child

had died of malnutrition in the hunger crisis that gripped Niger in 2005, largely because of extra income from selling firewood. Still, he said, the village has too many mouths to feed.

### **Project Oasis must remain farmer-led**

Chris Reij, now at the Free University Amsterdam in the Netherlands, presented the findings in Niger at the From Desert to Oasis symposium in Niamey. He wants to spread the success of Niger to neighbouring countries including Mali, Senegal and Burkina Faso. The programme will form part of the Oasis initiative to reclaim deserts, which was launched at the symposium in October 2006 by 11 African countries, with support from international research and government agencies [8].

Let's hope they will continue to let local farmers lead the projects, with scientists taking a supporting role. As Fred Pearce stressed of the Sahel miracle [5], "This is no high-tech breakthrough, nor a result of Western aid programmes." A major reason for the overestimation of land degradation is the underestimation of local farmers' abilities [6]. Scientists, policy-makers and aid workers must recognize the overriding importance of local knowledge and ingenuity for innovation, as well as the cooperative community networks for solving our problems of survival in times of climate change.

**The greening of Sahel is a clear example of how the dominant Western knowledge system had grossly misinformed policy-makers; and it was the knowledge and initiatives of local farmers that saved the situation.**