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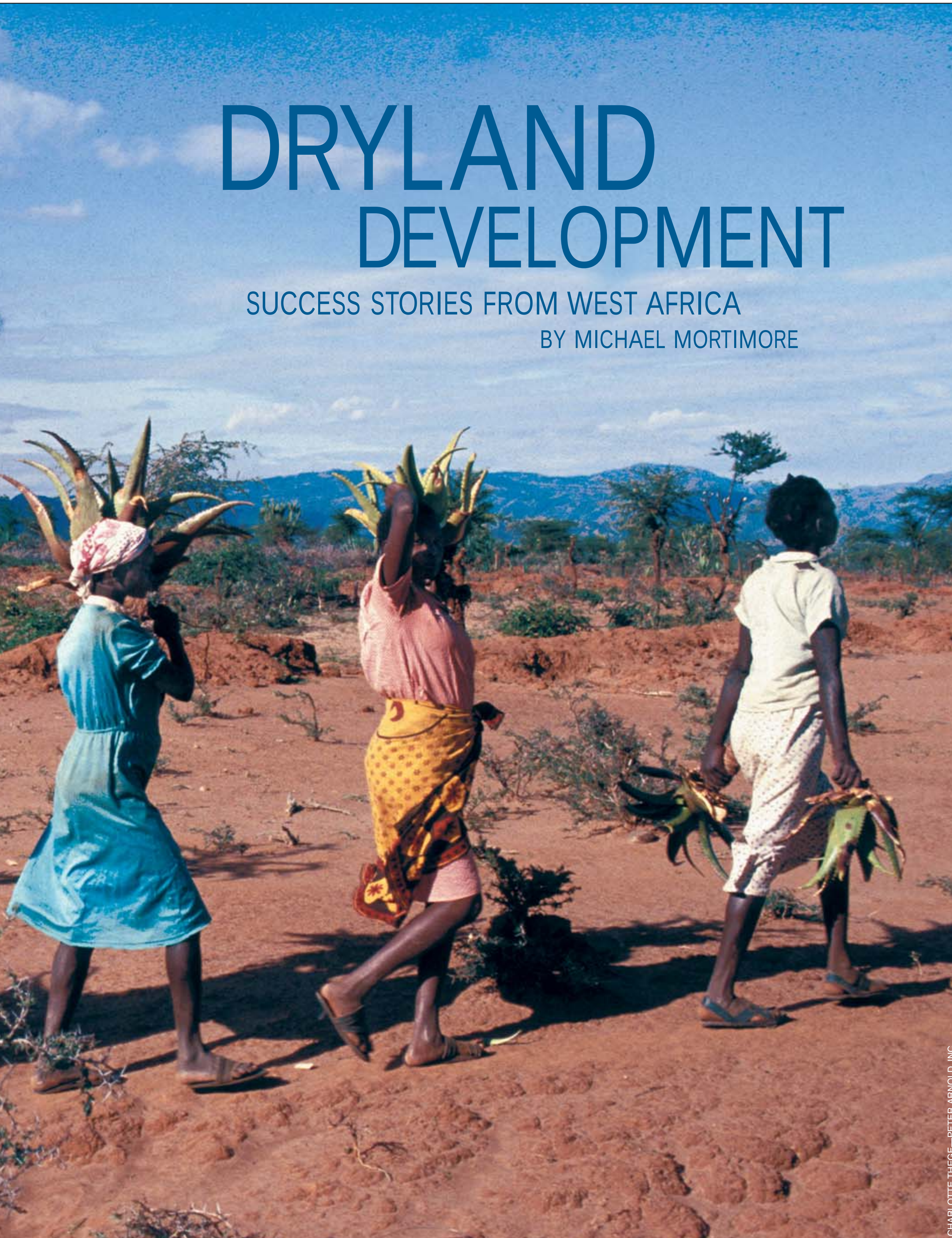
DRYLAND DEVELOPMENT

SUCCESS STORIES FROM WEST AFRICA

BY MICHAEL MORTIMORE



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The African continent spans a huge range of climates, from equatorial to tropical, desert, and subtropical on both sides of the equator. Much of Africa—around 40 percent—is dryland, receiving less than 1,000 millimeters (mm) of mean annual rainfall in short rainy seasons, the remaining months being relatively or absolutely rainless.[1] High temperatures during the tropical rainy season cause much of the rainfall to be lost in evaporation, and the high intensity of storms may cause much of it to run off in floods.

For securing human livelihoods, the principal constraints of dryland climates are aridity and the variability of the rainfall. In areas receiving less than 250 mm of rainfall during the growing season, farming is more or less impossible without irrigation, and most livelihoods are based on livestock. Yet in some parts of semiarid Africa, with rainfall of only 400–800 mm, very large and dense rural populations (up to 400 people per square kilometer (km^2)) are found. The variability of the rainfall compounds the effects of aridity and tends to increase the drier the location. Frequent and unpredictable droughts (and occasional floods) introduce high levels of risk into farming and livestock production. Rainfall variability also occurs over the long term. In the Sahel, Africa's biggest dryland, there was a decline of up to 33 percent in the average rainfall between the periods 1931–1960 and 1961–1990.[2]

Dryland soils—away from river valleys—have low natural fertility, measured in terms of the key plant nutrients.[3] Many soils are derived from desert sands and are incompletely formed. Scarce organic matter reflects the poor natural vegetation that grows with such a low rainfall.[4] Thus, nutrients limit plant growth where rainfall is higher, and aridity limits growth where rainfall is lower.[5] The economic output of cropping systems therefore depends on inputs and management.[6]

The African drylands are home to 268 million people—40 percent of the continent's population. That many of these people are very poor is not in doubt.

Although they receive little rainfall, many of Africa's drylands—including the Maradi Department, Niger, shown above—support large rural populations.

However, because drylands form subregions within nations, statistics on dryland incomes are rare. Access to health and education services is poor in rural areas; infant, child, and maternal mortality are high; and average life expectation at birth is low. Poor nutrition reduces available energy, and the high temperatures in early summer make farm work arduous. Given the large numbers of people, failure to reduce poverty in the drylands will prejudice the achievement of the Millenium Development Goals (MDGs).[7]

For the past five decades, the threat of desertification has dominated dryland development policy and debate.[8] The term "desertification" describes a set of land degradation processes, which include soil fertility decline, erosion by wind or water, dune formation, hydrological decline, biodiversity loss, deforestation, and declining bioproductivity. Some changes are irreversible and extend beyond the normal climatic oscillations of the desert edge and the effects of random droughts to forms of land degradation that are commonly attributed to the actions of humans.[9]

The mainstream view of dryland management continues to be that widespread and "inappropriate" land use practices require transformation. This view is reflected in the Convention to Combat Desertification, which was formulated after the Rio Earth Summit in 1992. In neo-Malthusian interpretations, unsustainable practices are blamed on population growth, which has driven human and animal populations beyond the rather low carrying capacity of the drylands.[10]

Challenging Malthus: The Machakos Story

In an article published in *Environment* in 1994,[11] based on a study of long-term change in Machakos District, Kenya, it was shown that degradation is not inevitable in African drylands. As long ago as the 1930s, the Machakos Reserve acquired some infamy among conservationists, who thought they saw "every phase of misuse of the land," leading to soil erosion and deforestation on a large scale, with its inhabitants consequently "rapidly drifting to a state of hopeless and miserable poverty and their land to a parching desert of rocks, stones and sand."[12]

By the 1990s, the district's population had multiplied sixfold, while expanding into previously uninhabited areas (most of them dry and risky). The study found, however, that erosion had been largely brought under control on private farmlands. This was achieved through innumerable small investments in terracing and drainage, advised by the extension services but carried out by voluntary work groups, hired laborers, or the farmers themselves. On some grazing land, significant improvements in management were also taking place. The value of agricultural production per km^2 increased between 1930 and 1987 by a factor of six and doubled on a per-capita basis.[13] At the same time, a rapid change in agricultural technology occurred, with a switch from an emphasis on livestock production to increasingly intensive farming, close integration of crops with livestock production, and increased marketing of higher value commodities (such as fruit, vegetables, and coffee). A social transformation also occurred with the enthusiastic pursuit of education, giving increased access to employment opportunities outside the district and intensifying rural-urban linkages.[14]

The Machakos story upset the Malthusian scenario for drylands, suggesting in its place the hypothesis that positive linkages between population growth and environmental management may occur under the right conditions.[15] As a widely cited "success story," is it a model for other African drylands?

What is a "Success Story"?

Dryland communities live and work on an intersection between managed ecosystems and human systems, which are coevolving as time goes on.[16] Seen this way, such interactions may take negative forms, leading to irreversible damage to the ecosystem, and/or impoverishment in the human system. Such a model means that change in the natural ecosystems should be in harmony with the course of human development. If not, negative impacts such as those characterized as desertification must occur. To guide policy, therefore, it is necessary to define what might be called a "success story." Farmers' and pastoralists' knowledge and achievements are central to success: Unlike outsiders, local peoples possess accumulated experience of specific dryland environments.[17]

Based on the Machakos experience, it is proposed that "success" may be evident in one or more of the following four interconnected domains: ecosystem management (soil and biological resources), land investments, productivity, and personal incomes or welfare (see Table 1 on page 12). For the conservationist, the first of these may be considered preeminent. However, without a healthy level of investment, ecosystem stability, functions, and services (economic products, biodiversity, hydrological cycles, microclimates, and so on) cannot be sustained under increasing exploitation. Likewise, if productivity fails, new investments cease, and human incomes or welfare stagnate. Conservation cannot be achieved by edict, because it is socially constructed in a given situation. Integrated approaches to understanding and managing ecosystems are seen to be essential for the future relations between societies and nature.[18]

In the Machakos story, long-term evidence suggests success in all four domains but not in all of the indicators (Table 1). A transition was achieved from acute risk of further degradation to a pathway characterized instead by con-

Women in Kenya's Machakos District dig terraces to prevent soil erosion.

Table 1. Defining "success" in drylands, based on the Machakos experience

Domain	Outcome	Indicators
Ecosystem management	Stabilization or reversal of degradation	Soil erosion controlled Soil water holding-capacity improved Nutrient losses minimized or compensated Trees managed sustainably[a] Useful biodiversity maintained
Land investments	Viability and sustainability in economic and/or social terms[b]	Private farm investments Cross-sectoral financial flows Acceptable economic rate of return on public investments
Productivity	Maintenance or increase	Stable or increasing crop yields or livestock production per hectare (ha) Increasing value of output per ha Increasing market participation
Incomes and welfare	Maintenance or increase in real terms	Increasing value of output per capita Strengthened access to off-farm incomes Rising achievement in education Asset accumulation on- and off-farm

[a]The major factor driving forest clearance in dryland Africa is agricultural expansion. In Europe and South and East Asia, it is accepted that the historical benefits of agricultural expansion exceed the value of lost woodland. In African drylands, where deforestation is often declaimed, woodland clearance is often later followed by conservation of trees on farms. M. Mortimore and B. Turner, "Does the Sahelian Smallholder's Management of Woodland, Farm Trees and Rangeland Support the Hypothesis of Human-Induced Desertification?" *Journal of Arid Environments*, forthcoming, 2005. It is not practicable to propose a reversal of agricultural expansion.

[b]Investments are made for social as well as financial benefits (such as houses for retirement, domestic water catchments, and gardens).

serving the ecosystem, with a strong narrative of soil and water conservation and terracing—on arable land in particular—that now extends to every corner of the old district.[19] These works present impressive evidence of investments at the farm level, and there is a range of other investments such as water catchments and storage and livestock structures. In the individual household, financial flows occurred between sectors, whereby farm profits financed education and off-farm employment, while off-farm incomes were themselves used to finance capital developments on-farm.[20] Farm output indicators show increased value of output per km^2, including crop and livestock production. This fed into income effects, with an improving trend in farm incomes per capita until 1987. Rising educational achievement supported off-farm employment and the diversification of livelihoods.

However, all success is relative and incomplete. Thus it is unlikely that any system, including that of Machakos, can score highly in all four domains at one time or perform equally well at all times. Incomes in particular are at the mercy of macroeconomic changes. For example, in Machakos, increasing value of output per capita may have hesitated after 1987, with adverse trends in global markets.[21] The indicators are not all relevant everywhere. This descriptive model, however, suggests key variables in very complex systemic interactions and measurable indicators that are amenable to policies.

Are There Success Stories in West Africa?

Success stories have been documented from a variety of locations in African drylands.[22] In West Africa, three of these stories are told in studies that were designed specifically to test the Machakos model under different conditions. Findings suggest that success is by no means unqualified.[23] However, evidence has been found of significant achievements in the first three domains—ecosystem management, land investments, and productivity—identified in Table 1. Such evidence, which emerges from analyses of long-term data and from well-supported inferences, runs counter to some current perceptions.

The Kano Close-Settled Zone, Nigeria

The significance of the Kano story lies in the scale and longevity of the area's intensive farming system. As originally delimited,[24] the zone now has a population of more than 5 million, excluding the urban population of the city of Kano, which exceeds 1.5 million (see Figure 1 on this page).[25] More than 85 percent of the land surface is occupied by farmland. Intensive farming of small holdings under annual cultivation, with less than 0.5 hectares (ha) per person, a dense scattering of trees, and livestock, is centuries old in the zone and is strongly oriented toward the conservation and care of land resources.[26]

It is possible to analyze ecosystem management as follows:

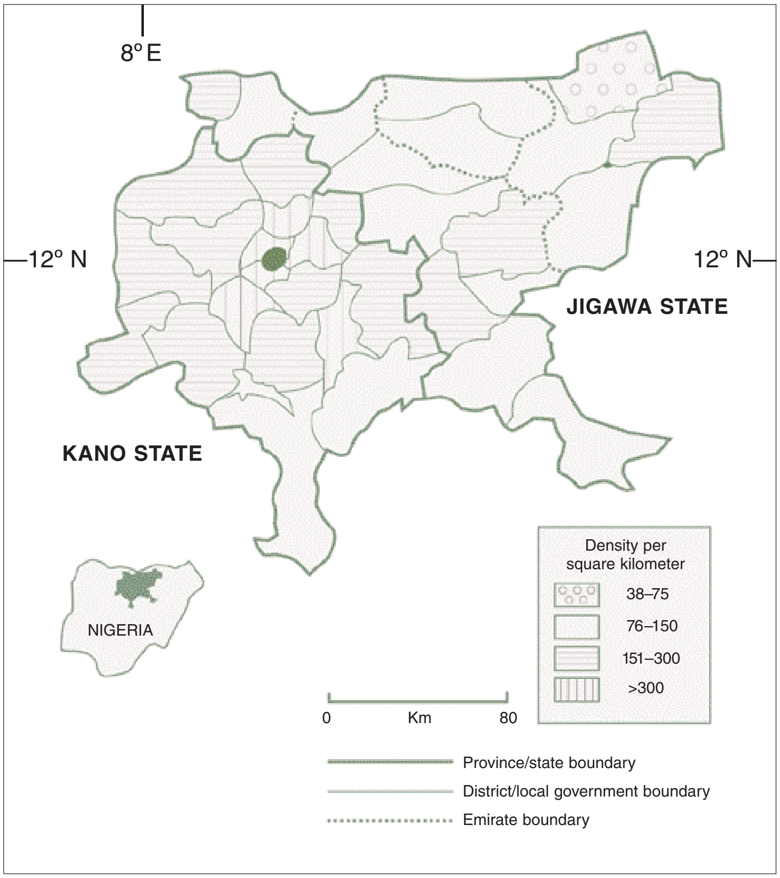
• Soil organic matter is protected by applying manure from domestic animals, dry compost, and waste at rates of 4–6 tons per ha per year. In the dry season, animals roam the fields during the day but are penned at night, where they stay during the growing season, feeding on cut-and-carried fodder. The manure and bedding are mixed and returned to the fields by cart, donkey's back, or even head loading.

• Plant nutrients are recycled through feeding crop residues, tree browse, and weeds to the animals; growing nitrogen-fixing crops such as cowpea or groundnuts that fix nitrogen with the grain (millet or sorghum); protecting leguminous trees (*Faidherbia albida*); and taking advantage of dust deposition in the dry season and low rates of leaching in the wet. When farm budgets permit, inorganic fertilizers are applied, but in small quantities—only about a third of recommended doses even when they were subsidized in the 1980s. Quantities of nitrogen, phosphorus, potassium, calcium, and magnesium in the soil vary from field to field and from year to year and tend to be low; nevertheless, no evidence was found of a general decline over a period of 13 years.[27]

• Soil moisture control is important where rainfall is scarce but intensive. It is achieved through field ridging (formerly by hand-hoeing but increasingly with ox-ploughing). This conserves runoff in furrows and maximizes infiltration between rainfall events. Competition between crops and weeds for scarce moisture is reduced by three or even four weeding operations during the short growing season (which is only 12–15 weeks long).

• Biodiversity is conserved in a functional sense through protecting or planting a variety of tree and shrub species on farms or along field boundaries and through on-farm selection and breeding of seed for at least 76 cultivars.[28] Biodiversity occurring naturally in the

Figure 1. Population density in Kano and Jigawa states, Nigeria, 1991



NOTE: The Close-Settled Zone corresponds to those areas having more than 150 persons per square kilometer.

SOURCE: Census of 1991, mapped by B. Turner (previously published in M. Tiffen, *Profile of Demographic Change in the Kano-Maradi Region, 1960–2000*, Drylands Research Working Paper 24 (Crewkerne, UK: Drylands Research, 2001).

ecosystem is protected for its contribution to food security.[29]

• Erosion by wind or water is controlled on the gentle slopes of the farmlands (usually at grades less than five degrees) by planted field boundaries (including the henna bush, *Lawsonia inermis*, and the grasses *Andropogon gayanus* and *Vetiveria nigritana*), by planting spreading intercrops (cowpea, groundnut) among the grain, and by maintaining densities of mature farm trees at 7–15 per ha.

The result is an intricate, anthropogenic landscape of permanent fields, farmed parkland, and hamlets. A misleadingly sterile appearance in the dry season is confounded by a startling luxuriance of biomass during the wet.

The investments that made this possible in the past were mainly in human labor (manuring, weeding, and animal tending), but during the twentieth century, groundnut exports and increasing opportunities for employment or trading in the cities provided cash. After groundnut production failed in 1975 (on account of rosette disease and drought), farmers switched to selling some of their grain. Monetary transactions are extremely common, and during the 1990s farm investments that were visibly evident, especially near Kano, included ox-ploughs and teams, livestock kept for fattening, and "modern" building materials such as metal roofing sheets.

For long-term yield trends it is necessary to depend on inferences, as compatible and accurate data are not available. At least one-third of households in inner, high-density villages were estimated to be food-insufficient in the 1960s, although whether this was from poverty or from specializing in groundnuts for export is unclear. Poverty was noticeable on highly subdivided holdings in a very densely populated village close to the walls of Kano City in 1970.[30] Yet in the 1990s, except after a drought,[31] farm holdings with only one-third of a hectare per person could still be self-sufficient in basic grains.[32] The population of Kano Emirate, which roughly coincides with the zone, increased at a rate of 1.9 percent per year from 1931 to 1991.[33] Certainly there are food-insecure households today. Nevertheless, the information available does not suggest a general decline in yields but rather a sustained effort to increase the output of food in line with increasing consumption needs.

The livestock population, the integration of which into the farming system is essential for maintaining organic inputs to cultivated soils, increases in density in line with the human population. People like to invest their savings in animals, and fattening the animals for market has become a thriving industry. Sheep and goats, being easier to manage on the crowded farmlands, are increasing at the expense of cattle, the owners of which have to rely on transhumance (grazing away from home during the cropping season).

With their sales of animals, higher-value crops (cowpea; sesame; and new, disease-resistant groundnuts), and labor and skills in the rapidly growing urban markets of Nigeria, farming families are participating in more monetary transactions than ever before. Kano City's markets are supplying a population six times larger than in the 1960s, and although the zone contributes only a small part of its needs, what it does sell is very important to local livelihoods.[34] During the same period, increased retail activity and increasing domestic capital, such as bicycles, motorcycles, radios, clothing, equipment, and furnishings, suggested a slow, incremental growth for better-off families until the 1990s.[35] However, there is much anecdotal evidence of rural poverty.

Long-term change in the zone suggests significant successes in ecosystem management, many small-scale investments, and no evidence of a decline in yields per hectare. But trends in rural incomes depend on impressionistic evidence that is ambivalent. Recently, positive trends have been held ransom by economic recession, inflation, and adjustment policies.[36]

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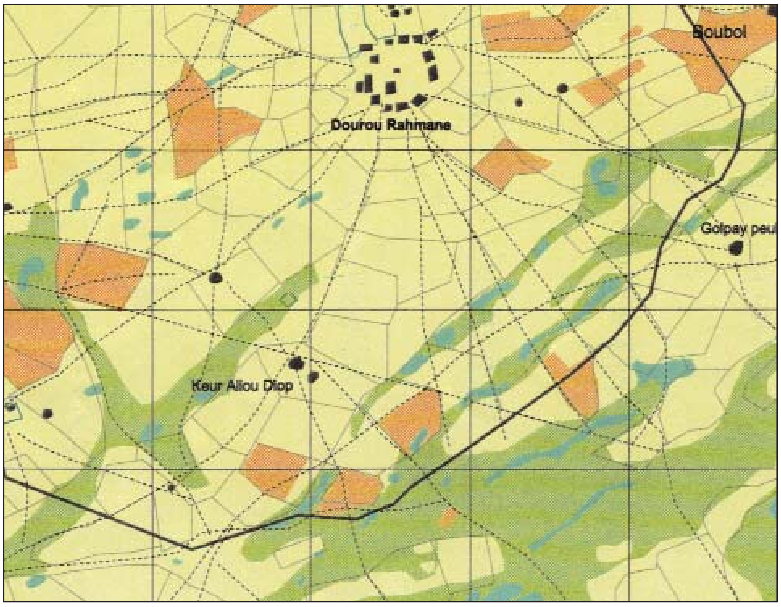
Sacks of groundnuts are piled into pyramid structures in Kano, Nigeria.

Diourbel Region, Senegal

According to land-cover maps of the administrative departments of Bambey and Diourbel, the Diourbel Region, like the Kano Close-Settled Zone, has more than 85 percent of its surface under cultivation (see Figure 2 below). But rural population densities are lower (46–150 per km^2); therefore, there is more land per capita (0.6–0.7 ha). More than a century of production for export, promoted by strong policy incentives, reduced the priority given to grain production.

Farm expansion, the demarcation of boundaries with perennial grasses or shrubs, the protection of economic farm trees, and the scattering of small settlements have produced a landscape resembling that seen around Kano. Consequently, in the face of repeated cultivation and the export of plant nutrients, maintaining soil fertility is a focal theme in ecosystem management. But the soil fertility equation in Diourbel differs from that in Kano. Less rainfall (500 mm compared with 650 mm), labor, and animal manure mean that fertility, measured in terms of chemical soil properties, can only be sustained on about a fifth of cultivated land, the *champs de case* (the fields nearest to the house).[37] On these, familiar strategies are employed: recycling organic matter and available plant nutrients, erosion control, and biodiversity protection. The remaining fields, the *champs de brousse*, used to be fallowed regularly, but economic pressures to bring them under annual cultivation led to the substitution of inorganic fertilizers for fallowing. This strategy was promoted by fertilizer subsidies under the national agricultural program from 1960 to 1980. When the subsidy was removed, fertilizer use fell, and soil fertility faced a crisis of economic sustainability.

Figure 2. Land use in Senegal's *bassin arachide*, 1978



NOTE: Each square is 500 x 500 meters, showing in yellow, cultivation; in orange, fallows; in green, shrubland (since cleared for farming); in blue, grassland seasonally flooded (since dried out).

SOURCE: M. Ba, M. Mbaye, S. Ndao, A. Wade, and L. Ndiaye, *Région de Diourbel: Cartographie des Changements d'Occupation-Utilisation du Sol dans la Zone Agricole du Sénégal Occidental* (Diourbal Region: Mapping Changing Land-Use in the Agricultural Zone of Eastern Senegal), Drylands Research Working Paper 21 (Crewkerne, UK: Drylands Research, 2000).

The Senegalese economy depended on groundnut exports from the inception of French rule in the 1880s until the 1980s.[38] In the late 1960s, a million tons per year were produced, making Senegal (with Nigeria) a leading world exporter. Under the French colonial policy and the independent government's *programme agricole*, the state took over responsibility not only for fertilizer promotion and supply but also for credit, groundnut seed supply, technical advice, marketing, processing, and export. From the sales of groundnuts, it deducted credit repayments, thus reducing the producers to a high level of dependency. It even subsidized rice imports so that Senegal could exploit its comparative advantage in growing groundnuts. Food commodity markets developed only slowly and late, as the Senegalese developed a strong preference for eating rice (mostly imported). Because the state was supplying much of the need for farm investments, private funds tended to be channelled into urban investments instead of agriculture.

The system proved to be financially unsustainable, as costs increased and global prices fell during the 1970s. At the same time, the Sahel Drought of 1968–1974 was followed by a persistent decline in annual rainfall until the 1990s. Structural adjustment policies, introduced in 1984, included an ending to credit and subsidies, the withdrawal of some agricultural services, late payments and stagnant, low producer prices. There was a dramatic fall in groundnut production, a diversion of output to local consumption, and agricultural stagnation. The amount of fallow land increased, and some farm tree populations may have declined.[39] In some areas, there was a slowing in the growth of the population and even absolute decline.[40]

However, not all the evidence on productivity is negative.[41] Long-term improvements in millet yields per ha and per mm of rainfall (though not per capita) are visible in official data.[42] Expanding production of cowpeas, which command a good price, and of crops for urban niche markets appear in the statistics or have been widely observed. Livestock populations have increased in response to buoyant meat prices, and fattening animals is a popular sideline for farming families even though they often have to purchase supplementary feed. Rural markets, for many years frustrated by the state's dominant role in commodity movements, are being reinvigorated.

The search for alternative incomes from outside farming is proportionately most important for households that, owing to small holdings or underinvestment, only produce a fraction of their annual cereal needs (see Figure 3 on this page). On the other hand, households that are food-secure throughout the year can generate five times as much agricultural income from crops and livestock.[43] Income diversification thus plays a critical role in the adjustment to changing conditions.

The evidence of success in Diourbel, therefore, is very different from that in Machakos and Kano. With regard to managing the ecosystem, there has been partial success in stabilizing or reversing degradation, but the collapse of state investment has left farmers unable to compensate, and only a proportion of the soil benefits from organic fertilization. Crop production and farm tree populations in some areas are said to be languishing.[44] But private investment is bouncing back in response to market signals, and the livestock sector is growing. Trends in rural incomes cannot be established from the data available, but much energy is devoted to widening the household's portfolio—whether from sheer necessity or in response to opportunity. The case for success rests essentially in the resilience that has characterized the responses of farming families, both to the failure of the government's state-led agricultural policy and the concurrent decline in rainfall.

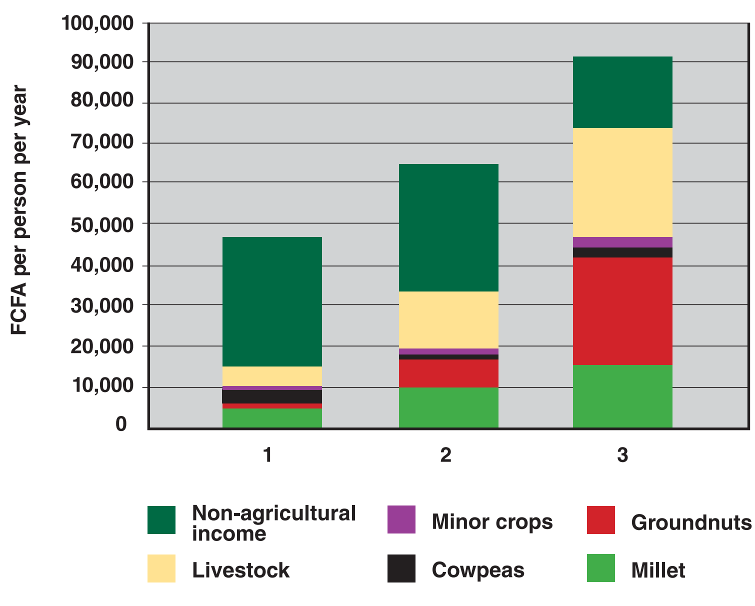
Maradi Department, Niger

The evidence of success so far assembled is found in densely populated regions where, according to Danish economist Ester Boserup's theory of agricultural change, land scarcity drives farmers to use labor-intensive practices and adopt new technologies, thereby increasing their output per hectare.[45] It is, however, in low-density regions that rapid population growth and agricultural expansion often draw attention to large-scale erosion and deforestation. One such region is Maradi Department in Niger, where until the nineteenth century, large areas lay uninhabited and where farming villages were mostly concentrated in the extreme south.

French colonization encouraged rapid migration from the south and from places further afield, taking advantage of relatively good rainfall during the 1950s and extensive cultivable land that stood unclaimed in the department's central *arrondissements*. The pace of change was rapid. The cultivated fraction in four representative village territories averaged 31 percent in 1957, according to aerial photograph interpretation.[46] In 1999, all four were virtually entirely cultivated, and between 1974 and 1996, satellite imagery of the whole department south of the effective limit of rainfed cultivation indicated an increase from 59 percent to 73 percent.[47] This confirms that little uncultivated land (and even less unclaimed land) remained (see Figure 4 on page 17).

The Sahel Drought exposed the risk associated with farming in such marginal areas, even as a growing population sought to appropriate more land for millet and groundnut production. Deforestation, soil fertility decline, erosion, falling yields, overgrazing, food insecurity, poverty, and increasing dependence on resources outside the area (food aid and urban employment) seemed to threaten

Figure 3. Incomes in Diourbel Region by type of household



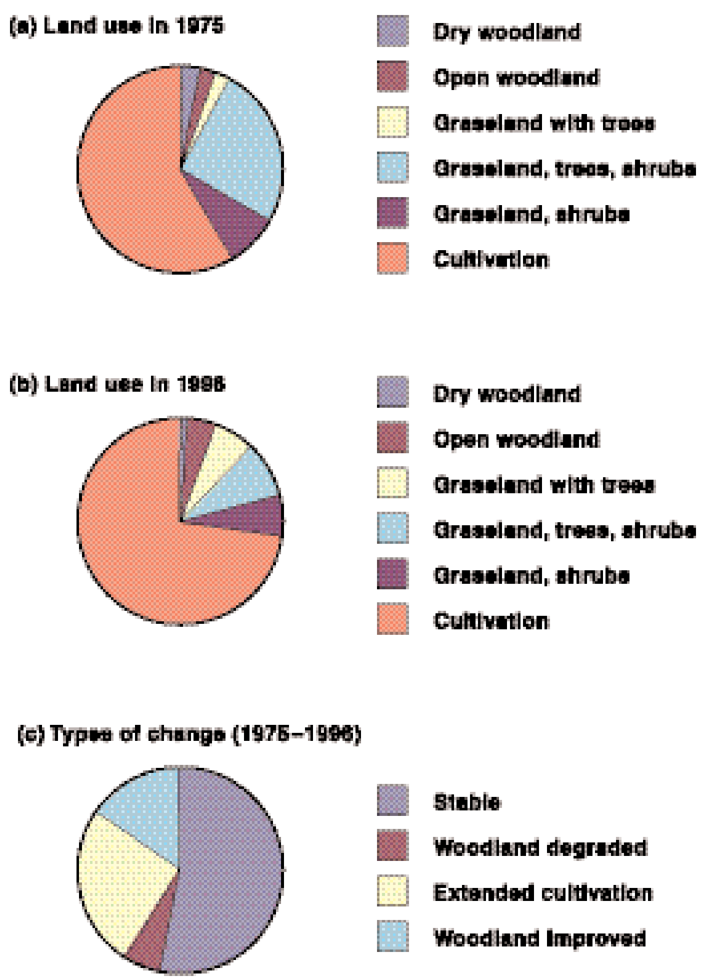
NOTE: Types of households are defined in terms of their ability to meet their food needs from millet and groundnut production for the following times after harvest: 1) less than 6 months; 2) less than 12 months; or 3) greater than 12 months.

SOURCE: A. Faye, A. Fall, and D. Coulibaly, *Région de Diourbel: Evolution de la Production Agricole* (Diourbal Region: Profile of Agricultural Production), Drylands Research Working Paper 16 (Crewkerne, UK: Drylands Research, 2000), Figure 2.

not only the environment but also economic sustainability of rural communities.[48] A major rural development project was put in place. The demand for cultivable land was driven by demographic, market, and institutional forces, as well as a threat of declining productivity.[49]

This was not an auspicious setting for a success story. However, there are some surprises to be found in long-term data and recent field investigations.[50] Two changes in the management of farmland have been detected. The first of these is a growing use of animal manure—especially in the southern arrondissements where land is most scarce—as well as inorganic fertilizer when it can be afforded. The second is the practice, called *défrichement amélioré*, of protecting trees that are regenerating naturally and that are considered to have economic value. Promoted by the development program, this indigenous practice is now firmly established, creating an increasingly wooded appearance in the once bare farmland around the villages. Individuals rather than patrilineal families are tending to take charge of the natural resources, and conservationist attitudes toward biodiversity resources are being reasserted.[51]

Figure 4. Land-use change in Maradi south of the Tarka valley, 1975–1996



SOURCE: A. Mahamane, *Usages des Terres et Évolutions Végétales dans le Département de Maradi* (Land Use and Vegetation Change in Maradi Department), Drylands Working Paper 27 (Crewkerne, UK: Drylands Research, 2001), Tables 1, 2, and 3.

Farm investments are thus already significant, and permanent fields and vegetated boundaries are appearing as private rights to the use of land are confirmed.[52] Livestock numbers in the department trended upward throughout the 1990s. Especially in southern areas, ox-drawn ploughs, seeders, and carts are becoming commonplace.

Crop yield data are available for each arrondissement and when compared, these suggest a positive trend for millet in the south (in response to the need to intensify farming practice) while in the north, where land is relatively abundant, they are stagnant.[53] In the department as a whole, cereal production kept ahead of the nutritional requirements of a rapidly growing population from 1964 until 1998, except in drought years.[54]

There are no long-term data on incomes and welfare, and recent surveys confirmed the continuing existence of poverty in Maradi.[55] Not too much should be claimed, therefore, in terms of success. But Niger as a whole is now less dependent on food aid than it was in the 1980s, despite its larger population. Maradi Department lies across the border from Katsina and Kano in Nigeria and is increasingly incorporated into buoyant transborder marketing chains in food commodities.[56]

Policies to Promote Success

Other regions in West Africa have also yielded counterintuitive evidence of positive trends in environmental management and productivity.[57] From the studies that have been carried out in all these regions, we can learn that the following policy-dependent agents have had positive impacts:

• *Agricultural product markets*. Without effective demand, no dryland farmer can generate an income from agriculture with which to cross-subsidize other sectors of the household economy (such as education fees and trading capital). Without a prospect of profit, no dryland farmer will use off-farm income to capitalize agriculture (such as soil or water conservation and purchased inputs). It is remarkable that there is no dryland region of any size that lacks linkages with one or more markets, however distant. The relevant policies concern price stabilization, the control of competition from imports, and deregulation that is properly balanced with the needs of local producers.

• *Physical infrastructure*. Increased market participation is unavoidable for dryland producers; they need to sell surpluses, buy their way out of deficit, achieve food security, and access labor and commodity markets. The provision of roads and transport systems reduces marketing costs and thereby increases producer prices, increases interaction, opens up new income-earning opportunities and educational access. With technological change, electronic communications infrastructure is also critical for accessing market information. The relevant policies are public investments in roads and telephones and regulatory frameworks that facilitate private sector investments in communications systems.

• *Institutional infrastructures*. Given a withdrawal of the state from many areas (including produce buying and processing and agricultural extension support), a failure of private sector enterprises to adequately fill the gap, and failures of local governance, attention is shifting to building the capacity of decentralized and autonomous institutions. These can restore local ownership of natural resources, negotiate on behalf of local communities with higher levels of government, control access to endangered resources, defend the common interests of local producers in wider markets, and supply needed information of all kinds to communities. The relevant policies concern genuine decentralization of government powers, recognition and support of producers' or traders' associations, and the facilitation of new or adapted institutions for ecosystem management (such as common resources) and of information networks. An area offering major potential for poverty reduction is institutional frameworks to manage risk, which go to the heart of the uncertainty of living in dryland environments.[58]

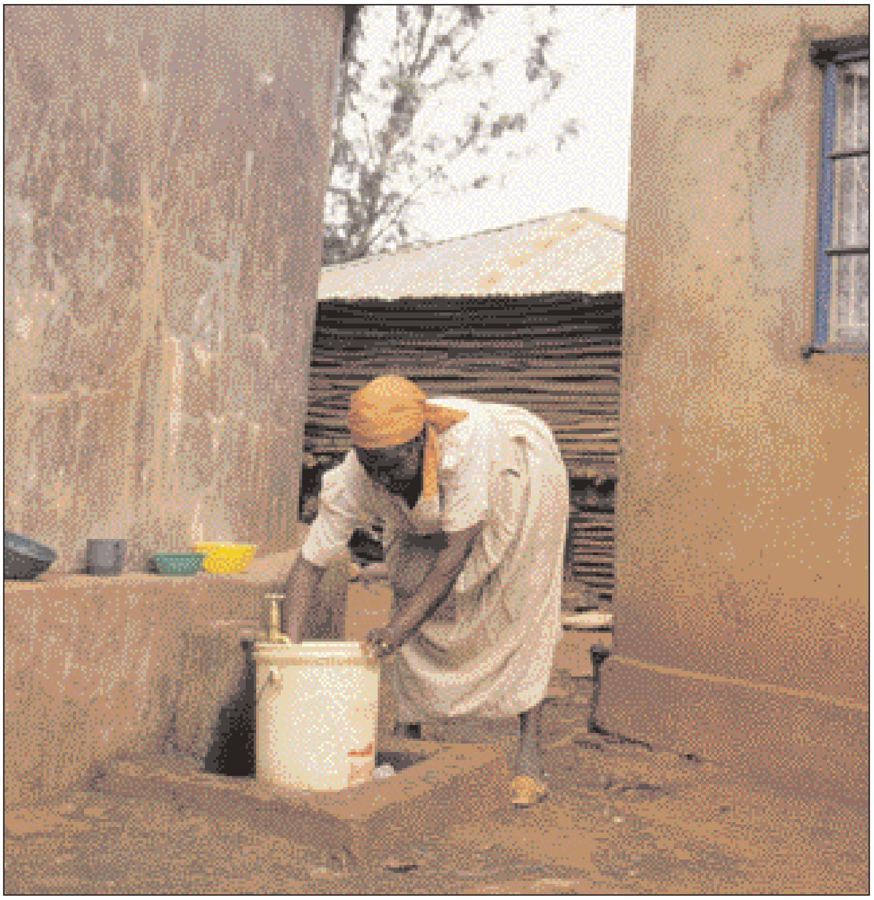
• *Knowledge management*. Useful technologies, rather than being spread by promotional blueprint, tend to be taken up in response to users' particular circumstances. Discriminating users in rainfed farming systems need a variety of options from which to choose. There have been no "miracle" technologies so far that resemble the high-yielding crop varieties used in humid or irrigated South and East Asia. Farmers' own knowledge, exchanges, and experimentation have been as important to the process as experimental agriculture. The relevant policies concern education provision and partnering local producers in extension systems. As knowledge is a public good, the state still has a role to play in putting new knowledge into the public domain and facilitating access to it by poor rural people.

Improved farming practices have allowed cereal production to keep up with nutritional needs in Maradi.

• *Investment incentives*. The assumption that all dryland families are too poor to invest is shown to be false in the cumulative growth of small on- and off-farm investments in the longer-settled and successful systems. Meanwhile, many of the problems of recently occupied, sparsely settled, and highly dynamic systems stem from a lack of investment. Attention was drawn to this priority in Maradi as long ago as 1980,[59] and the evidence suggests that the capitalization of the landscape using local peoples' own resources does indeed take decades rather than years. Clearly, secure title to use of and benefits from ecosystem resources is a necessary condition for investing scanty, private financial resources. The remarkable landscape of Machakos is a witness to what can be achieved in a half-century of incremental growth based on inputs of personal finance and family labor. The relevant policies, therefore, concern an enlightened adjustment by central government of variable incentives (such as taxation and exchange rates) and a prioritization of enabling incentives (such as secure resource tenure, dispute settlement, and conflict prevention) and efficient markets.[60]

• *Income diversification incentives*. Rather than posing a threat to urban areas, seasonal migrants from rural areas provide a range of services at minimal cost, in a dynamic and adaptive informal sector (which tends to defy government regulation). Urban informal sectors offer low average incomes, insecurity, squalor and sometimes ill-health. Paradoxically, perhaps, having such options available provides some of the flexibility necessary in rural drylands to cope with risk and recurrent food insecurity. They also provide investment funds for raising productivity and incomes in drylands, thereby helping to stabilize rural populations. Dryland peoples not only help themselves, they also help to integrate the national economy through consumption and investment streams. The relevant policies are relaxing controls on the movement of people, commodities, and capital around the country and ensuring the personal security of migrants. In an economic union such as the Economic Community of West African States (ECOWAS), these considerations apply to international movements, as drylands are interdependent with more humid or urbanized regions.

Policies, of course, evolve in response to articulated interests. To plead a special case for drylands, even if evidence-based, may have little impact on such a process. However, given the recent advances in democratic government in many countries of Africa, there are new opportunities to empower dryland people to plead their own cause with local and central government. This is especially true where evidence is available from targeted research. This type of empowerment relies on alliances between local people, researchers, and the private and voluntary sectors and on resources to support interactive debate and negotiation. Villagers can express their demands effectively when barriers of language and isolation are removed, as shown by experience in Kenya, Senegal, Niger, and northern Nigeria.[61]



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Evidence of Africans' achievements—such as increased investment in water catchments by the people of Machakos—runs counter to doomsday scenarios that often influence policymakers.

Conclusion

Is "success" a justified term in dryland environments where risk, low productive potentials, and high levels of poverty are endemic? Some areas can show evidence of achievements that run counter to the expectations generated by some orthodox models of desertification. There are four components of success: a movement toward more sustainable ecosystem management, evidence of increasing investment both on and off the farm, stable or improving output or output value per hectare, and evidence of improving incomes and welfare. Not all of these components are evident in every story, and the last in particular is difficult to pin down in the absence of data. However, a positive trajectory sustained over a timescale of decades is evidence too important to ignore, even though it may conflict with "expert" opinions based on shallow timeframes. It is remarkable that many African smallholders have sustained such achievements against policy failure and urban bias.[62]

The dryland cases show that rural development should be seen in a broader context than that of agriculture alone. Currently, efforts are being made to reemphasize the role of science and technology for improving productivity and food security in Africa. But it is acknowledged that if the potential of technology is to be fully realized, a market-led strategy is required to raise productivity.[63] The dryland success stories support the view that productivity trends respond to economic incentives. The capacities of resource-poor farmers to invest in on-farm improvements should not be underestimated, notwithstanding many constraints.

Basing dryland development policy on evidence of poor peoples' achievements offers a radical alternative to the doomsday scenarios that have a profound though not always admitted influence on policymakers. In starting with a perceived failure in ecosystem management—as implied in the idea of desertification—governments or donors drive themselves into a blind alley. Because the diagnosed "mismanagement" is defined and assessed in quantitative, biophysical terms, it calls for technical solutions that have to be imposed through an assertion of outsider knowledge over insider experience, devaluing the indigenous resource. Participatory rhetoric cannot on its own correct this distortion. On the other hand, knowledge partnerships, constructed on local peoples' achievements, imply equality between the agents of intervention and the intended beneficiaries, an equality that is too often denied in authoritarian governmental structures. This dilemma is widely recognized. It is especially acute in drylands, where the "knowledge gap" between insiders and outsiders is all the greater: The outsider is often unfamiliar with the harsh realities of managing relatively unproductive natural resources at high levels of risk.

By providing evidence of real achievements and internal potentials, success stories can therefore point the way toward laying a new foundation for evidence-led policies for dryland development: Rather than aiming to transform "inappropriate" local practices, such policies instead aim to build on local experience, suggesting a more organic model for development.

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NOTES

1. The United Nations (UN) Food and Agricultural Organization (FAO) defines drylands by the average length of the growing period, while the UN Environment Programme (UNEP) defines drylands by an index of aridity based on precipitation over potential evapotranspiration. See FAO, *Land, Food and People*, FAO Economic and Social Development Series 30 (Rome: FAO, 1984); and UNEP, *World Atlas of Desertification* (Nairobi: Arnold for UNEP, 1992). According to the first, drylands have fewer than 180 growing days per year, and according to the second, an aridity index between 0.05 and 0.65. M. Mortimore, *Roots in the African Dust: Sustaining the Sub-Saharan Drylands* (Cambridge, UK: Cambridge University Press, 1998), 12.

2. M. Hulme, "Rainfall Changes in Africa: 1931–1960 to 1961–1990," *International Journal of Climatology* 12 (1992): 685–99.

3. For example, in Maradi Department, Niger, levels of carbon are less than 0.2 percent, nitrogen less than 0.02 percent, and available phosphorus less than 4 parts per million (ppm) on uncultivated soils. M. Issaka, *Évolution à Long Terme de la Fertilité de la Sol dans la Région de Maradi* (Long-Term Change in Soil Fertility in the Maradi Region), Drylands Research Working Paper 30 (Crewkerne, UK: Drylands Research, 2001). These values for phosphorus are exceptionally low; in Kano, Nigeria, and Machakos, Kenya, 11–16 ppm are found. F. Harris and M. A. Yusuf, "Manure Management by Smallholder Farmers in the Kano Close-Settled Zone, Nigeria," *Experimental Agriculture* 37 (2001): 319–32; and J. P. Mbuvi, *Makueni District Profile: Soil Fertility Management*, Drylands Research Working Paper 6 (Crewkerne, UK: Drylands Research, 2000).

4. Organic soils comprise less than 0.4 percent of Maradi soils (see Issaka, ibid.).

5. F. W. T. Penning de Vries and M. A. Djiteye, eds., *La Productivité des Pâturages Sahèliens. Une Etude des Sols, des Végétations et l'Exploitation de Cette Ressource Naturelle* (The Productivity of Sahelian Pastures. A Study of Soils, Vegetation, and the Exploitation of this Natural Resource) (Wageningen, Netherlands: Pudoc, 1991).

6. Issaka, note 3 above; and F. M. A. Harris, "Farm-level Assessment of the Nutrient Balance in Northern Nigeria," *Agriculture, Ecosystems and Environment* 71 (1998): 201–14.

7. The Millenium Development Goals are: halving the proportion of people in extreme poverty and suffering hunger between 1990 and 2015; achieving universal primary education by 2015; eliminating gender disparity in education by 2015; reducing the under-five child mortality ratio by two thirds by 2015; reducing the maternal mortality ratio by three quarters by 2015; halting and beginning to reverse the spread of HIV/AIDS and the incidence of malaria and other diseases by 2015; ensuring environmental stability; and creating a global partnership for development.

8. The most widely used characterization is the revised definition used for the 1992 UN Rio Earth Summit: "Desertification means land degradation in arid, semi-arid and sub-humid areas resulting from various factors, including climatic variations and human activities." UN, *UN Earth Summit. Convention on Desertification*, UN Conference on Environment and Development, Rio de Janeiro, Brazil, 3–14 June 1992, DPI/SD/1576 (New York: United Nations, 1994). Definition is not, however, straightforward: More than 100 attempts have been recorded. M. Glantz and N. Orlovsky, "Desertification: A Review of the Concept," *Desertification Control Bulletin* no. 9 (1983): 15–20.

9. J. F. Reynolds and D. M. Stafford Smith, eds., *Global Desertification. Do Humans Cause Deserts?* (Berlin: Dahlem University Press, 2002).

10. Thomas Malthus argued, with respect to eighteenth-century England, that human populations outgrow their capacity to feed themselves. In his own time, his theory was answered by the industrial revolution, which financed the English in importing food from a growing world market and led to technical innovations that increased agricultural productivity. Since World War II, the inability of many poor countries to follow the same path led to a revival of "neo-Malthusian" thinking. Evidence of land degradation under pressure from rapidly growing farming populations, considered as a system closed to the larger economy, appears to offer only impoverishment and starvation. A summary is provided in M. Mortimore, "Technological Change and Population Growth," in P. Demeny and G. McNicoll, eds., *Encyclopedia of Population* (New York: Macmillan Reference, 2003), 932–35; and for a new discussion of some issues, see Q. Gausset, M. Whyte, and T. Birch Thomsen, eds., *Beyond Territory and Scarcity: Social, Cultural and Political Aspects of Conflicts on Natural Resource Management* (Uppsala, Sweden: Nordic African Institute, 2004).

11. M. Mortimore and M. Tiffen, "Population Growth and a Sustainable Environment: The Machakos Story," *Environment*, October 1994, 10–20, 28–32.

12. C. Maher, *Soil Erosion and Land Utilisation in the Ukamba Reserve (Machakos)*, Report to the Department of Agriculture, Mss, Afr.S.755, Rhodes House Library, Oxford (Nairobi: Department of Agriculture, 1937).

13. M. Tiffen, M. Mortimore, and F. Gichuki, *More People Less Erosion: Environmental Recovery in Kenya* (Chichester, UK: John Wiley & Sons, 1994), 93–96.

14. The Machakos story is told in great detail elsewhere: ibid.; J. English, M. Tiffen, and M. Mortimore, *Land Resource Management in Machakos District, Kenya: 1930–1990*, World Bank Environment Paper No. 5, (Washington, DC: World Bank, 1994); and M. Tiffen and M. Mortimore, "Malthus Controverted: The Role of Capital and Technology in Growth and Environment Recovery in Kenya," *World Development* 22, no. 7 (1994): 997–1010.

15. E. Boserup, *The Conditions of Agricultural Growth: The Economics of Agricultural Change under Population Pressure* (London: Allen and Unwin, 1965); and E. Boserup, *Economic and Demographic Relationships in Development* (Baltimore, MD: Johns Hopkins University Press, 1990).

16. P. F. Robbins et al., "Desertification at the Community Scale. Sustaining Dynamic Human-Environment Systems," in Reynolds and Stafford Smith, note 9 above, pages 326–56.

17. M. Mortimore, *Adapting to Drought, Farmers, Famines and Desertification in West Africa* (Cambridge, UK: Cambridge University Press, 1989); and Mortimore, note 1 above.

18. R. D. Smith and E. Maltby, *Using the Ecosystem Approach to Implement the Convention on Biological Diversity. Key Issues and Case Studies,* Ecosystem Management Series No. 2 (Gland, Switzerland: IUCN-The World Conservation Union, 2003).

19. The former Machakos District is now divided between Machakos and Makueni Districts. F. N. Gichuki, S. G. Mbogoh, M. Tiffen, and M. Mortimore, *District Profile: Synthesis*, Drylands Research Working Paper 11 (Crewkerne, UK, Drylands Research, 2000).

20. J. Nelson, *Makueni District Profile: Income Diversification and Farm Investment, 1989–1999*, Drylands Research Working Paper 10 (Crewkerne, UK: Drylands Research, 2000).

21. Tiffin, Mortimore, and Gichuki, note 13 above, 93–95.

22. Global Mechanism of the Convention to Combat Desertification (GM-CCD), *Why Invest in Drylands? A Study Carried out for the Global Mechanism of the Convention to Combat Desertification* (Rome: GM-CCD, 2004); and C. Reij and D. Steeds, *Success Stories in Africa's Drylands: Supporting Advocates and Answering Skeptics* (Amsterdam: CIS/Centre for International Cooperation, Vrije Universiteit Amsterdam, 2003).

23. The studies are reported in Drylands Research Working Papers 1–41, available at www.drylands research.org.uk. See also M. Tiffen and M. Mortimore, "Questioning Desertification in Dryland Sub-Saharan Africa," *Natural Resources Forum* 26, no. 3 (2002): 218–33.

24. The Kano Close-Settled Zone was defined by Mortimore as having local population densities of 350 per square mile (147 per square kilometer (km^2) or more, according to the census of 1962. M. Mortimore, "Land and Population Pressure in the Kano Close-Settled Zone, Northern Nigeria," *The Advancement of Science* 23 (1967): 677–88. Over an area of about 10,000 km^2, densities decrease regularly outward to distances of 40–100 km from Kano City. This threshold density is now exceeded over a wider area. In the innermost periurban districts, densities of more than 800 per km^2 are found. M. Tiffen, *Profile of Demographic Change in the Kano-Maradi Region, 1960–2000*, Drylands Research Working Paper 24 (Crewkerne, UK: Drylands Research, 2001).

25. Tiffin, ibid.

26. Harris, note 6 above; and M. Mortimore, "The

Intensification of Peri-Urban Agriculture: The Kano Close-Settled Zone, 1964–86," in B. L. Turner II, R. W. Kates, and H. L. Hyden, eds., *Population Growth and Agricultural Change in Africa* (Gainesville, FL: University Press of Florida, 1993), 358–400.

27. The exception was potassium, which declined significantly in the 59 samples analyzed. M. Mortimore, "Northern Nigeria: Land Transformation under Agricultural Intensification," in C. L. Jolly and B. B. Torrey, eds., *Population and Land Use in Developing Countries. Report of a Workshop* (Washington, DC: National Academy Press, 1993), 42–69.

28. M. Mortimore and W. Adams, *Working the Sahel: Environment and Society in Northern Nigeria* (London: Routledge, 1999), 78.

29. F. M. A. Harris and S. Mohammed, "Relying on Nature: Wild Foods in Northern Nigeria," *Ambio*, 32, no. 1 (2003): 24–29.

30. P. Hill, *Population, Prosperity and Poverty. Rural Kano, 1900 and 1970* (Cambridge, UK: Cambridge University Press, 1977).

31. Droughts have occurred unpredictably throughout the history of Kano and recently in the great Sahel Drought that hit Kano in 1972–1974, 10 years later in 1982–1984, and in several individual years during the 1990s (M. Mortimore, *Adapting to Drought: Farmers, Famines and Desertification in West Africa* (Cambridge, UK: Cambridge University Press, 2001); and M. Mortimore, *Profile of Rainfall Change in the Kano-Maradi Region, 1960-2000*, Drylands Research Working Paper 25 (Crewkerne, UK: Drylands Research, 2000)).

32. Grain yields ranged between 0.5 and 3 tons per hectare (depending on rainfall, fertilization, and weeding) on a small but accurately measured sample located 40 km from Kano. Some output might be sold, lent, or given away, rendering the household food-insecure. F. Harris, *Intensification of Agriculture in Semi-arid Areas: Lessons from the Kano Close-Settled Zone, Nigeria*, Gatekeeper Series No. 59 (London: International Institute for Environment and Development, 1996).

33. Tiffen, note 24 above.

34. J. A. Ariyo, J. P. Voh, and B. Ahmed, *Long-Term Change in Food Provisioning and Marketing in the Kano Region*, Drylands Research Working Paper 34 (Crewkerne, UK: Drylands Research, 2001).

35. An absence of long-term compatible data on real income is frustrating the analysis of income and welfare trends. Meanwhile, general price inflation (linked to a depreciation of the national currency by 200 percent since the 1970s) makes people strongly aware of hardship, especially since structural adjustment policies were introduced in 1986. A. R. Mustapha and K. Meagher, *Agrarian Production, Public Policy and the State in Kano Region, 1900–2000*, Drylands Research Working Paper 35 (Crewkerne, United Kingdom, Drylands Research, 2000).

36. Ibid.

37. A. N. Badiane, M. Khouma, and M. Sène, *Région de Diourbel: Gestion des Sols* (Diourbel Region: Soil Management), Drylands Research Working Paper 15 (Crewkerne, UK: Drylands Research, 2000); and P. Garin, B. Guigou, and A. Lericollais, "Les Pratiques Paysannes dans le Sine" (Farming Practices in Sine), in A. Lericollais, ed., *Paysans Sereer: Dynamiques Agraires et Mobilité au Sénégal* (Sereer Farmers: Agrarian Dynamics and Mobility in Senegal) (Paris: Editions Institut de Recherches en Développement, 1999), 211–98.

38. M. Gaye, *Région de Diourbel: Politiques Nationales Affectant l'Investissement chez les Petits Exploitants* (Diourbel Region: National Policies Affecting Small Farmers' Investments), Drylands Research Working Paper 12 (Crewkerne, UK: Drylands Research, 2000).

39. Farm tree populations are said to be under threat in the well-studied village of Sob, just outside the boundary of Diourbel Region. (See Garin, Guigou, and Lericollais, note 37 above.) Data gathered in 1999 in three villages indicated that the status of farmed parkland is more ambiguous than in Kano, with large variations between villages, abundant regeneration in places, but decline in some species and scarcities of middle-aged trees. S. Sadio, M. Dione, and S. Ngom, *Région de Diourbel: Gestion des Ressources Forestières et de l'Arbre* (Diourbel Region: Management of Forest Resources and Trees), Drylands Research Working Paper 17 (Crewkerne, UK: Drylands Research, 2000).

40. A. Barry, S. Ndiaye, F. Ndiaye, and M. Tiffen, *Région de Diourbel: Les Aspects Démographiques* (Diourbel Region: Demographic Aspects), Drylands Research Working Paper 13 (Crewkerne, UK: Drylands Research, 2000).

41. A. Faye, A. Fall, M. Mortimore, M. Tiffen, and J. Nelson, *Région de Diourbel: Synthesis*, Drylands Research Working Paper 23e (Crewkerne, UK: Drylands Research, 2001).

42. Official data at region and department level were used in the long-term analysis (1960–2000). They are based on a mixture of censuses and estimates. Small trends were only considered potentially significant if sustained over many years.

43. Such a difference is too large to be fully explained by the size of household, which averaged 10 members, 13 and 12 in types 1, 2, and 3 shown in Figure 2.

44. Garin, Guigou, and Lericollais, note 37 above; and Sadio, Dione, and Ngom, note 39 above.

45. See Boserup 1965 and 1990, note 15 above.

46. C. Raynaut, *Recherches Multidisciplinaires sur la Région de Maradi: Rapport de Synthèse* (Multidisciplinary Research in the Maradi Region: Synthesis) (Bordeaux: Maradi Region Research Programme, Université de Bordeaux II, 1980), 10.

47. A. Mahamane, *Usages des Terres et Évolutions Végétales dans le Département de Maradi* (Land Use and Vegetation Change in Maradi Department), Drylands Working Paper 27 (Crewkerne, UK: Drylands Research, 2001).

48. Raynaut, note 46 above; C. Raynaut, "Le Cas De La Région de Maradi (Niger)" (The Maradi Region Case, Niger), in J. Copans, ed., *Sécheresses et Famines du Sahel. Tome II. Paysans et Nomads* (Droughts and Famines in the Sahel. Farmers and Nomads) (Paris: Librairie Francoix Maspero, 1975), 5–43; and C. Raynaut, J. Koechlin, C. Cheung, and M. Stigliano, *Le Dévelopement Rural de la Région au Village—Analyser et Comprendre la Diversité* (Rural Development from Region to Village—Analysing and Understanding Diversity) (Bordeaux, France: Maradi Region Research Programme, Université de Bordeaux II, 1988).

49. The rural population of Maradi Department grew at more than 3.0 percent per year between 1960 and 1988 (Tiffin, note 24 above). Maradi Department was a breadbasket of Niger: It produced the staple food crop, bulrush millet and was the main center of groundnut production until 1975. It was also a cotton-producing area. During the 1990s, the development of Niger's Code rural (which was based on the principle of "land to the tiller") motivated farmers to claim as much free land as they could plant.

50. M. Mortimore, M. Tiffen, Y. Boubacar, and J. Nelson, *Department of Maradi: Synthesis*, Drylands Research Working Paper 39e (Crewkerne, UK: Drylands Research, 2001).

51. A. Luxereau, "Usages, Représentations, Évolutions de la Biodiversité Végétales chex les Haoussa du Niger" (Use, Perceptions, and Change in Plant Biodiversity among the Hausa of Niger), *Journal d'Agriculture et de Botanique Appliqué NS* (Journal of Agriculture and Applied Botany NS) 36, no. 2 (1994): 67–85; and A. Luxereau and B. Roussel, *Changements Écologiques et Sociaux au Niger* (Ecological and Social Change in Niger) (Paris: L'Harmattan, 1997).

52. Y. Boubacar, *Évolution des Régimes de Propriété et d'utilisation des Ressources Naturelles dans la Région de Maradi* (Changes in the Tenure and Use of Natural Resources in the Maradi Region), Drylands Research Working Paper 29 (Crewkerne, UK: Drylands Research, 2000).

53. Tiffin and Mortimore, note 23 above.

54. The nutritional requirements are estimated at 200 kilograms per person per year. This finding does not exclude the possibility that cereals were exported from the department, leaving some families food-insecure.

55. Cooperative for Assistance and Relief Everywhere (CARE), *Evaluation de la Sécurité des Conditions de Vie dans le Département de Maradi* (Assessment of Living Conditions in Maradi Department) (Niamey, Niger: CARE Niger, 1997).

56. Ariyo, Voh, and Ahmed, note 34 above; and K. Meagher, *Current Trends in Cross-Border Grain Trade between Nigeria and Niger* (Paris: IRAM, 1997).

57. V. Mazzucato and D. Niemeijer, *Rethinking Soil and Water Conservation in a Changing Society*, Tropical Resource Management Papers, No. 32 (Wageningen, Netherlands: Wageningen University and Research Centre, 2000); D. Niemeijer and V. Mazzucato, "Soil Degradation in the West African Sahel: How Serious Is It?" *Environment*, March 2002, 20–31; and C. Reij and T. Thiombiano, *Développement Rural et Environnement au Burkina Faso: La Réhabilitation de la Capacité Productive des Terroirs sur la Partie Nord du Plateau Central entre 1980 et 2000* (Rural Development and the Environment in Burkina, Faso: The Restoration of the Productive Capacity of Village Lands in the North of the Central Plateau between 1980 and 2000) (Amsterdam: CIS, Vrije Universiteit Amsterdam, 2003).

58. Grain banks and other attempts to counter the insecurity of living under drought risk have enjoyed only chequered success. It is arguable that this problem will be found as challenging as achieving sustainable natural resource management. Drought management will be the focus of a new initiative by UNDP's Dryland Development Centre, Nairobi.

59. Raynaut, note 46 above, page 66.

60. D. Knowler, G. Acharya, and T. van Rensburg, *Incentive Systems for Natural Resources Management*, (Rome: FAO Investment Centre, 1998).

61. M. Mortimore and M. Tiffen, "Introducing Research into Policy: Lessons from District Studies of Dryland Development in Sub-Saharan Africa," *Development Policy Review* 22, no. 3 (2004): 259–86.

62. Drylands Research, *Livelihood Transformations in Semi-Arid Africa 1960–2000: Proceedings of a Workshop Arranged by the ODI with Drylands Research and the ESRC*, in the series "Transformations in African Agriculture," Drylands Research Working Paper 40 (Crewkerne, UK: Drylands Research, 2001).

63. InterAcademy Council, *Realizing the Promise and Potential of African Agriculture. Science and Technology Strategies for Improving Agricultural Productivity and Food Security in Africa* (Amsterdam: InterAcademy Council, 2004.