



Adapting to drought in the Sahel: lessons for climate change

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The Sahel's experience of adapting to changes in rainfall on a scale at least comparable to that of climate change scenarios, between the 1960s and the 1990s, suggests that lessons can be learnt that may have a wider utility for policy in the future. The Sahel is a major global agroecological region and its success in adaptation will influence the achievement of the global Millennium Development Goals. From simple typologies of adaptation strategies, our understanding of adaptive capacity has evolved over time (with accumulating observations) into a contextual model which places drought management at the center of a development process. Climate change impacts in future are very uncertain. Policies and interventions should therefore aim to build on the platform of past achievements and existing local knowledge to enable flexibility and diversity and the protection of assets of small-scale farmers and herders. © 2010 John Wiley & Sons, Ltd. *WIREs Clim Change* 2010 1 134–143

'Africa is the most vulnerable region to climate change, due to the extreme poverty of many Africans, frequent natural disasters such as droughts and floods, and agricultural systems heavily dependent on rainfall'.¹

'the continent's low adaptive capacity serves as a major constraint to her ability to adapt' (Ref 2, p. 6).

'It is uncertain how rainfall in the Sahel, the Guinean coast and the southern Sahara will evolve in this century' (Ref 3, p. 866).

There is good reason to examine the adaptive capacities of societies who have lived for long with unpredictable environmental change.⁴ This article is about experience in the Sahel drylands of sub-Saharan Africa during the past 50 years.^a 'Ecosystem responses to past rainfall variability in the Sahel are potentially useful as an analogue of future climate change impacts'⁵ The premise is that lessons are ready to be learnt for a world that may be about to engage with an uncertain future.

In the Sahel, aridity and rainfall variability increase with latitude, in line with a declining

gradient of about 145 mm/100 km in mean annual rainfall. Between the mid-1960s and the mid-1990s, annual rainfall declined by 25–30% depending on location. At Kano, e.g., average annual rainfall was 853 mm in 1931–1960; 826 mm in 1941–1970; 807 mm in 1951–1980; and 714 mm in 1961–1990.⁶ The isohyets of mean annual rainfall (in 1940–1967 and 1968–2000) migrated southwards by up to 100 km.^b There was an increased frequency of drought events, within a heightened variability trend, both between years and within seasons. Growing seasons were significantly shortened by late starts and early finishes. The magnitude of these changes was as great as any predicted in global climate change scenarios up to 2050.⁷

The human ecological systems found in the Sahel were adapted to a great diversity of natural conditions—both in the rainfall regimes and in the soil formations, which are derived predominantly from former desert dunes and from dry lateritic plateaux, with wetlands and a very few perennial river valleys interspersed. On this unpromising terrain, a remarkable diversity of cultures, languages, political entities, and production systems developed during more than a thousand years.⁸ The Sahel is similar in some respects to the drylands of India, and in other ways to those of north-east Brazil; neither however has recently experienced a medium-term climatic perturbation on such a scale.

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WHY THE SAHEL MATTERS TO THE REST OF THE WORLD

The Sahel experience has a wider than regional relevance for the following reasons:

1. Adaptation strategies and policies are usually framed by the conventional paradigm of climate change defined in terms of more frequent and intense extreme events. Such is the challenge of drought in the Sahel. Less understood ideas of abrupt or dangerous climate change, involving in example, a reversal of the sign (or direction) of a climate parameter, may however also suggest utility for the Sahel experience as the rainfall trend over the past 100 years has exhibited relatively abrupt changes in direction, with a multidecadal wet period followed by a multidecadal dry period, currently in retrogression.⁴

The adaptive challenge faced by resource-poor farmers and herders in the Sahel is the unpredictable extreme event rather than the long-term trend itself. This is because seasonal rainfall has a direct impact on the means of subsistence for a majority of the population. Production decisions are made within this time frame. Strategies for managing a deficit are formulated with a view to the following harvest. At the community level, however, aggregate behavior by many individuals or households over several years describes an adaptive trend. This may be driven predominantly by a climatic variable, though other drivers ('multiple stressors') also take effect. Thus, it is impracticable to draw a distinction between adaptation to drought and adaptation to climate change.

2. As quoted above, it is conventional wisdom that poor people and Africans in particular will suffer the impact of climate change disproportionately, because they are too poor and they have the least capacity to adapt. If so, adaptation in a region as vast and as populous as the Sahel is a global and not only a local concern as it will affect the achievement of the Millennium Development Goals. How can a better understanding of this 'adaptive poverty' be achieved?
3. The Sahel countries have among the lowest rates of carbon emission in the world and are least responsible for global warming. On grounds of social justice, therefore, and given prevailing expectations of climate change, supporting adaptation in the Sahel is a global responsibility.⁹

4. Small-scale private and community capacities are critical to success, both in the Sahel and in many other tropical drylands, where millions of decision makers interact with their ecosystems on a daily basis. These capacities can be supported by wise policies, but may be impeded where there is a tradition of top-down governance, coupled with presumptions or even ignorance of local knowledge, and of the rationales of local environmental management.¹⁰
5. On account of its great extent, the management of the Sahel's ecosystems is important for a sustainable world, and needs to benefit from recent advances in the scientific understanding of coevolving human and biological systems, as they apply to the drylands.^{11,12} In these circumstances, local adaptive capacity is not a curiosity, but a platform for constructing enabling development policies.

ADAPTIVE STRATEGIES IN THE DROUGHT CYCLES OF THE 1970S AND 1980S

Rather than high level policy, international conventions and engineering interventions, this article focuses on the potential of community-based or individual adaptation.¹³ It was too easy to devalue the strategies employed by and the capacities of poor households, and accede to a conventional wisdom that emphasizes their limitations: i.e., farmers and herders in the Sahel—or people in Africa generally—have low (or weak) adaptive capacity:^{2,14,15}

- Adaptive strategies are *too costly* for poor people to adopt.
- Local adaptive strategies are *incompetent* to meet challenges deriving not only from climate but also from multiple developmental stressors.
- Local knowledge is scientifically *insufficient* (or *too limited*) (constrained by culture, institutions, remoteness from research stations, language, and education) for responding to future changes of climate.
- Individual or community responses only have local importance (*too local*), whereas state interventions at higher scales are necessary to accomplish adaptation.

This apparently plausible rationale for 'low capacity' (stated explicitly or implied in the IPCC Fourth Assessment of 2007) needs to be challenged in

the light of the Sahel experience. This review is based on a selective sample of drought adaptation data from northern Nigeria, 1968–2008. It is applicable widely in the region, but where necessary will be qualified in the discussion.

Too poor

Observers' understanding of responses to the food crises triggered by the drought cycles of the 1970s and 1980s evolved over the years in parallel with the environmental crisis itself. To begin with, an urgent contemporary report on farmers' responses focused on inventorying the strategies available to local communities, and framed by a sequence of decisions reached by individuals or households as they struggled to adjust to stepwise increments in the severity of the food shortage. Thus, selling assets to pay for food, offering one's labor to others, finding alternative 'famine foods' in the ecosystem, calling on kin for help, traveling to distant towns for work, begging, and finally migrating as a family were already well known and used when the 1972–1974 famine hit the rural Hausa population of Kano in Nigeria.^c Subsequently, 'drought coping strategies' became the theme of a small literature.¹⁶ Drought responses were treated as a nonsectoral field of enquiry in the science of human behavior.^d

A retrospective analysis based on fieldwork carried out between the drought cycles of the 1970s and the 1980s in rural Katsina went a step further in ranking responses in terms of the increasing commitment of domestic resources necessary as the emergency deepened with the passage of time.¹⁷ This implied a scale of diminishing reversibility. Thus, gathering famine foods or getting help from kin gave way in time to selling livestock, pledging or selling land, and eventually, permanent out migration. As households differed in their circumstances, such a framework linked up with scales of poverty, vulnerability, and other differentiating criteria.

Later analysis of the 1972–1974 Kano data suggested typological distinctions between, first, adapting to agricultural drought (agronomic strategies such as replanting, wider crop spacing, less fertilizer use, and changed crop mixtures), second, adapting to poverty (alternative incomes, selling assets, and mobilizing social networks), and third, adapting to hunger (changing staple foods, harvesting wild edible products from the ecosystem, and rationing meals).¹⁸

In a fresh study, carried out in north-eastern Nigeria during and after the drought cycle of 1982–1984 (when drought was even more severe than that of the 1970s¹⁹), a typology of environmental management strategies was proposed that included

the following categories: negotiating the rain, managing biodiversity, integrating animals (with crops), farming intensification, and diversifying livelihoods.²⁰ It is clear from these terms that the process of adapting to drought may now be best understood to consist in building and sustaining livelihoods in an uncertain environment. Some 25 years after the Sahel drought seemed to question the very survival of human communities, the farming systems persisted, village populations were stable or increasing, farming and livestock production were integrating and intensifying, and livelihoods were diversifying. Until 2008, visible indicators of monetization and investment were increasing. The impact of development projects was marginal or nonexistent in the four communities studied.

It follows that the distinction insisted on by some writers, between 'coping' and 'adaptation' responses, has little value in a dynamic and differentiated livelihood context. We are looking at adaptation through a livelihood lens, where droughts and natural resource management take their place alongside other priorities such as health, education, or marriage. Where such complexity exists, an assertion that people are generally 'too poor' to adapt is essentially meaningless.

Social differentiation affects access to adaptation strategies and economic outcomes. But because of kinship networks, and other foundations for social claims, material wealth is a poor guide to the economic security of an individual, e.g., of elderly dependents living alone. There has always been an 'opportunity framework' to which access must be gained by endless negotiation.²¹ An important question is whether the process of adaptation increases inequality. Divesting oneself of assets such as land, tools, or valuables is obviously regressive within a livelihood framework based on natural resources, but opportunities accessed through diversification or migration can reverse such an outcome. The subdivision of property through inheritance slows down individual accumulation through intergenerational wealth transfers. 'Too poor to adapt' needs a nuanced understanding of social and cultural change as they affect individuals and households.²² The capacity to manage contingencies was regarded as a key indicator of development at this level—Hausa people referred to those who could cope (*masu dan hali*) as opposed to those who could not. Such capacity was primarily linked to land, labor, and capital assets.

Incompetent

Climate change in future seems unlikely to proceed any faster than the onset of lower rainfall in the Sahel after the 1960s. Following a long run of wet years,

the drought cycle of 1969–1974 was accompanied by a severe food shortage, which encouraged some observers to estimate an excess mortality in the order of 300,000.^e Some livestock herders were displaced from their usual grazing areas and some (notably Tuareg) were dispossessed entirely of their herds. Market systems failed to deliver staple cereals in northern Nigeria for significant periods, although cassava, a substitute grown mostly in the south of the country, might sometimes be available at inflated prices. Starvation was widespread with large numbers of people depending on famine foods during the run-up to the much delayed rains of 1974.¹⁸

A decade later, the drought cycle of 1982–1983 was worse (in terms of precipitation) in Nigeria and southern Niger than that of 1969–1974. Yet decadal responses, many of them positive, could be identified at the scale of the village and that of the household. There were changes to the farming system in soil management, labor management, land holdings, cropping systems and technologies, as well as in sources of capital; and in livestock management, secondary occupations, and transport, which enabled a dramatic expansion of trading and migration circuits.¹⁸ However, changes had different impact from house to house, depending on a complex array of differentiating factors—and one person's strategy could be another's act of desperation.

There is qualitative evidence that well-being has improved, despite the challenge of negotiating increased variability in rainfall (bringing several exceptionally wet years as well as dry since the late 1990s). More houses are now roofed with metal sheets, there are more motor cycles and radios; cell phones have made their appearance; mosques have been rebuilt; retail traders have increased in number. There can be little doubt that a major contributor to these investments has been income earned on migratory circuits.

During these years, Nigeria experienced a significant transformation: with an oil boom, rapid urbanization, state-assisted expansion of manufacturing, contradictions in agricultural policy, corporate expansion, intensified political activity in the economic sphere, increased corruption, educational expansion, the appearance of a significant middle class, and a range of associated social changes.²³ The village data show the growing importance of macroeconomic determinants in adaptation. Although ahead of some other Sahelian states, northern Nigerian communities were finding adaptive pathways that have since become commonplace. The speed of such strategies, and their flexibility or competence for managing multiple stresses and opportunities, is determined

by macroeconomic rather than local factors. At the regional scale, economic integration facilitates adaptive strategies in the remotest villages of the Sahel. It appears that it is economic development, not adaptive capacity, that may be too slow.

Insufficient

Local knowledge (an amalgam of inherited wisdom and opportunistic adoption) although not organized along 'scientific' lines is comprehensive and location specific. For example, natural plant biodiversity is valued in Sahelian villages and conserved where possible. In one community, 121 nondomesticated plant species of economic value were inventoried.^{20,24} Some of these have value as 'famine foods',²⁵ and the local knowledge on identification and preparation is handed down between generations of women, who generally collect them. In northern Nigeria, 10 common and 47 less common species were catalogued during the famine of 1972–1974.¹⁸

Agrodiversity—the maintenance of a range of varieties of the staple crops—is important for continuity in systems dependent on uncertain rainfall from year to year. Farmers in four communities use from 3 to 12 named types of pearl millet, from 6 to 22 of sorghum, and from 14 to 42 other cultivars.²⁰ Farmers were found to be maintaining (through selection, storage, and replanting) private gene pools that effectively managed genetic diversity resulting from crossing both within and outside cultivated fields.²⁶ The rarer varieties, although all but abandoned by a majority, were still sustained through breeding by elderly farmers who liked their unique properties. On the other hand, new varieties of pearl millet and cowpea, developed originally on research stations, were found to have diffused rapidly through farmer-to-farmer exchange, without any government or project promotion (in the study area). Some long-cycle varieties, of course, may fail to mature when the rainy season ends early.^{27,28} But such a statement does little justice to the flexibility and diversity found in local seed management.

Livestock management and breeding similarly incorporates local expertise and goes well beyond mere 'risk reduction':

'The WoDaaBe production strategy, for example, is informed by studying cattle in their environment, controlling stress and facilitating the regeneration and transmission of desired functional behaviour. Matrilineal genealogies are carefully memorised. Reproduction is strictly controlled, less than 3 percent of the bulls being systematically used. Animal variability is fostered. Selected sires are intensively

circulated within the breeding network. Cows are rarely sired twice by the same bull. Culling of females focuses on reproductive capacity, and marketing of poorly performing animals. Selection is carried out within but not between lineages. Long-lasting lineages are sought after and protected from nonstrategic marketing in case of economic pressure'.²⁹

When the drought struck in 1972–1974, the ranks of regular seasonal migrants from a Nigerian village were abruptly swelled as almost all able-bodied men went to search for alternative incomes. Some went as far as Lagos (800 km), where the only employment available to them was as night guards of private or commercial properties. Sleeping on the streets and incurring few expenses other than transport, they brought back their earnings to support home consumption. As year succeeded year and droughts were repeated, a niche market for goats—and rams for the *Eid* festival—was identified, for which the villagers were well equipped as a result of their breeding and herding experience. It was not long before an association was formed to hire trucks and transport 200 or more animals each year. Profits from the trade accumulated for those most committed and one of the first Lagos migrants is now among the best-off people in the village.

These examples show a capacity to preserve and use local knowledge of biodiversity, adapt and develop agrodiversity, optimize animal domestication, respond to market opportunities, and maintain or create supporting institutions. Sahelian peoples do not lack adaptive knowledge, and equally impressive examples may be found elsewhere. This is not to claim that new ideas or approaches cannot be useful. But the primary constraints are in the enabling (or disabling) environment. It should be noted that these capacities, too, are not adaptations specifically to drought but address a broader goal of livelihood sustainability.

Too Local

A stereotype of Sahelian farmers and pastoralists portrays them as wholly dependent on natural resources and localized within a managed (or mismanaged!) farming ecosystem or grazing circuit. This myth of isolation ignores the history of the Sahel as a region periodically traversed by marching armies, traders, or settlers and historically linked with the humid coast of West Africa and with North Africa. It follows that the strategies used by the same farmers and pastoralists to survive dangerous climate events involve them in wider spatial relations through markets and migrations. Now more than ever before, Sahelian farmers and herders are compelled to see their interests as bilocal.

It has already been shown that migration in search of alternative incomes builds on regional economic integration, and though not new to West Africa, it has grown in scale of participation, geographical extent, and economic value throughout the Sahel.^{30–32} It is older than the regional institutions that promote trade and development today—notably the Economic Community of West African States (ECOWAS). This exemplifies the principle that cumulative local strategies add up to a regional process of development: ‘the interactions between macrostructure and microagency affect the way our world works and deserve more attention than they have received in the global change research enterprise to date’.³³ Such autonomous processes do not wait for ‘adaptation’ initiatives on the part of the state, which may help or impede them. More sophisticated approaches than the average-of-cases are needed to link these scales. Complex systems theory, with its recognition that systems are organized in hierarchical relationships,¹¹ has potential for understanding such linkages, as it does for managing better the resilient but unstable systems (a description that well fits the Sahel).³⁴

We can conclude from the foregoing review that a narrow or *in situ* specification of drought (or climate change) adaptation is insufficient either in scientific terms or as a guide to policy, and that since the Sahel drought of the 1970s, a progressive sophistication of analytical understanding has directed us to a developmental framework. If so, context is central.

THE SHIFTING CONTEXT OF ADAPTATION IN THE SAHEL

During the period of declining average rainfall (1960s–1990s) and thereafter, adaptation was framed by significant changes in key social and economic variables. Together, these variables (with others) constitute an historic and fundamental transformation, and as yet so incomplete that its final form cannot be predicted.

- *A demographic transformation.* Rural populations in the Sahel increased at rates of 2–3%/yr¹ and rural farming populations continue to increase notwithstanding rapid urbanization—concentrated in primate cities—that has attained 50% in Nigeria and Senegal; other countries are set on the same path. Rural population densities continue to increase in the expanding hinterlands of cities.^{35,36} Growth in urban formal sector employment has not been commensurate; but a growing informal sector and

(slightly) lower poverty levels, have attracted rural migrants.³⁷ In urban areas, businesses and households have access to more neighbors, goods and services, and employees have access to more job opportunities and infrastructure; these benefits are believed to increase with the size of the settlement.³⁵ Thus, demographic change—as always—is a fundamentally important driver of economic transition.

- *A transformation in rural land use.* In response to growing populations and overseas markets for cotton and groundnuts, rapid and far-reaching conversions of natural woodland or grassland into cultivated and fallow fields took place during the colonial era; after independence in the early 1960s internal markets increased rapidly.³⁸ This change reflected a long evolution from abundance to scarcity in the supply of agricultural land. Meanwhile, pastoral systems were faced with reduced rangeland, except in areas too dry for farming.
- Trees, following deforestation, were allowed to regenerate on farmland as their value increased, or even planted (especially fruit trees). Up to 3 million ha of improved tree management are reported in Niger.³⁹ Earth satellite data indicate a significant ‘regreening’ of the Sahel from the Atlantic to the Red Sea.^{40,41} This is likely due to the recovery of rainfall since the 1980s. The role of management is difficult to discern, but is likely to have significance.^f Land use transformation leads us directly to consider the impact of markets.
- *Emergence of internal agricultural markets driving development.* Given a high rate of urbanization and an accompanying fall in the proportion of the population engaged in farming (from 83% in 1960 to 62% in 1990, in West Africa as a whole), food commodity production per farmer must increase and the amount marketed must increase faster.³⁵ The capacity of the Sahel to feed itself was seriously questioned after the drought of the 1970s, and scepticism appeared to be justified by persistent food-aid dependence in some countries during the ensuing decade of declining rainfall and frequent droughts.⁴² However, long-term production profiles (40 years) have redirected the diagnosis—in the view of some observers—away from supply-side factors to demand and policy deficiencies, a finding that is not restricted to the Sahel countries.^{43,44} The growing demand for staple foods, the substitution of domestic (urban) for export markets, new or growing markets for niche products, increasing small-scale irrigation, buoyant livestock production, and fattening are widely observable, notwithstanding the setbacks caused by frequent production failures (when, however, prices and profits rise).
- *Market-driven growth in labor and land markets.* There has been no green revolution in either plant or fertilization technologies in the Sahel. Intensification (based mainly on organic fertilization) provided a pathway to more sustainable farming practices. When out migration began to have impact on the labor force during the growing season, labor markets emerged and labor-saving investments increased. There was more hiring of labor, plough teams, and carts. As farm sizes declined, and land became valuable, land markets and rental increased, although innovative resource tenure contracts (‘derived rights’) are widely preferred to outright sales.^{45g} Speculation became a factor on urban peripheries.
- *Soil nutrient markets* are growing. As restorative fallows become shorter, resort is taken to buying animal manure and a lack of capital is cited increasingly as the major constraint to opening new fields or fallows, or maintaining productivity on land that is cultivated every year.²⁴ As claims of degrading soils and a productivity crisis in African agriculture continue to gain currency with policy makers, interventions (subsidies) in the market for inorganic fertilizers are advocated, not least at the Abuja Fertilizer Summit (June, 1996).⁴⁶ Such policies reflect a supply-driven approach to agricultural productivity. An alternative view is that fertilizers have failed to transform farming systems in low productive drylands, because producer rewards have not justified investment.
- *Growth in agricultural service markets.* As state provision declined, agricultural service markets (new seeds, herbicides, pesticides, and chemical fertilizers) began to appear, though hesitantly in some areas. Communications services are marketable. One may hire the use of a cell phone or a ride on the pillion of a motor cycle, which extends the economic as well as the social horizons of rural people. In some rural areas, TV may be watched for a fee. Any such reduction in the costs of acquiring knowledge has important implications for livelihood opportunities. Many observers report increasing numbers of shops and a widening range of services. Periodic markets

multiply and grow, functioning as information emporia as well as for commodity exchange.

- *Destabilization of pastoral systems.* The demographic- and market-driven transformation of production systems has not been confined to sedentary and agricultural communities. Deprived by farm expansion of their informal grazing rights, driven out of arid areas by drought (in some years), displaced by conflicts with governments, or contested claims of other pastoralists, the mobile herding systems of the Sahel have come under pressure to move their circuits, extend transhumance further south (into more humid areas) or become semisedentary, and practice integrated crop and livestock production.⁴⁷ The last of these options offers the possibility of negotiating rights, even if only to a small holding. One result of these changes is a major revaluing of crop residues, which are conserved, sold, and bought in many areas. Another consequence is a reported decline in customary herding contracts between farmers and herdsmen, even as the increasing value of cattle as investments leads to cash herding contracts with city dwelling owners.
- *Off-farm income earning opportunities* are being sought on an unprecedented scale by both farmers and pastoralists. Mainly urban informal sector employment and trade contribute to most household incomes and are regarded not as a replacement for farming or livestock, but as necessary additions to livelihood portfolios. The inadequacy of informal sectors to absorb labor efficiently should not distract attention from their capacity to generate incomes (though small) for many seeking to loosen their dependence on primary resources (a process that has been termed 'deagrarianization').⁴⁸ Migrants from the Sahel are penetrating European labor markets.
- *Social and cultural transformation.* These complex transformations have social consequences, which in turn influence expectations and life decisions. On the positive side, Sahelian societies (or their more fortunate members) are enjoying better access to education, information, personal freedom (from family or political obligations), and ease of travel. On the negative side, the family, community, and customary institutions are under new pressures driven in turn by economic, environmental, and political changes.^{8,22} Primary resources are managed within increasingly complex livelihood 'portfolios' and in response to widening individual horizons. This process is uneven in time, in space, and in social terms.

This summary review of the complex, interlocking, and dynamic context of adaptation in the Sahel is confirmed and elaborated in field studies of long-term change in Senegal, Burkina Faso, Niger, and northern Nigeria.^{49–52} They indicate, on the basis of multivariable analyses over periods of 40 years or more, that trying to isolate adaptation from the broader process of development and change risks distortion. Given this context, the expectations, trade-offs, decisions, and investments associated with adaptive options form an essential part of the painstaking process of constructing livelihoods.

CONCLUSION: OVERCOMING CONSTRAINTS AND ENABLING ADAPTATION

The argument of this article is that at the community or local level, adaptation to drought in the Sahel is inseparable from a developmental context. This has been convincingly argued in relation to disaster risk in climate change adaptation.⁵³ The appropriate way forward for policy is to remove the constraints to, and enable the flexible practice of adaptive strategies, and to put in place an enabling environment. In doing so, locally defined goals should take priority over those imposed from outside by targets, donors, or experts.

Both scientific and institutional support can be given to such a policy framework. With regard to the first, technology development will need to recognize multiple livelihood goals, including risk avoidance, alongside a need for productivity enhancement. For example:

- In agriculture, this argues in favor of such strategies as rainwater harvesting and 'microdosing' fertilization rather than large-scale irrigation or field-scale fertilizer applications.
- Supporting agrodiversity and flexible responses to drought rather than promoting single input-dependent 'miracle' varieties.
- Livestock breeding must recognize that performance under Sahelian conditions is more important to smallholders than productivity at all costs.
- Small-scale producers, whose survival under increased climatic variability is essential for food sufficiency, will need to adapt to climate change impacts that will be felt through a range of variables, not simply rainfall alone, as past performance has shown. Research and policy need to take account of this complexity.^{54,55}

- Better seasonal weather forecasting may help, but West Africans already use local knowledge to good effect in managing drought impacts, and science inputs need to converge with such practice.^{56,57} There is evidence that the greatest benefits will come from simple but reliable information on the onset and overall adequacy of the rains, as this information helps in making input investment decisions.⁵⁸
- Development efforts in the past have often ignored risk management. In this respect, development policy must itself adapt to greater flexibility under uncertainty.
- Institutional experiments in providing crop and livestock insurance—using weather indices—are under way in some countries.
- ‘Safety net’ welfare programmes and other asset protection strategies will need to be put in place and adapted to temporal or interyear variability.^h
- Just as the most appropriate adaptation policies will need to be embedded in development trajectories, so development pathways need to balance production with risk minimization goals, controversial though this will be.

Adaptation should be proactive, not merely reactive, although much emphasis on vulnerability in the literature tends to presuppose the latter. Policy, institutions, and knowledge management should therefore aim to empower poor people—in the Sahel or elsewhere—in ways that must be specific to each country and locality. Increased dependency on state interventions or on external knowledge should be countered by an effective integration of local autonomy with state support and of local with science-based knowledge. Such an agenda lies beyond the competence of line ministries acting alone and of compartmentalized research disciplines or institutes. An integrative thrust—‘mainstreaming adaptation’—should not, however, mean removing the initiative from local communities to the central government. A ‘watch-dog function’ is needed to ensure that key adaptation

decisions continue to be made by poor people, for themselves, and in their context.

An addendum to this conclusion is that a continuing separation of climate change adaptation from development may be inefficient or damaging. A global priority for rushing adaptation to the top of the agenda may encourage the rebranding (and duplication) of conventional development knowledge and the neglect of development studies that are immediately relevant to adaptation. This was starkly evident in debates about the Sahel in the 1970s and could be repeated (there or elsewhere) if the need for integration of knowledge systems is neglected.

NOTES

^aDrylands are defined as areas with an aridity index (precipitation over potential evapotranspiration) of 0.05–0.65 (arid: 0.05–0.20; semiarid: 0.20–0.50; dry subhumid: 0.50–0.65). World Atlas of Desertification.
^bWest Africa Web Atlas O1a Rainfall (www.agrhymet.ne).

^c*Savanna. A Journal of the environmental and Social Sciences*. Ahmadu Bello University, Zaria, Nigeria, vol 1, No 2, 1973.

^dPerhaps, the common usage of the term ‘coping mechanisms’ reflected an urge to downplay individual creativity in favor of a deterministic understanding of behavior.

^eMuch larger numbers may still be encountered in the literature, but the scientific basis of such ‘guesstimates’ is hard to find.

^fThe possibility that land cover change across an area as large as the Sahel may have significant feedback on atmospheric circulation through changes in reflectance, soil moisture, or evaporation is beyond the scope of this article.

^gUnderstanding of West African land tenure dynamics under contemporary conditions has been advanced significantly by recent research.

^hAfrica Drought Risk and Development Forum, www.droughtnet.org/droughtforumreport.htm

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