Is There A New Paradigm of Dryland Development?

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Abstract: This paper takes a developmental approach to land degradation in drylands. There is a large knowledge bank on the science and technology of 'desertification' which has tended until recently to overly influence dryland development policy. This resource does not translate automatically into appropriate policies or development interventions, as shown by the poor record of 'desertification control' over the past half-century. There have been failures to impact on the scale expected either on poverty or on natural resource management. While there is still scope for further advancing the scientific understanding of land degradation, a review of the West African experience has highlighted the priorities of (i) understanding 'success stories' of dryland development, (ii) overcoming the constraints which block new or improved technologies through strengthening incentives for investment, and (iii) aligning development policy with dryland peoples' strategies to diversify their incomes and develop inter-regional linkages. It is therefore argued that a *developmental* approach is needed, in order to integrate science with policy making, as well as to identify priorities for research in future.

Key words: Desertification, drylands, investment, livelihoods, natural resources, success stories

For the past five decades, the threat of 'desertification' has dominated dryland development policy and debate[1]. Before then, the dynamics of the desert edge had made their mark on human history, its civilizations depending on apparently whimsical climatic oscillations (Huntingdon, 1924). Not until the twentieth century, however, did the idea that humans can make deserts become widely promoted. Droughts and famines too were linked up with it in a confused relationship. 'Desertification' connotes change: change that is seen as strongly negative in its consequences for human and biological activity, and always with at least a hint of irreversibility. In a majority of definitions (Glantz and Orlovsky, 1983; Reynolds and Stafford Smith, 2002), such change is perceived to go beyond the climatic oscillations of the desert edge, and the unpredictable and damaging occurrence of drought, to forms of land degradation that may be attributable to the actions of humans.

The most widely used characterization is the revised definition used for the UN Rio Earth Summit of 1992:

> 'Desertification means land degradation in arid, semi-arid and sub-humid areas resulting from various

[1] There was a convergence of several significant events, including: the launching of UNESCO's Arid Zone programme (1948), Aubréville's coining of the term désertification in West Africa (Aubréville, 1949), and the Indian National Science Academy's inauguration of arid zone research (1951-52).

factors, including climatic variations and human activities' (UN, 1994)

The term 'desertification' thus describes a subset of land degradation processes, which are intricately linked to one another, though traditionally analyzed independently by specialists in different disciplines. These include soil fertility decline, erosion by wind or water, dune formation, hydrological dessication, biodiversity loss, deforestation, and declining plant (and perhaps animal) bioproductivity. Grouping so many processes together in a conceptualization of a 'megaprocess' called 'desertification' creates a need for a complex theory. It also makes measurement and assessment intrinsically problematic. A second difficulty arises from a multiplicity of causes: aridity, variability, and human activities. Although human agency is no longer a necessary condition (as it was in the first UN definition, employed from 1977 until 1992)[2], it remains a sufficient cause, alone or (more likely) in combination with natural factors. Such causation cannot always be easily established. A lack of rigour, however, can create an undesirable dependence on the opinions of 'experts'. Given these ambiguities, the search for 'desertification indicators' is beset with difficulties, which can only be reduced by adopting a restricted focus on strictly defined, and easily quantified, short-term biophysical changes.

Notwithstanding these ambiguities, the term became institutionalized when the UN Conference on Desertification (UNCOD) took place in 1977, in the wake of the Sahel Drought which culminated in the years 1972-74, arousing global concern for the African environment on a scale that was unprecedented. As Swift has pointed out, the need to justify a new UN agency, mobilise funds from donors, and demonstrate activities soon obscured scientific caution about claims of the scale and impact of the process (Swift, 1996). UNEP's Desertification Branch was mandated to supervise a Plan of Action to Combat Desertification (PACD), which, given this background, was technically driven, top-down, and targeted at restoring sustainable natural resource management. This was seen as a precondition for maintaining the 'carrying capacity' of drylands for both humans and livestock. Such schemes as dune stabilization, soil salinity control, and reafforestation were given prominence, and anti-desertification technologies were promoted, as exemplified in articles in UNEP's journal, the *Desertification Control Bulletin.* Less attention was paid to indigenous knowledge or land use rationales, and still less to the economics of the proposed measures in relation to productivity potentials and peoples' livelihoods in the drylands.

Meanwhile, a vigorous scientific critique brought into question many of the claims that had been made at scales varying from the local to the global (Warren and Khogali, 1992). Local studies in particular invariably exposed the ambiguities present in the working of complex human-environmental

2 'Desertification is the diminution or destruction of the biological potential of the land. . .Overexploitation gives rise to degradation of vegetation, soil and water…the loss of biological productivity through the degradation of plant, animal, soil and water resources can easily become irreversible, and peramanently reduce their capacity to support human life. Desertification is a self-accelerating process, feeding on itself' (UNEP, 1977).

systems under conditions of variable rainfall. It is not the aim of this paper to detail these controversies, which appeared to have little impact on 'institutional desertification' before the 1990s. The issue was brought up again by African countries at the Rio Earth Summit in 1992, and soon enshrined in the UN Convention to Combat Desertification (CCD), which has been signed by more than 150 countries, and is implemented by a permanent office, the Global Mechanism of the CCD. However, new knowledge was fed into the negotiations of this convention and the proceedings of the six Conferences of the Parties (COPs) which have been held thus far. There is evidence that a fundamental paradigm shift is taking place as international agencies, influenced by a failure of the PACD ever to achieve its expectations (blamed on donors' reluctance to supply the amounts of cash requested (Buonajuti, 1991)), and by some costly project failures, now come to embrace a more 'people centred' development perspective for drylands. The UNDP, for example, recognises

> 'the overall goal of reducing poverty through the sustainable development of drylands leading to reduced vulnerability and improved livelihoods'(DDC, 2003);

and a recently published policy brief written by an independent group states that

> 'A people-centred approach to developing the drylands should aim to increase choice and opportunity, and to reduce vulnerability. . . . .creating choices for rural people – both in the sense of options and decision-making ability – are key to unleashing dryland potential. . . . . it is evident that a needs and a rights-based approach should play complementary roles'(Anderson *et al.*, 2003:8).

Such an emphasis shifts attention from a disputed 'desertification science' to poverty reduction, and its economic, institutional and policy determinants (DDC, 2003a; DDC, 2003b; Malhotra, 1980; UNEP, 2003; USAID, 2002). Under-investment in natural resource management appears as a dependent variable in such a perspective, giving priority to the search for enabling rather than controlling measures. Attention needs to be paid to the incentives for investment in sustainable natural resource management (FAO, 1998: Knowler et al. ?????).

In this short discussion, I shall invert normal practice, allowing developmental experience to speak to science, rather than *vice-versa.* In so doing, I hope to define new priorities for research. There is already a large bank of scientific knowledge about drylands in general, and desertification control techniques in particular. The size of this bank is especially impressive in India, where research in the arid zone in the north-west of the country has been consistently supported by the state for over half a century[3]. Many important questions are outstanding. But such research traditions pose a question for the future: should policy prioritise 'business as usual' or a change of direction? A view is widespread among both scientists and policy makers that the

3 The Central Arid Zone Research Institute at Jodhpur had already published 1,320 scientific papers by 1980 (Mann, 1980:xxix).

impact of research on poor peoples' livelihoods, though sometimes significant, has fallen below expectations. This suggests that the linkages between research and development policy still need attention, perhaps through new forms of participation. It therefore seems appropriate, in a review of 'desertification', to shift the focus to the development process, with a view to learning lessons for the future course of science.

In view of my own limitations, I shall base this discussion on a review of West African experience and documentation, in hope of posing questions that have generic application, before returning briefly to a global perspective in my final remarks.

> 'The African drylands are home to 268 million people, or 40% of the continent's population, and after excluding the deserts, they comprise 43% of the surface area. The drylands of Sub-Saharan Africa are spatially heterogeneous – overlaid on the rainfall gradient are rivers and wetlands within the drylands, a variety of soil types, and differences in market accessibility. Blueprint policies will not work. The low amounts of highly variable rainfall create risky environments for households. This is reflected in flexibility, adaptability and dynamism in the human systems, and in strong linkages between dryland economies and more humid or urbanized regions. Innovation and experimentation characterise the economic activities of dryland people, both in the use of natural resources and in the exploitation of livelihood opportunities elsewhere. Their knowledge forms a resource of great value in managing risky environments, as introduced technologies have often failed'(Anderson, Bryceson *et al*., 2003).

Desertification in Africa

Diagnoses of environmental degradation (*desséchement*, or desiccation) in the French West African colonies are on record in archives from the earliest years of occupation[4], and were published within two decades (Hubert, 1920). The theme was taken up by historians (Bovill, 1921). In the 1930s, the forester Stebbing's promotion of an 'advancing Sahara' (Stebbing, 1935) led to an Anglo-French Forestry Commission on the Nigeria-Niger border. Although neither its main report (Anglo-French Forestry Commission, 1937) nor a paper published by some of its members (Collier and Dundas, 1937) found support for his claims. Stebbing later extended his hypothesis to the Sudan (Stebbing, 1953). Another forester, Aubréville, returned to the theme in West Africa, with his diagnosis of désertification in the sub-humid and semi-arid forests (Aubréville, 1949). Here the issue was not desert advance, since the desert was many hundreds of kilometres away, but the substitution of savanna grassland for deciduous forest. From this, in the eyes of some, it was but a short step to the substitution, for the savanna, of desert. Agency for such trends was placed on population growth and inappropriate land

[4] Tor Benjaminsen, personal communication.

use practices among small farmers and livestock producers. Even though work in Nigeria showed that the forest margin is edaphically controlled, and that human action tended to stabilise rather than reverse it (Moss, 1969; Moss and Morgan, 1977), a powerful institutional orthodoxy centred in government forestry departments continued to promote the view that the forest zone was retreating along a frontier (Fairhead and Leach, 1994).

A cycle of wet years (during the 1950s), economic growth, and the distraction of political independence seem to have induced a collective amnesia in official circles with regard to 'desertification'. In particular, groundnut and cotton production for export reached new peaks in Senegal, Burkina Faso[5], Nigeria and Niger. So it is difficult to exaggerate the impact of the Sahel Drought of 1969-74 on the revival of the hypothesis of long-term degradation, and even of desert advance. Human agency ('overexploitation') received most of the blame, and was written into the definition of desertification (UNEP, 1977:3). Although the UN's PACD failed to attract the level of funding necessary to carry out its planned activities in full, its diagnosis and prescriptions, backed by the Desertification Branch of UNEP and supported by the FAO, influenced many bilateral and agency programs in Africa during the 1980s and 1990s. An unstated assumption of drylands development policy was that environmental (natural resource) conservation is a pre-condition for human and economic development. A consensus was assumed around the view that expert diagnoses of degradation called for priority being given to technical interventions.

This 'environment first' paradigm of dryland development, as mentioned earlier, is yielding place to new approaches. With regard to Africa, several reasons for this change may be suggested:

- Many desertification control projects, funded by donors, have failed to achieve their objectives, wasting financial resources
- Many planned projects failed to attract financial support, undermining the credibility of 'combating desertification' by technical means
- Technical interventions in environmental management, based on expert assessments, tend to cut across participatory modes of development, which are now in favor
- When local people are consulted, environmental conservation only rarely appears at the top of their developmental agendas. Productivity, incomes and public services are considered to be more urgent.
- Governance, accountability and institutions are attracting more attention among donors than environmental management.

A 'people first' paradigm of dryland development, on the other hand, brings back to the centre of the debate questions

5 Of course, older farmers and pastoralists could remember well the famines that followed the droughts of 1913, 1942 and 1947 (Hill, 1972, Watts, 1983, Mortimore, 1989).

6 Recent studies of long-term adaptation in four dryland areas in Kenya, Senegal, Niger and Nigeria have been documented by Drylands Research (<www.drylandsresearch.org.uk>)

concerning the adaptive capabilities of dryland peoples in Africa, documented in many studies (e.g., Mortimore, 1989, Mortimore, 1998, Tiffen *et al.*, 1994, Dessalegn Rahmato, 1991, de Waal, 1989, Raynaut, 1997)[6]. What are the main constituents of such an approach in justifying development assistance? I propose to highlight three: first, achievements documented in 'success stories'; second, the role of incentives in investment (including governance and institutional dimensions); and third, economic transition to more diversified income strategies.

What are the main constituents of such an approach in a context of development assistance? I propose to highlight three: first, achievements documented in 'success stories'; second, the role of incentives in investment; and third, economic transition to more diversified income strategies.

'Success' stories

After a century of colonial and post-colonial development policies, it is appropriate to take stock in the drylands, particularly in view of the prognosis of land degradation promoted during the past 25 years and the impoverishment it implies. The evidence is many-sided and controversial. Populations have grown at 2 to 3%/yr, but links with land degradation continue to be disputed, complex, or ambiguous (Tiffen and Mortimore, 1994). Agricultural intensification, with an emphasis on internal organic inputs, has permitted some of the more sustainable farming systems to evolve under the highest rural population densities, in accordance with the theory of Boserup (Boserup, 1965). Average rainfall has declined by about 25% in the settled Sahel, and its variability has increased. Yet rural communities sustain their increased numbers, though exporting migrants. Economic, policy and institutional factors seem to play as great a role as environmental ones in determining the incidence of poverty (Mortimore and Tiffen, 2003).

In a new review, Reij and Steeds have concluded from documented long-term studies in Africa that

> 'drylands people are remarkably resilient and have succeeded in increasing their incomes in sustainable ways, and in coping with all but the most severe natural calamities. Coping has entailed on-farm innovation in risk-reducing and productivity-enhancing techniques and activities, and developing off-farm income sources, which are often, but not always, invested in on-farm activities. A thriving agricultural economy promoted by sound policy is clearly necessary, but is not a sufficient condition for successful drylands development'(Reij and Steeds, 2003).

[7] Reij and Steeds also review 15 clearly successful dryland projects, finding that institutional development was a common theme (improved efficiency, capacity, and delegation of responsibilities to users' associations), and that technical innovations were broad-based (on farmers', researchers' and project staff knowledge) and flexible (free from planning rigidities). Economic rates of return from 12% to over 40% were obtained in specific forestry, soil and water conservation, and small-scale irrigation projects.

This type of change is termed 'area development' by the authors. Donor-funded projects necessarily have a short lifetime, and a question often hangs over the sustainability of their achievements when support is withdrawn[7]. Longer-term trajectories of positive change in larger areas or districts, on the other hand, may indicate such sustainability. The following trajectories of development at the area, rather than the project, scale illustrate on longer time-scales (20, 40, 60 and 100 years, respectively) how population growth and agricultural intensification do not need to lead to degradation, or to a disappearing agrarian base for rural livelihoods.

Burkina Faso, Central Plateau. This area has 500 to 700 mm of annual rainfall, soils of marginal fertility, and population densities up to 100 km^{-2} (Reij and Thiombiano, 2003). Burkina Faso was regarded as being one of the most degraded countries in Africa. In 1980, the Central Plateau suffered from degrading soils, declining yields, a loss of natural vegetation, falling water tables and out-migration of up to 25% of families (though between 1975 and 1996, the population of 12 studied villages still increased by 25%). However, over a relatively short period of 20 years, crop yields increased (**Table 1**), soil and water conservation led to an increase in on-farm trees (assisting soil conservation), livestock owned by farmers increased in numbers (providing manure), there was a better regeneration of vegetation (providing fodder), some local water tables rose, out-migration decreased and there was some return migration, and household food security improved.

There was a widespread adoption of soil and water technologies during the period by the Mossi farmers, but not all of the achievements can be credited to that. A critical role was played by sound macro-economic management and improvements to the infrastructure linking producers with markets.

Burkina Faso, Eastern Region. Over a period of 40 years, changes in a somewhat larger area have been documented (Mazzucato and Niemeijer, 2000). The Eastern Region has 600 to 900 mm of annual rainfall, soils of limited depth and low fertility, and population densities ranging up to 60 km^{-2}. Several trends that

Table 1. Grain yields in three provinces, Burkina Faso (kg ha^{-1})

Province and crop	984-88	1989-95	1995-2001
Bam			
Sorghum	446	489	703
Millet	406	478	619
Yatenga			
Sorghu	594	534	733
Millet	473	539	688
Sanmatenga			
Sorghu	408	644	680
Millet	509	515	580

Source: Reij and Thiombiano, 2003: 16.

Fig. 1. Grain area and production per capita in Burkina Faso's Eastern Province (Source: Mazzucato and Niemeijer, 2000:150).

are often considered to be linked to degradation were experienced: a quadrupling of human population, a tripling of livestock number, and a decline in average annual rainfall since the 1950s of about 300 mm (*ibid.:* 303). But instead of evidences of stress, the authors of this study found that average production of staple grains per capita increased more rapidly than the area cultivated after 1980 (**Fig. 1**); and that average yields increased by some 400 kg ha^{-1} without evidence of soil degradation.

There is a large repertoire of soil and water conservation strategies that also increase productivity. Farmers adjust, adapt, and experiment. But mechanization and inorganic fertilizers only explain a small part of the yield increases. Flexibility is also built into institutions that mediate access to natural resources. The Gourmantché farmers 'were able to maintain a productive and environmentally sustainable production system in light of changing natural and social conditions' (*ibid.:* 306). Even at the national level, 'there is little supporting evidence of widespread degradation of crop and fallow land in Burkina Faso', but rather, the evidence 'suggests that some form of agricultural intensification is taking place that allows food production to grow along with population' (Niemeijer and Mazzucato, 2002:29).

Kenya: Machakos District. A study of long-term change over a period of 60 years led to a controversial thesis of positive linkages between population growth, market development and sustainable environmental management (Tiffen *et al.*, 1994). Having been almost written off, in the 1930s and

Fig. 2. Value of output per ha in Machakos District, Kenya, 1932-1981 (1957 values) (Source: Tiffen et al., 1994).

1940s, by officials who were concerned about erosion on the hillside farms and clearance of dry woodland, Machakos District saw the value of output per hectare increase nearly elevenfold, and per capita nearly three-fold, between the 1930s and the 1980s (**Fig. 2**).

This was achieved, on the part of the Akamba farmers, by means of: a dramatic reversal of erosion, associated with the construction of thousands of kilometers of farm terraces and field drains; improved productivity, through integrated crop-livestock production systems; new or adapted farm technologies; increased labor inputs; and investments, which were financed in part from off-farm incomes. Project interventions played a key role at certain times, but the greater part of investment was private. Access to urban and overseas markets via Nairobi offered the necessary incentives for growing exports of coffee, fruit and horticultural produce, which are produced on the best land.

Nigeria: the Kano Close-Settled Zone (KCSZ). The KCSZ had 650 to 700 mm of annual rainfall in the 1990s (a decline of nearly 200 mm since the 1960s), sandy but relatively weathered soils whose fertility is low, and population densities which rise to 400 km^{-2} (excluding Kano City, but including non-agricultural households). Its interest for our argument lies in the fact that for more than 150 years, intensive agriculture has been practised here, by means of manuring, efficient nutrient cycling, and high inputs of family labor. There is evidence of sustainable management of soil nutrients, averaged over a number of sites, over a period of 13 years (**Table 2**), although at the field level, nutrient balances fluctuate with rainfall,

Table 2. Soil properties under annual cultivation, Kano Close-Settled Zone, 1977 and 1990 (top 20 cm)

Property	1977	1990	Per cent change
Bulk density (gm/m^3)	1.4	1.4	0
Particle size distribution (%):			
Sand	90	90	0
Silt	6	6	0
Clay	4	4	0
Organic carbon (%)	0.237	0.205	-13
Total nitrogen (%)	0.029	0.033	12
Exchangeable potassium (me per 100 gm)	0.1	0.06	-40
pH, soil water	5.9	6.1	3

Sources: Mortimore, 1993; Wall, 1979.

cropping system and the farmer's ability to provide inputs (Harris, 1998).

Hausa farmers, working in the proximity of one of the greatest markets in West Africa, have adjusted many times to changing economic circumstances. They once supplied the city with its staple grains, but diversified into growing groundnuts for export (after the railway came in 1911). This trade collapsed with drought and rosette disease in 1975, so they returned (in the 1980s) to growing cereals and legumes for what was, by then, a much larger and rapidly growing domestic market. Urban consumers increased from 0.25 to 1.5 million in Kano, which is also linked into a regional market in foods (Ariyo *et al.*, 2001).

Throughout the past century, against a background of agrarian policy shifts (Mustapha and Meagher, 2000), a more and more intensive farming system, based on family smallholdings, has evolved. Not until 1981 did a major externally funded agricultural development project made impact on the area. For a time, it provided subsidized fertilizers and other inputs, but under structural adjustment policies, these became less affordable. Livestock (whose numbers tend to increase with population density) play a critical role in intensification. Nevertheless, without opportunities for earning off-farm incomes, many households would be food-insecure. Complex livelihoods have been built upon efficiently recycling both plant nutrients and investment capital. Significant technical changes (new crops or landraces, ox-drawn ploughs and ridgers) indicate continuing farm investment; so do growing labor, input and land markets. Away from the urban perimeter, the high pressure on the land is not generally associated with visible degradation, and average slopes are low. Anecdotal evidence suggests that farm productivity fell, with declining yields and smaller farms, during the first half of the last century, but has since stabilized under intensive fertilization. Applications of up to 11 t ha^{-1} manure/dry compost have been recorded (Harris, 1998).

Critics of using the 'Machakos hypothesis' as a model for other African drylands have pointed to the exceptional advantages enjoyed by a few farmers in

having access to hillsides suitable for coffee, and to road infrastructure linking Machakos to Nairobi and Mombasa (Hazell, 2002). The West African cases summarized above suggest, however, that this model has wider application. Comparable studies have recently been carried out in districts in Senegal (Diourbel Region) and Niger (Maradi Department), which link up with the work carried out in the KCSZ. A follow-up study has also been completed in Makueni District in Kenya (which incorporates the drier lowlands of the former Machakos District). These four studies, covering the period 1960-2000, also carry forward the trajectories of economic and environmental change through more than a decade of structural adjustment programs[8].

From these studies, whose findings vary according to country and context, preliminary general conclusions are that: increased populations have continued to support themselves (though not exclusively) from agrarian-based livelihoods;

- markets have been extremely important in driving change, and farmers have been responsive to market opportunities;
- macro-economic policies have had discernible effects, both positive and negative, on the pursuit of livelihood objectives;
- farming systems have tended to move towards more intensive, diverse and sustainable combinations of crops and technologies;
- customary land tenure has had to adapt not only to a scarcity of land, but also to state legal or project interventions;
- social institutions have not impeded individual or community action, and the household remains the locus of diverse economic activity, investments, and the sharing of risks or benefits.

There is evidence supporting the general principle that smallholders can intensify under conditions of demographic and market growth and that in such circumstances, they have good reason to manage their natural resources sustainably, as well as productively. They also benefit from diversifying their livelihoods out of primary production (Faye *et al.*, 2001; Gichuki *et al.*, 2000; Mortimore *et al.*, 2001).

Such positive outcomes challenge neo-Malthusian perspectives on population growth and environmental degradation (Mazzucato and Niemeijer, 2000; Tiffen and Mortimore, 1994). It has been suggested that such successes only buy time against an eventual, and inevitable, Malthusian crisis. But neo-Malthusian theory should be empirically verifiable. The documentation of these opposing cases in high-risk and low-productive dryland environments offers a challenge, not merely to theory, but to policies based on it.

Investment and incentives

Achievements identified in 'success' stories rest in large measure on private investments made by small producers who have employed hybrid technology (combining indigenous with introduced

[8] The field studies in Machakos were carried out in 1990-91, which was too early for a proper evaluation of economic change since structural adjustment and liberalization policies were introduced in the 1980s.

Table 3. Examples of micro-investments

On the farm	In animals
enclosures,	animal pens,
tree planting and protection, hen houses,	
regular soil amendments,	tethering equipment,
storage structures,	riding gear, yokes,
wet or dry compost pits,	watering vessels and well lifting gear,
crop drying floors,	milk containers,
threshing floors,	ceremonial artifacts,
field drains,	salt cures,
erosion checks - terraces, vegetation strips, wells, supplementary feed (especially when natural fodder	
locally made tools,	is scarce).
seed selection, storage and purchase.	

knowledge). Where project incentives have been important in promoting particular technologies, longer-term sustainability still depends on attracting a continuing flow of private resources. These investments are typically made in small increments over a long period. Because of this, and the fact that many are created by family labor rather than by financial expenditures, they have been neglected by analysts; indeed, many studies have recorded the view that investments, other than those supported by project credit, are negligible, owing to the urgency of consumption needs.

Examples of such micro-investments, recorded in our field studies, are shown in Table 3. Aggregated and accumulated over time they are significant, and to consider small-scale production as an area of under-investment is therefore erroneous. To move from such small-scale investments into so-called 'modern' technologies, producers must overcome new barriers of cost, 'lumpiness' and risk. To overcome such limitations, investments are made adaptively: for example,

- plough-shares were made by local blacksmiths in northern Nigeria, as early as the 1960s (Tiffen, 1976);
- cross-breeding of composite maize from the research station (which had to be purchased year by year) with more drought-tolerant, self-selected local varieties took place in Machakos in the 1980s (Tiffen *et al.*, 1994);
- to overcome the disincentive of very small holdings, plough-teams were hired in by small farmers in the KCSZ in the 1990s (Mortimore and Adams, 1999).

Incentive structures are critical in drylands, and need to bridge the additional risk created by variable rainfall. Indirect incentives, which work through taxation, pricing, institutional and other measures, are within the reach of policy and can enhance the range of options open to small-scale producers. A consideration of incentives turns the spotlight away from

[9] 'Direct' incentives are those provided on a project basis, such as 'food-for-work'.

public sector investments financed by governments and donors, and from credit provision for technologies promoted by the state, to decision making by autonomous actors (FAO, 1998)[9]. They offer a means of influencing natural resource management, whether they are *enabling* measures (whose presence creates the opportunity for investment) or *variable* (e.g., prices or subsidies which can increase the incentive to invest). Conversely, 'distortions and inappropriate policies which lead to an undervaluation of the natural resource base create poor incentives for its maintenance and sustainable use' (*ibid.*,120). Current thinking emphasises the role of markets, institutions and policies, and the negative effects on natural resource management of getting any of these wrong. It is also important, in formulating incentives, to take account of the ways in which households situate natural resource management within the wider range of their activities. The impact of input subsidies, for example, works through the opportunity costs of substitutes (manure for inorganic fertilizer, ox-ploughs for tractors).

In the 'success' stories documented above, it is apparent that incentives for private investment came about as much by accident as intent, for example in Nigeria where external investment in the oil industry stimulated urbanization and the market for local food commodities. Over the long term (20-40 years) in which micro-investments by poor families need to accumulate, it is rare for consistent policies to be consciously maintained, and for natural resource management to be prioritized against competing interests. If 'desertification control' is going to be effected through investment incentives, more understanding is needed of the interactions between economic change and policy formation over periods of many decades (Mustapha and Meagher, 2000). The effects of liberalization policies on investment in sustainable natural resource management are obviously critical[10].

In risky drylands, the best incentives will not produce an investment response in every year; the slow capitalization of farming landscapes (and of livestock holdings) is characterized by 'stop-go', opportunistic behavior, and sudden setbacks when divestment takes place, for example in sales of livestock, equipment, inputs, land and even - in Ethiopia – houses. Opportunistic behavior is not necessarily efficient (Sandford, 1994; Scoones, 1994)). The same can be said, to a significant extent, of small farmers (Mortimore, 1998). Working on the interface between private and common resources is complex – grazing rights are usually common, but rights to cultivate, while essentially 'private', usually do not exclude other interests. A need to identify the elements of an enabling environment, in a given context, in order to facilitate small-scale private or community investments, calls for a re-orientation of dryland policy away from

[10] According to Knowler et al. ....., presumably referring to macro-economic policies prior to liberalization, 'a myriad of distortions created by inappropriate exchange rates, taxes and interest rates, combined with expansive fiscal and monetary policies, have conspired to alter the allocation of resources within West African economies in ways which affect NRM' (ibid.:123). However, recent World Development Reports of the World Bank admit that neither do liberalization policies necessarily all that is expected of them.

Fig. 3. A model of diversification in the household economy, northern Nigeria (Source: Mortimore and Adams, 1999: 145).

promoting technical solutions *per se* and towards:

- Creating or supporting locally specific institutional environments (e.g., for CPR management), and
- Macro-economic management, which subsumes sectoral concerns (e.g., agriculture, forestry, livestock) in a broader policy framework that maximises investment incentives.

Diversifying livelihoods

Land degradation has tended to be seen in technical terms, to be treated by professionals in forestry, range management, agriculture, soil and water conservation or hydro-geology. The costs and benefits of 'desertification control' activities have also received some attention, but usually in a narrow project framework useful to donors (Reij and Steeds, 2003). The costs of land degradation at a national level are the subject of studies recently commissioned by the Global Mechanism of the Convention to Combat Desertification (Berry *et al.*, 2003)[11]. But an interdisciplinary approach to questions of resource allocation at household level, where decisions are made that determine the sustainability or otherwise of natural resource management, is under-developed. Yet it is at this level, or that of the individual, that livelihoods are constructed. Natural resources should be perceived as one component (if a large one) of a mixed portfolio.

Prominent features of dryland livelihoods are their diversity and fluidity; that is, incomes are sought from an increasingly wide range of activities, geographically dispersed, and flexibly over time. In a northern Nigerian context, a

11 In costing land degradation, these studies address the question, 'What are the costs of NOT investing in drylands?' which is the obverse of the question 'Can it pay to invest in drylands?', to which an answer has been provided in the affirmative by Reij and Steeds (2003).

diversification trajectory implies feedback loops having critical importance for investment in natural resources (**Fig. 3**).

Not least in Western Africa, this has been so for several centuries. To refer only to the areas discussed earlier, Mouride trading networks were active in central Senegal early in the nineteenth century (Cruise O'Brien, 1971); Tuareg nobles operated long-distance commodity exchanges including the Saharan salt caravan (*azalai*), and capitalized millet production by servile farmers, in what are now Niger and northern Nigeria (Baier, 1980); and the trade in *kola* nuts from the northern fringes of the rain forest to markets in the Sudan zone was managed by – among others – farmers in the KCSZ (Lovejoy, 1976). In East Africa, the Akamba of Machakos operated an extensive trading diaspora in the nineteenth century. Under colonial rule, a concentration of external capital in coastal zones created new disparities of opportunity, amplifying seasonal movements of labor between interior and coastal West Africa, movements whose cost became widely affordable thanks to new transport infrastructure (Rouch, 1956; Prothero, 1959). Participation was, and remains, fluctuating or episodic, peaking after food security crises. However it has always been strongly seasonal, and while there is some sloughing-off when families depart permanently, a majority choose to retain community bonds and in particular, claims to land. Such movements of labor, capital and skills - whether economically exploitative (Amin, 1974) or beneficial (Mabogunje, 1972) – should not be treated as irrelevant to natural resource management, since allocative decisions at the household level were (and are) based on the opportunity costs of scarce factors. Land degradation can result when the needs of natural resources for investment are not competitive with other parts of the portfolio.

The term 'de-agrarianization' has been introduced to describe a social process which is detaching increasing numbers of rural Africans from a livelihood based in agriculture (Bryceson, 2002), a process which is linked specifically with the impact of liberalization policies since the 1980s. In a dryland context, it is important to situate this idea within the historical context just referred to. What has changed? Essentially two things: first, free land for farming or grazing is hard to find, while competition for what is available increases, threatening food security in poor rainfall years, and threatening the viability of household livelihoods; second, urbanization, communications infrastructure and growing commodity markets create more options for earning non-farm incomes. This trend gathered strength under colonial policies to develop mining or export agricultural production using labor that had to be

[12] Socially and economically disruptive effects seem to have been greater in southern and eastern than in western African drylands. Because the scarcity of labor was greater in the first region, the costs in wages foregone of remaining in farming became unacceptable, and meanwhile a commercial farming sector privileged by policy appropriated the function of feeding the new urban populations, with the incentives and benefits that implied. Perhaps Machakos was a 'success story' because Kenya was too far from the mines, and its independent government began early on to dismantle the privileged basis of commercial farming.

attracted from small-scale farming and livestock production[12].

A detachment from primary dependence on agriculture is predicted in models of economic transition at the macro-scale (Tomich *et al.*, 1995). Such a transition – urbanization, rural-urban migration and circulation, increased dependence on non-farm incomes, stagnation in the rural labor force - has been argued on the basis of evidence from the Kenya, Senegal, Niger and Nigeria drylands already referred to (Tiffen, 2003)[13]. For some policy-makers, it may be a wrench to drop time-honored (and erroneous) perceptions of African dryland peoples as either subsistence farmers or specialized nomadic pastoralists. However, without such interregional patterns of dependency and opportunity, drylands would be a persistent drain on public assistance.

Drylands are marked out from sub-humid and humid rural areas by three factors:

- First, *seasonality* and *variability (risk)*, which predispose dryland people to participate in off-farm activities and migration - not merely as 'coping' strategies but as historically rooted patterns of cultural adaptation – also impose an episodic pattern on trajectories of investment and resource allocation over time. Such a pattern does not lend itself to conventional planning.
- Second, many drylands are marginal to national or regional economic nodes, on which their populations may depend for markets or employment, yet their proximity to national borders makes them vulnerable to interference in *cross-border movements* that link interdependent economic spheres.
- Third, the role of land as *social as well as natural capital*, regardless of its productivity, acts as a brake on 'de-agrarianization' and ensures that acceptable solutions to conflicting claims, or to common pool resources management, will continue to be needed as a condition of sustainable investment. In Machakos, some peoples' holdings have become so small that they are mere house-plots. But the house is important!

A necessary condition for 'better policies for dryland people' is an acceptance – by agencies and policy makers – of a more complex developmental paradigm that recognises the geographical linkages (including cross-border linkages) that permit dryland peoples to access the wider economy. In return, they will likely channel some of their incomes into natural resource investments, which is in turn a necessary condition for controlling degradation. Primary production is insufficiently profitable to finance such investments on its own.

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13 'De-agrarianization' in drylands could have three meanings. If it refers to a reduced relative dependence of rural households on real incomes derived from primary production, it conforms with many observations, though baseline data are hard to find, and trends even harder to interpret. If it refers to a general redistribution of population, and of income-earning opportunities, from rural to urban areas, it would be predicted by trends in census data. If, however, it refers to a decisive breaking of links with primary production, on the part of those living in rural areas (or even of those engaged in short-term rural-urban circulation), it is less evident, at least in West Africa.

Out of Africa

The term desertification necessarily implies a negative change in natural resource management, and embodies a *diagnostic-prescriptive* approach that is traditional to applied science in tropical countries, where contradictions between 'scientific' and indigenous practice were given some prominence from early in the last century. It generates a predictable need for external intervention, based usually on technology. On the other hand, the foregoing review of African experience shows that a *developmental* approach – which prioritises time series data, and aims to understand change processes from a multi-disciplinary or intersectoral perspective – can dispel many myths about drylands, and in particular, the inevitability of land degradation under population growth in semi-arid conditions. It also helps to identify – from observed history - the conditions of change or transition in natural resource management, where it has occurred, and points to potentials that can be mobilized by policy changes.

Diagnostic-prescriptive approaches have dominated dryland development during the past half-century, if the literature on desertification is anything to go by. For example, Mainguet's standard work (Mainguet, 1994) provides a wide-ranging review of scientific and technological issues. Yet while the work is sub-titled 'Natural background and human mismanagement', no systematic analysis of management is offered, still less any critical justification for the assumption that human agency is responsible for desertification. In an earlier collection of essays on arid zone research in India (Mann, 1980), a section is devoted to 'social research', and introduced by a far-sighted remark that in order to understand man as 'the most important agent of biotic interference', 'investigations have been conducted to assess the nature and type of available human resources with a view to suggest ways and means for their optimum utilization' (Malhotra, 1980). However, most of the social research reported in this volume was accessory to the main task of developing and promoting technologies. In an overview of arid zone research in India, socio-economic aspects are similarly reduced to one chapter, annexed to 27 concerned with science and technology (Faroda and Singh, 1998). Of course, social science research is conducted by other national institutions in the Indian research system[14]. The question arises, here as elsewhere, whether a closer integration of the two approaches would be productive. More knowledge, generated from a *developmental* approach, is required to extract policy lessons from the record of technological and economic change – a record which is becoming better known as long-term data sets are increasingly available.

On the basis of the foregoing discussion, the following challenges need research:

- *Reconstructed time trajectories* are important for establishing long term trends and removing myths. History matters. From a developmental perspective, 'success' stories challenge

[14] The Institute of Social and Economic Change at Bangalore is particularly relevant. Many studies have been conducted of change in Indian villages, including dryland ones (e.g., Walker and Ryan, 1990).

the common perception of desertification as a human-induced, inevitable or irreversible process of land degradation premised on the mismanagement of natural resources. This does not deny the possibility of degradation. However, more documentation and analyses of 'success stories' would generate lessons for policy – why did some areas develop relatively sustainably while others fail to do so?

- A common error is to *equate drought and desertification*. The links between extreme events and smoothed trends need to be better understood. What is the impact of variability on behavior, not only in ecosystems and in climate change, but also in management strategies? How can variability be planned for in development? Insurance was recommended by the UNCOD (UNEP, 1977), on the basis of exhaustive discussions at a contributory workshop, but policy makers fight shy of unpredictability. The possibility of strengthening indigenous insurance systems, or protecting them from dissolution under market pressures, has not been taken seriously in 'desertification science'. This is not a peripheral issue, as poverty can be defined as a lack of assets, and many assets are created by investment, and lost through vulnerability to drought and its effects[15]. A beginning can be made by studying the experience of the village grain bank movement in West Africa[16].

- A better understanding of the *interactions between human and environmental systems* is required. We begin with Holling's pioneering distinction between resilience and stability, which allows dryland ecosystems to be characterized as resilient and unstable (Holling, 1973), or non-equilibrial (Behnke *et al.*, 1993), in time-perspective. High coefficients of variation in rainfall, as the dominant driver of ecological behavior, impose uncertainty on human managers – whether livestock or crop producers –requiring opportunistic management modes. In a 'managed ecosystem', thresholds may be precipitated by human action, leading to new states of the system. Models of sequential change with strong relevance for planning have been elaborated (Gunderson *et al.*, 1995). With specific reference to desertification, a recently published model of a relationship between human and environmental systems, sustained over time, suggests that degradation results when the two interacting systems fail to co-evolve synchronously (Robbins *et al.*, 2002). A richer understanding of these complex, multivariate system relationships now appears to be a necessary condition for moving beyond the simplistic formulations of 'human-induced degradation' that have guided (or misguided) science and policy alike. More cases (from local to national scales), better methods (from nutrient analysis to remote sensing, from the household to macro-economic policy),

[15] Access to effective insurance appears to be the primary factor protecting natural resource-based enterprises in rich but drought-prone countries.

[16] An attempt to apply the principles of grain banking at village level to the northern Nigerian situation was suggested by this author some years ago (Mortimore, 1978).

and stronger theoretical analysis are called for.

- *Incentive structures* are not well understood because one myth has it that poor people cannot or will not invest in their natural resources. Incentives must govern the conditions for a transition from a degradational to a more sustainable trajectory in natural resource management (Zaal and Oostendorp, 2002). New technologies have yet to realise their full potential in such transitions. The capabilities of poor farmers and livestock producers to mobilise their own small, incremental private investments are evident from their achievements in capitalising landscapes at high levels of agricultural intensification. Their investments are not only in sustainable natural resource management or conservation but also (or mainly) in raising productivity. Indian and Chinese evidence suggests that returns to investment in 'less-favored areas' (which include all the semi-arid rainfed farmlands) are now higher than those in irrigated or high potential areas (Hazell, 2002)[17].
- *Cross-cutting sectoral and spatial perspectives* are needed on land degradation. Actors construct their livelihoods from the opportunities offered them, not only by their natural resource entitlements, but also in the wider economy. As constraints affect expected benefits from natural resources, better opportunities may become available elsewhere, thanks to cheaper transport, urban economic growth or technological change. It seems likely that bi-local residence and income generation will increasingly characterise the livelihood strategies of farming and herding households in drylands. This holistic dimension requires recognition in policy, which is a difficult challenge given the compartmentalization of policy making. Links with other sectors or places may determine the viability of technical packages designed to reverse degradation. Such links may extend to the global level. Drylands have been suggested as sinks for CO_2 sequestration (Glen *et al.*, 1993). What implications could carbon trading payments - in return for taking land out of cultivation – have for local livelihoods?.
- *Research-policy linkages.* A challenge facing science is how to move from the familiar territory of technology development into involvement in participatory policy formation. Land degradation is a dependent variable – not only on inappropriate land use practices, as so often claimed, but more fundamentally on the economic, institutional and policy realities that foster such practices. Evidence-led policy making involves, by implication, not only the policy maker but also the scientist (Crewe and Young, 2002).

Conclusion: Sideways Out of the Impasse

This paper takes a developmental approach to land degradation in drylands. There is a large knowledge bank on the science and technology of 'desertification' which has tended until recently to overly

17 The finding should be seen in historical context: the 'best bets' may have been exhausted, at least in the more favoured areas, which have traditionally been privileged with more investment funds.

influence dryland development policy. This resource does not translate automatically into appropriate policies or development interventions, as shown by the poor record of 'desertification control' over the past half-century. There have been failures to impact on the scale expected either on poverty or on natural resource management. There is still scope for further advancing the scientific understanding of land degradation in arid and semi-arid areas, and developing control technologies. However, a review of the West African developmental experience has highlighted some other priorities: (i) understanding 'success stories' of dryland development, and what they have to teach us; (ii) overcoming the constraints which block investment in improved technologies, through strengthening incentives; and (iii) aligning development policy with dryland peoples' own strategies to diversify their incomes across sectors, between regions.

Merely shifting resources from natural science and technology research to the social sciences is not the answer to an impasse which is defined here as a failure to realise the full potentials of science and technology for dryland development, whether this is understood in terms of poverty reduction or sustainable natural resource management. A *developmental* approach can strongly complement the *diagnostic-prescriptive* approach and assist in *integrating* not only research disciplines with one another but science as a whole with policy making. Dryland peoples need to be enabled better to capitalise knowledge resources for their own ends. Policy needs to be better fitted to the peculiar constraints and opportunities they face.

References

Amin, S. Ed. 1974. *Modern Migrations in West Africa.* Oxford University Press, for the International African Institute, Oxford.

Anderson, J., Bryceson, D., Campbell, B., Chitundu, G., Clarke, J., Drinkwater, M., Fakir, S., Frost, P., Gambiza, J., Grundy, I., Hagmann, J., Jones, B., Jones, G.W., Kowero, G., Luckert, M., Mortimore, M., Phiri, A.d.k., Potgieter, P., Shackleton, S., and Williams, T. 2003. C*hance, change and choice in Africa's drylands. A new perspective on policy priorities*? Bogor, CIFOR.

Anglo-French Forestry Commission 1937. *Report of the Anglo-French Forestry Commission, December 1936 - February 1937. Nigeria Sessional paper No 37 of 1937*, Government of Nigeria, Lagos, Nigeria.

Ariyo, J.A., Voh, J.P. and Ahmed, B. 2001. Long-term change in food provisioning and marketing in the Kano Region. *Drylands Research Working Paper 34.* Drylands Research, Crewkerne, United Kingdom.

Aubréville, A. 1949. *Climats, forêts et désertification de l'Afrique tropicale. Société d'Editions Géographiques*, Maritimes et Coloniales, Paris.

Baier, S. 1980. *An economic history of central Niger*. The Clarendon Press, Oxford.

Behnke, R.H., Scoones, I. and Kerven, C. (Eds.) 1993. *Range ecology at disequilibrium. New models of natural variability and pastoral adaptation in African savannas.* Overseas Development Institute, London.

Berry, L., Olson, J., Campbell, D. and Santibanez, F. 2003. *Case studies: Impact and Costs of Land Degradation (Draft Reports).* Rome: Global Mechanism of the CCD.

Boserup, E. 1965. *The conditions of agricultural growth: The economics of agricultural change under population pressure.* Allen and Unwin, London.

Bovill, E.W. 1921. The encroachment of the Sahara on the Sudan. *Journal of the African Society* 20: 174,259-185, 269.

Bryceson, D.F. 2002. The scramble for Africa: Reorienting livelihoods. *World Development* 30/5: 725-739.

Buonajuti, A. 1991. External evaluation of the Pland of Action to Combat Desertification. *Desertification Control Bulletin* /20: 30-34.

Collier, F.S. and Dundas, J. 1937. The arid regions of Northern Nigeria and the French Niger Colony. Empire Forestry Journal 16/184: 194-?????

Crewe, E. and Young, J. 2002. Bridging research and policy: context,evidence and links. *ODI Working Paper 173.* Overseas Development Institute, London.

Cruise O'Brien, C. 1971. *The Mourides of Senegal: the political and economic organization of an Islamic brotherhood.* The Clarendon Press, Oxford.

DDC, 2003. A new integrated Drylands Development Programme. Nairobi, Drylands Development Centre, United Nations Development Programme.

DDC 2003a. *The Global Drylands Imperative second Challenge Paper series: Land tenure reform and the drylands*, United Nations Development Programme Drylands Development Centre, Nairobi.

DDC 2003b. *The Global Drylands Imperative second Challenge Paper series: Pastoralism and mobility in the drylands*, United Nations Development Programme Drylands Development Centre, Nairobi.

de Waal, A. 1989. *The famine that kills: Darfur, Sudan, 1984-1985. Oxford, The Clarendon Press.*

Dessalegn Rahmato 1991. *Famine survival strategies.* Scandinavian Institute of African Studies, Uppsala.

Fairhead, J. and Leach, M. 1994. *Misreading the African landscape: society and ecology in a forest-savanna mosaic.* Cambridge University Press, Cambridge.

FAO 1998. *Incentives systems for natural resources management: the role of indirect incentives*, Investment Centre, Food and Agriculture Organization of the UN, Rome.

Faroda, A.S. and Singh, M. 1998. Fifty Years of Arid Zone Research in India. Central Arid Zone Research Institute, Jodhpur. ???

Faye, A., Fall, A., Mortimore, M., Tiffen, M., and Nelson, J. 2001. 'Région de Diourbel: Synthesis', *Drylands Research Working Paper 23e.* Drylands Research, Crewkerne, United Kingdom.

Gichuki, F.N., Mbogoh, S.G., Tiffen, M. and Mortimore, M. 2000. Makueni District profile: Synthesis, *Drylands Research Working Paper 11.* Drylands Research, Crewkerne, United Kingdom.

Glantz, M. and Orlovsky, N. 1983. Desertification: a review of the concept. *Desertification Control Bulletin* /9: 15-20.

Glen, E., Squires, V., Olsen, M., and Fuyo, R. 1993. Potential for carbon sequestration in the drylands. *Water, Air and Soil Pollution* 70: 341-355.

Gunderson, L.H., Holling, C.S., and Light, S.S. 1995. *Barriers and bridges to the renewal of ecosystems and institutions.* Columbia University Press, New York.

Harris, F.M.A. 1998. 'Farm-level assessment of the nutrient balance in northern Nigeria', *Agriculture, Ecosystems and Environment* 71: 201-214.

Hazell, P. 2002. Why invest in less-favored areas? Paper presented at European Forum on Development Cooperation, Montpellier, 2002", International Food Policy Research Institute, Washington, DC.

Hill, P. 1972. *Rural Hausa. A village and a setting.* Cambridge University Press, Cambridge.

Holling, C.S. 1973. Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics* 4: 1-23.

Hubert, F. 1920. 'Le desèchement progressif en Afrique Occidentale', *Bulletin du Comité d'Etudes Historiques et Scientifiques d'AOF*, 1920: 401-467.

Huntingdon, E. 1924. *Civilisation and climate. 3rd edition.* Harvard University Press, New Haven.

Lovejoy, P.E. 1976. *Caravans of kola.* Ahmadu Bello University Press, Zaria.

Mabogunje, A.L. 1972. *Regional Mobility and Resource Development in West Africa.* McGill-Queens University Press, Montreal.

Mainguet, M. 1994. *Desertifiation. Natural Background and Human Mismanagment. 2nd ed.* Springer-Verlag, Berlin.

Malhotra, S.P. 1980. Social research in arid zone - its retrospect and prospect. *Arid Zone Research and Development* (Ed. H.S. Mann), pp. 423-427. Scientific Publishers, Jodhpur.

Mann, H.S. (Ed.) 1980. *Arid Zone research and development. International symposium at Central Arid Zone Research Institute, Jodhpur*. Scientific Publishers, Jodhpur, India.

Mazzucato, V. and Niemeijer, D. 2000. Rethinking soil and water conservation in a changing society. *Tropical resource management papers 32*. Wagneingen University and Research Centre, Wageningen.

Mortimore, M. 1978. Grain reserves at the village level in drought-prone areas of Nigeria. *The aftermath of the 1972-74 Drought in Nigeria. Proceedings of a Conference held at Bagauda, April 1977*: (Ed. G.J. van Apeldorn), pp. 220-226. Centre for Economic and Social Research, Ahmadu Bello University, Zaria.

Mortimore, M. 1989. *Adapting to dRought, Farmers, Famines and Desertification in West Africa*. Cambridge University Press, Cambridge, UK.

Mortimore, M. 1993. Northern Nigeria: land transformation under agricultural intensification. *Population and Land Use in Developing Countries. Report of a Workshop* (Eds. C.L. Jolly and B.B. Torrey). National Academic Press, Washington DC.

Mortimore, M. 1998. *Roots in the African Dust: Sustaining the Sub-Saharan drylands*. Cambridge University Press, Cambridge, UK.

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

Mortimore, M. and Tiffen, M. 2000. Promoting research-policy dialogues: lessons from four studies of dryland development in Sub-Saharan Africa', *Drylands Research Working Papers 41*. Drylands Research, Crewkerne.

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

Moss, R.P. 1969. The ecological background to land-use studies in tropical Africa, with special reference to the West. *Environment and land use in Africa* (Eds. M.F. Thomas and G.W. Whittington), pp. 193-240. Methuen, London.

Moss, R.P. and Morgan, W.B. 1977. Soils, plants and farmers in West Africa: Parts 1 and 2. *Human ecology in the tropics. Symposia of the Society for the Study of Human Biology* (Eds. J.P. Garlick and R.W.J. Keay), pp. 16: 27-77. London, Taylor and Francis.

Mustapha, A.R. and Meagher, K. 2000. Agrarian production, public policy and the State in Kano Region, 1900-2000. *Drylands Research Working Paper 35*. Drylands Research, Crewkerne, United Kingdom.

Niemeijer, D. and Mazzucato, V. 2002. 'Soil degradation in the West African Sahel: how serious is it?'. *Environment* 44/2: 20-31.

Prothero, R.M. 1959. *Migrant Labour from Sokoto Province, Northern Nigeria*, Government Printer, Kaduna.

Raynaut, C. 1997. *Sahels - Diversité et Dynamiques des Relations Sociétés-nature*. Editions Karthala, Paris.

Reij, C. and Steeds, D. 2003. *Success Stories in Africa's Drylands: Supporting Advocates and Answering Skeptics*, CIS/Centre for INternational Cooperation, Vrije Universiteit Amsterdam, Amsterdam.

Reij, C. and Thiombiano, T. 2003. *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 2001*, CIS,Vrije Universiteit Amsterdam, Amsterdam.

Reynolds, J.F. and Stafford Smith, D.M.E 2002. *Global desertification. Do humans cause deserts?* Dahlem University Press, Berlin.

Robbins, P.F., Abel, N., Jiang, H., Mortimore, M., Mulligan, M., Okin, G.S., Stafford Smith, D.M., and Turner, B.L.I. 2002. Desertification at the community scale. *Sustaining Dynamic Human-environment Systems. Global Desertification. Do Humans Cause Deserts*? (Eds. J.F. Reynolds and D.M. Stafford Smith), pp. 326-356. Dahlem University Press, Berlin.

Rouch, J. 1956. 'Migrations à Ghana', Journal de la Société des Africanistes, 26/33: 196-??????????

Sandford, S. 1994. Improving the efficiency of opportunism: New directions for pastoral development. In *Living with uncertainty. New Directions in Pastoral Development* (Editor name please), 174-182. Intermediate Technology Publications, London.

Scoones, I. (Ed.) 1994. *Living in Uncertainty. New Directions in Pastoral Development in Africa*. Intermediate Technology Publications, London.

Stebbing, E.P. 1935. The encroaching Sahara: the threat to the West African colonies. *The Geographical Journal* 88: 506-524.

Stebbing, E.P. 1953. *The Creeping Desert in the Sudan and Elsewhere in Africa 15 to 30 degrees latitude*. McCorqudale, Khartoum.

Swift, J. 1996. Desertification: narratives, winners and losers. In *The Lie of the Land. Challenging Received Wisdom in African Environmental Change and Policy* (Eds. M. Leach and R. Mearns), pp. 73-90. James Currey, Oxford.

Tiffen, M. 1976. *The enterprising peasant: Economic development in Gombe Emirate, North Eastern State, Nigeria, 1900-1968.* Her Majesty's Stationery Office, London.

Tiffen, M. 2003. Transitions in Sub-Saharan Africa: Agriculture, urbanisation and income growth. *World Development* (in press).

Tiffen, M. and Mortimore, M. 1994. Malthus controverted: The role of capital and technology in growth and environment recovery in Kenya. *World Development* 22/7: 997-1010.

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

Tomich, T.P., Kilby, P. and Johnston, B.F. 1995. *Transforming Agrarian Economies: Opportunities Seized, Opportunities Missed.* Cornell University Press, Ithaca.

UN 1994. *UN Earth Summit. Convention on Desertification. UN Conference on Environment and Development, Rio de Janeiro, Brazil, June 3-14, 1992. DPI/SD/1576.*, United Nations, New York.

UNEP 1977. *Report of the United Nations Conference on Desertification, 29 August - 9 September 1977. United Nations Environment Programme, Nairobi.*

UNEP 2003. *The Global Drylands Imperative: Increasing Capabilities through an Ecosystem Approach for the Drylands*. United Nations Environment Programme, Nairobi.

USAID 2002. *Nature, Wealth and Power. Emerging Best Practice for Revitalizing Rural Africa*. US Agency for International Development, Washington, DC.

Walker, T.S. and Ryan, J.G. 1990. *Village and Household Economies In India's Semi-arid Tropics.* Baltimore

The Johns Hopkins University Press.

Wall, J.R.D. (Ed.) 1979. The land resources of Central Nigeria: agricultural development possibilities. Vol 6B: the Kano Plains. *Land Resources Study 29.* Land Resources Development Centre, Tolworth, Surrey.

Warren, A. and Khogali, M. 1992. *Assessment of Desertification and Drought in the Sudano-Sahelian Region*, United Nations Sudano-Sahelian Office, New York.

Watts, M.J. 1983. *Silent Violence: Food, Famine and the Peasantry in Northern Nigeria.* University of California, Berkeley.

Zaal, F. and Oostendorp, R.H. 2002. 'Explaining a miracle: intensification and the transition towards sustainable small-scale agriculture in dryland Machakos and Kitui Districts, Kenya'. *World Development* 30/7: 1271-1287.