LAND DEGRADATION & DEVELOPMENT
Land Degrad. Develop. **13**: 449–459 (2002)
Published online in Wiley InterScience (www.interscience.wiley.com). **DOI**: 10.1002/ldr.532

LAND DEGRADATION IS CONTEXTUAL

A. WARREN*
Department of Geography, University College London, London, UK

Received 14 May 2002; Revised 8 July 2002; Accepted 14 August 2002

ABSTRACT

Land degradation cannot be judged independently of its spatial, temporal, economic, environmental and cultural context. Evaluations are therefore almost infinitely variable and very dynamic. These observations are examined in two contexts, first in two case studies. One, from the southern Levant, makes use of a long and well-documented history of environmental assessment that varied greatly between communities. The other, from contemporary Niger, shows finer scale differences among villagers. Second, the dynamic and multiple assessment of futures (sustainability) is illustrated with data from the same case study in Niger. In this wider context, multiplicity and dynamicity are largely a consequence of the choice of model of the environmental or social future. The usually positive difference between large-scale and finer scale assessments of degradation is dubbed the 'social delivery ratio'. Simplified systems of evaluation may be necessary for allocation, but they need to be treated with great caution if the argument here is accepted. Copyright © 2002 John Wiley & Sons, Ltd.

KEY WORDS: land degradation; sustainability; Levant; Negev; Sinai; Niger; dryland Africa

INTRODUCTION

Land degradation is examined in many ways: by biophysical scientists, by those who have to distribute funding for mitigation, by economists and political scientists and from the point of view of land users. From time to time its existence is questioned. The default assumption in almost all of these inquiries is that there is one, correct way of measuring of the problem, albeit contested.

The argument here, on the contrary, is that assessment is inevitably variable and dynamic because land degradation can only be judged in its spatial, temporal, economic and cultural context. The argument builds on ideas floated by Johnson and Lewis (1995), and the concerns of Rasmussen (1999). It is also a response to a new and harsher climate for environmentalists, of which Bjorn Lomborg's book (2001) is a symptom. Lomborg's analysis of land degradation is itself cursory and not well informed, but it is noteworthy that he too chooses a single measure of the problem. For him it is the rate of erosion. For all that, replies to Lomborg's kind of attack will require renewed rigour.

The argument here rests on the simple observation that the same biophysical change (say erosion) may have very different consequences in different contexts. If the erosion is of no consequence to production at a larger spatial scale, it does not contribute to degradation in the wider context. If it has no impact on future production, it is not degradation in the longer term. A change in an environment component that cannot be accessed with present technology or finance, or is inconsequential to a present way of life, does not, *per se*, amount to degradation.

The difficulties of establishing biophysical change and changes in methods of measurement themselves introduce dynamism and variability. Change cannot be fully confirmed (or denied) without the specification of a large set of conditions. These include the input conditions, both 'natural' and cultural (weathering, nutrients, soil, labour, etc.), their balance with outputs, the spatial units and pattern, the models that have been used to judge future

*Correspondence to: Prof. A. Warren, Department of Geography, University College London, 26 Bedford Way, London WC1H 0AP, UK. E-mail: a.warren@ucl.ac.uk

behaviour and, finally, the extent of that future. When the biophysical phenomena are then evaluated, dynamism and variability increase exponentially, for evaluation must be in terms of a particular component of the productivity or potential, the effect on the future of a specified group and the adoption of some model for that future.

I will examine two contexts for evaluation: on the ground with the land user; and the wider context, including national considerations and posterity (in other words, the context of sustainability).

MULTIPLE AND DYNAMIC APPRAISAL ON THE GROUND

The focus this paper is agriculture in dryland Africa. Although the first case study is drawn from elsewhere, it is not intended to distract from that focus.

Research into land degradation in dryland Africa has concentrated on two facets: nutrients and erosion. For each, there are pessimists and optimists. As to nutrients, the pessimists see a crisis (Breman *et al.*, 2001), (review by Sanchez, 2002). Much of peasant agriculture in Africa is said to be living on borrowed time: it is 'mining' nutrients that it does not replace. This view relies on research at the country level (Stoorvogel and Smaling, 1990) and on the farm (Van der Pol and Traoré, 1993). As to erosion, the pessimists rely on what evidence there is of high rates of erosion (for example UNEP, 1997). The Sahel has been dubbed a 'hot-spot' for soil erosion even by an authority who is generally an optimist about erosion (Crosson, 1997). The outcome of this kind of belief is a large number soil conservation projects in dryland Africa (Reij, 1989). Optimists point to cases where, despite (perhaps because of) increasing population, there have been increases in production (Tiffen *et al.*, 1993; Fairhead and Leach, 1996; Mortimore *et al.*, 2001; Niemeijer and Mazzucato, 2002).

Neither case is conclusive. The pessimistic case, as regards nutrients was attacked by Ian Scoones and Toulmin (1998), who pointed to problems with data. And, good though the science of soil erosion in the Sahel has been, it has not adequately sampled in space or in time for there to be firm conclusions (reviewed in Warren *et al.*, 2001a). This level of uncertainty is not surprising in the light of the acrimonious debate about the same issues in the United States, which has the most monitored and researched environment on earth (Trimble and Crosson, 2000a,b).

The pessimists rely on precise, biophysical definitions, such as budgets of particular nutrients, erosion rates or crop responses to either. Most of the indices are calibrated against small plot experiments. More sophisticated assessments rely on models of future behaviour, such as the EPIC model (Michels *et al.*, 1997), but most authorities who use these models acknowledge that they have severe limitations. Few of these indices consider the economic or social context, and few are scale-dependent, this last being the principal issue in the argument about erosion in the United States, mentioned above.

The optimists evade full assessment with two stratagems. One is to use increased production as an index of the absence of degradation. There is a useful discussion on this point in Niemeijer and Mazzucato (2002). Another stratagem is to take the land user's definition of degradation in preference to or as a check on that of the scientist (for instance Dahlberg, 2000). Problems can be found with both approaches. For example, increases in production may be masked by the input of fertilizers, but at rates that are themselves not sustainable. And there is the scale issue, discussed at length below. Land users' assessments seldom consider the wider national or global future, which are themselves subject to multiple and dynamic appraisal, as also discussed below.

Thus, scientific and academic approaches to land degradation in dryland farming in Africa have themselves produced many different appraisals, and the process itself has been dynamic.

Multiple and Dynamic Land Appraisal at Broad Cultural and Temporal Scales

Major differences between cultures are needed to demonstrate multiple and dynamic environmental appraisal. The differences are best seen in a marginal environment, and for convincing demonstration they should be well documented. All these criteria are met in the southern Levant.

Despite the diversity of agricultural systems, in 1962 the WMO believed it could produce a biophysical classification applicable to all rainfed agriculture in the Middle East (Wallén and Perrin de Brichambault, 1962; Figure 1). The classification is an early example of a centralized, unidisciplinary assessment of environmental

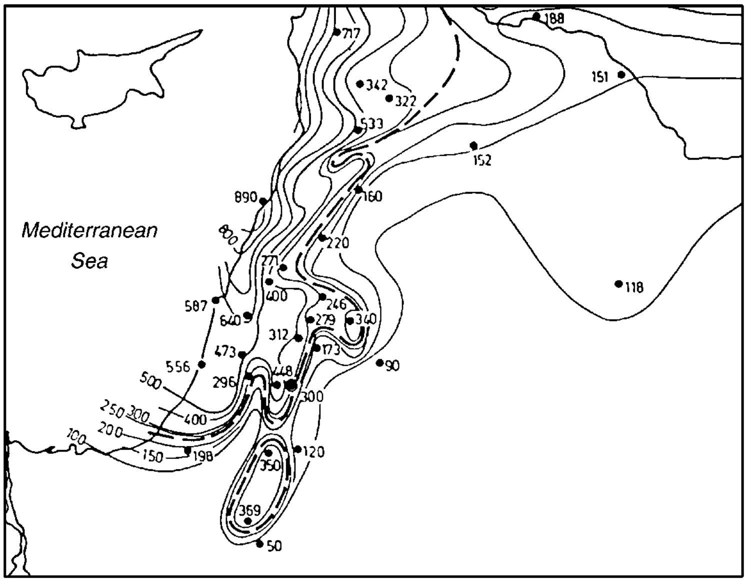

Figure 1. Detail from Wallén and Perrin de Brichambault's (1962) agrometeorological classification of the Middle East. The dashed line supposedly defines the limit of rainfed cultivation.

suitability, a precursor to the many other assessments that have followed, some mentioned below. In the present context, it is the hypothesis. It will be tested against the realities of rainfed agriculture in the region.

The WMO classification was based on an index that combined mean annual rainfall and its variability. A critical value of the index was used to define a line between 'the desert and the sown'. The line, which is shown in Figure 1, did indeed quite accurately delimit the 'sown' for rainfed agriculture by fellahin (settled cultivators), perhaps by design. It did so largely because of its emphasis on rainfall variability, for most fellahin at that time were sharecroppers who did not have the reserves to survive a run of dry years, since some 50 per cent of their crop went each year to their landlords (Firestone, 1975). Firestone's main conclusion, as it happens, is a caution against a simplistic economic interpretation of the sharecropping system in the first half of 20th century, and this complements the present argument. The sharecroppers and their landlords reacted to many other signals than money; in other words, even within this group evaluations were complex.

Holding to intercommunal scale for the moment, the crucial point here, in terms of the present argument is that there have been and still are successful systems of rainfed agriculture beyond the WMO limit (Figure 2). The first of these systems was that of the Nabbateans and the Israelites of Roman times, whose primary advantage was a technology for runoff agriculture. But their cropping of what was desert to the WMO depended also on slave labour and capital from their extensive trading networks. Michael Evenari and his colleagues (1971) were able to reproduce the ancient technology in their research project in the 1960s, but with no access to cheap labour, they could reclaim only a small fraction of the area that it had once served. Incidentally, Evenari's success lays to rest the notion that Nabbatean agriculture depended on a significantly different climate at the time when it operated (an idea first floated by Huntington in 1911). This is not to ignore the history of climatic change in this area, which will be discussed shortly, but only to infer from the successful recreation of the system that the climate has not changed significantly since the Nabbateans were in business.

The bedouin, today and in the past also, sow and less frequently reap barley from areas that are desert to the fellahin and the WMO. The bedouin can do this because they have many other sources of income to allow them to survive years without harvests (herds, salt and date production, smuggling, pilgrim caravans and so on).

Modern kibbutzim also have other resources that allow them to survive droughts in their rainfed fields, which also extend well beyond the WMO line. These resources come both from irrigated agriculture within the same enterprise, this being watered from the national water carrier from the north of Israel, and from foreign investment

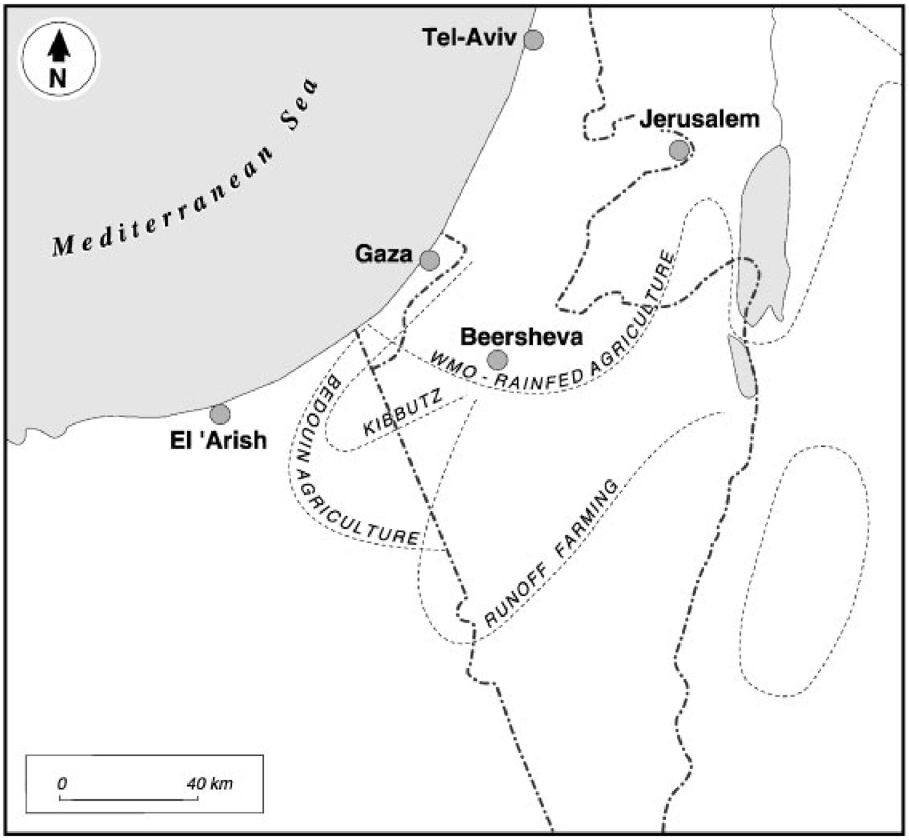

Figure 2. Different deserts in the southern Levant, as defined by different culturally determined limits of rainfed agriculture.

of various kinds. Their resolve to remain in this area is also bolstered by the political need to demonstrate their occupation and mastery of the desert, or to 'produce facts' (Ben Gurion, 1965).

Another contrast in environmental appraisals in this area, this time of the seminatural vegetation cover of grazing land (Warren and Harrison, 1984), is independent of WMO agroclimatology. For those for whom a decline in plant cover is a sign of desertification, the sharp decrease in vegetation cover across the Sinai/Negev border is a clear sign of degradation. A more informed view of grazing ecology, based on Noy-Meir's model (1978), would maintain that the higher standing biomass (production) on the Israeli side need not, and probably does not mean more productivity of grazable material. The less vegetated Sinai side of the border may even be more productive in grazing, and is certainly more productive of livestock, despite having less standing biomass. Yet another view, held by some wildlife conservationists, regards the better vegetated Israeli side of the border as an improvement on the lower vegetation it has replaced since 1949.

Some of the explanation of these differences in environmental appraisal are to do with the soil, which did not feature in the WMO system. Runoff farming needs slopes and soils that can form a crust readily, for example. However, quite as important in explaining the different appraisals were differences in scientific paradigms, technologies, sources and amounts of capital, attitudes to risk, ideologies, social formations, teleologies, and political and social objectives (Figure 2). The marginality of the area enhances the contrasts.

Appraisal, moreover, has been dynamic, for the social environment has been dynamic. The natural environment has also been dynamic, as is now being demonstrated with new dating techniques (Rendell *et al.*, 1993). The climatic changes in the past as revealed by these studies, or in the future (which they can be used to infer), might have brought or might yet bring degradation to some people, but improvement to others, depending on its nature.

Lavee *et al.* (1998) speculated about the effects of such change. A climate with less rainfall, they believed, would be accompanied by more runoff, largely because bare, vegetation-free surfaces develop crusts that shed more of incoming rainfall than do the vegetated surfaces of wetter climates. Thus the fellahin would suffer from such a change because the crops on their hillside fields would suffer from less rainfall. But runoff farmers might find increased prosperity, because the hillsides would shed more water onto their valley-bottom fields. The bedouin and kibbutzim might be unaffected, since there is little runoff on the sandy or level loessic land that they cultivate.

Cultural complications were not anticipated in the WMO study. It was frustrated by the intricacy of social and technical appraisal in the southern Levant, as similar intricacies continue to frustrate more recent classifications in this and other parts of the world. It is failures in assessment like these that fuel the arguments of people like Lomborg.

Multiple and Dynamic Appraisal at a Finer Scale

Multiplicity and dynamicity at a finer scale (household or even within-household) is illustrated by our own study of Fandou Béri in Niger. The details of our methods and a discussion of their limitations are given in Warren *et al.* (2001a,b). Our measurements of soil erosion (mostly by wind) showed the rate to be higher than was predicted by some of the models that had been used to dub the Sahel a 'hot spot' for soil erosion (see above).

More important in this argument, the rate of erosion bore a complex relationship to household characteristics. The comparison of erosion rates, field by field, with social data (Warren *et al.*, 2001a), shows that many of the fields with the highest rates of erosion are worked by households that have many options, both agricultural and off-farm (chiefly petty trading, Batterbury, 2001). These households in the main cultivate many fields, having the labour both to clear and plant. If they lose some of the crop, from whatever cause, they can rely on other resources. They believe the causes more usually to be drought and pest attack than erosion, although it is difficult, if not impossible to disaggregate the causes of loss. Disaggregation might be possible in an extensive and lengthy agronomic experiment, but one has yet to be undertaken. Thus to these households, soil erosion is an inconsequential, incidental effect, except for occasional short-term effects as in sand-blast and the exposure or burial of seedlings (this issue is given fuller treatment in Warren *et al.*, 2002, and Osbahr and Allen, 2002). These findings tally with those of Bielders *et al.* (2001), who found that farmers in this area put wind erosion low on their list of problems.

Households with fewer options are more cautious. These include some Peulh households (a minority ethnic group), who have less land security, and Djerma households (from the majority ethnic group) with fewer fields or fewer male members than those discussed above. Our measurements show that many of the fields of households like these suffer less erosion, probably because they are better manured and planted with more care. This two-part categorization of farming households is, of course, a simplification, but is justified by our data. (Batterbury, 2001; Osbahr, 2001)

A further complication in assessing degradation in Fandou Béri arises from another risk-spreading strategy. Because rainfall can be highly variable in space and time, farmers prefer to plant a number of widely spaced fields, so that at least one catches the rain. They also chose to plant fields on different soils. A crop may succeed on one kind of soil in a wet year, but on another soil in a dry year. The same quantity of erosion might affect overall yield if it jeopardized this strategy, but might have no effect if it left it still possible.

Variability and dynamicity are therefore characteristic of the effective evaluation of land degradation within a community. Indeed, they are indispensable to survival. To extend the list of variables that determine differential judgement which have been given in the Middle Eastern example, evaluation of land degradation at Fandou Béri depends also on age, gender, education, ethnicity and many other factors. There is no single 'scientific', nor indeed a single indigenous, judgement of land degradation in the village, just as there is no unique assessment for a region like the Middle East, or the Sahel.

This needs emphasis: our study was of only one village where the soil, in the eyes of most of the farmers, does not have a high capital value, for it does not produce many marketable crops. It is true that there are very many more villages in which soil resources are probably viewed in much the same way; there are certainly many more in the same rainfall belt and with very similar soils (Grove and Warren, 1968). But there are also many others where soil loss is much more economically destructive, or where the soils are more vulnerable such as in the Burkinabé villages studied by Leslie Gray (1999). There are many more combinations of the variables across the Sahel (Raynaut, 1997), to say nothing of dryland Africa as a whole. The results of our study cannot be interpreted as an argument against soil conservation, even in Fandou Béri. The case study has no more function here than to show how the evaluation of land degradation at the household scale is contextual, and therefore variable and dynamic.

Land Degradation and Scale: the 'Social Delivery Ratio'

A further implication our findings at Fandou Béri is that land degradation occurs in a fine scale pattern: its impact varies more from field to field than from village to village, let alone from region to region. Even within a field there can be very large differences in impact. The same was found in Lars Krogh's study (1997) of soil nutrients in northern Burkina Faso. Yet most of the studies that have deduced the absence of degradation from data on increased production have done so for whole districts, like Machakos in Kenya (Tiffen *et al.*, 1993), or of whole countries, like Burkina Faso (Niejmeijer and Mazzucato, 2002). If the pattern is finer, these studies may be glossing over the effects of small patches of degradation, burying the consequences of degradation in small parcels in statistics dominated by the performance of farms that may be few in number, but on which the successes are great. In Machakos, Murton (1999) found a much more patchy picture of improvement than had the earlier broader brush study of Tiffen *et al.*

This phenomenon could be called the 'social delivery ratio' comparable to the phenomenon known in biophysical studies of erosion as the sediment delivery ratio, whereby erosion rates are always smaller in bigger areas (Walling, 1983). The 'social delivery ratio' is the result of the masking of the effects of degradation in a few fields or households by the wider success of an agricultural system. The social delivery ratio probably has different values in different situations and applies in the temporal as well as the spatial sense: degradation in the short term may not add up to degradation in the long term. These observations move the argument to the larger context.

WIDER CONTEXTS: SUSTAINABILITY

Scale is crucial. In the spatial dimension, degradation for a farmer need not be degradation for the community. Degradation of a field need not be degradation in the village.

But as to the temporal scale, the scale of 'land degradation' should be restricted. Land degradation does not occur if one crop is lost, or even one herd. If restriction of the temporal scale to the medium and long term is accepted, ideas about land degradation mesh easily with those about sustainability, which also has long time and large spatial horizons. Land degradation is an assault on sustainability. And, as such, land degradation is part of a much larger discussion, for sustainability is now an obsession in environmental thinking about the developing world (Adams, 2001). Recently, the literature of sustainability has brought some valuable ideas to the understanding of land degradation.

The concept of sustainability has attracted heavy criticism when used in the term 'sustainable development' (Sneddon, 2000), but in its simpler form it still has some credibility (Redclift, 1999). Sustainability is probably inescapably value-related and incapable of precise definition (Pretty, 1994), in which case it is not only a scale that ideas of sustainability share with those of land degradation. There are many models of sustainability, a well-known one being the 'capitals framework' (Serageldin, 1996). It is an attempt to introduce practical criteria, and for all its faults it has been adopted by many development agencies such as in the UK Department for International Development's Sustainable Livelihoods Programme (Carney, 1998, 1999).

In brief, the capitals framework proposes that rural communities make their living out of different types of capital. Serageldin (1996) proposed four: natural, social, human and human-made capitals. Others have different lists. The framework's greatest contribution in the present discussion is to steer the sustainability debate away from an obsession with the biophysical environment. It acknowledges that resource-using systems cannot continue to function unless the environment is induced to continue to yield wealth by a social system that remains viable. There must be environmental sustainability as well as social sustainability.

Sustainability at the Local Scale

Some more of our findings at Fandou Béri place these ideas in the present argument.

In the capitals framework, two kinds of model of the future are needed: environmental and socio-economic. Figure 3 is the basis for a model of the one of the elements of the 'natural capital' of the village (its soils). It shows that the most extensive of the cultivated soils, the tassi (sandy soils or arenosols), are probably deep enough to survive the prevailing rate of erosion (and even moderate increases) for a very long time. It must be stressed that the diagram is speculative, but it does conform to what is known about the surficial geology of the area (Bergoeing and Dorthe-Monachon, 1997).

The future of 'social capital' component is more problematical. The land-use system has been and is very dynamic, even more dynamic than in the Middle Eastern case study discussed above. If we follow present trajectories, we would predict that in just a few years farming will be more intensive and therefore based on a smaller area and that there will be much more investment in livestock (which brings better income than crops). Most of the tassi fields that are now being lost to erosion would play no part in these new economies. The conclusion, if we accept these models, is that the conservation of most of the sandy soils would be irrelevant to sustainability.

More field research at Fandou Béri, as in other areas, might be able to narrow the environmental options, by producing better models of the behaviour of the erosional system or of the nutrient budget, but they would always be subject to large uncertainties. The modelling of the future of the social and economic system is likely to be yet more uncertain, for not only does each individual, household or community have its own model of the future, but these models will change over time, as the social system itself changes. There have been some attempts at modelling at the village scale (Barbier, 1998; Lu and Stocking, 2000), and although there is clearly a future for this approach, models are unlikely ever to be able to include more than a few components of these very complex systems, and they will seldom apply to more than a few agricultural systems in a vast array. Huge uncertainties will undoubtedly remain.

Sustainability in National or Global Context

Judgement of degradation at the national or global scales also depends on models of the future, either biophysical or social. In the biophysical domain, the modelling of national nutrient budgets has already been mentioned above. There are also some larger scale models of soil erosion (Drake *et al.*, 1999), but most are in early stages of development. At temporal scales above the decadal or greater, climate-change models are also appropriate, but these are even more subject to uncertainty (Hulme, 2001). Of the modelling of socio-economic systems in dryland Africa, I know little beyond the West Africa Long-Term Perspective Study (WALPTS) of the OECD (Cour, 2001). WALPTS predicts a very much more urbanized West Africa in the early 21st century, with much more capitalized, and more intensified agricultural systems near the cities, which, as at Fandou Béri, will probably produce more from smaller areas on only the better soils. It is not difficult to imagine the uncertainties in these models, caused by political change if nothing else.

Moreover, the models themselves will change. They will be accepted by some national bodies, but not by others, according to national circumstances (for example, the degree of dependency on agriculture). The determinants of these choices will also change. National societies differ in their ability to absorb degradation: more organized societies absorb it more easily, as in shown by the response to the progressive salinization of land in ancient Mesopotamia or a sequence of droughts on the Great Plains (Bowden *et al.*, 1981). In more organized, better-buffered societies, biophysical changes have less impact. In the Levant, the example discussed above, the Ottoman, British Mandate, Israeli, Egyptian and Palestinian states have had very different views of the land degradation. The Ottoman state was indifferent. The Mandate occurred at a time when there was worldwide environmental concern after the Mid-Western Dust Bowl (Anderson, 1984) and this was reflected in some of the Mandate's environmental policies (Lowdermilk, 1944). The succeeding Israeli state sees environmental conservation as vital. These observations are the larger scale corollary of our finding at Fandou Béri that those with more options have a more relaxed view of degradation.

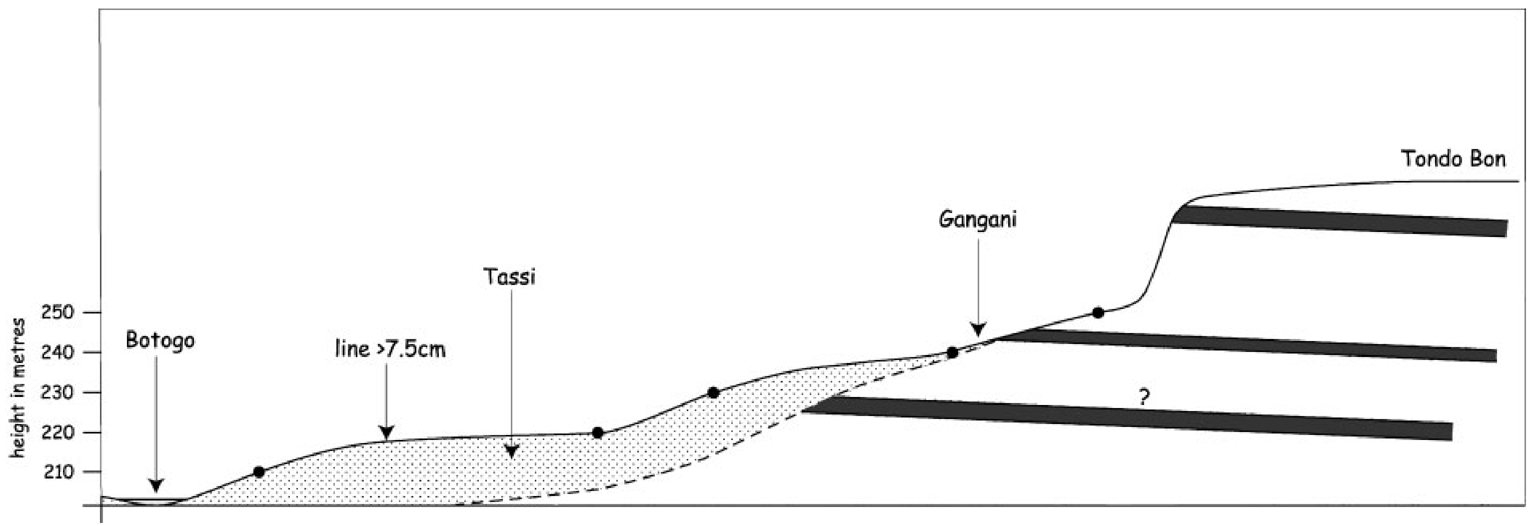

Figure 3. A model of long-term land degradation at Fandou Béri, in southwestern Niger, showing the soils and surface deposits. The model shows the apparently great ‘supply’ (depth) of sandy *tassi* soil compared to the rate at which it is being eroded (the thickness of the line is proportionately greater than the amount of soil lost over 30 years). *Botogo* is clayey soil in hollows; *gangani* soil is clay-rich soil revealed by erosion of the *tassi*; *tondu bon* is thin soil over ferricrete horizons (themselves shown as the bands of dark shading).

In brief, the judgement of land degradation at a large scale is as subject to dynamicity and multiplicity of judgement as is its assessment at the finer scale. It is for this larger scale that institutions have to develop a policy for evaluation. For this they need indicators for the allocation of resources to environmental protection. What has been said above signals that, necessary as they may be, simplified indicators should be treated with great care. If allocation is to be effective, the organizations which are responsible, such as the Convention to Combat Desertification (the CCD), will have to face a reality that is much more variable and dynamic than they have acknowledged. The scale, both spatial and temporal, at which these assessments is made needs explicit statement.

DISCUSSION

The argument here has been based mainly on agricultural communities, and, despite the excursion into the Middle East, also on dryland Africa. It is, nonetheless, intended to be general. It should apply as well, for example, to pastoral communities in Africa, where there has been an even more radical shift in the appraisal of degradation (summarized in Warren, 1995), yet where the assumption of unique systems of evaluation still underlies most studies. But as a pastoral economy moves from subsistence to commercial production, resources take on new meanings. Resources that were once vital are no more so; ones that were marginal may become more valuable. What was not land degradation before may become so, and vice versa. New social arrangements as, for example, communal management, group or individual ranches, are each associated with different appraisals of the resource and of its degradation, or improvement than were older systems. Different ideas of the future and new time horizons have the same effects. The relationships of categories are never fixed here or anywhere else.

CONCLUSIONS

- Environmentalism in general, ideas about land degradation in particular, and the CCD in even more particular, have been jeopardized by weak arguments about the basis of their environmental appraisal, and can only survive in the new more competitive green political environment if they are much more rigorous.
- One of the weak arguments is the idea that there are simple, universal systems of judging land degradation. Lal *et al.*'s calls (1989) for precise criteria, or criteria based on economic performance are in vain. The evaluation of land degradation cannot be reduced to nutrient budgets, soil depth, soil water holding capacity, to economics or to politics.
- This is not to say that these issues are not part of the processes of degradation and its appraisal, or that land degradation does not occur, or that it is impossible to assess. Present methods for estimating land degradation could be as well underestimating as overestimating the problem.
- Assessment is almost infinitely variable, and very dynamic. The only valid assessment is by those who may suffer the consequences, now or later, a conclusion that is close to Julian Pretty's judgements about sustainability (1994).
- Land degradation probably always occurs at a fine spatial scale, so that it is difficult to detect at district or country scales. A new term, 'social delivery ratio' is suggested to describe the way in which the effects of fine-scale degradation are buried in the statistics for larger areas. This, in turn, suggests that many surveys of land degradation have probably been too broad brush to detect degradation.
- Assessments have been concentrating on general rates of processes, where effort might be better spent in looking for systems near a threshold of change. The work of Lavee *et al.* (1998), discussed above, suggests that there may be one such environmental threshold in the Levant.
- Many factors influence the judgement of degradation. In very general terms, land degradation matters less to individuals, households, communities or states with more options. Land degradation is of more consequence to constrained economies.
- The assessment of land degradation depends largely upon models of environmental and social and economic change, which apart from themselves changing, are variably appropriate in different circumstances.

- The argument here raises problems for the development of systems of assessment for the distribution of scarce resources (which must underlie policy). That is another and much longer discussion, but it can be said here is that these systems should be administered by people who have a firm grasp of their limitations, in other words an awareness of the real, and large problems in judging land degradation.

ACKNOWLEDGEMENTS

Some of the ideas in this paper first appeared in a presentation to the International Workshop: Implementing the United Nations Convention to Combat Desertification (CCD)—Past Experience and Future Challenges, 26–27 February 2002, at Skjoldenæsholm in Denmark, financed by the Danish Foreign Ministry. It has been published as Warren (2002). The meeting was organized by Dr Henrik Secher Marcussen and Ivan Nygaard at the Department of Geography and International Development Studies, Roskilde University, and Annette Reenberg at the Institute of Geography in Copenhagen. I would like to thank all these bodies and individuals for their assistance, and also the other participants at the workshop, who will see that I have now incorporated much of our discussion in this paper. I also thank my colleagues Simon Batterbury, Adrian Chappell and Henny Osbahr for their contributions to the study of Fandou Béri.

REFERENCES

Adams WM. 2001. *Green Development II.* Routledge: London.

Anderson DM. 1984. Depression, dust bowl, demography and drought: the colonial state and soil conservation in East Africa. *African Affairs* **83**(332): 321–343.

Barbier B. 1998. Induced innovation and land degradation: results from a bioeconomic model of a village in West Africa. *Agricultural Economics* **19**(1–2): 15–25.

Batterbury SPJ. 2001. Landscapes of diversity: a local political ecology of livelihood diversification in southwestern Niger. *Ecumene* **8**(4): 437–464.

Ben Gurion (and Pearlman M). 1965. *Ben Gurion Looks Back in Talks with Moshe Pearlman.* Weidenfeld and Nicolson: London.

Bergoeing J-P, Dorthe-Monachon C. 1997. Etude préliminaire de la morphologie du site Salt-Hapex-Sahel, Niger, 1995. *Zeitschrift für Geomorphologie* **41**(4): 505–518.

Bielders CL, Alvey S, Cronyn N. 2001. Wind erosion: the perspective of grass-roots communities in the Sahel. *Land Degradation & Development* **12**(1): 57–70.

Bowden MJ, Kates RW, Kay RW, Riebsame WE, Warrick RA, Johnson DL, Gould HA, Weiner D. 1981. The effect of climate fluctuations on human populations: two hypotheses. In *Climate and History*, Wigley TML, Ingram MJ, Farmer G (eds). Cambridge University Press: Cambridge; 479–513.

Breman H, Groot JJR, Van Keulen H. 2001. Resource limitations in Sahelian agriculture. *Global Environmental Change—Human and Policy Dimensions* **11**(1): 59–68.

Carney D (ed.). 1998. *Sustainable Rural Livelihoods: What Contribution Can We Make*? Department for International Development: London.

Carney D. 1999. Approaches to sustainable livelihoods for the rural poor. Poverty Briefing 2. Overseas Development Institute (ODI): London. http: //www.odi.org.uk/briefing/pov2.html.

Cour J-M. 2001. The Sahel in West Africa: countries in transition to a full market economy. *Global Environmental Change—Human and Policy Dimensions* **11**(1): 31–47.

Crosson PR. 1997. Will erosion threaten agricultural productivity? *Environment* **39**(8): 4–31.

Dahlberg AC. 2000. Interpretations of environmental change and diversity: a critical approach to indications of degradation—the case of Kalakamate, northeast Botswana. *Land Degradation & Development* **11**(6): 549–562.

Drake NA, Zhang X, Berkhout E, Bonifacio R, Grimes D, Wainwright J, Mulligan M. 1999. Modelling soil erosion at global and regional scales using remote sensing and GIS techniques. In *Advances in Remote Sensing and GIS Analysis*, Atkinson PM, Tate NJ (eds). Wiley: Chichester; 241–261.

Evenari M, Shanan L, Tadmor N. 1971. *The Negev: The Challenge of a Desert*. Harvard University Press: Cambridge, MA.

Fairhead J, Leach M. 1996. Rethinking the forest-savanna mosaic. In *The Lie of the Land: Challenging Received Wisdom on the African Environment*, Leach M, Mearns R (eds). Heinemann/James Currey: London; 105–121.

Firestone Y. 1975. Crop-sharing in Mandatory Palestine. *Middle Eastern Studies* **11**(1): 3–23; (2): 175–194.

Gray LC. 1999. Is land being degraded? A multi-scale examination of physical measurement and social explanations from western Burkina Faso. *Land Degradation & Development* **10**(4): 329–343.

Grove AT, Warren A. 1968. Quaternary landforms and climate on the south side of the Sahara. *Geographical Journal* **134**(2): 194–208.

Hulme M. 2001. Climatic perspectives on Sahelian desiccation: 1973–1998. *Global Environmental Change—Human and Policy Dimensions* **11**(1): 19–30.

Huntington E. 1911. *Palestine and Its Transformation.* Constable: London.

Johnson DL, Lewis LA. 1995. *Land Degradation.* Blackwell: Oxford.

Krogh L. 1997. Field and nutrient balances in millet cultivation in northern Burkina Faso: a village level case study. *Journal of Arid Environments* **35**(6): 147–159.

Lal R, Hall GF, Miller FP. 1989. Soil degradation. I. Basic processes. *Land Degradation & Rehabilitation* **1**(1): 51–69.

Lavee H, Imeson AC, Sarah P. 1998. The impact of climate change on geomorphology and desertification along a Mediterranean arid transect. *Land Degradation & Development* **9**(5): 407–422.

Lomborg B. 2001. *The Sceptical Environmentalist.* Cambridge University Press: Cambridge.

Lowdermilk WC. 1944. *Palestine, the Land of Promise.* Gollancz: London.

Lu Y, Stocking M. 2000. Integrating biophysical and socio-economic aspects of soil conservation on the Loess Plateau, China. Part III: the benefits of conservation. *Land Degradation & Development* **11**(2): 153–165.

Michels K-H, Potter K, Williams JR. 1997. Simulation of wind erosion damage to pearl millet in West Africa using EPIC. In *Abstracts: Wind Erosion, an International Symposium*, 2–5 June, Skidmore E, Tatarko J (eds). Wind Erosion Research Unit: Manhattan, KA; 21.

Mortimore M, Tiffen M, Boubacar Y, Nelson J. 2001. Synthesis of long-term change in Maradi department, Niger, 1960–2000. Drylands Research Working Paper, 39e. Drylands Research: Crewkerne.

Murton J. 1999. Population growth and poverty in Machakos District, Kenya. *Geographical Journal* **165**(1): 37–47.

Niemeijer D, Mazzucato V. 2002. Soil degradation in the West African Sahel: how serious is it? *Environment* **44**(2): 20–31.

Noy-Meir I. 1978. Grazing and production in seasonal pastures: analysis of a simple model. *Journal of Applied Ecology* **15**(3): 809–835.

Osbahr H. 2001. Livelihood strategies and soil fertility at Fandou Béri, southwestern Niger PhD thesis. University College London: London.

Osbahr H, Allen C. 2002. Soil management at Fandou Béri. SW Niger: ethnopedological frameworks and soil fertility management. *Geoderma Special Publication on Ethnopedology* (In press).

Pretty JN. 1994. Alternative systems of inquiry for a sustainable agriculture. IDS Bulletin, 25. Institute for Development Studies, University of Sussex: Brighton; 37–48.

Rasmussen K. 1999. Land degradation in the Sahel-Sudan: the conceptual basis. *Danish Journal of Geography, Special Issue* **2**: 151–160.

Raynaut C (ed.). 1997. *Societies and Nature in the Sahel.* Simon D, Koziol H (trans). Routledge: London.

Redclift M (ed.). 1999. *Sustainability: Life Chances and Livelihoods*. Routledge: London.

Reij C. 1989. *L'etat actuel de la conservation des eaux et du sol au Sahel*. Comité permanente inter-états pour la Lutte contre la Sécheresse au Sahel (CILSS)/Organization for Economic Co-operation and Development (OECD)/Club du Sahel: Paris; D(89) 329.

Rendell HM, Yair A, Tsoar H. 1993. Thermoluminescence dating of periods of sand movement and linear dune formation in the northern Negev, Israel. In *The Dynamics and Environmental Context of Aeolian Sedimentary Systems*, Pye K (ed.). Special Publication 72. Geological Society: London; 69–74.

Sanchez PA. 2002. Soil fertility and hunger in Africa. *Science* **295**(5562): 2019–2023.

Scoones I, Toulmin C. 1998. Soil nutrient budgets and balances: what use for policy. *Agriculture, Ecosystems and Environment* **71**(1–2–3): 255–268.

Serageldin I. 1996. Sustainability and the wealth of nations: first steps in an ongoing journey. Environment and Sustainable Development Studies, Monograph Series 5. World Bank: Washington, DC.

Sneddon SC. 2000. 'Sustainability' in ecological economics, ecology and livelihoods: a review. *Progress in Human Geography* **24**(4): 521–549.

Stoorvogel J, Smaling E. 1990. Assessment of soil nutrient depletion on sub-Saharan Africa, 1983–2000. Report 28. The Winand Staring Centre for Integrated Land, Soil and Water Research: Wageningen.

Tiffen M, Mortimore M, Gichuki F. 1993. *More People, Less Erosion: Environmental Recovery in Kenya*. Wiley: Chichester.

Trimble SW, Crosson P. 2000a. U.S. soil erosion rates: myth and reality. *Science* **289**(5477): 248–250.

Trimble SW, Crosson P. 2000b. Measurements and models of soil loss rates: response. *Science* **290**(5495): 130.

United Nations Environment Programme (UNEP). 1997. *World Atlas of Desertification*, 2nd edn. Arnold: London.

Van der Pol F, Traoré B. 1993. Soil nutrient depletion by agricultural production in southern Mali. *Fertilizer Research* **36**(1): 79–90.

Walling DE. 1983. The sediment delivery problem. *Journal of Hydrology* **65**(1–3): 209–237.

Wallén CC, Perrin de Brichambault G. 1962. *A Study of Agrometeorology in Semi-arid and Arid Zones of the Near East.* Interagency Project on Agrometeorology, Food and Agriculture Organization of the United Nations (FAO)/United Nations Educational. Scientific and Cultural Organization (UNESCO)/World Meteorological Organization (WMO): Geneva.

Warren A. 1995. Changing understandings of African pastoralism and environmental paradigms. *Transactions of the Institute of British Geographers* NS **20**(2): 193–203.

Warren A. 2002. Can desertification be simply defined? In *CCD: Implementing the United Nations Convention to Combat Desertification. Past Experience and Future Challenges*, Markussen HS, Nygaard I, Reenberg A (eds). SEREIN Occasional Paper, 14. Sahel-Sudan Environmental Research Initiative, University of Copenhagen: Copenhagen; 19–46.

Warren A, Harrison CM. 1984. People and the ecosystem: biogeography as a study of ecology and culture. *Geoforum* **15**(3): 365–381.

Warren A, Batterbury SPJ, Osbahr H. 2001a. Soil erosion in the Sahel of West Africa: a review of research issues and an assessment of new approaches. *Global Environmental Change—Human and Policy Dimensions* **11**(1): 79–95.

Warren A, Batterbury SPJ, Osbahr H. 2001b. Sustainability and Sahelian soils: evidence from Niger. *Geographical Journal* **167**(4): 324–341.

Warren A, Osbahr H, Batterbury S, Chappell A. 2002. Indigenous appraisal of soil erosion at Fandou Béri, southwestern Niger. *Geoderma, Special Issue on Ethnopedology* (In press).

