

**Overestimating land degradation, underestimating
farmers in the Sahel**

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INTRODUCTION

Ever since the 1930s, it has been claimed that African farmers are degrading their land: first because of shifting cultivation, later because population growth brought about “overcultivation”. During the 1990s, the idea that Africa could be heading for environmental disaster was strongly voiced in reports from a number of international organizations. For instance, a recent FAO report notes that the annual deforestation rate in the period 1990-1995 was 0.7% for Africa, which is over twice the world average (FAO 2000). Drawing from data from the GLASOD project¹, an IFPRI discussion paper recently stated that as much as 65% of Africa’s agricultural land is degraded (Scherr 1999), while the UNEP Atlas of Desertification (UNEP 1997), drawing from the same data, holds that almost 30% of the Sahel is affected by human-induced soil degradation. For about half of this area soil degradation is said to be moderate to extreme. Smaling *et al.* (1997) argue that strongly negative N, P, and K balances demonstrate that “soil fertility in Africa is at stake”.

This issue paper is based on a 4-year study in eastern Burkina Faso. It has been estimated that between the mid 1950s and the mid 1990s, 40% of the natural woody vegetation cover had been destroyed (Parkan 1986). A map by Somé *et al.*, from 1992 suggested that as much as 75% of Burkina Faso was suffering from important to very severe land degradation, while a widely quoted FAO-sponsored soil nutrient budget study (Stoorvogel and Smaling 1990) estimated annual nutrient deficits for 1983 of 12 kg ha⁻¹ for potassium (K₂O), 14 kg ha⁻¹ for nitrogen (N), and 4 kg ha⁻¹ for phosphorus (P₂O₅). If these and other reports are to be believed, land degradation is rampant in Africa and in particular in Sahelian countries, such as Burkina Faso.

High rates of population growth coupled with widespread poverty and a lack of agricultural intensification are widely claimed as responsible for land degradation (Bationo *et al.* 1998; Breman 1998; Cleaver and Schreiber 1994; Gruhn *et al.* 2000; Kessler *et al.* 1995; MFP 1993; Vierich and Stoop 1990). In Burkina Faso, the population has more than doubled in the last 40 years, and average rural population densities can reach over 80 inhabitants per square kilometre in some provinces, making it one of the most densely populated countries in the West African Sahel. Burkina Faso is also one of the world’s 14 poorest countries in terms of its GNP per capita estimated at US \$240 in 1998 and with 65% of its rural population below the poverty line (World Bank 1999, 2000). Finally, use of modern agricultural technology is very low. Annual

¹ Global Assessment of Human-Induced Soil Degradation; an expert based assessment on worldwide soil degradation (for details see Oldeman *et al.* 1991).

fertilizer consumption in 1994 was just 7 kg per hectare of cropland (mainly used on commercial crops such as cotton) compared with a developing world average of 89 kg (World Resources Institute 2000). Almost 80% of all cultivated plots are tilled by hand or not at all (MARA 1996).

These characteristics, thought to be harbingers of land degradation in Burkina Faso (as in much of Africa), make the doom and gloom reports compelling. But recent academic studies (e.g., Fairhead and Leach 1996; Leach and Mearns 1996; Tiffen *et al.* 1994) question such interpretations and assumptions. Though the importance of these studies and their strong empirical roots are widely acknowledged, doom studies still appear to dominate current agricultural and environmental policies, probably because they are often based on what are perceived to be “hard facts” derived from remote sensing, GIS, and computer models.

This issue paper will explore the evidence for land degradation in Burkina Faso to question whether local farming practices are indeed as unsustainable and environmentally destructive as many reports suggest. It begins with a short discussion of land degradation. Next, a quantitative analysis of agricultural productivity and soil fertility is presented to investigate the evidence for land degradation. This is followed by a discussion of local land management practices and social networks, and how they may contribute to sustainability and productivity. The paper ends with a short conclusion.

LAND DEGRADATION DEFINED

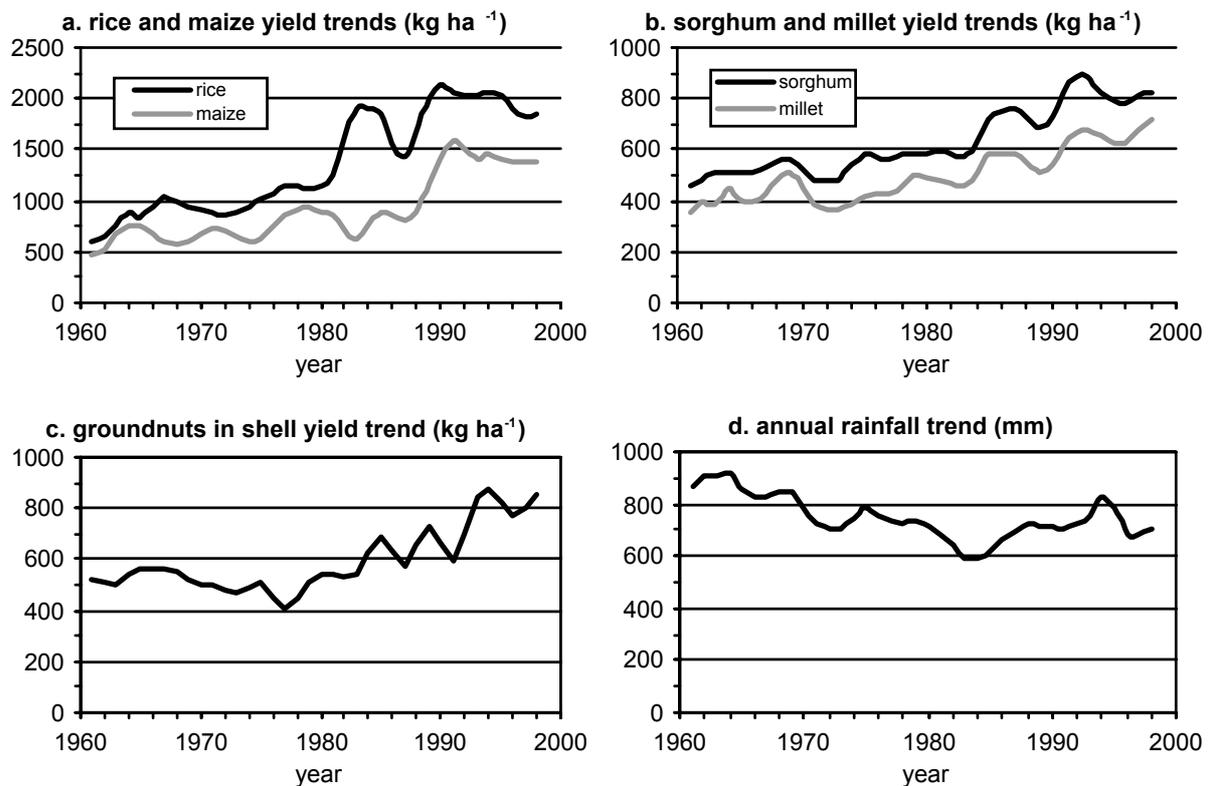
There are many definitions of land degradation, but most of them essentially refer to a loss in productivity of the land (Blaikie and Brookfield 1987). This implies that in order to measure land degradation it is not enough to establish changes in the condition of land, but also necessary to ascertain a causal link between those changes and a decline in productivity of the land. This is not so easy, because productivity is affected by many factors other than land quality (e.g., rainfall, labour, and technology), while changes in land may not always lead to a productivity decline. Due to the inter-dependent nature of land and its productivity, it is necessary to base claims of land degradation on multiple, complementary proxies that include measurements of land (e.g., soil, water and vegetation) properties as well as productivity indicators (Mazzucato and Niemeijer 2000b).

PRODUCTIVITY OF AGRICULTURAL LAND

Detailed estimates of productivity loss caused by land degradation are hard to find. Scherr (1999) summarizes several global studies that provide productivity loss estimates for Africa. For cropland these are in the order of 0.5 - 1% per year and would suggest a productivity loss of at least 20% over the last 40 years compared with a situation without soil degradation.

However, in Burkina Faso, as Figure 1 shows, yields of the major crops do not appear to have declined over the last forty odd years, despite a general downward rainfall trend since the late 1950s. By contrast, there is evidence of a yield increase. This can in part be attributed to a slight reversal of the downward rainfall trend since the mid 1980s and, in the case of maize and rice, to increased irrigation, mechanisation, and fertiliser use in some parts of the country. For sorghum, millet, and groundnuts, the yield increase is more moderate and steady. It can hardly be attributed to increased use of external inputs, because these crops receive little fertiliser and are largely based on hand hoe cultivation. Even taking into account the poor quality of national level data, it appears unlikely that the productivity of the land has significantly declined over the last few decades. These figures prompt a number of questions, given the widespread belief that population growth has led to overexploitation. They warrant a closer look at the relation between population pressure and agricultural productivity.

Figure 1. Yield trends for Burkina Faso (1961-1998)



Source: Figure 5.5 in Mazzucato and Niemeijer (2000b)

For this purpose a spatial analysis was conducted of agricultural productivity and population density, whereby the relation was examined between agricultural productivity and population density across Burkina Faso's 30 provinces (for a detailed discussion of the methods used see Mazzucato and Niemeijer 2000b). Agricultural productivity was calculated as the total energetic value per hectare produced by all major food crops (millet, sorghum, maize, rice, fonio, cowpeas, Bambara groundnuts, yam, sweet potato, groundnuts, sesame and soybeans). These figures were compared with provincial data conceiving pressure on natural resources, technology use, and the environment (see Table 1 for a detailed list of included factors).

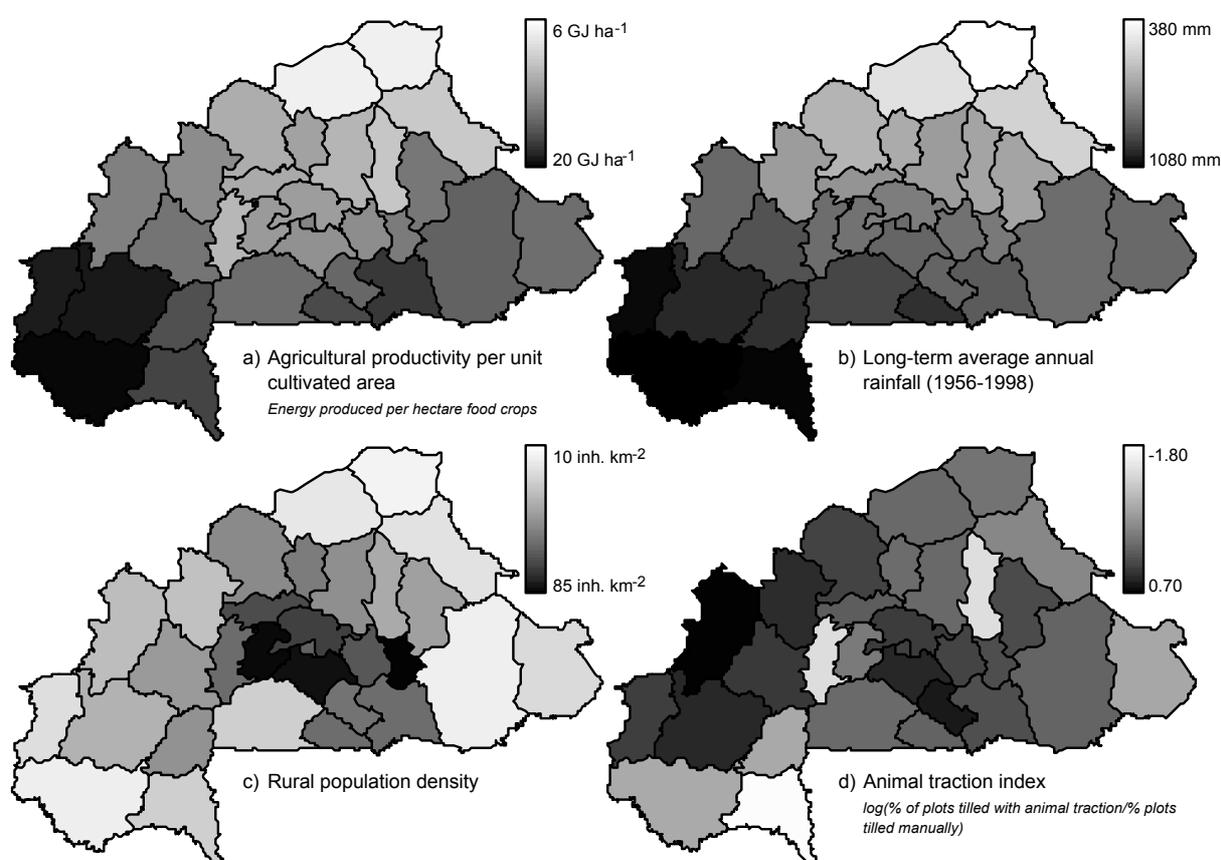
Table 1 Factors included in the analysis of the relation between pressure on resources and agricultural productivity

Factor	Proxy/Variable	Unit
	Agricultural Productivity (dependent variable)	
Land productivity	Energy production of food crops per hectare	GJ ha ⁻¹
	Pressure on natural resources (independent variable)	
Population density	Rural population density on unprotected areas	inh. km ⁻²
Livestock density	Livestock density in TLUs on unprotected areas	TLU km ⁻²
Proportion of area under cultivation	Percentage of unprotected provincial area under cultivation	%
	Technology (independent variable)	
Animal traction index	Proportion of plots tilled with animal traction/ proportion of plots tilled manually	
Plough usage	Total ploughs per cultivated hectare	ploughs ha ⁻¹
	Ox ploughs per cultivated hectare	ox ploughs ha ⁻¹
	Donkey ploughs per cultivated hectare	donkey ploughs ha ⁻¹
Fertilizer usage	NPK per cultivated hectare	kg ha ⁻¹
	Urea per cultivated hectare	kg ha ⁻¹
Manure usage	Livestock density in TLUs on unprotected areas	TLU km ⁻²
Soil and water conservation	Percentage of plots with anti-erosive measures	%
Agricultural extension	Percentage of household heads receiving extension advice	%
	Percentage of household heads receiving advice from the national extension service	%
	Environment (independent variable)	
Climate	Long-term average annual rainfall (1956-1998)	mm

Source: Table 5.6 in Mazzucato and Niemeijer (2000b)

Figure 2 presents maps which show the most salient variables in each category. From the figure it is immediately obvious that agricultural productivity per unit of cultivated area is mainly correlated with long-term average annual rainfall (environment) and barely related to rural population density (pressure on resources) or animal traction (technology). This is confirmed by a stepwise regression analysis of which the results are given in Table 2.

Figure 2. Maps of Burkina Faso depicting: a) agricultural productivity per unit cultivated area; b) long-term annual rainfall (1956-1998); c) rural population density; d) animal traction index



Source: Figure 5.7 in Mazzucato and Niemeijer (2000b)

Table 2 shows that more than 86% of agricultural productivity per unit area can be explained by long-term average annual rainfall, animal traction use and the proportion of land under cultivation. The fact that rainfall contributes over 80% of the explained variance implies that environmental conditions are by far the most determining factor in crop production. Productivity is only partly influenced by technology, of which the animal traction index appears to be a more useful proxy than, for instance, fertiliser use. After the effects of environment and technology have been accounted for, the proportion of area under cultivation also turns out to be significant. As the proportion of area under

cultivation increases, productivity decreases, which can most likely be attributed to the fact that some marginal soils are taken into production as the area under cultivation increases, thus depressing the average productivity of the soils under cultivation. This does not imply an actual decline of soil fertility of the individual soils. Similar analyses, but for total dry production per hectare (which includes cotton) and for energy and dry production per unit labour lead to comparable results (Mazzucato and Niemeijer 2000b).

Table 2. Stepwise regression of energy production per hectare

Order ^a	Variable	R ² (adjusted)
		(%)
1	Rainfall 1956-1998	80.6
2	Animal traction index	82.8
3	Proportion of area under cultivation	86.7

Source: Table 5.7 in Mazzucato and Niemeijer (2000b)

Note: Variables were added to the regression equation if significant correlations existed between the residuals of the prior variables and any of the other variables in the pool (see Table 1). The table shows how R² increases with each addition of a new variable. The process of adding variables stopped if none of the remaining variables had a significant relationship with the residuals.

^aThis column gives the order in which variables were added to the regression.

These findings suggest that, at the present state of technology usage in Burkina Faso, environmental conditions, more than anything else, determine productivity. At the same time there is no indication whatsoever that pressure on resources in the form of rural population density or livestock density has affected land productivity. As such, the spatial analysis of agricultural productivity of cultivated land does not provide any evidence of soil degradation as a result of pressure on soil resources.

THE FERTILITY OF AGRICULTURAL LAND

We are faced with an interesting paradox. Land degradation is claimed to be widespread but no evidence can be found for decline in productivity associated with rising population density. While there may be some delay between degradation of land properties and a productivity impact, this can hardly explain the apparent inconsistency between the alarming reports of widespread land degradation (that go as far back as the colonial period, see Anderson 1984; Swift 1996) and agricultural yields that appear to have increased over the last 40

years. If we consider that Sahelian soils have little “buffering capacity” to cope with degradation processes, we must consider the possibility that changes in land properties have been grossly overestimated. At national level no consistent soil data are available so we will now turn to the eastern region to examine data on soil chemical fertility.

A temporal analysis of soil chemical fertility

To determine if we could find any evidence of declining soil fertility over a 30-year period, we compared soil chemical fertility data provided by a French soil survey (Boulet and Leprun 1969) carried out in Burkina Faso’s eastern region in the late 1960s with analyses of soil samples from the same region in 1996. Such a comparison is, of course, not without problems. There may be differences in the way soil has been sampled and in the procedures used for the various analyses. However, by focusing the comparison on total nutrients rather than on available nutrients (except for potassium for which totals are seldom determined), the effect of possible differences in chemical analysis methods can be reduced. Another problem was that the survey samples from the 1960s were collected all over the region, while our samples originate from two research villages, in the northern and southern part of the region.

To achieve greater reliability, two sets of comparisons were made, using different data sets for both years (for details see Mazzucato and Niemeijer 2000b). The first comparison looked at the differences in chemical soil properties between the two years for the three major soil types, while the second examined nutrient differences for cultivated (bush fields) and uncultivated land. This gives a total of twenty data pairs as can be seen in Table 3. Taking all comparisons together, in two cases a lower N was found for 1996, in two other cases a higher C for 1996 and in two cases a higher K for 1996. For P, no notable or significant differences were observed. Given the complications involved in such a comparison it is remarkable how similar the fertility levels were found to be: in 14 out of 20 comparison pairs no considerable or significant differences were found. The data thus do not provide any proof of a fertility decline over the 30 years between the samples, despite this being a period in which the regional population almost tripled and during which yields of the main staples showed a growth pattern similar to the one recorded at national level (Mazzucato and Niemeijer 2000b).

Table 3. Changes in soil fertility between 1969 and 1996 in eastern Burkina Faso

	% C	% N	% P ₂ O ₅	K (meq. 100 g ⁻¹)
Data set 1				
Slightly weathered soils (Entisols)	-	↓	-	-
Leached ferruginous soils (Alfisols)	↑	-	-	↑
Brown tropical soils (Eutropepts)	↑	-	-	-
Data set 2				
uncultivated	-	↓	-	↑
cultivated	-	-	-	-

Note: Hyphens indicate no considerable or significant change, up arrows indicate a higher fertility in 1996 and down arrows a lower fertility in 1996.

A spatial analysis of chemical soil fertility

We also conducted a spatial analysis of chemical soil fertility to add another type of evidence establishing the relationship between population pressure and land degradation. Soil fertility data were compared between the two research villages because of the very different pressure on resources experienced in the two villages (Table 4).

Table 4. Population pressure on resources in the research villages

Village	Proportion of village territory		Population density	Provincial livestock density
	Cultivated	Under recent fallows		
Southern village	5%	10%	13 inh. km ⁻²	9 TLU km ⁻²
Northern village	20%	45%	50 inh. km ⁻²	26 TLU km ⁻²

Source: Mazzucato and Niemeijer (2000b)

Applying a General Linear Model to 124 topsoil samples and correcting for factors such as local soil type, soil texture and land use, no significant differences between the villages were found in terms of organic matter, total nitrogen, total phosphorus and available potassium (Mazzucato and Niemeijer 2000b). This once again suggests that there is no relation between chemical soil fertility and pressure on natural resources.

An analysis of the chemical soil fertility of cultivated versus uncultivated land

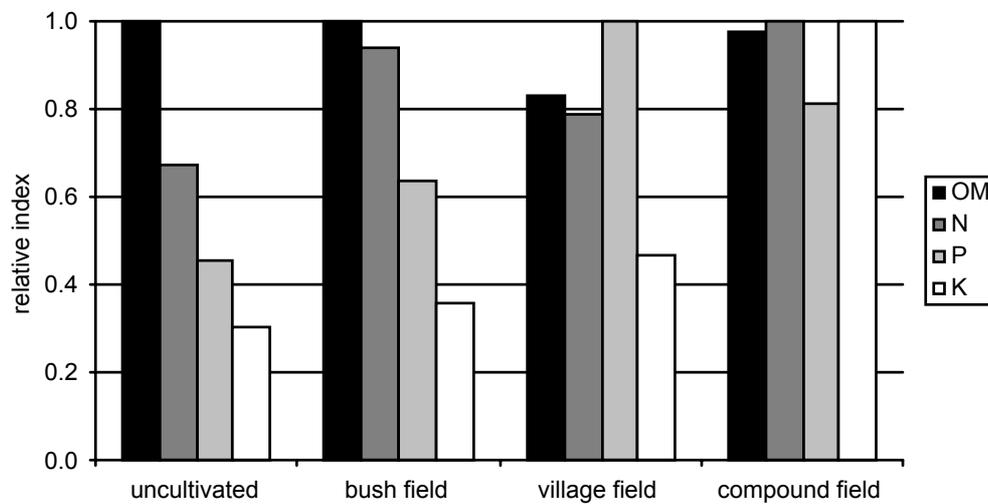
All of the evidence presented so far suggests that local land management practices are sustainable. A final proof is to see whether fertility on cultivated fields has been maintained at the same level as land which has not been cultivated for a long time. In order to answer this question a further analysis of the soil samples was done.

In eastern Burkina Faso, as in other parts of West Africa, a so-called ring management system of land is common (Mazzucato and Niemeijer 2000b; Prudencio 1993; Vierich and Stoop 1990). In this system the following field types can be recognized with increasing distance from the compound: compound fields, village fields and bush fields. Duration of cultivation and management intensity generally decrease as one moves further away from the compound. Samples were collected from all of the field types, as well as from long-term uncultivated sites.² As can be seen in Figure 3, all three nutrients (N, P, and K) show higher values on cultivated than on long-term uncultivated land.³ Only organic matter shows slightly lower values on intensely cultivated land (village and compound fields). This suggests that farmers have been able to find the right balance between duration of cultivation and managing fertility, creating an environmentally sustainable cultivation system.

² Samples on long-term uncultivated land were taken from soils that had not been cultivated for at least 20 years and that informants considered equally suitable for agriculture as currently cultivated land. In some cases this land has never been cultivated because it is considered sacred.

³ A General Linear model was used, corrected for local soil type and soil texture. Expected cell means were converted to an index relative to the highest value of each fertility measure (total nitrogen, organic matter, total phosphorus, and available potassium), so that all fertility measures could be displayed in a single graph.

Figure 3. Soil fertility on different types of land use: organic matter, nitrogen, phosphorus and potassium



Source: Data from Mazzucato and Niemeijer (2000b)

THE PUZZLE

This presents us with an interesting puzzle. How is it possible that, despite strong population growth and across a wide range of population densities, there is no evidence of widespread soil degradation and fertility decline in Burkina Faso? It is clear that farmers have not achieved environmental sustainability through a capital-intensive path (e.g., Reardon *et al.* 1996; Sanders *et al.* 1996). As was explained in the introduction, use of agricultural technologies is very low in Burkina Faso. This suggests that farmers have somehow been able to adjust their land management practices to the increased population density in an environmentally sustainable way. To investigate this issue, a detailed study was made of the livelihood and farming systems of the Gourmantché, the majority ethnic group in the research villages in eastern Burkina Faso.

LAND MANAGEMENT PRACTICES

When it comes to environmental sustainability, soil and water conservation practices are an important aspect to consider. These practices not only refer to mechanical practices such as stone bunds, grass strips and living hedges, which are used on just 10% of the plots according to a 1993 national agricultural

survey (MARA 1996), but also refer to less conspicuous agronomic and biological practices such as mulching, selective clearing and adapted plant spacing. Such practices are used throughout the country. Table 5 lists some of the most important practices.

Table 5 Soil and water conservation practices in Burkina Faso applied by farmers

Agronomic and biological practices	Mechanical practices
crop sequencing, crop rotation, fallowing, weeding, selective clearing, intercropping, appropriate crop & landrace selection, adapted plant spacing, thinning, mulching, stubble grazing, weeding mounds, paddocking, household refuse application, manure application, crop processing residue application, compost pits	perennial grass strips, stone lines, wood barriers, earth barriers, brick barriers, stalk barriers, stone bunds, earth bunds, living hedges, zai

Source: Mazzucato and Niemeijer (2000b)

Farmers, thus, have a rich repertoire of soil and water conservation technologies to choose from. But, perhaps more important than the practices themselves, is the way they are used. Farmers vary practices and the intensity with which they are used with the different field types, allowing them optimally to adjust limited labour and input availability to the requirements of different crops and soils. This experience with different management systems, ranging from intensive to extensive, is an ideal point of departure for dealing with increased resource scarcity. Farmers do not need to invent new management systems as land becomes more limited, all they need to do is apply some of these practices more intensively. In fact, in the more densely populated research village, we noted a more intense use of soil and water conservation practices on bush fields compared with the land rich southern village (Mazzucato and Niemeijer 2000b).

Another way in which farmers make best use of the resources they have, but also deal with inter- and intra-seasonal variation, is by applying land management practices only when and where needed. Using their knowledge of crops and soils (Niemeijer and Mazzucato 2001), farmers treat only those parts of their field needing particular attention at any one time. For instance, rather than constructing one large stone bund across a whole field, smaller stone lines are constructed where a farmer observes excessive erosion; not all at once, but in response to a location specific problem, allowing the farmer to weigh the pros and cons of further investments in this field, as compared with moving to another field, clearing a new field, etc.

Major questions concern how people are able to mobilize the resources necessary to intensify under increased resource scarcity? How are they able to access resources needed for environmentally sustainable production, and how do they evade the poverty trap, often blamed as a prime cause of land degradation?

SOCIAL NETWORKS FOR ENVIRONMENTAL SUSTAINABILITY

People were found to invest heavily in creating and maintaining social networks. An analysis of consumption, spending and investment by 35 married men and women in the two research villages over a 2-year period revealed that gifts given in ceremonial and non-ceremonial occasions comprised an important item on virtually every individual's budget both in terms of frequency and value (Mazzucato and Niemeijer 2000b). Contrary to what is argued in literature looking at African agricultural production systems (Berry 1989; Reardon and Vosti 1995), these networks were found to contribute to agricultural production by enhancing people's ability to cultivate in an environmentally sustainable way. Six types of networks were identified (see Table 6) giving people the ability to access productive resources and avoid the poverty trap. Below we explain how these two abilities contribute to environmental sustainability of the production system and how networks enable people to acquire these abilities.

Access to productive resources

By providing access to productive resources, networks allow a reallocation of slack resources so that people are not obliged to overcultivate their land and it gives people the possibility to intensify cultivation by applying more soil and water conservation practices on their fields (Mazzucato and Niemeijer 2000a, 2000b). Both land networks and women's natal networks allow people to borrow land in case their own land needs to be left fallow. This has the effect of redistributing land between those that have accumulated use rights to more land than they need to cultivate at any one time, and more recent settlers who were not able to accumulate use rights to enough land to be able to leave their own land fallow. This means that more land can be put under cultivation than were borrowing not possible, but at the same time ensures that all land which is cultivated is allowed to regenerate through fallow periods. Cattle networks also have the effect of reallocating slack resources because they allow cattle to be herded on transhumance. This allows unused bush land to be used for grazing while land around villages can be used for crop production. Although this

system is not without its conflicts, it does permit farmers to own an increasing number of cattle,⁴ while reducing crop damage and not overgrazing village territory, which would otherwise be incurred were cattle permanently grazed close to the village.

Table 6 Social networks and their functions

Land networks	Provide access to land through borrowing agreements. Farmers ask a relation to use the land during the cultivation cycle of a field. Once the land is no longer fit for cultivation, it is left fallow and use rights return to the original owner. Agreements do not involve explicit payments but the borrower is under a tacit obligation to provide the lender with part of the crop in case the lender is in need, symbolic gifts, and/or political allegiance.
Labour networks	Provide access to temporary labour. Labour from one household may be borrowed by another household to carry out production or household tasks. Work parties are another form of labour borrowing in which a group of people are called to perform an agricultural task in exchange for food and drink. No official payment is necessary but participation in a work party is reciprocal.
Women's natal networks	The ties that women have with their natal family. Provide access to land in different village territories, a diverse set of landraces, starter seed for the first cohort of women in agriculture, gifts of agricultural production, and a place for women to keep their livestock. This access is usually dependent on a woman's ability to maintain contact with her paternal family through visits during the dry season and help with harvesting during the agricultural season.
Cattle networks	Provide access to cattle. Ties with Fulbe pastoralists enable Gourmantché agriculturalists to entrust their cattle for transhumance grazing. Relationships between the two groups are either based on historical ties or on relationships of trust created by a series of monetary loans given by Gourmantché to Fulbe.
Technology networks	Provide access to technologies such as plough, traction animals, and carts through borrowing. Agreements do not entail explicit payments but the borrower usually offers a gift in return.
Cash networks	Provide access to cash. Participants contribute regular payments to a central pot and when participants are in need, they receive the cash. Such networks are based on kin or religious affiliation.

⁴ Cattle numbers in the eastern region have grown from less than 50,000 heads between 1910 and 1930 to just under 700,000 heads in 1994, amounting to a density of almost 14 head km⁻² (Mazzucato and Niemeijer 2000b).

Networks also allow an intensified use of land enhancing measures, allowing farmers to complete agricultural tasks on time by giving them temporary access to labour and technologies. For example, labour called through a work party or a plough borrowed from someone permits a farmer to complete tasks such as field preparation, weeding, or harvesting quickly and on time. This has the effect of freeing a farmer's own time for applying the labour intensive soil and water conservation practices discussed in the section above. Furthermore, women's natal networks, as they often extend to different villages with differing agro-climatic characteristics, were found to provide farmers with a richer variety of landraces to match to variations in rainfall and the changing qualities of their soils. Cattle networks with Fulbe pastoralists include herding agreements in which pastoralists graze cattle on farmers' fields so as to increase access to manure. Finally technology networks make ploughs available to people, which should increase moisture and nutrient availability by better incorporating plant residues into the soil.

Avoiding the poverty trap

Networks also give people the ability to avoid the poverty trap. Poverty is seen as a condition that leads people to degrade because they are unable to postpone production in order to practice land enhancing measures and because their livelihoods are solely dependent on agriculture and thus they are forced to reap all they can from the land, resulting in overcultivation (Dasgupta 1993; Ehrlich *et al.* 1993; Hudson 1991). How do networks allow people to avoid the poverty trap? They allow people to diversify their livelihoods and minimize risks of harvest failure.

Labour, cattle and cash networks as well as women's natal networks allow people to diversify their livelihoods. Labour networks provide labour to complete agricultural tasks and thus free farmers' own labour so that they can pursue non-farm activities such as commerce. Cattle networks enable farmers to continue to dedicate their labour to agriculture while at the same time engage in livestock activities by entrusting their cattle to Fulbe pastoralists. Cash networks make cash available to farmers when confronted by an urgent need. Women's natal networks provide women with gifts of grain that they can eat or sell. All of these possibilities give farmers additional income that is not dependent on their own crop production and on which they can rely if harvests do not suffice to ensure their family's subsistence.

Consequently, these additional income-earning opportunities ease the pressure that farmers would otherwise face, to have to eke out all the production they can

from their limited land resources. Networks also serve to minimize the risk of both crop and livestock production failure, which helps farmers avoid having to sell their assets, consume their seed stocks rendering livelihoods precarious and force them into a poverty trap. Declining rainfall trends since the wet 1950s have meant that rainfall variability has increased (Sivakumar 1991). In the Sahelian and Sudano-Sahelian ecological zones, slight variations in rainfall make a large difference in crop production. Farmers living in the same compound, thus, were found to spread their fields over different farming areas in order to minimize the risk of localized rainfall shortage. However, having access to lands in different farming areas is only possible by borrowing land from within one's land network. Second, with the rise in livestock numbers, farmers ensure themselves against a livestock disease wiping out their entire herd by spreading their animals between different areas. Again, this is possible through farmers' networks with Fulbe herders and through women's natal networks. We came across farmers owning between 5 and 40 cattle, who kept them with different Fulbe herders, thus reducing the likelihood of a disease wiping out the entire herd. Women's natal networks also permit women to keep their livestock, usually goats or sheep, with their natal family so that their livestock are split between two locations.

Changing network use

It is important to note that while these networks have always been part of the livelihood system, their composition and uses have changed over time in order to allow the agricultural system to adapt to new conditions (Mazzucato and Niemeijer 2000a, 2000b). For example, land borrowing agreements are used more frequently than they were a century ago, so as to be able to continue fallowing under higher population densities. Labour networks have changed both in their composition and use. While in the past labour networks primarily consisted of kin-based relationships, spreading out to different farming areas has necessitated that these networks now include non-kin field neighbours who are called to participate in work parties when one organizes them. Work parties were largely called for prestige reasons some fifty-odd years ago, whereas today they have a strong production purpose, allowing people to get agricultural tasks done on time. Women's natal networks are today used not only by the household to gain access to productive and reproductive resources as in the past, but also for women to access seed, gifts of production to sell in markets, and a place to keep their livestock. This helps them to meet their new needs, given their increased roles in crop and livestock activities and the monetization of their household responsibilities brought on by greater market integration. Cattle networks have been started on a large scale within the past 50 years because,

during this period, cattle have become a preferred means of savings for farmers. Finally, as more technologies are available to farmers through research and development and as their cash needs increase given greater market integration, so have technology and cash networks been created or spread in order to gain access to technologies and cash.

CONCLUSION

All in all, there appears to be little supporting evidence of widespread degradation of crop and fallow land in Burkina Faso. While this finding does not preclude localised spots of severe degradation nor suggests that Sahelian soils are particularly fertile, it does call into question the widespread belief that low external input practices used by West African farmers are leading to region-wide land degradation processes. It would seem that the common assessment by ‘experts’ of land degradation, as well as nutrient budget models may very well be overestimating land degradation. The discrepancies found between our empirical assessment of land degradation (based on both productivity indicators and land properties) and the expert assessments and models that form the basis of most land degradation studies suggest that the methodology of those studies needs to be improved in several ways. Most notably, they need to deal better with the spatial and temporal dimensions of the problems they observe (Fresco and Kroonenberg 1992; Rasmussen 1999). This implies that experts need to discriminate more carefully between a naturally bad state, a temporary bad state and a degraded state of land. The naturally poor status of many West African soils and drought related declines in production and vegetative cover has been confused with signs of irreversible degradation and has led to an overestimation of land degradation. For experimental and model based assessments, more farm and village level measurements need to be made and methods for scaling-up need to be improved. In addition, results need to be validated against time-series of agricultural statistics (e.g. cultivated areas, yields), environmental data (e.g. rainfall, soil fertility), and management data (e.g. soil and water conservation practices, tillage) to make sure that estimations capture reality.

A major reason for the overestimation of land degradation has been the underestimation of the abilities of local farmers. There is much more to soil and water conservation and technological intensification than agricultural statistics reveal. Farmers have a large repertoire of technologies to draw from. They have developed flexible, efficient, and effective land management strategies to deal with the limited availability of labour and external inputs, as well as the harsh environment in which they work. What is more, they have been able to adapt

their social institutions to accommodate opportunities for increased market activity as well as the constraints posed by increased natural resource scarcity. The major challenge for future land degradation assessments will be to incorporate the effect of farm management practices, including their social and institutional dimensions, on soil loss, yields and nutrient budgets.

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