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Sustainability and Sahelian soils: evidence from Niger

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It is difficult to produce systems for judging sustainability, despite general enthusiasm for the concept. Here we evaluate the 'capitals' formulation for sustainability, which attempts to bring together the social and the environmental dimensions of the issue, and which has gained wide currency. We concentrate our attention on the 'natural capital' element in this framework, which has apparently been seen as its least problematical component. We use data on soil erosion from a Sahelian agricultural community in Niger. Despite apparently high rates of erosion, we find it difficult to decide whether the system is sustainable (using the capitals or any other framework), although it may be. It is even dubious whether sustainability is an urgent concern. We caution against imposing yet another poorly formulated set of concepts on this and similar systems.

KEY WORDS: Niger, Sahel, sustainability, soil erosion, agriculture, natural capital

Introduction

Enthusiasm for sustainability as an ideal must be tempered with anxiety about its elusiveness as a concept. To be achievable, it must be recognizable. As an ideal, few would disagree that sustainability is the maintenance '. . . of a society that works for us and our descendants ecologically, economically, morally, culturally, and politically' (Prugh *et al.* 2000, xv), but there is much more disagreement about practical criteria (e.g. Pearce 1993; Redclift and Sage 1994; Middleton 2001). There are authoritative calls for more scientific and thematic coherence (Board on Sustainable Development 1999; Kates *et al.* 2001). It is to this project that we wish to contribute.

A good place to begin a search for a coherent framework is in papers by Ismail Serageldin (1996 1999), for they are clearly presented, and draw upon a coherent line of thinking at the Environment Department at the World Bank and elsewhere (see also Daly 1992). In this 'capitals school', sustainability is the maintenance of stocks of capital, of which Serageldin saw four types: natural, human, social and human-made. A sustainable society is one that nurtures, or if possible enhances, these stocks. The key perception of this approach is that the maintenance of natural resources—'natural capital'—depends on the maintenance of social systems and human skills (see also Reardon 1995; Pieri and Steiner 1997). Conserving natural capital means conserving human communities. The approach is thus an attempt to bring environment and society into one framework, which, though perhaps not intended to be analytical, does have clear practical intent.

In the language of this framework, 'strong sustainability' is the maintenance of as much natural capital as possible. Belief in strong sustainability is based on doubt that technology can continue to substitute natural capital with other forms of capital, and this leads to calls for communities that live, as much as possible, within the constraints imposed by their own geography (Pearce 1993; Eswaran *et al.* 1997; Wackernagel and Rees 1997). The 'strong sustainability school' dominated much of the early discussion of sustainability, for it is based on concern for natural resources, which is where the sustainability debate began. A second tradition has a different, and if anything a stronger advantage, for it has the authority of neoclassical welfare economics,

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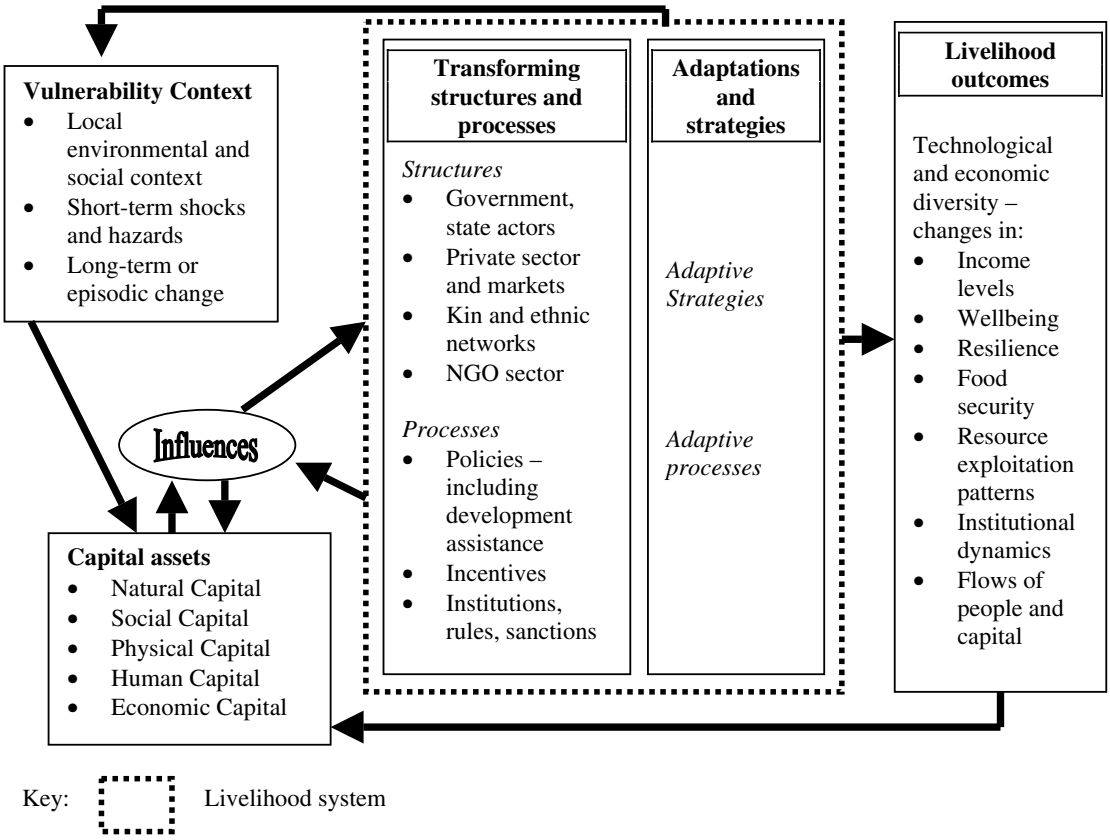


Figure 1 A framework for sustainable rural livelihoods
Source: Batterbury and Forsyth (1999), adapted from Carney (1998) and Scones (1998)

notably the work of Hartwick and Solow (Hartwick and Olewiler 1986; Solow 1986). In Serageldin's terms, this is the 'weak sustainability' paradigm (see Neumayer 1999, 25), which, *contra* the strong sustainability school, allows the substitution of natural by human-made capital, provided that the total stock of capital is maintained (or enhanced). It is argued that this is possible because market-driven technological innovation will find substitutes for depleted resources, and that it is anyway necessary for economic growth and the satisfaction of human needs. Serageldin (1996) was more cautious than either of these schools. He argued that because the poor had little capacity to forgo consumption, they had to convert some natural capital into other assets, but they should not do so excessively. To introduce a term that is now widely used in the 'capitals' literature, they should maintain 'critical natural capital'. The conservation of critical natural capital is, in effect, Serageldin's 'sensible sustainability' position.

These are dangerously abstract ideas, for, as Neumayer (1999) argued, they rely on arguments and propositions that are not falsifiable. Yet they are clearly intended to influence planning, community development and mainstream economic policy. And attempts are being made to operationalize them for development projects, most of which now adopt the language of sustainability (Sneddon 2000; Adams 2001). In this respect, Serageldin's and Daly's work has informed other frameworks. These include work on sustainable livelihoods in several research programmes (Carney 1998 1999; Scoones 1998), notably in the UK Department for International Development (DfID), where there is now a Department of Sustainable Livelihoods (see 'Livelihoods Connect' at www.livelihoods.org, accessed 10 October 2001). The DfID/IDS approach is based, in effect, on the notion of sensible sustainability. It sees rural households as juggling five types of capital: natural, economic, human, physical and social (Figure 1). Natural

capital includes soil, land, water, wildlife and biodiversity. Economic capital includes resources like savings, credit, remittances and profits. Human capital is skill, knowledge, ability to provide labour and health. Physical capital is basic infrastructure and tools. Social capital includes networks, status, membership of informal institutions and access to more formal institutions (Anand and Sen 1997; Scoones 1998; Bebbington 1999). The term 'livelihood', when used in these schemes (and in Figure 1), is the sum of the capabilities, assets (stores, resources, claims and access) and activities required to make a living. A 'sustainable livelihood' is one that uses the different forms of capital to maintain and enhance its capabilities and assets, to cope with and recover from stress and shock and to provide opportunities for the next generation.

There have now been several attempts to apply these frameworks (Farrington *et al.* 1999; Budelman and Defoer 2000; Goldman *et al.* 2000; www.livelihoods.org). These have fuelled a debate in which some now argue that the capitals approach has severe drawbacks. First, as a framework for policy, it is implicitly interventionist, not to say neocolonialist. Second, it does not disclose processes of conflict—for example, instigated by those who seek to appropriate scarce resources and political power (Bryceson 2000). Third, its focus on households and single communities deflects attention from the political and economic constraints that rural households face, but over which they have no control, such as political mismanagement or economic liberalization (Bryceson 1999 2000; Brett 2000). Fourth, there are difficulties in measuring any of the capitals or the flows between them (Neefjes 2000). Finally, this last point is part of the case of a growing school that dislikes the whole idea of social capital (Harriss and de Renzio 1997; Foley and Edwards 1999; Fine 2000). We return to some of these issues later.

Our contribution to these debates is to open up a somewhat neglected aspect of the framework, namely the way in which it treats natural capital. The neglect may reflect a belief that natural capital is the least vulnerable element in the framework, although it will be seen that we find its conceptualization in the capitals framework to have the same kinds of weakness that others have found in its conceptualization of the other forms of capital.

Our evaluation focuses on soil as a form of natural capital, in the particular context of dryland agriculture in the Nigerien Sahel. This should be a severe test, for two sets of reason. First, it is severe because soil is a crucial form of natural capital, which sustains by far the greatest amount of agricultural production; soil is generally only slowly replaced or re-made, if at all; and agriculture, almost everywhere, accelerates its loss to rates that are in excess of replacement (Stocking 1994). Most soil must therefore be seen as a non-renewable resource (with some caveats given later). Second, the test is severe because of the way in which the Sahel has been cast as a 'global hot spot' for soil erosion (Crosson 1997); a place where the population–resource relationship is unbalanced; and indeed one that is suffering severe environmental degradation of all kinds (Griztner 1988; Batterbury and Warren 2001; Breman *et al.* 2001); a place, among other semi-arid ones, where induced change, including the acceleration of wind erosion, might tip the environment from one state to a much worse one (Phillips 1993). These perceptions have been translated into many calls for more soil conservation in the Sahel, and have inspired some very extensive interventions (Rochette 1989; Reij *et al.* 1996).

More precisely, we address two sets of question, which add up to a challenge either to reformulate sustainability frameworks more precisely (at the least); or (at most) to find a better framework for discussing futures in small villages. The questions are:

1. Could 'strong sustainability' ever be contemplated in the Sahel? In other words, is strong sustainability (what could be termed 'environmental sustainability') compatible with the sustainability of communities ('social sustainability')? Could Sahelian farming systems survive if they were forced to maintain a large portion of their natural (soil) capital?

2. Can 'sensible sustainability' be recognized? Unless there are unambiguous criteria, sensible sustainability could be claimed by almost any livelihood system or environmental project, for the claims would be hard or impossible to contest. Investment in sustainability would have uncertain outcomes. A more specific question in this context: is the notion of 'critical natural capital' viable?

The site

Over 50 per cent of the population of the West African Sahel live in rural areas, where they depend on agriculture and/or pastoralism (Cour 2001). Fandou Béri, in southwestern Niger (13° 31.8N, 2° 33.4E) (Figure 2), is typical of the communities in which these people live. As in most of these areas, rain-fed agriculture is conducted in conditions of constant uncertainty, poverty is widespread and farmers have few 'exit' options. Research on human–environment relationships has been conducted at Fandou Béri since 1995 (Chappell *et al.* 1998a 1988b; Batterbury 2001; Warren *et al.* 2001; Osbahr and Allan forthcoming). The village now

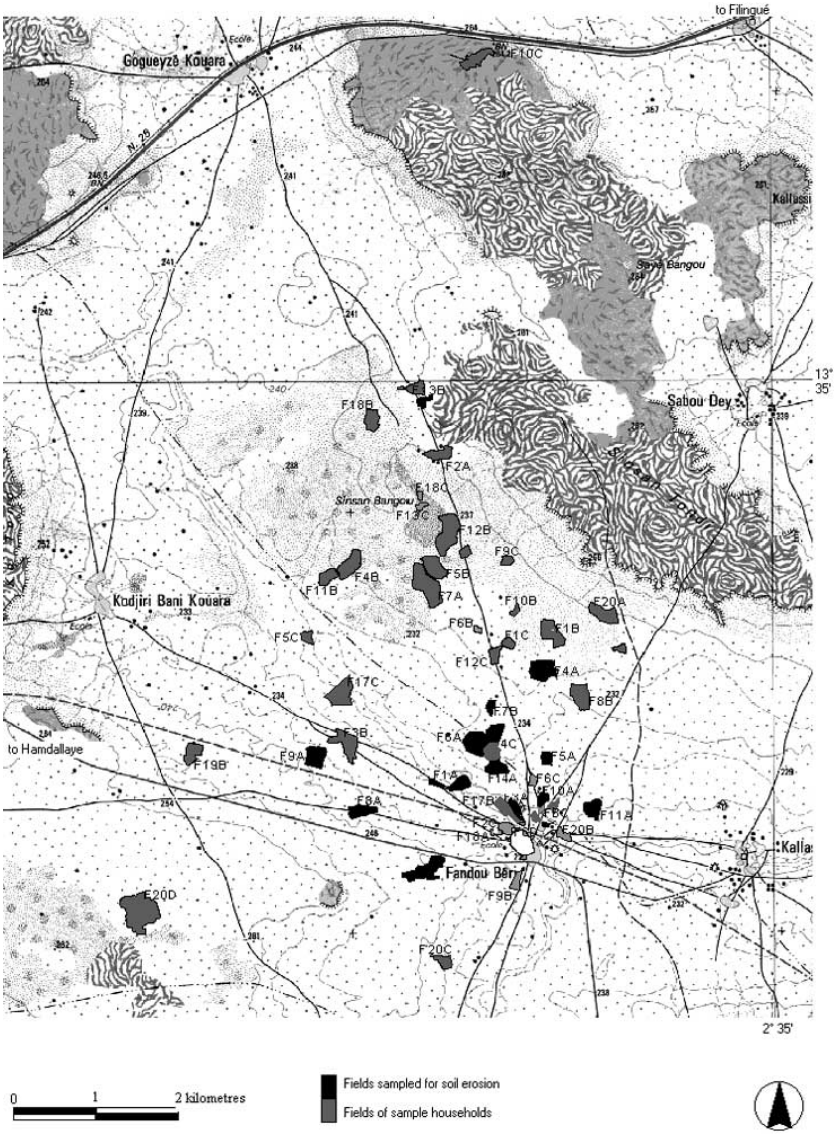


Figure 2 The case study village in Niger, showing location of sampled fields and terrain

numbers over 400 adults with an estimated population density of 20 people km^{-2} (Figure 2). The dominant ethnic group is Djerma (Zarma), most of whom are dependent on cultivation (though many have livestock). The first Djerma migrated from the more heavily populated region of the Dallol Bosso in the nineteenth century, driven by land pressures. Some Djerma in the village claim descent from the original lineages, but they are now augmented by later Djerma arrivals and by others from different ethnic groups. Many Djerma households have members who migrate great distances in search of cash remittances, particularly from the trading of household goods in rural, northern Côte D'Ivoire (Rouch 1956). The village is also within a two-hour drive of the capital, Niamey, and, since the early part of the twentieth century, trade and exchange with the capital and the town of Hamdallayé, along the route, have played an important role in the local economy. Improving transport has encouraged these and other non-agricultural activities. There are fewer Fulani (Peulh), most of whom settled in

Fandou Béri in the 1970s. The Fulani also cultivate, but most have much larger herds of cattle and smallstock than the Djerma. They take a large proportion of these (and some Djerma stock) north towards the border with Mali in the wet season, when the crops in Fandou Béri must be protected from grazing, and when the northern pastures are usually rich.

The long-term mean annual rainfall is about 550 mm, though yearly totals fell to lower figures in much of the 1970s and 1980s, and in some years in the 1990s. The rain comes in a well-defined season, from April to September, giving an average number of growing days of about 100 per annum. The village lands are in a wide, shallow valley, filled with now stabilized, Late-Pleistocene dune sands, which thin out onto uncultivable, low ferricrete hills (locally *tondo bon*). Most of the fields, therefore, have sandy, acid soils (locally *tassi*), typical of a large proportion in the Sahel and many other semi-arid areas. There are some clayey soils (*botogo*) in the larger hollows between the old dunes, and along the narrow course of a now-dry meandering river course. On the edges of the plateau there are silty *gangani* soils, which are prone to surface crusting, although they give good yields in wet years. There is an appreciable input of dust to soils in the Harmattan season, and this appears to replace the calcium and potassium removed by crops, but not the phosphorus (one of the few renewing soil processes in these soils). Phosphorus is the main limiting factor in crop growth in these low-CEC, acid soils. These climatic and edaphic conditions favour millet production; sorghum is grown in much smaller quantities, mostly on the *botogo* soils; there is a portfolio of intersown crops, such as cowpeas, peanuts and hibiscus. There is a complex fallowing system (Osbahr 1997).

Strong sustainability at Fandou Béri

The budget of soil loss and replacement at Fandou Béri makes a strong *prima facie* case for soil conservation. We will focus on soil depth (rather than on the more complex, though more ephemeral, issue of soil nutrient supply). Soil depth is critical to crop production, being the ultimate control on the supply of nutrients and water to crops, and it is jeopardized by erosion. In theory, soil lost in erosion is replaced by soil produced from the underlying rock (and from added dust), but in these soils, developed as they are from Late Pleistocene dune sands, the replacement rate, excepting the small input of dust, is negligible (Warren *et al.* 2001).

We measured soil loss on 16 village fields with the ^{137}Cs (caesium) method (Ritchie and Ritchie 2001). ^{137}Cs is an artificial isotope that is produced in nuclear reactions. Large quantities were released into the atmosphere by bomb testing, peaking in the mid-1960s. These were distributed worldwide and most of the isotope was adsorbed to clays in the upper part of soil profiles. Measures of present ^{137}Cs content in a soil profile (compared to a reference sample) give a measure of soil loss (or gain) over a 30-year period. Measurements of ^{137}Cs have been taken in the Fandou Béri area since 1995 (Chappell *et al.* 1998a). The median rate of erosion on the 16 fields in 1997 was 30 t ha^{-1} yr^{-1} (over the preceding 30-year period). The range was 26–46 t ha^{-1} yr^{-1} . At first sight, these figures are alarming, for they are considerably greater than the estimates for this part of the Sahel produced using other techniques (Lal 1993). The erosion is by wind and water; water erosion occurs very obviously on the edges of the plateau (Figure 2). Wind erosion is the greater threat to the great majority of fields, which are on the loose sandy, *tassi* soils. Most of the wind erosion occurs during the first storms of the rainy season, many of which are preceded by strong downdraft winds, and which meet little resistance in the fields that have already been cleared for cultivation.

Moreover, the rate of erosion is almost certainly on the increase, for the area under cultivation is extending. A comparison of an air photograph of Fandou Béri in 1950, with one taken in 1992 (Figure 3), shows that the cultivated area has very considerably expanded from 11.3 per cent to 23.4 per cent of the village territory over these 40 years (Table 1). The clearance rate is almost certainly related directly to the erosion rate. Furthermore, Table 1 shows evidence that the cultivation–fallow rotation is accelerating. This is a common trend in Southwest Niger (Taylor-Powell *et al.* 1991; Heasley and Delehanty 1996; Amissah-Arthur *et al.* 2000), as elsewhere in the Sahel (Raynaut 1997). At Fandou Béri, there has been a shortening in the mean fallow cycle (the ratio of fallow aged over three years to young fallow fell from 0.9 years in 1950 to 0.3 years in 1998) (Osbahr 2001). There is a corresponding decrease in the ratio of fallow to land under cultivation (1.5 in 1950 to 0.5 in 1998). The reasons include an increase in population and the anticipation of a new Rural Code that will restrict land ownership to those who can prove it in law or prove long-term use (Lund 1998 2000). These trends have undoubtedly been accompanied by greater erosion, for erosion is accelerated many-fold on cleared land in this area of Niger (Bielders *et al.* 1998).

To the gloomy picture of presently high and historically accelerating rates of erosion can be added a confident forecast that erosion will con-

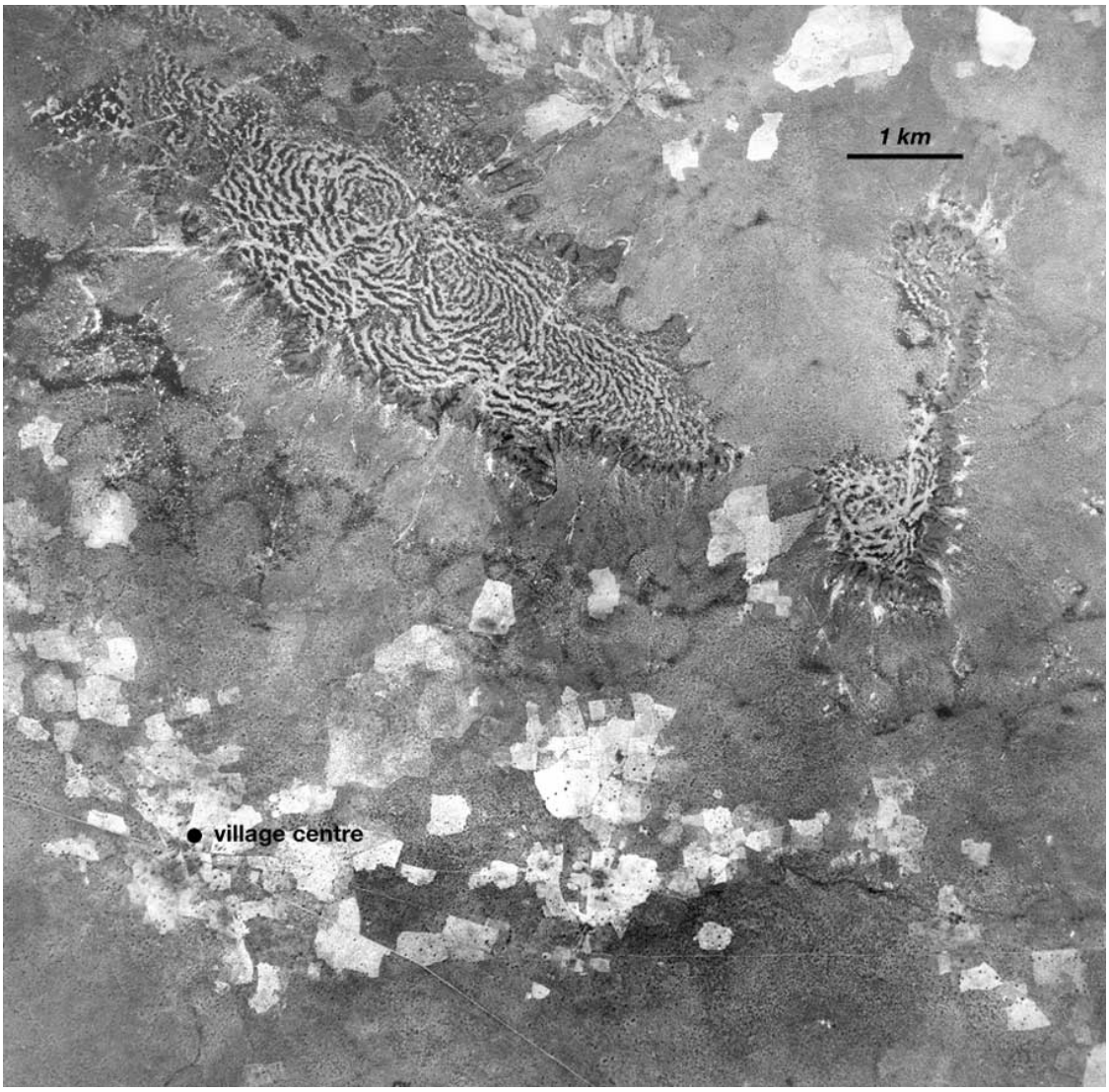


Figure 3 (a)

tinue to accelerate. Detailed survey work (for the 1997 farming year, with the 16 households that worked the 16 sample fields) shows that erosion has been fastest on the fields of the families with the most economic opportunities and a plentiful supply of labour. These households have the labour to prepare marginal fields with poor soils, and thus put them at risk of erosion (because of the poor state of their surfaces as well as the lack of plant cover at the critical time). This is apparently because their resources of land, labour and stock allow them to add large amounts of manure to their better fields, so that should the crop fail on the poor soils, they can fall back on the crops from these better fields, or on the income from their trade, livestock, other forms of capital, or from the remittances from their migrant members (some of these data have been analysed in Warren *et al.* 2001). An acceleration in the availability of options other than agriculture is likely for many such households, and if the present relations are maintained, this would mean a continued acceleration of erosion.

Thus, to those who argue for 'strong sustainability', in which resources of soil as natural capital

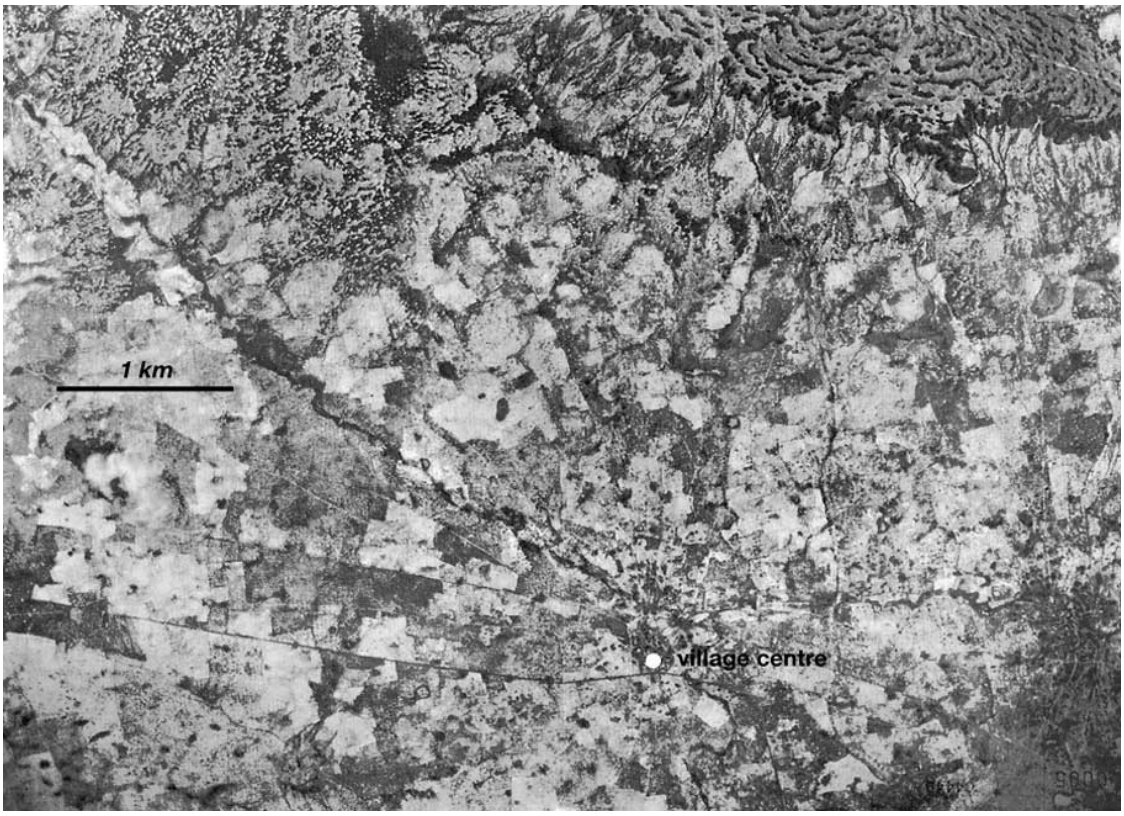


Figure 3 (b)

Figure 3 Land use change between 1950 and 1992. (a) 1950. Village centre shown bottom left. Plateau with characteristic tiger-bush vegetation, upper left. (b) 1992. Expanded cultivation, with village centre shown centre-bottom

are conserved in as intact a state as possible, the position of Fandou Béri is bleak. A vital resource is suffering accelerated depletion. Some might call this 'soil mining': converting the soil to income, while knowing that the resource is finite (van der Pol 1992). It is reasoning like this that underlies calls for intensified soil conservation in the Sahel (Lal 1993), although there are also more populist reasons behind calls of the same kind (Critchley *et al*. 1992). It is worth noting that many calls for urgent conservation and land rehabilitation, with their usual condemnation of degradational practices, are grounded much more in the discourse of agronomists and soil scientists, than in the rounded understandings of livelihood dynamics or rural economies that the capitals framework gives us. Indeed, it was just this kind of narrow view of sustainability that frameworks like Serageldin's were developed to temper. Before we judge their ability to do so, however, we must ask another question.

Table 1. Land use and cover change of village lands, Fandou Béri, 1950–1992

Land use category	% of the 35 km^2 Fandou Béri terroir 1950	1992
Scrub/bush	76.3	34.1
Tiger bush*	4.7	4.1
Current fields	11.3	23.4
Recent fallows	4.1	27.4
Older, detectable fallows	3.5	10.9
Settlement	0.1	0.1
Total	100	100

*Characteristic linear vegetation bands, found on plateaux.
Source: Air photo interpretation and ground-hunting, 1996.

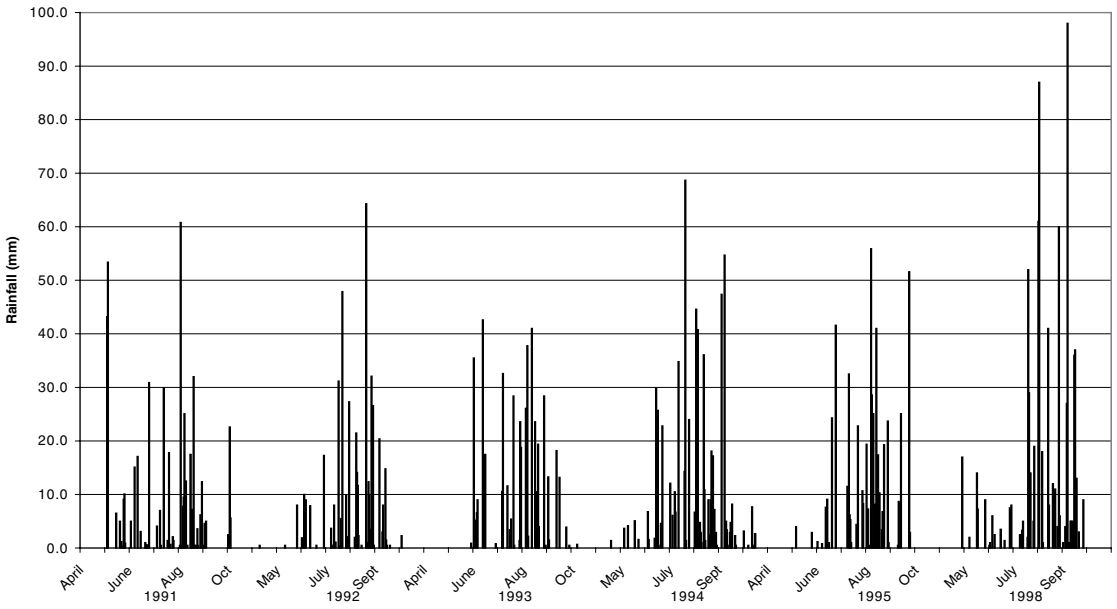


Figure 4 1991–1995, 1998 seasonal rainfall data for Fandou Béri
Source: data from village

Would the sustainability of natural capital at Fandou Béri conflict with the sustainability of livelihoods?

We must first consider whether, if it were desirable as a long-term goal, strong sustainability could be contemplated in practice by farming households in Fandou Béri? Could the farming system survive a strong effort to conserve soils? Is there a conflict between the demand to sustain or restore soil, and the need to sustain society and culture?

Household survival (social sustainability) in Fandou Béri depends on many things, not simply on the soil. Even in the agricultural component of household economies alone, the soil resource is not necessarily central. It takes little research to appreciate that variation in yield depends much more strongly on rainfall than on soil quality. The management of the risks inherent in rainfall variability must, for most farmers, take precedence over those of managing the soil (Lamers and Fiel 1995). Figure 4 shows just how variable between-season and within-season rainfall can be at Fandou Béri. Graef and Haigis (2001), working with data from other sites in southwestern Niger, have shown that spatially variability can also be large, even within quite small distances.

The discussion of rainfall leads rapidly on to yet other factors in the farmers' calculations, for the management of agriculture in the face of unreliable rainfall cannot be understood without a knowledge of the full portfolio of risk, of natural, social and economic origin. The most stressful, difficult and risky time is early in the rainy season. With the imperative of getting a grain harvest always in mind, farmers need first to muster labour to clear the land (especially if it is to be cleared from fallow). This labour must be taken from other, arguably more gainful employment like trading. Available labour must then be managed flexibly enough to plant when, or very soon after, there is judged to have been enough rain, and to plant again if the rain fails early in the season (sometimes replanting six times). This depends on having the maximum labour capability available at very precise, but unpredictable times. For neither of the early tasks (nor for later tasks like weeding), is labour assured: men may be working abroad, critical household members may be ill, and so on. Box 1 shows the history of one season for one farmer.

It is difficult for farmers to control wind erosion when they have so many other concerns at the critical time of year (critical from the point of view of labour, rainfall and erosion). The soil must be cleared and ready for sowing shortly after the rains begin, but this is precisely the time of the strong winds that accomplish most of the erosion (Bielders *et al*. 1998). The imperative to clear and plant must generally override the farmers' own concern about the erosion process. Farmers in this part of Niger do acknowledge that erosion has a short-term effect

Box 1 A detailed account of one farmer's choices and priorities for his farm during the 1998 agricultural season (Osbahr 2001)

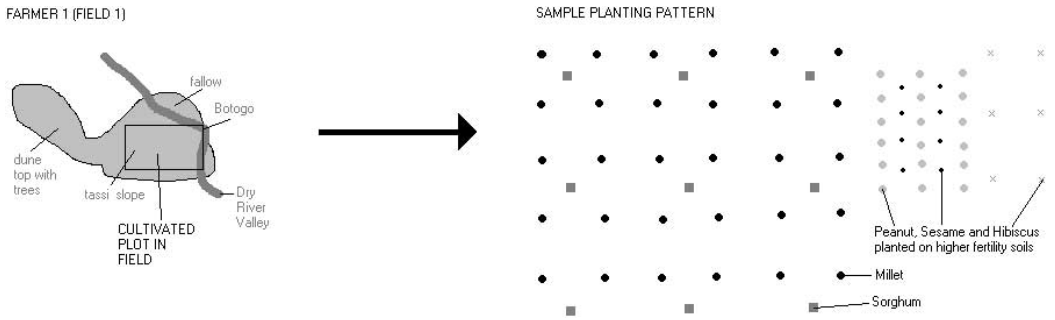
Amadou Abdoullaye is a middle-aged Djerma farmer. His family comes from an early lineage in the village. He inherited three fields of different soil type from his father. Two are of low productivity, being predominantly low-fertility *tassi* soil with some pockets of silty *botogo*. The third, in the middle of the territory, has sandy soil with a hard crust that is difficult to work (*gangani*). He considers the largest mixed-soil field nearest to the homestead to have the lowest soil fertility and to be the least productive because it has been continuously cultivated for over 50 years. With a below-average household annual income he only can afford to put manure from his two livestock on one field and chooses to put the animals on the low-fertility field, because its proximity to the village reduces labour demands. His only alternatives for improving his soils are to leave the low-fertility parts of his fields to rest in fallow and to lay crop residues on the surface to decompose (mulching).

Amadou Abdoullaye relies heavily on help from his family and two sons to run the farm because he has never been able to afford to pay others to help. He admits that labour bottlenecks at critical times in the season have always been difficult to manage. His family's subsistence is dependent on the farm, which must produce a minimum of 330 *botes* (bundles) of millet each year. The 1997 season was a particularly stressful one for him. The previous few years had seen drought and unreliable late-season rains, and 1997 was no exception. The drought had, moreover, failed to reduce the grasshopper population and swarms had eaten his young millet crops after each sowing. Most of the farm had been abandoned and his family had harvested only 146 *bottes*.

After the harvest, Amadou Abdoullay left the village and travelled to friends on the Ivory Coast to earn some money in non-skilled manual work through the dry season. He returned in February 1998 with enough money to purchase seed while it was still affordable (his family had eaten what should have been seed). He spent a month cutting and laying the millet stalks from the last season millet as well as the branches from *Guiera senegal*ensis bushes. This was to protect the exposed surfaces of the fields from early season winds and to attract termites. Slow burning in the sheltered area of his large field reduced the risk of parasite attack in the early season and probably helped to release local concentrations of phosphorous, calcium, magnesium potassium and even nitrogen. The timing was critical as ash may also increase the alkalinity of these acid soils and burning too close to the early rains carries the risk of having the ash washed away. However, early storms did not come when predicted.

Experience had told him that the sandy soils would be more productive in another dry year and consequently he decided to clear a three-year fallow on his large *tassi* field. He chose not to dry-seed his crops this year in anticipation of rains, because he thought it to be a risky strategy and he had precious little seed. He decided to miss the chance of a first flush of nutrients with the first rains. He decided to carry the manure from his household livestock to his *gangani* field. The field was over two kilometres from the homestead, but he hoped that with additional organic matter the surface would be easier to work. The previous year he had persuaded local Peulh to graze cattle on the crop residues on this field for two months after harvest, but this year he would not be able to afford the 7,000 CFA payment.

The first rains in 1998 followed a large dust storm on the afternoon of 30 April. He and his family planted the millet seed on the *tassi* parts of the large field three days later. The reason he gave publicly for the delay was the belief that the next rains would be over two weeks away, but privately the reason had been because labour had been diverted to clear a four-year fallow along his field boundary to prevent a dispute with his neighbour. This was unusual, since boundary land is rarely left in fallow for more than three years. He had misjudged the cloud formations and was unlucky as the next rains fell on 7 and 17 May and he was not ready to sow until 19 May. He planted a fast growing millet cultivar (known locally as red millet) on the *tassi* fields. He partitioned his labour so that during May and June the work focused on the *tassi* fields, and thus he abandoned the preparation of the fields with other soils. The younger millet crop was thinned and beans intercropped in the are a just cleared from fallow and in a small area that his wife had cultivated the year before. He chose to plant different crops on the different soils and different fields, reflecting their fertility and moisture-retention capability. Planting density reflected the microvariability, as the diagram below shows:



As rainfall frequency improved later in June and July, he redirected work to planting the *botogo* and *gangani* fields. The *botogo* soils were additionally able to support sorghum, sorrel and hibiscus that could be planted at the same time as the millet and he also planted groundnuts on these soils 15 days later. Because much of the farm's *botogo* had not been prepared, he was unfortunately constrained to cultivating only those parts already prepared. There was not enough time to clear the field and sow the crops as well as to tend to the developing crops on the *tassi* soils. The fallow area was increased as he began to weed the cultivated areas. High levels of weed growth, including Striga varieties, had resulted from the improved rains in 1998 and several parts of the worst affected areas were abandoned in the second weeding. Overall, 1998 had brought more sustained late-season rain and he hoped that he would be also able to work in Niamey after his best harvest in several years. He considered labour and access to manure to be the most serious constraints on his farm's productivity. The decision to clear early season fallow was largely a result of these constraints, whereas the clearing of late season fallow was a result of rainfall distribution and equalities in soil fertility over the field. His limited labour resource made his priorities for action especially difficult and made him vulnerable to unpredictable rainfall patterns. The previous end-of-seaon's low capital resources had resulted in a complex set of problems and constraints in other essential resources, such as seed, manure and labour.

on yield, as Bielders *et al*. (2001) found in a multi-village study, and this belief has been confirmed by scientific work on sandy soils like those at Fandou Béri (Sterk 1997). They also know that the wind can unearth seedlings and destroy them by sand blast, and that it removes organic matter and some nutrients preferentially, and this is also confirmed scientifically in many parts of the world (Leys and McTainsh 1994). In all this, however, the payoffs from investment in conservation (by maintenance of a vegetation cover on the soil surface until well past the season of high winds, for example) are generally much less clear than from the other elements of investment in a crop, and the two sets of investment decisions are often in conflict.

This general account (and the particular one given in Box 1) illustrates the interdependence of the farmers' strategies with regard to the soil (natural capital) and those with regard to their other sources of income, as from migrant labour (human and social capital). Labour is vital for agriculture, but might bring greater returns if invested in employment elsewhere, for without a secure cash crop market, farming is generally seen as only a subsistence activity. Few households in Fandou Béri rely entirely on the soil, and they are foolish or unfortunate if they do. As with other households across the Sahel, they are sustained by many activities, as they must be if they are to survive the uncertainties of rainfall and of the political and economic environment (Mortimore and Adams 1999). In this village, the economically most important alternative activities are livestock rearing and trading by men and women (by 75% of households in our sample). There is also a small market for agricultural waged labour, some local business activity and market trading (but only a small cash crop market) by both men and women, and long distance seasonal or longer-term migration to work as traders in northern Côte D'Ivoire (involving 30–40% of men in a given year). Although the mix of these activities varies by gender and age, households as a whole opportunistically 'switch' between these activities, just as the capitals framework suggests.

In short, to be 'socially sustainable', some farmers of Fandou Béri must engage in practices that lead to erosion, and so may be jeopardizing environmental sustainability. This is not true of all farmers, of course, and some do protect their soils by retaining bushes and laying millet stalks on the soil surface after harvesting (*paillage*). There are many different responses to environmental and economic forces, depending on the material situation and the social networks in which an individual household finds itself in a given season. The responses and the capabilities of individuals are indeed constantly changing, making it difficult to distinguish one trajectory for the use of 'natural capital', let alone one for the combined management of all the capitals (social networks, migration, agriculture, market trading etc.). As Table 2 shows, some people have a greater capacity to convert assets than have others, depending on their wealth, power, status and household demography.

If we were to continue to use the language of the 'capitals' framework, we might be tempted to ask: is there some 'critical' level of social or human capital that must not be passed, just as there is said to be of natural capital? To answer, we would have to be able to account for and measure social capital in some way, or to define thresholds beyond which the rural society and its culture was unduly threatened with dissipation or fundamental change. We are dubious about the feasibility of doing so, for reasons that we elaborate later.

Sensible sustainability at Fandou Béri

If strong sustainability is so problematic, we are left, like Serageldin himself, with 'sensible sustainability'. Indeed, this is probably what the community at Fandou Béri is already practicing, for could it otherwise have survived? But the problems of judging whether this is so, or whether sensible sustainability will continue to be the case are not straightforward. We will start our argument about these difficulties with an analysis of the rather obvious rigidities in the strong sustainability case as presented above, taking into account also the issues of social sustainability, described in the last section, before moving on to a more fundamental problem.

First we will consider the rigidities. The case for strong sustainability, as given rather starkly above, depends on two simplistic assumptions. The first of these is that a reduction in the depth of soil is directly and always related to crop yield. The farmers of Fandou Béri know better, as do most agronomists (e.g. Xu and Prato 1995). Soil depth does not have a significant effect on yield until the soil is so thin that its water-holding capacity is no longer sufficient to support the crop through the growing season. A similar principle applies to nutrient-holding capacity. It may be true, as some of the older farmers at Fandou Béri maintain, that some of their soils have been losing water-holding capacity and nutrients in recent years, but this is more because of the loss of organic matter content in the upper profile than because of the diminution in soil depth, and as such it is not a permanent loss (as occurs when the depth of soil is diminished). But, these opinions apart, we have no good evidence for changes in soil fertility, and the increasing intensity of the management of the fields near the

Table 2. Comparing farm and non-farm activities for households in Fandou Béri in 1997

Household number	Millet harvest (bottes, a local grain measure)	Household millet requirements (bottes, a local grain measure)	Soil flux on main field (bulked samples) (t ha^{-1} yr^{-1})	Annual household income (CFA)	Annual household expenditure (CFA)	Household financial balance (CFA)	Household animal ownership (Tropical Livestock Units)	Numbers of migrants in family	Total household size	Local petty trading	Remarks—household status
1	146	300	41.09	179425	188650	-9225	2	0	12	son	Some influence
2	153	400	41.48	542125	507450	+34625	73	1	8	no	Chief. cash income from taxation
3	191	360	44.23	250825	820100	-569275	12	4	27	no	Religious leader
4	146	300	40.27	208300	351800	-143500	6	2	8	no	Religious leader
5	129	300	38.85	119225	169000	-49775	3	3	12	By hh head	
6	178	250	37.66	375875	246700	+129175	13	1	8	no	Wife is prominent entrepreneur
7	161	200	26.43	137475	110900	+26575	7	0	8	no	
8	235	200	35.28	215925	227350	-11425	5	0	7	By hh head	
9	174	330	42.73	183225	264100	-80875	9	0	9	no	
10	270	250	45.28	262025	320575	-58550	22	3	16	By hh head	
11	191	360	46.46	209800	224885	-15085	5	2	10	no	
12	74	150	40.06	N/A	N/A	N/A	18	2	8	no	Religious leader
13	187	200	33.12	196050	200750	-4700	10	1	3	no	
14	144	300	38.95	224125	316600	-92475	74	2	5	no	Peulh
15	67	300	41.89	206925	136600	+70325	51	0	6	no	Peulh
16	210	450	N/A	414825	366000	+48825	141	1	4	no	Peulh
17	288	300	N/A	N/A	N/A	N/A	13	N/A	17	N/A	
18	220	300	N/A	N/A	N/A	N/A	17	N/A	13	N/A	Chief's son
19	150	300	N/A	N/A	N/A	N/A	90	N/A	14	N/A	
20	291	500	N/A	N/A	N/A	N/A	12	N/A	15	N/A	

Source: Batterbury (2001). In 1997, $1=625 CFA (approx.).

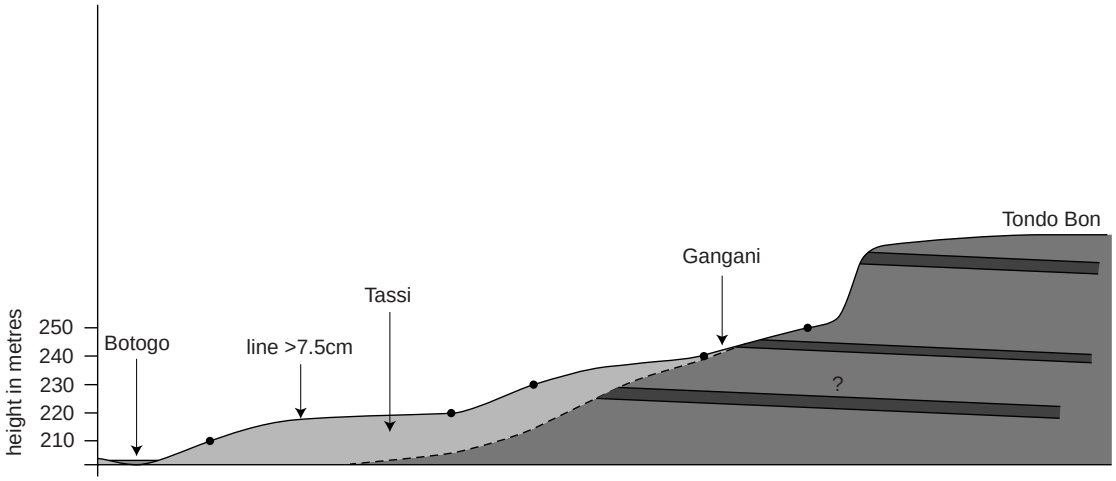


Figure 5 Cross-section of village, showing possible soil loss

village, particularly in terms of inputs of manure and labour, suggest that some fields may even have been increasing their fertility (perhaps even while being eroded). If fertility is decreasing anywhere, it is probably only in the outfields, where there is little manuring or kraaling of stock and where fallows have been shortening. It is more certain that the soil on some fields has been eroded to the point at which it is so thin that its water-holding capacity is below the critical level, these fields being those where the soil was initially thin (where the sands thin out over the harder soils, Figure 5). But it is arguable whether the loss of these fields has had a significant effect on overall yields, if only for the reason that they were poor fields already. The loss of many fields like these, as has undoubtedly occurred across the country, has apparently made no dent on national production, for cereal production in Niger has increased in the last 20 years (FAO 2001). In Fandou Béri, the point at which yields on the deep sandy soils as a whole (which produce most of the crop) would seriously be endangered is probably very many decades away (see, for example, Olofin's 1992 model for the erosion of sandy Sahelian soils, quoted by Mortimore 1998). This, of course, is not to say that the lost soil might not ever be useful again, an issue that is discussed below.

The second rigidity in the strong sustainability case, as argued above for the case of soil, is the assumption that this form of natural capital retains its value as rural communities modernize and develop economically. This is as dubious at Fandou Béri as it was for crofters in the Scottish Highlands in the early nineteenth century (Taylor *et al*. 1996), or for many other subsistence or near-subsistence agricultural systems the world over. In these cases, soil did, or probably will, lose both its financial and use value, as people rely less and less upon it for income.

The value of soil is likely to diminish in all of three, each quite likely, scenarios for Sahelian agriculture. The first of these scenarios is held to be the most likely, if not indeed the only possible one, by many agronomists and development experts operating in the Sahel, namely intensification. In this vision, yields are raised with inputs of manure or artificial fertilizer and efficiency gains are made from soil conservation works and the use of animal traction (Breman *et al*. 2001). Only the soils in the best locations relative to labour, water availability and markets, and the best in their response to inputs, would be needed. Many marginal soils now in cultivation would fall out of production.

There are indeed signs of intensification in Fandou Béri. Weeding has intensified in recent years, there is more frequent re-sowing, more careful use of appropriate landraces, more attention to plant spacing, thinning, intercropping and sequencing, as well as fodder integration and especially increased recycling of green manures and mulches (Osbahr 2001). There has been a move from long fallow to short fallow or permanent cultivation, often on a smaller total area per household, as in other parts of the Sahel (Mortimore and Adams 1999). The most noticeable change in this direction, particularly after the withdrawal of state and NGO support in the 1980s, has been the increased

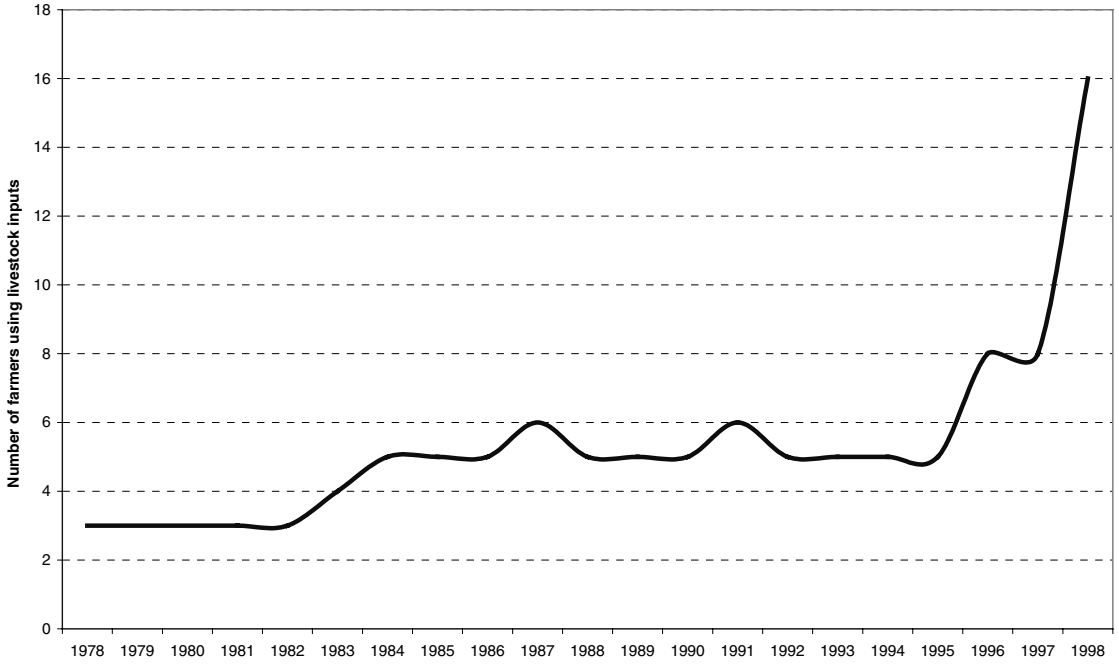


Figure 6 Growth in number of Djerma farmers with access to manure from livestock in Fandou Béri between 1978 and 1998 (weighted by numbers of informants, thus controlled for changing sample size)*
*1978–1996 data from the SERIDA Project/1997–1998 data from Osbahr (2001) (n=20)

investment in livestock, as in nearby villages (Turner 1999) (Figure 6). This means that there is more manure available to help the intensification process.

The second scenario is the almost complete abandonment of agriculture in the long term, or at least its downgrading to a very minor role in household economies. Families would rely on off-farm incomes. Agricultural production in West Africa would come from areas better endowed with natural capital (better soils, rainfall or location relative to markets). Perhaps only livestock production would be economically viable at places like Fandou Béri. The West Africa Long Term Perspective Study (WALTPS), sponsored by the OECD's Club du Sahel, develops this theme, forecasting greater interdependence between the economy of the Sahel and that of the humid coast (Cour 2001). A third, related, and still plausible scenario anticipates the continuing symbolic attachment to homelands and the need to maintain farming as an option and thus the option value of the soil resource, in case of extreme deprivation. In this case, agriculture would never be wholly abandoned, but would continue in some very attenuated form.

The conservation of a high proportion of soils is central to none of these scenarios. It is here that we begin to face two much more fundamental problems with the 'capitals' framework. The smaller issue, but the main conclusion from our analysis here, is the definition of 'critical natural capital', which is central in deciding how much of the soil needs to be conserved, according to whichever scenario. The bigger, but closely related issue, which can only be illustrated by our discussion of natural capital, is the measurement of, or judgment about the value of the other capitals and their transformation one to another.

First, how is the 'criticality' of natural capital to be recognized in such a diverse and spatially variable society and environment? A plausible interpretation of the soil profile at Fandou Béri is given in Figure 5. It must be emphasized that Figure 5 is speculative, for little is known about the subsoil at Fandou Béri, and the argument here might have to be modified if the bedrock outcrops were nearer to the surface than shown in the figure, or if the sandy soils were not of uniform quality throughout. If we accept the diagram, which does have *prima facie* support, it can be seen that the sandy *tassi* soils are very deep compared to the rate of erosion for the last 30 years, in other words that the point at which the conservation of soil becomes critical to the future of Fandou Béri (even if no big change occurs in its economy), is a long time in the future. Even if it is a

long-distant concern, we might still need to assess how much *tassi* soil is 'critical' for agricultural production, but this depends on the chosen scenario. If the future were to be agricultural intensification, very few of the deep sandy soils might be needed (a low level of critical natural capital). The large inputs of organic matter characteristic of intensive agricultural systems in this part of Africa would produce much higher yields and farming could therefore take place on much smaller areas (Williams 1997; Mortimore and Adams 1999), although this would be dependent on increased labour availability or labour-saving technologies, currently constraining farming in Fandou Béri. If the future were to see an increase in economic diversification or in more circular peri-urban migration, with the growth in the informal sector, then there might be less dependence on *in situ* agricultural yields. As regards criticality, the conclusion would be the same as for the first scenario. If the future is to be much like the past (low-investment, extensive arable agriculture with some livestock), then perhaps as much *tassi* soil should be conserved as possible, at least when it gets to some threshold thinness for crop production, implying a much higher level of criticality. Thus 'criticality' of soil depth at Fandou Béri cannot be defined with physical measures alone, and we suspect that the criticality of any form of natural capital would be difficult to pin down. It is notable that another attempt to judge sustainable thresholds in soil, but using examples from the Mid-West of the United States, reached much the same conclusion: thresholds depend on how the soil is valued (Popp *et al*. 2000). The evaluation of natural capital, in other words, is flexible. Can a framework for judging sustainability itself be sustained against this kind of uncertainty?

The judgement of other stocks of capital and the transformation of one to another is the more fundamental issue, but one that has the same underlying problematic. There can be little doubt that family exchanges, friendly agreements between neighbours, landlords and tenants and those with complementary skills (like the Djerma and the Fulani), or the sale of crops, are all processes that convert natural (soil) into other forms of capital (networks, houses, education, cash, etc.), but measurement of or even judgment about the processes is much more problematic. Physical measurement is obviously inappropriate in the case of human, social or economic capital. Neither is economic evaluation (as proposed by Solow 1986) a solution, because it employs surrogate measures (monetary value) to compare the different forms of capital. Indeed, Serageldin's formulation, coming as it does from the World Bank, is remarkable in its abjuration of economic evaluation of any kind.

'Social capital' is the most vulnerable concept in the capitals framework, the one on which it may founder. Many scholars still see major difficulties in its assessment. Some despair of compressing the richness of individual knowledge, status, power and capability to mediate access to capital assets, networks and support into this kind of shorthand (Fine 2000). Even the more positive critics have found definitional problems (Grootaert and van Bastelaer forthcoming). Many donor agencies, including the Social Development team at the World Bank, continue to use Putnam's (1993) interpretation of social capital as the associational ties built on 'horizontal' elements—cultural norms of identity, trust and reciprocity. To these scholars, neither the emotional ties of family nor the vertical networks of authority, patronage, trust or reciprocity can be counted as social capital. In a recent survey of the field, Woolcock and Narayan (2000) identified four broad approaches to social capital: communitarian (focusing 'horizontally' on associations); networks (also 'horizontal', but in the form of bridging and bonding); institutional (building good governance); or synergetic (i.e. 'horizontal' and 'vertical' linkages, including those to the state). They believed the term should only be used to refer to vertical linkages, but this is in conflict with much of the social capital literature, which argues for the superiority of horizontal over vertical ties.

These arguments do not help in the application of the framework to Fandou Béri. In such a society, with strong family ties, but without strong community organizations, these debates about social capital seem normative and prescriptive. 'Horizontal' ties do exist, but there are also important 'vertical' ones, such as in patron–client relations involving credit, farm inputs and tenure arrangements. Fandou Béri also illustrates another problem with the term: 'social capital' may have malign as well as positive effects on the conservation of resources. In Fandou Béri, conflicts over rights to fodder, grazing and cultivation, stemming from particular forms of social relation ('social capital'?) produce situations in which there is destructive use of resources, and the social networks that sustain migration apparently encourage erosion on some fields, as has been described above. A similar but more generalized picture is painted by Maxwell and Wiebe (1999).

We argue that evaluation of all the capitals, including natural capital, are bound in a local system of understanding based on access and capacity to acquire the entitlements that enable farm investment. Understandings and evaluations change over time, and are socially differentiated

within the community. If we can reach no firm idea of how to measure the individual elements of a sustainable livelihood, how could we judge their conversion? How could we establish, for example, whether natural capital at Fandou Béri was being sensibly converted into other forms, merely 'squandered' on consumption, or expended on combatting risk? These are issues that have been explored elsewhere, but are very far from resolution (Röling and Jiggins 1998; Bebbington 1999; Mehta *et al.* 1999; Woolcock and Narayan 2000; Scoones 2001).

Hence, 'sensible sustainability' may be more attainable, realistic and desirable in agricultural communities like these than strong sustainability, given that it balances environmental with social sustainability. It may even have been attained at Fandou Béri, but without adequate methodological tools, we cannot demonstrate that critical thresholds for natural or social capital have or have not been surpassed. Sensible sustainability is undoubtedly to be preferred to the 'almost anything goes' views of the supporters of weak sustainability (whose applicability to Fandou Béri we have not discussed). But the concept has very serious operational and methodological difficulties.

Conclusions

We can now attempt to answer the two questions posed in our introduction:

'Strong sustainability' is not a feasible option in this part of the Sahel. No social system can be envisaged that could conform to the constraints of strong natural capital sustainability.

The 'sensible sustainability' option in the 'capitals' framework does emphasize the interdependence of natural resource conservation and the maintenance of socio-economic systems. In the case of Sahelian agriculture, it allows for the point that the maintenance of 'natural capital' (in this case soil) must always be part of a complex trade-off between agricultural and non-agricultural activity.

Notwithstanding the desirability of 'sensible sustainability' and the way in which its complexity is expressed in the 'capitals' framework, the condition is difficult, if not impossible to recognize in Fandou Béri or, we suspect, any other agricultural community, as it is currently defined. If a formulation anything like the 'capitals' framework were to be adopted by development projects, the challenge would be to resolve the tension between the need for unambiguous understandings of key terms like 'natural' or 'social capital', which is what Neumayer (1999) argued for, and the need to maintain the flexibility to deal with the fluidity of Sahelian (or similar) livelihood systems. These systems are unlikely to be able to function under the imposition of strict 'sustainability' criteria that might issue from ecological or economic modelling, but the attempt to counter this approach by introducing social considerations in the capitals framework creates its own problems. It introduces ambiguities that allow anything to masquerade as sustainability, but to counter the ambiguities would introduce rigidities that would constrain livelihoods that can only be sustained if flexible. These arguments about the capitals framework may concern its practical application, but they depend on the much more fundamental problem of the compression of complex social issues into terms like 'social' or 'human capital'.

The sustainable livelihood model may eventually be seen to have been the basis of a heuristic for achieving sustainability; yet refining it into a practical instrument will not be simple. Röling and Jiggins noted that, 'a sustainable society is not automatic or God-given, but the outcome of a self-willed and learned transformation' (1998, 285). Sustainable development is a process, not an end-point. But operationalizing these perceptions, let alone improving sustainability science, as Kates and his colleagues want (2001), must have better conceptual bases if sustainability is to be delivered. The approach must indeed, as it is now widely argued, be more 'pluralistic' than the early models of sustainability that depended only on environmental modelling (Tait and Morris 2000), a realization that was, in effect, the main *raison d'être* for the introduction of the 'capitals' approach.

The capitals framework has a long way to go before it is applicable to places like Fandou Béri. What Sahelian villagers do not need is the imposition of yet another poorly formulated ideology by policy-makers or donors, like those that underlay calls for them to observe 'carrying capacities', or to guard against 'desertification' (Batterbury and Warren 2001). They will not profit from the deployment of generic narratives, like 'sustainability', if they are based on vaguely defined criteria that may be invoked to support all manner of activities or to censure activities deemed to be 'unsustainable'. But Sahelian villagers do need more secure futures, sustainable or not.

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