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**International
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Environment and
Development**

Sustainable Agriculture
and Rural Livelihood
Programme

Gatekeeper Series no. 101

Social Networks and the Dynamics of Soil and Water Conservation in the Sahel

**Valentina Mazzucato,
David Niemeijer,
Leo Stroosnijder and
Niels Röling**

2001

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2001

Executive Summary

Soil and water conservation projects in Africa have, at best, a patchy record. New policies and practice are needed. This paper presents the results of an integrated approach to the study of soil and water conservation and discusses the validity of some of the major assumptions that continue to shape soil and water conservation policies and interventions.

The paper analyses quantitative and qualitative data collected at both the national and village level in Burkina Faso between 1994 to 1998. Contrary to the dominant degradation narrative that depicts African farmers as miners of their soil nutrients, this study found no evidence that soil fertility is declining, despite increasing population pressure and declining rainfall. Farmers were found to be well aware of land degradation processes and how to halt these, making use of a wide range of soil and water conservation technologies applied in a flexible and adaptive way.

While farmers make few monetary investments in agriculture and land enhancing measures, they instead invest heavily in social networks that give them flexible access to resources necessary for agriculture and soil and water conservation, as well as allow them to spread risk and diversify their livelihood strategies thereby relieving the pressure on the land. Farmers were also found to have amended social networks and technologies to adapt to the changing context in which agriculture is practised. Based on these findings six recommendations are made concerning the policy and practice of soil and water conservation in the West African Sahel.

These include the need for:

1. More accurate ways of measuring land degradation.
2. New soil and water conservation technologies that increase farmers' flexibility to deal with variable climate, soil, and human health conditions.
3. Development interventions that broaden the scope and scale of social networks, rather than focus solely on the development and extension of technologies.
4. Development interventions that facilitate social *and* market exchanges.
5. A new, flexible approach to development that does not have fixed targets and outputs. This implies a major change in the methods and procedures for the development and evaluation of interventions.
6. Natural resource management projects that explore how to strengthen local resource management networks and make them spread beyond the village, rather than undercut them by focusing on an imaginary fixed geographical entity such as the village in the '*Gestion de Terroirs*' approach.

SOCIAL NETWORKS AND THE DYNAMICS OF SOIL AND WATER CONSERVATION IN THE SAHEL

Valentina Mazzucato, David Niemeijer, Leo Stroosnijder and Niels Röling

Introduction

Soil and water conservation in Africa has been at the centre of attention since the beginning of the 1930s when colonial governments became concerned about the impact of soil erosion on land productivity. Despite this long history, researchers and development practitioners began to realise in the 1980s that soil and water conservation interventions had, at best, a patchy record (Hudson, 1991; Pretty, 1995; Reij, 1991). New approaches were developed that tapped into indigenous knowledge and were based on small-scale initiatives, participation of the local population and simple technologies. While in many ways progress has been made, success stories remain few and new approaches are being sought once again (Biot *et al.*, 1995; Mazzucato and Niemeijer, 2000b).

In this paper we explore the validity of the paradigms and assumptions behind much of the current research and practice of soil and water conservation in the Sahel. We draw on a four-year field study (1994-1998) in Burkina Faso that investigated the technical, economic and social aspects of soil and water conservation (Mazzucato and Niemeijer, 2000a, 2000b). The paper is mainly based on research carried out in two villages in the eastern region: one in the northern Gnagna province, and one in the southern Gourma province. However, a national level analysis also carried out during this research indicates that the dynamics observed in these villages reflect what is happening elsewhere in the country and region. The villages are inhabited predominantly by Gourmantché agriculturists but also include wards of semi-sedentary Fulbe pastoralists. Research methods included use of secondary data, remote sensing, market, household and budget surveys, archival research, oral histories, agronomic measurements, and participant observation. Based on this research we propose new ways in which soil and water conservation should be conceptualised, studied and put into practice.

First, we provide a brief overview of how soil and water conservation is currently conceptualised and the assumptions on which research and practice are based. We then discuss the validity of each of these assumptions and suggest alternative perspectives. The paper ends with implications for policy and practice.

How soil and water conservation is currently conceptualised

There are three major approaches underpinning the study and practice of soil and water conservation: paternalist, populist and neo-liberal (Biot *et al.*, 1995). The paternalist approach consists of large-scale interventions, often with heavy machinery and limited (if not coercive) involvement of the local population. In contrast, the populist approach emphasises small-scale interventions, bottom-up participation of local populations, and simple technologies based on indigenous techniques. The neo-liberal approach emphasises the role of institutions, political and economic incentives and the inter-relation between poverty, population growth and land degradation.

Notwithstanding their differences, a number of assumptions underlie most of these approaches:

- Land degradation is widespread.
- Local farmers are insufficiently aware of the processes of land degradation and their role in these processes.
- Farmers' traditional agricultural practices are disintegrating or no longer sustainable under current population densities and are failing to feed the growing population.
- Lack of financial resources limits the willingness and ability of farmers to invest in agriculture and land enhancing measures.
- Local institutions hinder rather than encourage investments in agriculture and land enhancing measures.
- Farmers tend to stick to old habits rather than change the way they practise agriculture and are therefore unable to cope with changing environmental, social and economic contexts without outside technological and institutional interventions.

While today there are few researchers, policymakers, and development practitioners who would endorse all the above points, these assumptions continue to shape current research and development practice. In the subsequent sections we will address the validity of each of these assumptions.

The occurrence of land degradation

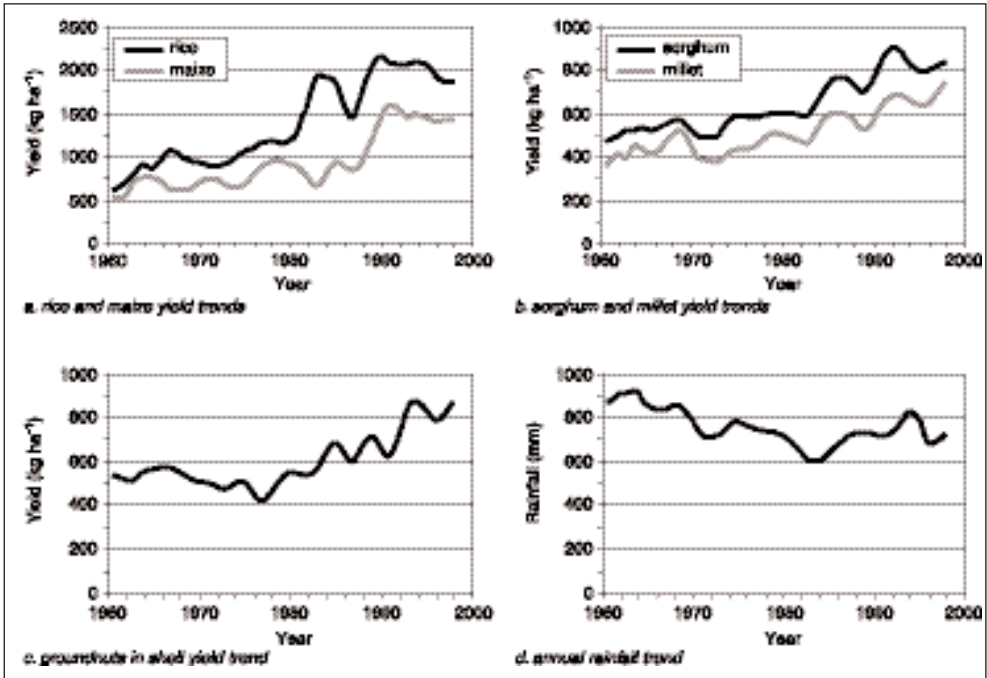
According to the UNEP *Atlas of Desertification* almost 30% of the East and West African Sahel region is affected by human-induced soil degradation (UNEP, 1997). Burkina Faso shows the highest ranking of any Sahelian country on the Severity of Human Induced Soil Degradation index calculated by the World Economic Forum

(2001). Other reports suggest serious nutrient depletion and rapid deforestation (eg., Henao and Baanante, 1999; MET, 1994). A combination of factors is claimed to be causing this land degradation, including repeated cycles of drought, increased population pressure on natural resources, deforestation caused by firewood demands, uncontrolled migration, and inappropriate cropping and pastoral practices (eg., Ramaswamy and Sanders, 1992; Vierich and Stoop, 1990). In other words, the evidence for a physical deterioration of land (soil, water and vegetation resources) seems to be overwhelming and the causes plausible.

One would expect such a deterioration to go hand in hand with a decline in productivity. In fact, land degradation is usually defined in terms of a loss in productivity of the land (Blaikie and Brookfield, 1987). Following estimates for African cropland quoted in Scherr (1999), a productivity loss can be expected of at least 20% over the last 40 years compared with a situation without soil degradation. This is in line with the common perception that yields have been declining in Burkina Faso and other West African countries (Bationo et al., 1998; Ramaswamy and Sanders, 1992). However, this is not what is found when yield statistics are examined.

Pieri (1989) has already noted that between 1960 and the early 1980s yields of most crops in Sahelian countries have been stable or in some cases have increased. Figure 1 shows that when yields for the 1980s and 1990s are also incorporated into the analy-

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



Source: Mazzucato and Niemeijer (2000b).

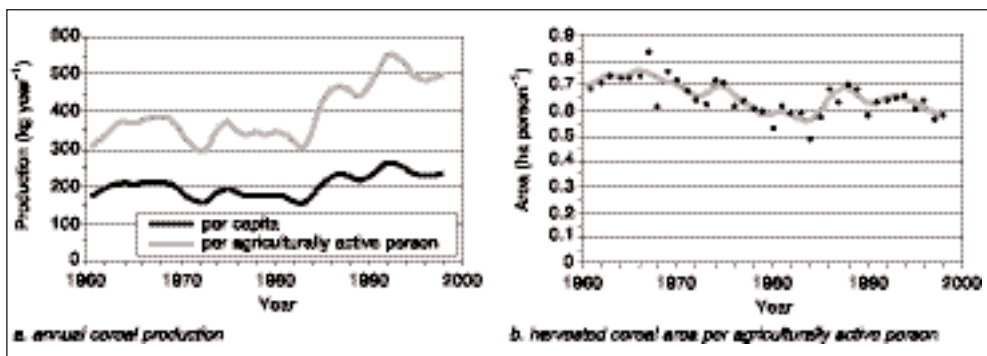
sis, yields of the most important crops in Burkina Faso have actually considerably increased over the last 40 years according to national level data provided by FAO and the Ministry of Agriculture, despite a 20% decline in annual rainfall over that same period (calculated from data of the National Meteorological Service). Rice and maize yields increased by a factor of three and sorghum, millet and groundnut yields by a factor of two. While increased mechanisation, irrigation and fertiliser use have contributed to some degree to the increase in rice and maize yields, these are unlikely to be significant factors in the case of the other crops, which tend to be cultivated using hand-hoes and few inputs. The expected productivity loss of land resources thus does not seem to have taken place. On the contrary, farmers have apparently been able to even increase output without relying on external inputs to replenish soil fertility.

The resident population of Burkina Faso grew from 4.6 million in 1961 to 10.3 million in 1996, more than doubling the pressure on the land (and reaching an average density of 38 inhabitants per km (inh. km⁻²) and rural densities ranging from 12 to 83 inh. km⁻²). However, judging from Figure 1 this has not led to a decline in productivity. Figure 2, in addition, shows that it has also not led to a decline in labour productivity, nor to a decline in the amount of cereals produced per person. This is despite a gradual decline in the area cultivated per agricultural worker. In productivity terms, there is very little evidence of a land degradation trend.

The above discussion applies to agricultural land. Recent remote sensing studies (e.g., Prince *et al.* 1998), however, also found little evidence of a downward trend in land productivity in terms of changes in the (natural) vegetation.

If no productivity decline can be found, then perhaps earlier assessments are over-estimating degradation. First, it is well known that land degradation assessments, whether in the form of expert assessments, erosion measurements or nutrient budgets, are

Figure 2. Annual cereal production per capita, agricultural labour productivity, and harvested cereal area per agriculturally active person in Burkina Faso (1961-1998).



Source: Mazzucato and Niemeijer (2000b).

methodologically problematic partly because of high spatial variability and site specificity of the observed phenomena, the difficulties in upscaling point or plot measurements to watershed and regional level and the complexity of temporal dynamics underlying changes in land properties (eg., Blaikie and Brookfield, 1987; Rasmussen, 1999; Scoones and Toulmin, 1999). Secondly, several studies in Burkina Faso (Gray, 1999; Mazzucato and Niemeijer, 2000b, 2001; Prudencio, 1993) have shown soil fertility of agricultural fields to be comparable to, if not better than, similarly situated uncultivated or very old fallow land. This suggests that local farming practices do not necessarily deplete soil fertility.

All in all, there are good reasons not to take land degradation as a given. In some areas it may be a problem, in others not. Soil and water conservation can prevent land degradation or be a response to land degradation. It is important to bear in mind that preventive measures do not have to be as drastic as curative measures, and that what farmers are already doing might actually be more suitable than the land degradation literature has assumed.

Farmer awareness of land degradation

Many sustainable development projects start by teaching the local population about land degradation. The assumption behind this practice is that local land users are simply unaware of the creeping processes of degradation and their causes or do not know what to do about them. This may seem surprising after over two decades of indigenous knowledge studies, but the fact is that most of these recent studies have focused on factual knowledge, such as local soil and vegetation classifications and on practical knowledge related to local technologies.¹

The few studies which have looked at conceptual and perceptual issues surrounding land degradation have shown that land users are often aware of the processes influencing soil fertility, soil formation and soil erosion (eg. Mazzucato and Niemeijer, 2000b; Niemeijer and Mazucato, 2002; Östberg 1995). The Gourmantché, for instance, have a special term for water erosion (*ninkoadima* or *ninkuadigu*, which literally means scraping water) and recognise not only rill and gully erosion, but also less conspicuous sheet erosion. Farmers readily explain the various qualities of different kinds of organic material as sources of soil fertility and note how cultivation, removal of natural vegetation, burning, animal trampling and grazing all affect soil erosion and soil fertility (Mazzucato and Niemeijer, 2000b; Niemeijer and Mazucato, 2002). In the case of the Gourmantché, and this is probably true for most other African farmers, there appears to be little need for awareness campaigns about land degradation. Time and resources are probably better spent exchanging perceptions and assessments with local farmers to learn about possible differences in ideas on land degradation and their implications for development.

¹ The only exception is probably soil fertility, which has been relatively well studied.

The flexibility of local soil and water conservation practices

It is often said that 'traditional' farming practices are disintegrating, that indigenous soil and water conservation practices are being abandoned and that where these are still carried out they are inappropriate or insufficient to deal with increased population pressure. Farming societies and their environment are changing continuously and factors such as rapid changes in population densities, rainfall patterns or market access may influence the use of soil and water conservation practices. For example, in the eastern region of Burkina Faso we found a decline in the use of stone lines compared with the past. At first this seemed like a clear-cut case of the abandonment of a 'traditional' practice; however, on closer inspection a very different picture emerged (Box 1).

Box 1. Abandonment or adaptation?

Informants readily agreed that few stone lines are located on today's fields and that instead one regularly finds the remains of stone lines on old bush-covered fallows that had been cultivated by their fathers and grandfathers. They explained this change as follows. Until the 1950s people used to cultivate higher ground because of flooding problems on lower land. On higher fields runoff and erosion are often a problem, requiring the construction of erosion reducing barriers. Reduced rainfall levels in recent decades have decreased yields on higher fields and lessened the flooding problems on the low lands. Farmers have shifted their fields to flat and lower land where erosion is much less an issue and therefore no stone lines are constructed. Those people who still cultivate high and sloping land continue to use stone lines where necessary. This story is confirmed by comparing aerial photos from the mid 1950s and the 1980s/1990s for the two research villages. In the northern, densely populated village (50 inh. km⁻²) cultivation on high and sloping land had slightly declined, while on flat and low land a threefold increase was found. For the southern, sparsely populated village (13 inh. km⁻²), cultivation on higher and sloping land doubled, but on low and flat land it increased by a factor of seven. A similar transition from higher to lower lands has been reported for other parts of the eastern region (Swanson, 1979) and elsewhere in Burkina Faso (Vierich and Stoop, 1990), though in the latter case the cause was attributed to a fertility decline of the higher lands, not a lack of rainfall. Farmers in our study villages never mentioned soil fertility decline as a cause.

It was also found that Gourmantché farmers use soil and water conserving practices more intensively as population densities have risen and the amount of uncultivated land has declined. Table 1 lists the soil and water conservation practices used by farmers in eastern Burkina Faso. Similar practices are found elsewhere in Burkina Faso. It is important to note that farmers use the relatively inconspicuous agronomic and biological practices more widely than the mechanical practices, which are used on just 10% of the plots according to the 1993 ENSA national agricultural survey. As a consequence a lot of soil and water conservation goes unnoticed by the outside observer.

Table 1. Local soil and water conservation practices found in eastern Burkina Faso

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

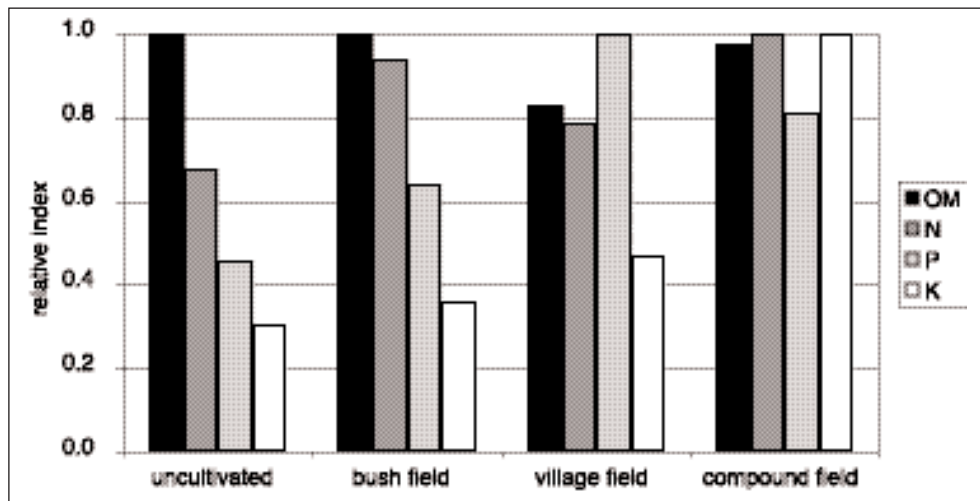
Source: Mazzucato and Niemeijer (2000b).

As Table 1 shows, farmers have a large repertoire of conservation practices to choose from. But, perhaps more important than the practices themselves, is the way they are used. Farmers use the practices adaptively in response to observed erosion or yield decline: only when and where needed. When a farmer observes that a certain part of a field is suffering from erosion or yielding worse than other parts, he or she will, for example, lay out a small stone line or apply mulch to that part to retain its productivity. As a consequence, conservation practices increase in number and in area covered as a field gets older, until the farmer decides that leaving the field fallow and moving elsewhere involves less risk and trouble than continuing to improve it. This kind of adaptive management allows an optimal adjustment of limited labour and input availability to the (changing) requirements of soil and crop.

The question is of course whether all these practices add up to a sustainable cultivation system. The results of an extensive analysis of soil samples collected on cultivated and long-term uncultivated land in the research villages do suggest it is sustainable at least in chemical terms. Figure 3 shows how the small fields located close to the compound have a relatively high fertility because continuous cultivation is compensated for by inputs of household refuse, manure and other organic matter. The village fields, located a little further from the compounds and also cultivated for relatively long periods show relatively good phosphorus (P) and potassium (K) levels, mainly from inputs from roaming livestock, but are lacking in soil organic matter (OM) and nitrogen (N). This indicates that these fields are essentially overexploited. The large bush fields several kilometres away from the compounds are difficult to supply with inputs, but are only cultivated for 5 to 10 years in a row and therefore show lower fertility than the compound fields, but higher fertility than bordering land which has been long uncultivated. Overall, cultivated land on average shows equal or higher fertility than land which has been fallow for some time (20 to 100 years) because cultivation practices apparently sufficiently compensate for nutrient losses through crop growth.²

² For more details see Mazzucato and Niemeijer (2000b, 2001).

Figure 3. Soil fertility on different types of land use: organic matter (OM), nitrogen (N), phosphorus (P) and potassium (K).



Source: Mazzucato and Niemeijer (2000b).

Investments in agriculture and land enhancements

Farmers are often seen as unable or unwilling to invest in agriculture and land enhancing measures due to their lack of knowledge or financial means. We have dealt with the former above, so here we turn to farmers' financial means to see whether and how they invest in agriculture and in soil and water conservation. We studied transactions made by 35 individuals reflecting a cross-section of society in two villages over a one-year period.³

This revealed that individuals do make very few direct investments in crop production. Expenditure on crop production, such as the purchase of equipment or inputs, is extremely low for all people, ranging between 0% and 4% (with the exception of three rice growers in the southern village who hired a tractor for land preparation). This seems to contradict the fact that for most people crop production is the single largest contributor to their total inflows⁴ (Mazzucato and Niemeijer, 2000b). Why would people invest so little in an activity that contributes so much to their overall income? Poverty is not a satisfactory explanation because people do invest in non-subsistence items such as livestock, off-farm businesses and luxury goods.

³ The small number of individuals was expressly chosen so that we could discuss sensitive information around social transactions which often does not come out in large-scale surveys where there is little rapport between interviewer and interviewee.

⁴ Inflows refer to what is received by selling, borrowing, or producing items, or through gifts received.

We argue that farmers do invest in agriculture and soil and water conservation, but not in a way that is visible by only looking at direct monetary allocations made for agricultural technologies or labour. Instead, we found that ‘social transactions’ was the most important expenditure category after spending on basic necessities in terms of frequency, the number of people that engaged in them, and the percentage they comprise of people’s total expenditures⁵. Social transactions are one of the major ways in which people create and maintain social networks. We argue in the next section that social networks are a way in which farmers invest in agriculture and soil and water conservation.

The importance of social transactions in terms of how people allocate their in-cash and in-kind resources is an intriguing finding because while people invest heavily in social relationships, they also function within a well-integrated, market society. Virtually every villager buys and sells goods on a daily basis, the market value of goods is well known by villagers, and people engage in profit-seeking behaviour. This highlights that market-oriented behaviour coexists with social objectives. We will return to this point in the conclusions.

Local institutions and soil and water conservation: the role of social networks

Most literature on African agricultural systems tends to consider local social institutions as hindering agricultural production because they divert resources from production and into things such as funerals and marriages (Berry, 1989; Reardon and Vosti, 1995). Studies that more specifically focus on soil and water conservation either ignore the influence of social institutions on people’s ability to engage in conservation practices or consider them only in the form of land tenure arrangements or farmer organizations/associations. However, we argue that farmers’ networks are a vital social institution for enabling farmers to conserve their soil and water resources.

Through social networks people are able to access the resources they need for practising soil and water conservation (Table 2 and Box 2). As was shown above, farmers have a large repertoire of soil and water conserving technologies. However, it is not enough to know about them; one also needs to have the resources, such as labour, to be able to implement these technologies. For example, manure application requires both manure and labour; fallowing requires land to move to; and weeding requires labour.

⁵ Expenditures include in-cash and in-kind transactions but exclude consumption of own production.

Box 2. The bush fallow system

The bush fallow system is one of the principal soil conservation practices, as in many parts of Africa. After cultivating a field for several years, farmers move to a new field, leaving the old one fallow to regenerate. In a context of increasing land scarcity due to rapid population growth, this system is said to be no longer feasible. However, land networks that allow people to borrow land from each other enable the bush fallow system to be practised at higher population densities than if it were not possible to borrow land. At the village or watershed level, borrowing land enables slack resources to be redistributed. For example, in a two person village, person A has 6 ha of land and he cultivates 2 ha. Person B has only 2 ha of land and cultivates all of it. After 5 years of cultivation, both persons A and B need to move to new fields and leave their old ones fallow. Person A moves to 2 ha of his fallow land. If person B is unable to borrow land he is forced to over-cultivate his land. But under a borrowing scenario, he can borrow person A's remaining 2 ha of fallow land. After another 5 years, both person A and B can return to their original fields. Whilst fallows may have shortened, no one was forced to over-cultivate their land. This example only works for a certain population:land ratio. As population density increases a shift to a more intensive cultivation system that is less dependent on fallow regeneration will be necessary. This was confirmed by our findings that in the northern more densely populated village, there was a gradual shift taking place to an increased use of soil and water conservation practices and inputs, and away from bush fallow.

Secondly, networks also allow people to avoid the 'poverty trap' by diversifying their livelihoods and thus reducing the likelihood of a crop failure. Severe poverty is often seen as the cause of degrading practices (eg., Hudson, 1991). For example, poor people cannot afford to postpone production to sustain the land. Networks help people access resources such as time, money or knowledge necessary for practising different livelihood-earning activities and avoiding the poverty trap (Table 2 and Box 3).

Box 3. Spreading the risks

The bush fallow system of cultivation not only requires access to land but also requires people to take on a certain degree of risk. This is because the first year of cultivating a new field requires a lot of labour for clearing, so people may not be able to clear as much land as they would ideally need to feed their entire family. Furthermore, cultivating a new field is risky because the farmer does not know the field well enough to practise effectively many of the soil and water conservation practices mentioned above, which depend on the farmer's detailed knowledge of his soil.⁶ To take these risks, people need to know that they can access sources other than crop production in order to meet their consumption needs, and thus avoid the poverty trap if too little food is produced. Social networks are important at these times by giving farmers access to additional labour to conduct off-farm activities as well as access to gifts of food or low-cost loans.

6 Cultivation histories revealed that until recently, farmers rarely cultivated the same bush field twice during their lifetime, and in that time would move fields between five to ten times.

Table 2. Social networks for soil and water conservation (SWC)

Type of networks	How they function	How they affect people's ability to practise SWC S = spreading resources spatially D = livelihood diversification T = can apply SWC technologies
Land networks	Provide access to land through borrowing agreements. Farmers ask a relation to use their land for cropping during the cultivation cycle of the 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 crop production, symbolic gifts, and/or political allegiance.	Allows people to practise fallow under higher population densities (T) Compounds can spread to different farming areas thus reducing the risk of being in an area of localised rainfall shortage (S)
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/or drink. No official payment is necessitated but participation in a work party is reciprocal.	Get agricultural tasks done on time (T) Use own labour also for off-farm activities (D) Use SWC knowledge to full capacity by having the time to conduct labour-intensive SWC (T)
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.	Access land and landraces necessary for the application of SWC technologies (T) Keep livestock in different geographical areas thereby reducing the risk of having an entire herd killed by disease (S) Access gifts of production to consume or sell (D)
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.	Access to cattle manure (T) Reduce crop damage from livestock (T) Access labor for cattle herding (D) Reduce overgrazing (T)
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.	Frees labour for application of SWC technologies (T) Use own labour also for off-farm activities (D)
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.	Gives alternative source of cash income (D)

The importance of social networks for agricultural purposes raises the question of why this institutional form is preferred over market exchange⁷ as a way to access resources and minimise risk. This question is important to explore as most literature on soil and water conservation (e.g. Reardon *et al.*, 1996; Sanders *et al.*, 1996), as well as development projects, emphasise input and output markets as the primary way to make African agriculture more environmentally sustainable. Social networks are hardly mentioned.

Social networks enable a flexible form of exchange that is fundamental for coping with the variability endemic in Sahelian agricultural systems. Five characteristics of networks make them flexible:

1. Networks are multipurpose: the same relationship can be used for many purposes. In a market exchange, a purchased good can only be used for the purpose for which it was meant.
2. Networks can be invested in at various times: one can create and maintain the relationships that comprise one's network at various times throughout the year, depending on resource availability. This contrasts with market exchanges, where debt repayment has fixed time periods and interest puts a value to the timing of repayment.
3. Networks can be invested in through a variety of means: they function on the principle of reciprocity so one has indebted oneself by using a network to access something. However, this debt can be paid back with various means such as labour and political allegiance. In market exchange, money is the only means of exchange and thus excludes the poor.
4. Networks allow access to factors at a scale appropriate to the specific agricultural system. For example, tasks such as weeding or clearing need to be done on time and therefore a farmer needs many labourers on one day rather than one labourer over a month. Labour contracts based on market principles cannot sustain such a labour force needed for a very short time in peak periods. Another example is the practice of borrowing small pieces of land (e.g. 0.05 ha) surrounding one's own field in order to expand when one's labour availability allows the cultivation of slightly more land.
5. Networks transgress geographical boundaries: they can expand and contract in reaction to changing social, economic and environmental contexts. They can be based on relationships within a compound or a village but can also extend to members outside the village or region. For example, technology networks allow farmers to access new varieties through relations with people who live in or have travelled through different regions. Land networks extend to members beyond the village territory so that

⁷ Market exchange refers to transactions guided by the laws of supply and demand in free market competition.

farmers can access cultivable land beyond the village. This is contrary to the geographical rigidity of the '*Gestion de Terroirs*' approach to natural resource management, currently the dominant development approach in Burkina Faso. It focuses on formalising resource access and land management within a fixed social and physical space, the village territory, which is assumed to be well-defined and uncontested. This focus has often led to increased conflict and ecological and economic vulnerabilities (Painter et al., 1994; Turner, 1999).

Changing agricultural practices

Often social networks are associated with a 'traditional' way of life and are thus conceptualised as static, unchanging institutions. This study instead reveals that social networks have changed over time in their composition and this has been one of the major ways farmers have been able to adapt to the changing context in which agriculture is practised (Mazzucato and Niemeijer, 2000a; 2002). For example, cultivation, life and village histories indicate that land borrowing agreements are used more frequently than they were a century ago so as to be able, as was argued above, to practise the fallow system of cultivation under higher population densities. Table 3 indicates how each type of network has changed and in response to which factors.

Table 3. Changes in social networks

Type of networks	Change in networks	Response to changing context
Land networks	Increased use	Increasing population densities Declining rainfall
Labour networks	Change in composition (non-kin) and use (production)	Smaller production units Increased market integration Increasing population densities Declining rainfall
Women's natal networks	Customs less restrictive and natal networks change in use	Smaller production units Increased market integration
Cattle networks	New networks (with Fulbe) and new means of establishing them (monetary loans)	Increased market integration Increasing population densities Declining rainfall
Technology networks	Change in use	Increased market integration Greater technology availability
Cash networks	New networks (cash associations)	Increased market integration

Conclusions

These findings are mainly drawn from a case study in eastern Burkina Faso. However, as the area is facing the same trends (rapid population growth, declining rainfall since the wet 1950s and increasing yields) and has a similar production system (characterised by low external input use), as many other Sahelian regions, our conclusions are pertinent to a wider geographical area.

The six major findings are as follows:

1. There is no evidence of serious land degradation in the region.
2. Farmers in the region are knowledgeable about processes of land degradation.
3. Farmers are familiar with and use a wide range of technologies for soil and water conservation. They use these technologies in a flexible and adaptive way in response to social and environmental changes at field and landscape level.
4. A large part of farmers' investments in agriculture and land enhancing measures is in social networks, rather than in direct monetary allocations to labour or technologies.
5. Social networks play an important role in soil and water conservation in that they allow people to: a) access the resources to implement their conservation knowledge, and b) avoid risk by spreading their resources spatially and by diversifying their income sources.
6. Farmers continue to adapt the use and composition of social networks and their farming technologies in response to changing social, economic and environmental conditions.

These findings contradict some of the dominant assumptions about land degradation processes and farmers' ability to deal with change in order to practise an environmentally sustainable form of agriculture.

Based on these findings we make some general recommendations about approaches to soil and water conservation in the Sahelian region:

- Current land degradation assessments are based on flawed methodologies. We need better ways to measure on-farm realities and environmental conditions so as to increase the reliability of quantitative analyses of the state of the land. This implies more farm and village level measurements, more attention to spatial and temporal variability, improved techniques for upscaling, longer measurement programmes and better cross-validation with other methods and data sources. Given the various dimensions (social, economic, environmental) that impinge on the state of the land, any study addressing land degradation needs to be interdisciplinary and make use of a variety of research methods including historical methods, such as life histories, historical aerial photographs, and archives.

- New technologies for soil and water conservation should aim at increasing farmers' flexibility to deal with variable climate, soil, and human health conditions. Technologies should be able to be applied in a piecemeal fashion and be effective even if applied only partially. For instance, the effectiveness of hybrid seeds should not depend on specific fertiliser applications, anti-erosive measures should also be effective (and not counter productive!) if applied bit by bit instead of covering a whole field in one go. This is far from the current approach to technology development that treats rainfall, fields, and labour as homogeneous or constant and requires the application of a full technology package to be effective.
- Soil and water conservation is not only achieved through technical, but also through social means. Thus interventions aiming at conservation need to address social institutions, for example, by broadening the scope and scale of social networks, rather than focusing solely on the development and extension of technologies. For example, this could be achieved by helping people to be more mobile by organising events where farmers from different areas can meet, through setting up bicycle or moped borrowing schemes making it possible for people to travel further than by foot. Another example is to support communications centres in which media ranging from the radio to the internet can be accessed.
- Interventions should not just aim at greater market development. Development paths are many: social institutions have been adapted to a context of increasing market integration so that social and market objectives co-exist. The forms in which these systems co-exist depend on local social and environmental histories. Development emphasis should be on facilitating exchange, accepting that in certain contexts, this may be better done through non-market channels such as social networks. Understanding the forms this should take requires knowledge about local social and environmental histories.
- The system of soil and water conservation described here has evolved by farmers choosing, adapting and experimenting with the resources at hand given a specific social and environmental context. Interventions should mirror this process by providing an array of development options from which local people can choose and amend and adapt to their local context. As a result, development institutions cannot expect to foresee the end result. This implies a major change in methods and procedures for the development and evaluation of interventions.
- Social networks consist of ties between people that transgress village, regional and, at times, national boundaries. They are flexible to expand and contract in space and can be redefined over time. This flexibility is the fundamental characteristic of networks that has enabled farmers to practise soil and water conservation under changing social, economic, and environmental contexts. Natural resource management projects should explore how to strengthen the network-based local resource management institutions rather than undercut them through the focus on an imaginary fixed geographical entity, such as the village in the '*Gestion de Terroirs*' approach.

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