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Global cotton and local environmental management: the political ecology of rich and poor small-hold farmers in southern Mali

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This study examines the hypothesis that poor households engage in less sustainable soil management practices than rich households in a similar socioeconomic environment. This broad objective is explored in Mali's southern cotton belt through three specific research questions. First, is there empirical evidence to support the claim that poor households engage in less sustainable soil management practices than rich households? Second, what local and extra-local factors influence household agricultural management approaches in southern Mali? Third, what broader scale political and economic processes are linked to the factors that influence local-level agricultural management approaches? The author reports that soil quality measures on the farms of rich and poor households are not significantly different, refuting the conventional wisdom that the wealthy are better managers of the environment. A variety of environmentally deleterious practices are associated with export-oriented cotton production, an activity more vigorously pursued by wealthy than poor farmers. Finally, the focus on poverty in international environment and development discourse has allowed the government of Mali to avoid a serious debate on the sustainability of cotton production. The study's findings are based on household interviews describing agricultural management practices, an analysis of farm field soil measures, and discussions with donors and national policymakers.

KEY WORDS: West Africa, Mali, cotton, political ecology, poverty, soil degradation

Introduction

With the rise of the sustainable development paradigm in the late 1980s, poverty came to be identified as one of the major causes of environmental degradation in the tropical regions of the world, especially Africa. Emblematic of this view are statements made in the 1987 Brundtland Report:

> [t]hose who are poor and hungry will often destroy their immediate environment in order to survive: they will cut down forests; their livestock will overgraze grasslands; they will overuse marginal lands; and in growing numbers they will crowd into congested cities. The cumulative effect of these changes is so far reaching as to make poverty itself a major global scourge.
>
> WCED 1987, 28

Other institutions and authors have arrived at a similar conclusion (e.g. UNCED 1993; World Bank 1996; Beckerman 1992; Barrett 1996).

It is argued that poorer households are more likely to degrade the environment for at least two reasons: a lack of resources to invest in environmental conservation; and pressure from shorter time horizons. The following quote from a World Bank publication notes these two reasons: '[p]overty is also a factor in accelerating environmental degradation, since the poor, with shorter time horizons . . . are unable and often unwilling to invest in natural resource management . . .' (1996, 13).

The idea that the poor degrade the environment because they do not have the necessary resources to engage in conservation is closely related to the belief that economic growth is necessary for sustainable natural resource use (see Beckerman 1992; Pearce

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and Atkinson 1993; Barrett 1996). In its 1992 development report (devoted to the environment and development), the World Bank states that '[e]conomic development and sound environmental management are complimentary aspects of the same agenda . . . income growth will provide the resources for improved environmental management' (1992, 25). In commenting on Africa specifically, the World Bank asserts that '[t]he prospect of strengthened economic growth in Africa presents a promise of greater resources available for environmental management . . .' (1996, 17).

It is also thought that the poor are more prone to degrade the environment because they have shorter time horizons, or they are more preoccupied with surviving in the present than thinking of long-term needs. In other words, poverty and hunger leave households with no choice but to abuse the immediate environment in order to meet their most basic needs. Dasgupta noted that '[a] recent intellectual tradition argues that the reason the poor today degrade their environmental resource base is that their poverty forces them to discount future incomes at unusually high rates' (1997, 13). Along these lines, Murphree asserts that the behaviour of lower income households in Zimbabwe towards the environment is indicative of a high rate of time preference.

> A culture of poverty [exists] in which the individual is preoccupied with survival in the present and where any effective concern for the future is missing. A culture of poverty is one in which the future is discounted at a very high rate. This is a recipe for accelerated degradation because poverty is both the cause and effect of environmental degradation.
>
> Murphree 1993, 1–2

This study examines the hypothesis that poor households engage in less sustainable soil management practices than rich households in a similar socio-economic environment. This objective is pursued through three specific research questions. Firstly, is there empirical evidence to support the claim that poor households engage in less sustainable soil management practices than rich households? Secondly, what local and extra-local factors influence household agricultural management approaches in southern Mali? Thirdly, what broader scale political and economic processes are linked to the factors that influence local level agricultural management approaches?

The study was undertaken in the Sudano-Sahelian ecological zone of the Republic of Mali as this nation, and the West African Sudano-Sahel more generally, has long been known for its high rates of poverty and environmental degradation. Based on 1999 data, the World Bank (2001) ranked Mali 196th of 206 countries in terms of GNP per capita (adjusted for purchasing power). According to the Brundtland Report, Africa's Sahel region offers the most pronounced example of the vicious cycle between poverty and environmental degradation: 'No other region more tragically suffers the vicious cycle of poverty leading to environmental degradation, which leads in turn to even greater poverty' (WCED 1987, 27). Of all places, the literature suggests that the notion of poverty as a cause of environmental degradation should be operating in this part of the world. If this is not the case, or if the thesis is partially inaccurate, then there may be cause to re-assess the prevailing wisdom.

Mali is also attractive as a research site as it has purely subsistence producers as well as households linked to the larger global economy through cash cropping, especially of cotton. Cotton cultivation in Africa may be environmentally problematic given its heavy nutrient demands and associated use of inorganic fertilizers and pesticides (Camara *et al.* 2000; Ton 2000; Bingen 2004). This mixture of different types of producers allows for a more nuanced understanding of how households may interact with the natural resource base. Two areas in southern Mali were selected as field areas, Siwaa and Djitoumou (see Figure 1), both of which have been engaged in export-oriented cotton production for different lengths of time. Siwaa, a group of villages near the district town of Koutiala, is at the centre of the old cotton basin where smallholders have been farming improved varieties of cotton for export since the 1950s. Djitoumou, a group of villages south of the capital city of Bamako, has been engaged in export-oriented cotton production since the early 1970s and is considered part of the new cotton basin.

Research design and methodology

This study's basic research design involved taking a random sample of households (133 in total), stratifying these households by wealth, and examining associated environmental indicators and management practices. While a variety of environmental variables in this context could have been selected, the focus is on farm field soil quality (infiltration, bulk density, pH and aggregate stability), as this is frequently mentioned as a major environmental concern in southern Mali (GoM 1998; World Bank 1997) and such variables are easier to relate to specific households with known wealth levels. The measures for infiltration, pH-KCL and aggregate stability are all considered to be better when they are higher (in this region of Mali, but not necessarily in others). The exception is bulk density, which is considered to be better when it is lower. Limited

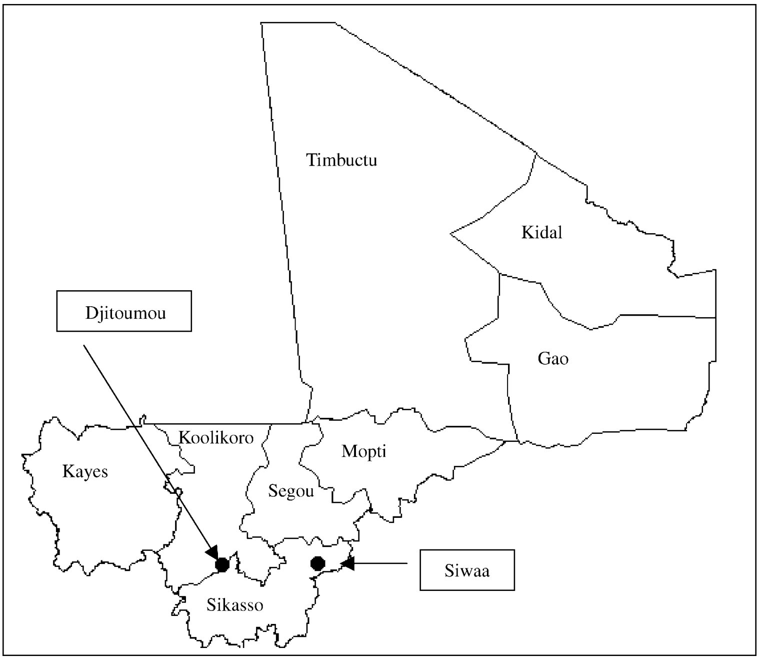

Figure 1 Map of research locations

application of soil amendments (namely manure), inadequate fallowing, and/or overly invasive soil tillage practices will cause infiltration rates and aggregate stability to decline and bulk density to increase. The overuse of ammonium fertilizers without adequate organic inputs may lead to declines in pH-KCL (NRCS 1996).

The study's random sample of households was taken from four villages in the Siwaa area and from four villages in the Djitoumou area of southern Mali. Wealth levels were determined for each household based on an inventory of savings and assets. Assets and savings were assessed via a semi-structured interview with at least two members of each household. Total wealth was then calculated by summing the cash value of all assets (using common 1999 CFA prices agreed upon by the communities).

The analysis relies heavily on local definitions of wealth and poverty as well as a relative, rather than absolute, conception of these terms (Moseley 2001). In large group meetings, villagers consistently referred to numbers of domestic animals (especially cattle), housing materials (e.g. a tin roof) and, although less frequently mentioned, other types of productive and non-productive physical assets (e.g. ploughs, bicycles, and motorcycles) as measures of household wealth. Such descriptions of household wealth are consistent with other studies that have examined local conceptions of wealth and poverty (Narayan 2000). Households were classified as rich, intermediate or poor using these local conceptions of wealth (see Figure 2 for the distribution of wealth and wealth groups). Data on agricultural management practices were collected for all households while soil analysis was undertaken on a subset of farms.

In addition to understanding the poverty–soil management dynamic at the local scale, data were collected in an attempt to understand the broader political and economic context and its potential connections to this local dynamic. In addition to reviewing the literature, about 40 semi-structured interviews were conducted with representatives of the government, multilateral and bilateral donors, and non-governmental organizations (NGOs) in order to understand the prevailing wisdom regarding the poverty–environment dynamic and political economic dimension of cotton production at the provincial, national and international levels. The representatives of these agencies were also given the opportunity to respond to my preliminary conclusions during three formal presentations in Bamako (the capital city) and the provincial town of Sikasso.

Wealth categories and the rural wealth poverty spectrum

An important element of this study was the distinction between rich and poor households in southern

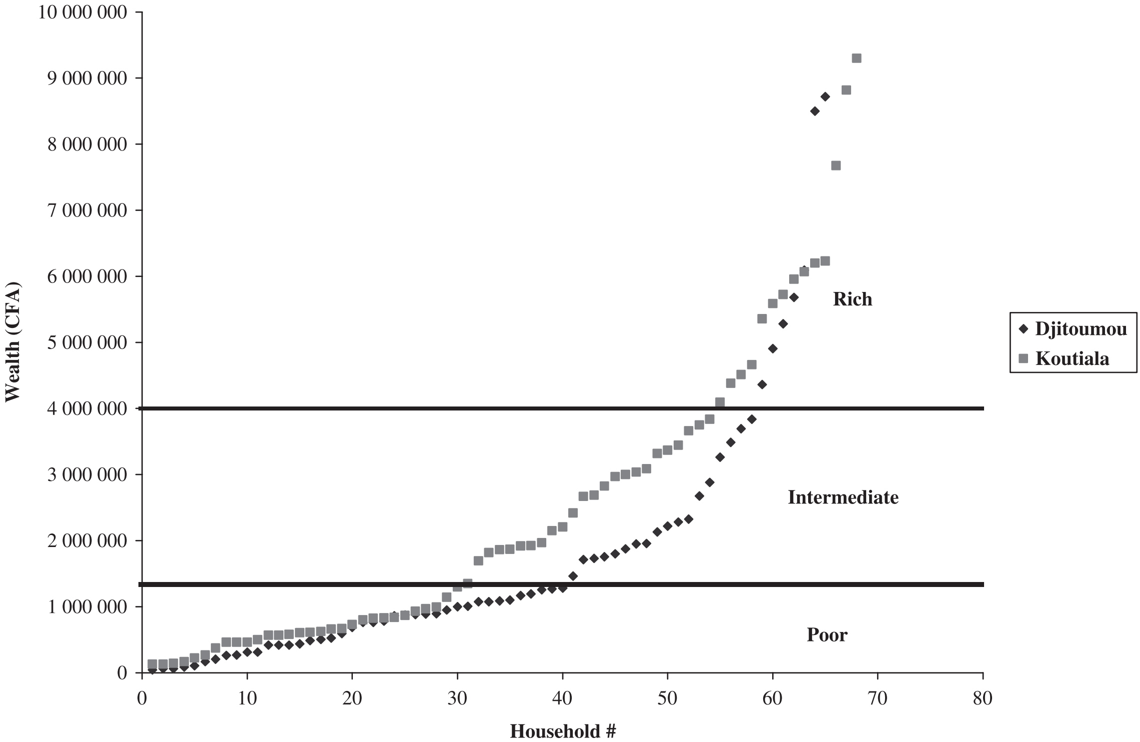

Figure 2 Household wealth groups for Djitoumou and Siwaa (Koutiala) in 1997–99

Mali. Average household wealth in the 1997–99 period was higher in the Siwaa area (2 439 033 CFA or $3752) than in Djitoumou (1 740 792 CFA or $2678) (see Table 1). There were more poor than intermediate or rich households in each of the areas. Using local definitions of wealth, the sample of households in Siwaa was broken down into 20.6% rich, 33.8% intermediate and 45.6% poor, whereas the household sample in Djitoumou consisted of 10.8% rich, 27.7% intermediate and 61.5% poor. The rich group in Siwaa was 9.5 times wealthier than the poor group, while wealth differences between these two groups varied by a factor of 9.4 in Djitoumou. Wealth differences were even greater when the poorest 10% of the population was compared to the richest 10% in each area, varying by a factor of 45 in Siwaa and 59 in Djitoumou. With a few exceptions (e.g. chickens and guinea fowl in Siwaa, and goats and guinea fowl in Djitoumou) the number of animals and physical assets increased in step with the wealth category in both areas.

The spread in wealth described above is difficult to relate to many international comparative studies which typically examine poverty in terms of annual income. At the international level, many studies identify the poor as those who subsist on less than $1 or 2 per day. Given these international poverty lines, the World Bank (2001) found 72.8% of Mali's population to fall below the $1 per day level and 90.6% below the $2 per day level. However, southern Mali (typically the Sikasso Region and the southern portion of the Koulikoro Region) is generally considered to be wealthier than the rest of the country due to cotton cultivation as a source of revenue (Keeley and Scoones 2003).

In both areas, wealthier households have more members than poorer areas. In Djitoumou, average household size increases from 14.3 for poor households, to 25.5 for intermediate households, to 35.4 for rich households. A similar trend is evident in the Siwaa area, where average household size increases from 11.7 for poor households, to 21.7 for intermediate households, to 30.9 for rich households. While wealthier households have more working age adults (men and women) than poorer households in both areas, their dependency ratios are not always lower. Household size appears to be positively related to household wealth, as wealth per household member is higher for larger households. Larger household size and/or lower dependency ratios are sometimes reflective of extended families that have chosen to remain together (or resisted splitting up) as a single

Table 1 Average number of animals and equipment per household by wealth strata in Siwaa and Djitoumou areas in 1997–99

	Djitoumou				Siwaa			
	Poor	Intermediate	Rich	Average	Poor	Intermediate	Rich	Average
Sample size (*n*)	40	18	7	65	31	23	14	68
Household size	14.3	25.5	35.4	19.6	11.7	21.7	30.9	19.0
Workers	6.9	10.6	20.1	9.3	4.7	8.7	11.6	7.5
Dependency ratio[1]	1:2.07	1:2.41	1:1.76	1:2.11	1:2.49	1:2.49	1:2.66	1:2.53
Cultivated area (ha)	7.4	12.6	21.8	10.4	7.2	13.2	18.9	11.7
Plough oxen	2.0	4.9	7.7	3.4	2.3	5.0	6.7	4.1
Cattle	1.3	10.9	52.6	9.5	0.7	9.0	38.6	11.3
Goats	3.0	5.8	5.1	4.0	1.1	7.1	12.6	5.5
Sheep	0.9	5.2	7.9	2.8	1.0	6.3	16.5	6.0
Donkeys	0.7	2.2	2.0	1.3	0.7	1.5	1.7	1.2
Chickens	19.7	27.3	37.9	23.8	22.3	58.8	48.2	40.0
Guinea fowl	0.6	0.5	0.0	0.5	4.2	34.1	8.1	15.1
Swine	0.0	0.0	0.0	0.0	0.2	0.7	0.5	0.4
Multiculteur (type of plough)	0.9	1.4	2.6	1.2	1.0	1.8	2.4	1.6
Moldboard ploughs	0.8	2.2	2.4	1.4	1.1	2.0	2.6	1.7
Carts	0.5	1.2	1.7	0.8	0.7	1.4	1.6	1.1
Seeders	0.4	1.1	1.7	0.7	0.5	1.0	1.4	0.8
Pesticide applicator	0.5	0.8	1.3	0.7	0.6	1.4	1.4	1.1
Bicycles	1.6	2.7	4.0	2.2	1.4	3.0	4.0	2.5
Motorcycles	0.1	0.7	1.4	0.4	0.1	1.0	2.2	0.8
Tin roof houses	0.8	2.1	5.1	1.6	0.5	3.6	5.6	2.6
Radio	1.8	3.6	4.0	2.5	1.4	3.1	4.8	2.7
Television	0.0	0.4	0.9	0.2	0.1	0.1	0.4	0.1
Value of household assets CFA[2] (US$)	664 570 (1022)	2 390 365 (3677)	6 220 306 (9570)	1 740 792 (2678)	638 645 (983)	2 673 586 (4113)	6 040 267 (9293)	2 439 033 (3752)
Value of assets per household member CFA (US$)	50 204 (77)	107 045 (165)	185 183 (285)	80 481 (124)	62 184 (96)	156 866 (241)	232 850 (358)	129 346 (199)

1 The dependency ratio is the ratio of able-bodied adults to dependents (children, elderly and disabled). These terms were self-defined by the individuals interviewed.
2 650 CFA francs = $US1.

production unit. Large households (often extended families) are typically considered to be more advantageous for agricultural production.

The nuclearization of households in Siwaa is thought to be more advanced than in Djitoumou (and is supported by the household size and dependency ratio data presented here), and is attributed by some to the longer period of cash crop production and monetization of the local economy (Jonckers 1995). The notion, supported by comments from farmers in the author's interviews, is that greater household cash income leads to a greater probability that brothers in an extended family will disagree on how funds are being managed, and therefore possibly they will dissolve into smaller units.

Integrity of soils and agricultural management practices

Other than rainfall, soil health is perhaps the most important environmental variable for an agricultural community. While soil health is composed of a number of different aspects, four soil quality measures were examined (infiltration, pH-KCL, bulk density and aggregate stability), based on their relation to soil organic matter and management practices, as well as logistical constraints. Soil organic matter was not measured directly due to a limited ability to keep soil samples cool.

Samples were taken from 14 farms in the Siwaa area and eight in the Djitoumou area of comparable soil texture classes. These farms were selected from the larger 133-household survey. The farms selected for soil analysis constituted a stratified random sample from a subgroup of the 65–68 farms in each research site that shared similar soil characteristics. In most cases, eight samples or tests were run on each farm, with four from a sorghum or finger millet field, and four from a cotton field (if it existed)[1]. The focus was on the most common soil texture class in each study area in order to facilitate the comparison of results, with emphasis on loamy sands in Siwaa, or *guechien* in Minianaka (Keita *et al.* 1994); and sandy clay loams[2] in Djitoumou, or *daba dugukolo* in Bamanan (Diallo 1991; Moseley 1993, 1996).

The soils in both areas have been characterized as *sols ferrugineux tropicaux*, which roughly correspond to Alfisols in the USDA taxonomic system. Tropical Alfisols are generally found under woodland or grassland savannas and are characterized by clay accumulation in the B horizon, low levels of carbon and organic matter, and low cation exchange capacities (Aubert and Tavernier 1972). Pol (1992) estimates the existence of 1% organic matter content for untilled soils in southern Mali.

Examination of soil measures by wealth group

The results of the soil tests are presented in Tables 2 and 3[3]. The higher level of samples in Siwaa (than in Djitoumou) allowed for limited, parametric statistical analysis. A non-parametric test was used to assess the potential difference of means for the Djitoumou soils data. A dummy regression model was run on the soils data for Siwaa (i.e. a simple linear regression model with soil data classified as rich, intermediate or poor) in which no significant relationship was found between the wealth group variable and any of the soil quality measures. While the relationship between the wealth group variable and soil quality measures for the aforementioned model was insignificant, the B coefficient, or constant, was significant. This suggests that in the cases of bulk density, aggregate stability, and infiltration, the poor would tend to fall slightly above, and the rich slightly below, the measures that would be expected in the absence of wealth. This indicated that the poor tended to fare slightly better on infiltration and aggregate stability, and the rich slightly better on bulk density.

Given the small sample sizes in Djitoumou, a non-parametric statistical test (Mann–Whitney) was run on the data to determine potential differences in mean rank in soil quality measures. This analysis suggested that the mean rank of infiltration measures was significantly better for the intermediate group than for the rich; aggregate stability was worse for the poor than for the rich; and that bulk density was better for the poor and intermediate than for the rich (see Table 3). This mixed result suggests that there is no clear difference between the rich and poor in Djitoumou, although it could be argued that the intermediate group is doing better than the rich (as the mean rank for two of the four measures was significantly better than that of the rich).

It is difficult to make a convincing case that soil measures are significantly better or worse for the rich or the poor in either Siwaa or Djitoumou. This finding alone raises questions about the notion that the poor are a proximate cause of soil degradation. The next section will examine potential differences in management practices employed by each wealth group as well as links between agricultural management practices and soil quality.

Agricultural management practices

This sub-section explores the extent to which soil management practices may differ in southern Mali, with a particular focus on the situation in Siwaa. From a soil quality perspective, the ideal land steward in southern Mali would apply large amounts of organic fertilizer, practice intercropping and

Table 2 Mean (and standard deviation) of integrity measures by wealth strata in the Siwaa area for loamy sand soils

Group	Statistic	Final infiltration (cm h^{-1})	pH-KCL[1]	Bulk density (g cm^{-3})	% Water-stable aggregates
Poor	Mean	20.46	5.55	2.20	12.7
	SD	15.91	0.54	0.18	8.3
	CV[2]	0.778	0.097	0.082	0.654
	N/farms	41/6	43/6	43/6	43/6
Intermediate	Mean	15.24	5.49	2.12	14.1
	SD	11.94	0.58	0.22	7.7
	CV	0.783	0.106	0.104	0.546
	N/farms	30/4	32/4	32/4	29/4
Rich	Mean	16.52	5.53	2.13	9.8
	SD	11.35	0.54	0.14	5.3
	CV	0.687	0.098	0.066	0.541
	N/farms	31/4	32/4	32/4	32/4
Average	Mean	17.73	5.52	2.15	12.2
	SD	13.59	0.55	0.19	7.4
	CV	0.766	0.100	0.088	0.607
	N/farms	102/14	107/14	107/14	104/14
Control	Mean	30.68	5.74	1.84	21.9
	SD	22.50	0.38	0.16	10.8
	CV	0.733	0.066	0.087	0.493
	N	9	5	8	5

Note: Using a dummy regression model, no significant relationship was found between the wealth group variable and any of the soil quality measures.

1 The figures for pH-KCL are roughly comparable to those found by de Vos (1991) for the village of Try (one of the Siwaa study villages). De Vos (1991) found pH-KCL values of 6.0 under natural vegetation and 4.8–5.6 in farm fields. These are averages for all soil texture classes.

2 CV = coefficient of variation.

no-till on a large proportion of farm fields, minimize the use of insecticides and herbicides, and use moderate amounts of mineral fertilizers. Organic inputs (compost or manure applications) are the best way to maintain or improve levels of soil organic matter and its associated benefits. Higher levels of organic inputs should lead to a higher percentage of water-stable aggregates, improved infiltration and lower bulk density. Organic inputs also buffer the soil from acidification. In the case of all the agricultural management practices discussed, interviews suggested that farmers make decisions based on their own economic constraints, environmental constraints (soil conditions, land availability), the perceived benefit/cost ratio of a certain practice, short-term production goals and longer term sustainability concerns.

Tables 4 and 5 present information on the management practices employed by those whose soils were sampled as well as the larger household survey for Siwaa. Given the small sample size for each wealth group, the non-parametric Mann–Whitney test was used to determine if there was a significant difference in mean rank for the agricultural management practices examined. In the smaller sample of households whose soils were sampled (Table 4), it was found that the intermediate group applied significantly more organic inputs than the poor, and that the rich applied significantly more inorganic fertilizers than the poor (in terms of quantity applied per hectare). It is notable that the mean inorganic fertilizer applications per hectare for the rich in the small sample (353.7 kg ha^{-1}) exceeded the recommended fertilizer application of 200 kg ha^{-1} on land that was actually fertilized (47.1% of total). The figure in Table 4 is lower because it is a farm-wide average.

The significant difference in inorganic fertilizer use in the small sample is also reflected in the larger household survey for Siwaa (Table 5). As before, while the average level of inorganic fertilizers applied by the rich (147.2 kg ha^{-1}) does not exceed

Table 3 Mean (and standard deviation) of integrity measures by wealth strata in the Djitoumou area for sandy clay loam soils

Group	Statistic	Final infiltration (cm h^{-1})	pH-KCL	Bulk density (g cm^{-3})	% Water-stable aggregates
Poor	Mean	7.48	6.23	1.56*	34.5*
	SD	6.38	0.45	0.17	16.3
	CV[1]	0.853	0.072	0.109	0.472
	N/farms	23/4	16/4	24/4	24/4
Intermediate	Mean	9.25**	5.93	1.55*	43.4
	SD	6.81	0.40	0.16	12.6
	CV	0.736	0.067	0.103	0.290
	N/farms	17/2	8/2	18/2	14/2
Rich	Mean	3.72	6.32	1.70	48.9
	SD	2.10	0.41	0.16	18.5
	CV	0.565	0.065	0.094	0.378
	N/farms	9/2	5/2	9/2	9/2
Average	Mean	7.41	6.16	1.58	39.9
	SD	6.21	0.45	0.17	16.5
	CV	0.838	0.073	0.108	0.414
	N/farms	49/8	29/8	51/8	47/8
Control	Mean	33.00	6.52	1.53	48.4
	SD	38.13	0.39	0.31	13.9
	CV	1.155	0.060	0.203	0.287
	N	8	6	9	9

1 CV = coefficient of variation.
*Significantly different ($P < 0.05$) than the rich using Mann–Whitney mean rank test.
**Significantly different ($P < 0.01$) than the rich using Mann–Whitney mean rank test.

Table 4 Farming practices by wealth group for soil survey sample (n = 14) in the Siwaa Zone, 1997–99

Wealth group (n)	Statistic	Total ha	% ha in no-till	% ha intercropped	% ha with organic fertilizer	Organic fertilizer per ha (carts)	% ha with inorganic fertilizer	Inorganic fertilizer (kg ha^{-1})	% ha with insecticides
Poor (6)	Mean	5.6	33.3	6.3	11.1	8.5	35.3	36.8	11.9
	SD	3.7	32.3	15.6	13.8	11.7	24.1	38.3	13.8
	CV[1]	0.661	0.970	2.476	1.243	1.376	0.683	1.041	1.160
Intermediate (4)	Mean	12.9	14.2	19.7	34.3	13.8*	60.9	97.8	27.5
	SD	6.2	13.3	15.7	9.1	15.5	6.1	14.7	19.9
	CV	0.481	0.937	0.797	0.265	1.123	0.100	0.150	0.724
Rich (4)	Mean	19.6	18.8	2.6	20.1	10.0	47.1	166.6*	30.6
	SD	12.4	21.2	5.2	16.8	10.6	16.0	130.2	10.5
	CV	0.633	1.128	2.000	0.836	1.060	0.340	0.782	0.343
Average (14)	Mean	11.6	23	9.1	20.3	10.4	46.8	91.3	21.6
	SD	9.2	25.3	14.4	16	11.8	19.7	87.5	16.4
	CV	0.793	1.100	1.582	0.788	1.135	0.421	0.958	0.759

1 CV = coefficient of variation.
*Significantly different ($P < 0.05$) than the poor using Mann–Whitney mean rank test.

Table 5 Farming practices by wealth group for larger household sample (*n* = 68) in the Siwaa Zone, 1997–99

Wealth group (*n*)	Statistic	Total ha	% ha in no-till	% ha intercropped	% ha with organic fertilizer	Organic fertilizer per ha (carts)	% ha with inorganic fertilizer	Inorganic fertilizer (kg ha^{-1})	% ha with insecticides
Poor (31)	Mean	7.2	30.1	12.9	20.9	8.2	48.1	77.4	23.8
	SD	3.1	23.4	18.2	17.8	10.5	21.5	37.6	11.2
	CV[1]	0.431	0.777	1.411	0.852	1.280	0.447	0.486	0.471
Intermediate (23)	Mean	13.2	18.8	29.8*	28.4	12.7	58.2	95.7	32.7**
	SD	6.1	18.0	18.6	18.8	15.8	16.7	21.1	15.8
	CV	0.462	0.957	0.624	0.662	1.244	0.287	0.220	0.483
Rich (14)	Mean	18.9	24.1	11.7	19.2	5.8	53.3	147.2**	32.2**
	SD	8.1	21.6	15.0	16.5	7.2	18.9	150.8	8.3
	CV	0.429	0.896	1.282	0.859	1.241	0.355	1.024	0.258
Average (68)	Mean	11.7	25	18.4	23.1	9.2	52.6	98.0	28.5
	SD	7.1	21.6	19.3	18.1	12.2	19.7	76.8	13.0
	CV	0.607	0.864	1.049	0.784	1.326	0.375	0.784	0.456

1 CV coefficient of variance.
*Significantly different ($P < 0.01$) than the poor and rich using Mann–Whitney mean rank test.
**Significantly different ($P < 0.05$) than the poor using Mann–Whitney mean rank test.

Table 6 Cotton by wealth group in Siwaa and Djitoumou zones in 1997–99

Zone	Wealth group	% Farming cotton	Cotton (ha)	% Total ha in cotton
Siwaa	Poor	93.5	2.0	23.8
	Intermediate	100	4.4	33.1
	Rich	100	6.2	32.2
	Average	97.1	3.7	28.7
Djitoumou	Poor	82.5	1.9	22.4
	Intermediate	100	3.8	29.4
	Rich	100	8.5	39.1
	Average	89.2	3.1	26.1

the recommended dosage, this limit is surpassed on the 53.3% of land that actually receives the fertilizers (at a level of 276 kg ha^{-1}). Unlike the small sample, there is no significant difference in the average quantity of organic inputs applied in the larger sample. Other differences that show up in the larger sample are that the intermediate group intercrops a greater proportion of their fields than the rich or the poor, and that the rich and intermediate groups apply insecticides to a larger proportion of their fields. The fact that the rich apply more inorganic fertilizers and insecticides than the poor is not surprising as these inputs must be purchased, making it likely that these factors would correlate more highly with wealth. Use of these inputs is also highly correlated with cotton production and the rich have a higher proportion of their farmland in cotton than the poor (see Table 6). While insecticide use may affect soil biota and soil quality eventually, the connection is tenuous enough that one would not expect to find this difference in use of insecticides reflected in soil integrity measures.

The larger Siwaa data set does not support the conventional wisdom among donor agencies and some researchers working in West Africa that the rich apply more organic fertilizers than the poor (Gray 1999). The standard reasoning among donor agencies is that the rich are likely to have more cattle and donkey carts (an assumption supported by this study's inventory of assets in Table 1) and thus have the means to apply more organic inputs (carts are used to transport manure and compost

Table 7 Soil quality rank of 14 Siwaa households

Farmer	Household wealth (CFA)	Overall rank[1]	Infiltration m h^{-1}	Infiltration rank	pH-KCL	pH rank	Bulk density (g cm^{-3})	Bulk density rank	% Water stable aggregates	Stable aggregate rank
Seydou	226 706	1	45.29	1	5.96	2	2.1657	8	21.13	1
Felix	4 515 151	2	24.33	2	5.78	4	2.1867	11	14.66	4
Aly	129 010	3	18.45	5	6.10	1	2.2811	13	12.05	6
Cemogo	3 751 717	4	17.59	6	5.69	5	2.2493	12	12.95	5
Issa 1	3 090 387	5	14.64	8	5.54	7	2.0279	1	20.59	2
Issa 2	731 003	5	18.92	3	5.67	6	2.044	2	9.67	8
Masa	6 199 817	7	14.14	9	5.88	3	2.1555	7	9.65	9
Ousmane	608 940	8	18.65	4	5.41	9	2.3760	14	6.78	11
Wafara	568 210	9	12.51	12	5.09	12	2.0732	4	19.87	3
Mamarou	4 660 017	9	15.27	7	5.31	10	2.1113	5	8.83	10
Drissa	1 969 749	9	10.02	13	5.05	13	2.1714	9	11.51	7
Broulaye	8 818 184	12	13.30	10	5.14	11	2.0491	3	6.26	13
Bakary	271 000	13	9.03	14	5.53	8	2.1151	6	6.00	14
Kuluju[2]	578 300	14	12.76	11	4.57	14	2.1754	10	6.50	12

1 Combined rank for infiltration, % water-stable aggregates and pH-KCL. Same number rank indicates tie.
2 Kuluju's household was not selected for a case study because soil analysis was only performed on one of his fields and socioeconomic data for his household were incomplete.

to fields). Although the rich certainly have more cattle than the poor in Siwaa (over 55 times as many), they only have 2.3 times as many donkey carts while the area the rich farm relative to the poor is 2.6 times larger. This last factor, combined with the fact that the rich have a higher dependency ratio than the poor (1:2.66 versus 1:2.49)[4], suggests that the rich may face more labour constraints when engaging in the labour-intensive operation of applying manure and compost. This is not to suggest that children and elderly household members do not work, but that the process of manure application generally requires adult workers.

It is difficult to explain why the intermediate group intercrops more than the poor and the rich. It is perhaps easiest to understand why the rich intercrop less, as this group has received a larger amount of agricultural extension services. Historically, the agricultural service was not appreciative of intercropping (Moseley 1993 1996; Simpson 1999).

While there are few to no significant differences between soil quality measures for rich and poor households in Siwaa and Djitoumou, there does appear to be a weak relationship between some agricultural management practices and wealth (e.g. insecticide and inorganic fertilizer increase with wealth level). However, in contrast to the conventional wisdom, the practices adopted with increasing wealth are not uniformly good for the environment (e.g. greater pesticide use). While not borne out significantly in the data sets, it is suspected that some environmentally beneficial practices, such as no-till (or direct seeding) may be inversely related to wealth. Other variables (such as labour available per hectare) may also be equally or more important than wealth in determining the intensity of some beneficial practices such as the application of organic inputs.

Given the small size of the data set, it is not possible to make a tight connection between agricultural management practices and soil quality. However, an examination of household farming practices on a case by case basis provides greater insight. The author examined the best and the worst cases (in terms of soil measures) in order to understand what factors may be contributing to these outcomes. Table 7 presents the mean soil data (based on approximately eight samples per farm) for each household in Siwaa and their relative ranks. The overall rank is a composite of the single measure ranks for infiltration, pH-KCL and aggregate stability. Bulk density is not included in this combined rank as the author is not as confident in the quality of these data compared with the others.

Table 8 summarizes the key elements of four household cases examined. When examined on a case by case basis, higher soil indicators generally seem to match with better management practices. The proper balance of techniques seems to be more important than any specific mix of practices (e.g. if not organic inputs then practices that preserve soil organic matter). The application of

Table 8 Summary of management practices for households with best and worst soil measures in Siwaa

Resources/practices	Household(s) with best soil measures	Household(s) with worst soil measures
Wealth ($US)	Seydou 349; Felix 6946	Bkary 415; Blaye 13 566
Dependency ratio	Seydou 1:2.5; Felix 1:2.25	Bakary 1:1.4; Broulaye 1:3.9
Fallow (% cultivated area)	Seydou 88.9; Felix 41.7	Bakary 0; Broulaye 46.2
% ha in no-till	Seydou 38; Felix 0	Bakary 30; Broulaye 19.6
% ha intercropped	Seydou 38; Felix 10.4	Bakary 0; Broulaye 0
% ha with organic fertilizer	Seydou 11.1; Felix 41.7	Bakary 20; Broulaye 21.5
Carts of organic fertilizer per ha	Seydou 6.1; Felix 25	Bakary 2; Broulaye 8.4
% ha with inorganic fertilizer	Seydou 11.1; Felix 41.7	Bakary 30; Broulaye: 54.1
Inorganic fertilizer (kg ha^{-1})	Seydou 98; Felix 354.2	Bakary 40; Broulaye 114.3
% ha with insecticides	Seydou 0; Felix 41.7	Bakary 20; Broulaye 29.7
% ha with herbicides	Seydou 0; Felix 0	Bakary 0; Broulaye 0
% ha in cotton	Seydou 0; Felix 41.7	Bakary 20; Broulaye 29.7
Total cotton (ha)	Seydou 0; Felix 4	Bakary 1; Broulaye 11

sufficient organic matter to fields is critical for maintaining soil fertility when other traditional measures have been abandoned (no-till, intercropping, fallow-rotation). This situation is exemplified by the case of Felix's wealthy household that applies 25 carts (a relatively high amount) of compost and manure per hectare to their fields on average. If such a level of organic inputs is not available, then it seems possible to maintain a balance with lower levels of organic inputs, no-till, intercropping and fallow-rotation; a combination illustrated by Seydou's poor household.

These 'poor' and 'rich' paths to sustainable soil management may be juxtaposed with a number of unsustainble combinations. These include rich and poor households that neither apply sufficient organic inputs nor a mix of measures to maintain or restore soil organic matter (no-till, intercropping, fallow-rotation). Examples of unsustainable combinations include Broulaye's rich household and Bakary's poor one. Broulaye's limited labour (with a dependency ratio of 1:3.93) may help explain why he has difficulty applying enough organic inputs (as he certainly has enough cows). Bakary's poor household is only able to provide limited organic inputs (2 carts ha^{-1}) and has no fallow on which to rotate, nor does he intercrop (although he still practices no-till on 30% of his land). Since the proper mix of soil management techniques is not necessarily related to wealth (with wealth leading to some beneficial techniques and poverty leading to others), this helps clarify why soil quality measures do not tend to differ significantly between groups. So while there appear to be two viable paths to sustainable soil management, some rich and poor households are unable to stay on these paths.

Local political ecology: cotton farming and local dynamics shaping resource management

In this section, the local and extra-local factors influencing household agricultural management approaches in southern Mali are explored. It is argued that the system of cotton farming, not poverty, better explains agricultural soils degradation in Siwaa and Djitoumou. Some of the impacts of cotton farming are directly observable (particularly on those farms where sound traditional techniques have been abandoned without the mitigation of organic inputs) while other impacts are more indirect, and, to varying degrees, more difficult to trace back to the cotton production system. The author first examines the relationship between cotton production, agricultural management and environmental change (mostly farm field soil quality). The indirect effects of cotton production on livelihoods are then scrutinized in terms of labour and land exchanges, 'introduced' technologies, and the use of common property.

Local wealth–cotton–management–environment dynamics

While cotton production has generated wealth for a number of parties (government, cotton companies and farmers), it is a problematic pursuit because it has also brought about changes in farming systems that are undermining the long-run productive potential of agricultural soils. At the local level in Siwaa and Djitoumou, the rich are clearly more involved in cotton production than the poor (Table 9). In Siwaa, the rich have three times as much land in cotton as the poor (6.2 versus 2.0 ha on average),

Table 9 Cotton by wealth group in Siwaa and Djitoumou zones in 1997–99

Zone	Wealth group	Household production (kg)	% Households farming cotton	No. ha per household in cotton	% Cultivated area in cotton
Siwaa	Poor	2242	93.5	2.0	23.8
	Intermediate	5024	100	4.4	33.1
	Rich	6141	100	6.2	32.2
	Average	4066	97.1	3.7	28.7
Djitoumou	Poor	2036	82.5	1.9	22.4
	Intermediate	3226	100	3.8	29.4
	Rich	8464	100	8.5	39.1
	Average	3181	89.2	3.1	26.1

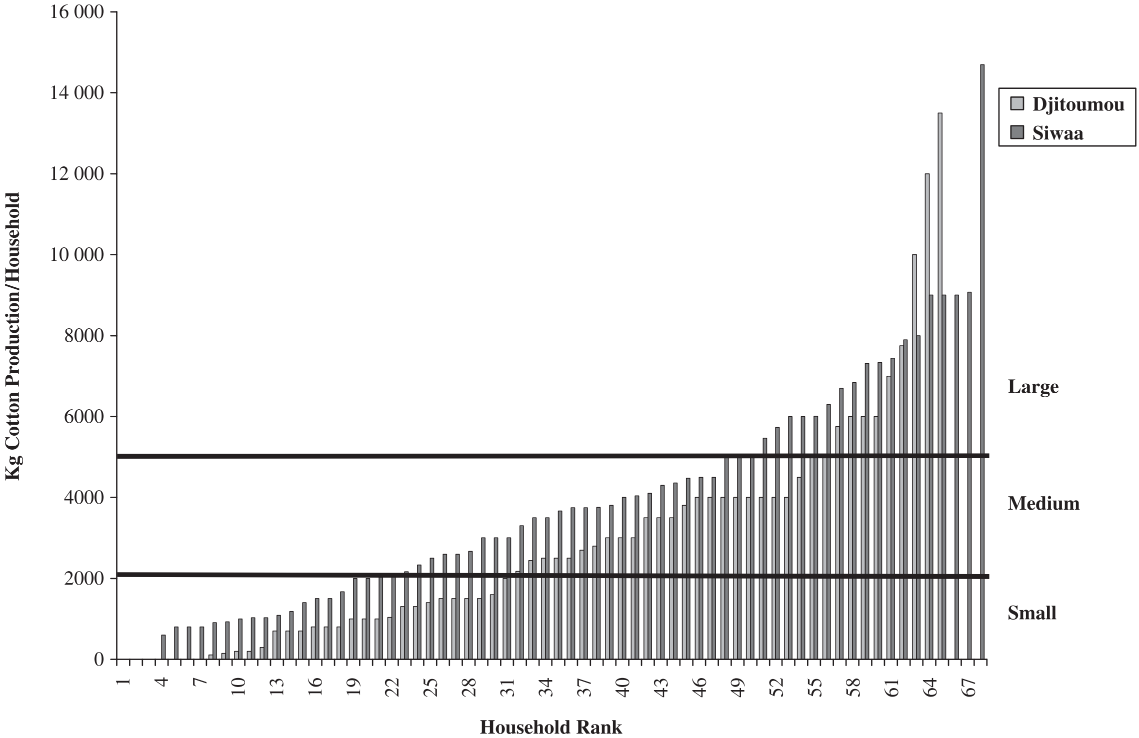

Figure 3 Distribution of small, medium and large cotton producers in sample of Siwaa and Djitoumou households, 1997–99

as well as a greater proportion of their total cultivated area devoted to the crop (32.2 versus 23.8%). This disparity is even more accentuated in Djitoumou where the rich have over four times as many hectares in cotton as the poor (8.5 versus 1.9 ha), and a much larger portion of their cultivated area devoted to the crop (39.1 versus 22.4%). While there is a greater disparity between rich and poor in cotton production in Djitoumou than in Siwaa, the average household in Siwaa produces more cotton (4066 versus 3181 kg) and devotes more land resources to the crop (3.7 versus 3.1 ha) than its counterpart in Djitoumou. The greater involvement of the average Siwaa farmer in cotton production is related, in part, to the longer history of export-oriented cotton production in the area, which began in the 1950s (compared with the early 1970s in Djitoumou).

A household's level of engagement in cotton production has a direct bearing on many of the agricultural management practices it employs. In order to understand the relationship between cotton farming and management practices, it is helpful to examine practices relative to the level of cotton production (rather than wealth). Cotton producers in Siwaa and Djitoumou may be classified as small, medium or large (see Figure 3 for the distribution of cotton producers)[5]. It is noted that similarly ranked producers in Siwaa tend to produce more than their counterparts in Djitoumou.

Table 10 presents mean data on characteristics and management practices of the different producer groups in Siwaa[6]. Using the Mann–Whitney mean rank non-parametric statistical test, it was found that a number of characteristics and management practices are significantly different for the low-production group relative to the medium and large producers. As might be expected, household size, wealth, area farmed and percentage of area in cotton increase in step with the level of cotton production. Differences (or non-differences) in management practices between groups are even more interesting. Both inorganic fertilizer and insecticide use are significantly lower for those who farm less cotton. A comparison of univariate linear regression models using data from the 68 households in Siwaa surveyed suggests that higher cotton production (i.e. total cotton produced per household) is more significant than wealth in explaining higher levels of insecticide and mineral fertilizer use. While the (inverse) relationship between cotton production and no-till farming was not significant, there is a greater inverse association between these two variables than there is between wealth and no-till.

Historically, it is reported that the wealthiest households were initially singled out by the agricultural extension service for involvement in cotton farming (Piters 1989). Cotton farming, and its associated technologies, then helped these households become even wealthier in the short term. Agricultural extension in southern Mali has been focused on developing cotton rather than rural development or even agricultural production in general. Other authors have noted that there is a cotton bias to agricultural extension efforts in southern Mali (Schrader *et al*. 1998). Institutionally, this bias is related to the fact that the cotton company (rather than a more neutral agricultural service) is responsible for providing all agricultural and natural resource management extension services in southern Mali. Farmers who grow cotton receive more attention and extension advice. Women and poorer households are often excluded from this process. Extension agents have discouraged a number of

Table 10 Mean characteristics/management practices by size of cotton producer in Siwaa, 1997–99

Size of producer	Wealth (US$)	Household size	Cultivated area (ha)	% Cultivated area in cotton	Organic fertilizer per ha (carts)	Inorganic fertilizer per ha (kg)	% ha intercropped	% ha no-till	% ha insecticide
Low (0–1999 kg)	849*	9.2*	5.6*	18.1*	6.3	64.3*	16.3	31.1	16.5*
Medium (2000–4999 kg)	3436	15.7	14.5	30.7	10.9	95.4	16.2	23.5	30.7
High (5000+ kg)	6678	32.1	19.3	35	10.4	115.8	23.2	22.0	36.0

*Significantly different from the medium and high production groups at the 0.01 level.

traditional practices such as direct seeding (no-till) and intercropping as they (at least until very recently) were viewed by formally trained agricultural personnel as 'backward' (Peter and Runge-Metzger 1994).

Involvement in cotton production is not only a good predictor of certain management practices, but changes in cotton production patterns provide insights into wealth–environment interactions in southern Mali. Average household production in Djitoumou has risen between the two periods (from 2125 to 3181 kg per household) while it has dropped in Siwaa (from 4191 to 4065 kg per household). Production gains in Djitoumou are largely related to more extensive farming, as average cotton yields in the area have declined by 17%, yet land devoted to cotton has more than doubled between the two periods[7]. In Siwaa, cotton yields declined by 16%, but land devoted to cotton only increased by 19% (leading to the slight loss in average household production). In particular, the large producers in Siwaa have experienced a fall in production as their yields have declined. In 1982–84, the top Siwaa cotton farmers (i.e. those with over five metric tonnes of annual cotton production) produced an average of 8 tonnes on 5.5 ha at a yield of 1546 kg ha^{-1}. The situation had changed such that by 1997–99, the top cotton farmers only produced an average of 7.3 tonnes on 6.6 ha at a yield of 1214 kg ha^{-1}.

Indirect effects of cotton farming

The system of cotton farming also generates a number of indirect social and ecological effects that are not necessarily contained within the household. These indirect effects may have positive or negative consequences for other households and the community. This section explores three examples of such indirect effects.

First, farmers (especially the rich) in the Djitoumou area typically seek to expand the number of hectares devoted to cotton in years when prices are high. The possibilities for expansion are much more limited in Siwaa due to little remaining uncultivated land. As the rich often have all of their land resources in production, they ask those with fallow fields (often poorer households) if they may 'borrow' fields to increase cotton production. The poor find it difficult to refuse such demands, and, as far as the author could tell, simply lend the land for an indefinite period without compensation. The local land tenure system, based on usufruct rights, makes it difficult to refuse lending someone land unless it is being used. This is because the local perception is that a person is greedy if they refuse to lend fallow fields. While not the case in Djitoumou, Kebe and Brons (1994) point out that in certain areas of Mali, where there is demographic pressure on the land, many farmers have begun putting fallow land into production out of fear of losing their customary rights to a given plot. It was also mentioned that a farmer may have outstanding loans with the household requesting land and wants to remain on good terms with this person. When the poor lend their land to others they have less and less land with which to operate a rotating fallow system. A more constrained rotation fallow system may be less sustainable and lead to declining soil quality and crop yields. Bremin *et al.* (2001) calculated that a farmer needs approximately 4 ha in fallow for every one in production to operate a sustainable fallow-rotation system. For example, in Djitoumou a farmer named Njajo lent 6 of his 14 ha in fallow to a wealthier farmer. The result is that, with the 6 ha taken out of his rotation schedule, he now has only 2.3 ha in fallow for every one farmed, compared with 4 ha before he lent the land. This constrained fallow system, and its consequences for soil fertility, is a cost brought on by the rich but borne by the poor.

Second, the rich typically own more ploughs and oxen, and tractors in a few instances, allowing them to cultivate larger areas. This greater level of animal traction/tractor power is not only a function of wealth and involvement in cotton production, but a historical remnant of pilot farmers (i.e. those farmers identified as being top producers) being the first to be given access to new technology (often under concessionary terms) from the agricultural service or donor agencies (Jonckers 1987; Piters 1989)[8]. Those households that posses(ed) superior animal and motorized traction were and are able to take advantage of a traditional land tenure system that grants usufruct land rights to original inhabitants (and outsiders with permission from an original inhabitant) who are able to till a particular piece of land. As such, those with a capacity to till more land are better positioned to win out in the race to convert remaining forest fragments into farm land, and thus secure the usufruct rights to these areas. The rich obtaining usufruct rights to land more quickly may mean that the poor find themselves with insufficient land resources to operate a sustainable fallow-rotation system. It could also mean that the poor are left with less desirable land on which to expand (i.e. marginal land that could be more prone to erosion).

The plough, and the way it was introduced, creates at least two potential environmental problems. First, the economics of crop production changes for those who possess enhanced tillage technology (ploughs and/or tractors). Such technology makes it cheaper in the short run to extensify (farm a larger area with low yields) than to intensify

Table 11 Area farmed in Siwaa and Djitoumou zones, 1997–99

Zone	Wealth group	Household size (persons)	Working age members	No. ha farmed	No. ha farmed per household member	No. ha farmed per worker
Siwaa	Poor	11.7	4.7	7.2	0.707	1.67
	Intermediate	21.7	8.7	13.2	0.697	1.91
	Rich	30.9	11.6	18.9	0.744	2.08
	Average	19	7.5	11.7	0.711	1.83
Djitoumou	Poor	14.3	6.9	7.4	0.540	1.14
	Intermediate	25.5	10.6	12.6	0.540	1.40
	Rich	35.4	20.1	21.8	0.630	1.28
	Average	19.6	9.3	10.4	0.550	1.23

(farm a smaller area with higher yields). Pieri (1989) found that the introduction of the plough led to a 20% reduction in work hours per hectare (mainly through reductions in time for tilling, seeding and early weeding). The problem, however, is that while the plough helps with tilling and planting, it does not help with the majority of weeding nor with the harvest (creating the labour bottle necks discussed earlier in this section). As such, it has been found that when a hand-tilled and plough-tilled system are compared, the area farmed is larger for plough-tilled systems but the productivity per worker (in terms of quantity of crops produced) is not all that dissimilar (Pieri 1989). The data show that land farmed per worker and per household member is greater for the rich than the poor in both Siwaa and Djitoumou (see Table 11). An extensive, lower labour input system operated by a wealthy household is exemplified by the case of Broulaye previously described.

More extensive cultivation is an environmental problem if it entails moving onto more marginal land that is less suitable for farming and more prone to erosion. It also leaves less land for alternative uses, and less biomass for maintenance of the hydrologic cycle. Both of these costs have been externalized in that it is the community as a whole, rather than the wealthier households, that must bear these costs.

It may be argued that the plough would have eventually been introduced to, or imported by, Malian farmers (irrespective of the efforts of the cotton company). Nonetheless, the distortions created by the subsidized and selective distribution of this technology to wealthier farmers might have been less had the technology been introduced differently. The unequal distribution of usufruct land rights and more extensive cultivation on the part of wealthier households was a direct result of the plough that was introduced as part of the cotton cash cropping system.

Finally, the poor historically relied on common property resources as a way to make ends meet through activities such as shea nut collection and fishing. Increasing livestock numbers means that there is growing competition for these resources. While shea nut collection is open to any household willing to gather nuts, the exploitation of common lands for grazing depends on the size of the livestock heard maintained by the family. The use of the commons for grazing favours the rich as they tend to have larger herds (see Table 1). One indication of the changing use of common property is that revenues from livestock sales for the rich in Siwaa rose from 5% to 17% of annual income between 1982–84 and 1997–99, while the poor saw their income from artisanal production (of which shea butter production is a major component) decline from 20% to 17% of annual income over the same period[9]. Livestock also puts pressure on fallow reserves as fallow fields that are grazed do not recuperate as quickly (Pol 1992).

While village common property resources were historically regulated by traditional rules and authorities, this traditional power has been weakened in the face of wealthy households that wield considerable economic power at the local level village (Picard 2000). In addition to certain activities (e.g. shea nut collection) suffering directly from the reduction of biomass on common lands, the position of most common property in the landscape means that its degradation affects neighbouring parcels of land. Village common land is spatially located at the bottom and the top of the toposequence in many cases, that is, on elevated plateaus where marginal soils are located and along seasonal stream beds. Overgrazing at the top of the toposequence often leads to reduced infiltration and increased runoff (de Vos 1991). This may lead to increased erosion in the mid to lower sections of the toposequence where the majority of farms are located. Degradation of the stream bed, combined with erosion in the

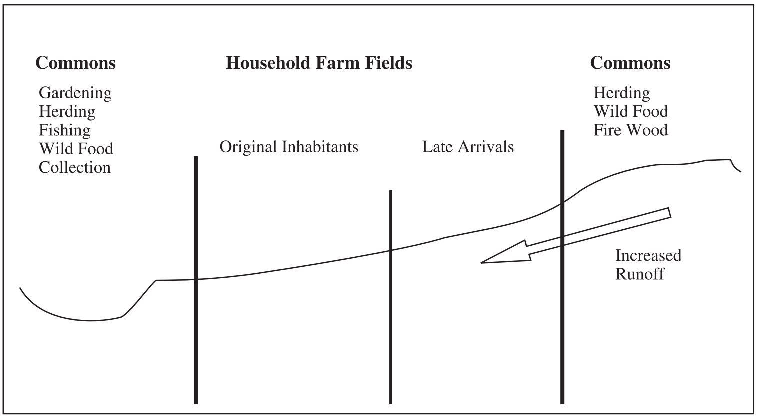

Figure 4 Generalized location of common property in the toposequence and increased runoff from overgrazing

upper levels of the watershed, often lead to the infilling of stream beds, a process that impacts seasonal fishing, animal watering, and gardening opportunities.

The participatory community mapping exercise conducted in each village indicated that those who settled in the village after the original inhabitants often received inferior land. Inferior land was located on coarser soils near the top of the toposequence. These farms were more likely to suffer from the impact of increased runoff from the common lands at the top of the toposequence. A schematic representation of common property, farm field location and runoff patterns may be found in Figure 4.

Regional political ecology: connections with national and international political economy

While Mali historically had a lively market for locally produced indigenous cotton varieties, the French undertook a number of steps in the mid-twentieth century to re-orient these efforts in favour of the production of hybrid varieties in southern Mali for export (Roberts 1995, 1996). This production has been maintained in the post-colonial era through the work of a quasi-privatized parastatal, the *Compagnie Malienne pour le Développement des Textiles* (CMDT), that has monopoly control over the local cotton market. In light of the erratic world market for cotton, including long (several year) stretches when world cotton prices remained low, steady increases in production over the past 50 years have been maintained through guaranteed purchase, a minimum floor price and credit for inputs (support that is not available for any other crop in Mali).

Malian cotton production peaked in the 1998–99 season when it produced over 500 000 metric tonnes, making Mali the leading producer of the crop in sub-Saharan Africa (EIU 1998; Bah 2000). Production for the 2001–2002 season was even higher (USDA 2001). Total output from the Africa Franc Zone (of which Mali accounted for 22.5%) in 1998–99 totalled 2.1 million metric tonnes and made the region the world's third largest exporter after the United States and Uzbekistan (Manley 1999; Levin 1999). Dramatic production increases through the late 1990s tended to confirm that the cotton growing areas are the 'success story of agricultural and rural development in Mali' (Bingen 1998, 271). This cotton success story has been touted by donors and the Malian government. Cotton is frequently referred to as the 'motor of development' (GoM 1998, 16). This notion has been reinforced by a number of authors who have written on the positive aspects of cotton production in southern Mali, highlighting the benefits of this activity for household food security and the modernization of agricultural practices (e.g. World Bank 1990; Fok *et al.* 2000).

The government of Mali has been very reluctant to recognize ecological problems associated with cotton cultivation. In general, the environment has been less of a priority for the government than economic development. In an interview (Lange 2001, 116), Askia Muhamed, press secretary for former Malian President Alpha Konare, said, in relation to the potential damming of the Bani River, 'the national interest must override the local. Mali cannot feed itself . . . The Priority is development. One cannot stop development, even to save the country's heritage'. Perhaps more importantly, part of the government's reluctance may be explained by the fact that it depends on cotton for nearly 50% of its revenues (the actual figure varies between 43% and 48%). One Malian government official referred to cotton production as the country's *vache laitière* or cash cow. As such, tempering cotton production for environmental reasons would entail considerable fiscal hardship. Rather than seeking to temper production while searching for more sustainable alternatives, the government is hoping to increase cotton production to 700–800 million metric tonnes over the next few years (Berthe 2000).

While cotton has long been an important source of revenue for the government, this source of income is increasingly important in light of agreements with multilateral donors to implement policies of structural adjustment that put added pressure on the government to balance the budget (World Bank 1997; IMF 1999). Somewhat ironically, democratization has also created new financial constraints as some highly unpopular forms of taxation, such as the head tax, were eliminated with the transition to a popularly elected government in 1992.

In general, the government and the CMDT have preferred to expand production in new areas rather than seek sustainable alternatives in older production zones. This has led to a situation of declining yields in the old cotton basin (where Siwaa is located) and expansion into the new cotton basin (where Djitoumou is located) and cotton frontier (Kita District) (Bingen 1998). Interestingly enough, there is a growing awareness among farmers in the old cotton basin that the current production system is unsustainable. This includes increasing calls from the farmers' union (SYCOV)[10] for improved extension and government support for alternatives to cotton (Sanogo 2000–2001). The CMDT has tried to introduce specific techniques that would lead to more sustainable soil management (e.g. composting, rock lines). The problem is that the CMDT has been reluctant to explore more fundamental changes that may jeopardize short- or medium-term production levels of cotton as it is dependent on these revenues for its own operating budget.

There is now some debate about whether production declines in the old cotton basin represent a short-term economic problem (related fluctuating world prices) or a longer-term crisis related to ecological deterioration. While an awareness of the latter possibility is most palpable in the old cotton basin, the CMDT can avoid serious national debate on the issue by maintaining national production statistics by continuing to push for production increases in the new cotton basin and further west on the cotton frontier. The way in which Mali (with some of the oldest cotton producing zones in the region) chooses to deal with the current cotton crisis may set a precedent for the rest of the African Franc Zone, a region in which the French-owned *Développement des Agro-Industries du Sud* (DAGRIS)[11] is a stakeholder in most of the national cotton companies.

A convenient development at the level of international environment-development discourse has been the notion that poverty is the cause of environmental degradation. The World Bank has been especially fond of the poverty-induced environmental degradation thesis (e.g. World Bank 1992 1996) and one wonders if this is because it allows the Bank to push on with its structural adjustment package focusing on increased export earnings and leaner government services. This international discourse has now pervaded the national policy-making apparatus in Mali. Donors, government officials and NGO representatives routinely suggest that poverty is at the root of many of Mali's environmental problems.

This focus on poverty in environmental discussions has allowed the government to avoid a serious debate on the sustainability of cotton production. If poverty is the source of environmental degradation in southern Mali, then the government, the cotton company and donors can feel comfortable pushing for further increases in cotton production. Such increases will enrich all parties concerned (including the donors who want to see debts repaid), while allowing them to assert that this is a key step in the process of poverty reduction and improved environmental management.

Conclusion

The results of this study indicate that there is no significant difference in soil quality measures for rich and poor households in southern Mali. An examination of soil management practices from the household survey, as well as individual case studies, suggests that agricultural management practices do appear to be influenced by wealth levels as well as other factors, especially involvement with cotton farming. Wealth encourages some practices that are environmentally beneficial (such as fertilizer use up to a point) as well as other practices that are environmentally detrimental (such as pesticide use or the abandoning of intercropping and no-till). This mixed wealth effect (rather than no effect at all) explains why soil quality measures are not clearly better for one group than another.

The proper balance of techniques seems to be more important than any specific mix of practices for maintaining soil quality (e.g. if not organic inputs then practices that preserve soil organic matter). The result is that there seem to be 'poor' and 'rich' paths to sustainable soil management that include a number of 'either/or' combinations for arriving at relatively better soil quality measures. The more sustainable soil management paths may be juxtaposed with a number of unsustainable combinations. These include rich and poor households that neither apply sufficient organic inputs, nor a mix of measures to maintain or restore soil organic matter.

Rather than poverty driving environmental degradation in southern Mali, soil degradation seems to be more clearly linked to the technological package of export-oriented cotton production as well as the wealth spin-offs of this production. In other words, it is the use of chemical inputs and animal traction, the high nutrient demands of the cotton crop itself, the decline in intercropping and no-till, and cattle investments that all seem to have interacted to cause soil degradation.

Although there are growing ecological concerns related to cotton production in southern Mali, poverty remains the favoured causal explanation for environmental degradation in this region of Africa. The prevalence and continued strength of this narrative may be linked to a constellation of actors (donors, the government of Mali, the Malian cotton company and its French-owned parent corporation) who would all prefer to expand cotton production and ignore associated environmental issues. Blaming poverty for environmental degradation suggests that cotton production, as the engine of economic growth in southern Mali, should expand rather than be tempered.

The findings of this study support the notion, long held by many political ecologists, that international capitalism is the ultimate cause of local land degradation. However, the on-the-ground specifics of how this degradation unfolds are different than those described by many political ecologists. For these thinkers, capitalism creates poverty, which in turn leads to environmentally destructive behaviour. For example, Blaikie notes that poor households from whom surpluses are extracted 'then in turn are forced to extract "surpluses" from the environment . . . [leading] to degradation' (Blaikie 1985, 124). Furthermore, '[p]easants destroy their own environment in attempts to delay their own destruction' (Blaikie 1985, 29). Similarly, Watts suggests that a central tenet of political ecology is that 'society and land-based resources are mutually causal in such a way that poverty, via poor management, can induce environmental degradation which itself deepens poverty' (2000, 591).

This research suggests a slightly different scenario by asserting that the relatively rich, rather than the relatively poor, are the proximate cause of environmental degradation. Due to their favourable position in terms of production and access to the natural resource base, international capital sought out the local wealthy through agricultural extension programs in order to proliferate and intensify cash cropping and its associated technologies. It is these introduced crops, technologies, and their indirect effects (e.g. investment in livestock) that have been detrimental to the environment. While other members of rural communities sought to emulate the rich when they saw the short-term profits generated by cash cropping, they never had the means to practice resource exploitation on the same scale.

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Notes

1. The distinction between cotton and grain fields is actually nominal as farmers rotate cotton and grain crops from year to year. This is done for agroecological reasons (i.e. mixing up nutrient demands) so that grain crops may benefit from fertilizers applied to cotton fields in the previous season.
2. I actually undertook soil analysis on five different soil texture classes in Djitoumou, but only belatedly recognized that I should have focused on the dominant (and preferred) soil class, i.e. sandy clay loams or *daba dugukolo*.
3. Those familiar with the normal range of bulk density measures will notice that the findings presented here are extremely high, particularly for Siwaa. I believe this is related to my practice of air drying the samples in the mid-day sun on a tin roof. While significant roof top temperatures were obtained (normally 55 C), this is below temperatures in the normal oven drying approach. This less intense drying process probably accounts for the high bulk density measures. While bulk density figures are most likely inaccurate in an absolute sense, they may be used to make relative comparisons as the same drying process was consistently applied for all samples.
4. Another way of making a similar point is that poor and intermediate households in Siwaa have more able bodied workers per hectare than the rich (0.60 and 0.52 versus 0.48 labourers ha^{-1}).

5 This categorization was based largely on the distribution of production levels in Siwaa, and the natural breaks in that distribution.
6 Similar information is not presented for Djitoumou as the data are incomplete.
7 In other words, despite the fact that cotton yields (kg ha^{-1}) are declining in Djitoumou, the dramatic increases in surface area (possible because of relatively plentiful land in Djitoumou) have allowed for production gains.
8 Ploughs were first introduced in Mali by the French in 1929. Distribution of ploughs did not become significant until the 1960s (Pieri 1989).
9 Based on interviews with at least two persons per household by the author in 2000 (Moseley 2001).
10 The farmers' union has become increasingly sophisticated in recent years and has a sound knowledge of the world cotton market due to its contacts with the international labour and farmer movements (Docking 1998).
11 Until very recently, this entity was known as the *Compagnie Française pour le Développement des Textiles* (CFDT).

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