Population Growth and the Environment in Africa: Local Informal Institutions, the Missing Link*

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Abstract: Population and environment debates regarding Africa, whether Malthusian or Boserupian in nature, focus on population levels as the driving force behind the relationship between environment and society. This article argues, instead, that *how* people adjust to their rise in numbers is more important than are population levels. It focuses on the role of local informal institutions, such as land tenure systems, but also on customs, norms, and networks, and their change over time in mediating the relationship between people and the environment. The article is based on fieldwork conducted between 1995 and 1998 in the Sahelian and Sudano-Sahelian zones of Africa, as well as on a review of colonial documents pertaining to the area written in the first half of the twentieth century. The article concludes that adaptations made to local, informal institutions within the past century have enabled an environmentally sustainable land use within the context of a rising population and growing scarcity of natural resources.

Key words: West Africa, Burkina Faso, population, environmental sustainability, institutions.

Neo-Malthusian and neo-Boserupian thinking are highly influential in shaping the current population-environment debates. They provide two divergent reasonings as to the effects of population growth on the environment: one negative and one positive. These views either do not take into consideration the role of institutions in mediating the relationship between population and the environment or assume a specific institutional development path. This article contributes to an increasing literature questioning "received wisdom" or "orthodoxies" concerning environmental degradation (Benjaminsen 1997; Fairhead and Leach 1996, 1998; Tiffen, Mortimore, and Gichuki 1994) by focusing on the role of institutions in affecting the relationship between population growth and the environment.

Although there have been plenty of studies on institutions in the population-environment nexus, they tend to consider only high-level formal institutions (e.g., governmental policies, research and extension organizations), macrotrends and structures (e.g., migration, poverty, factor markets), and land tenure regimes (see, for example, Bernstein, Crow, and Martin 1990; Cleaver

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and Schreiber 1994; Hayami and Ruttan 1985; Lele and Stone 1989; Pingali, Bigot, and Binswanger 1987; Turner, Hyden, and Kates 1993). This study adds to the population-environment debates by focusing on the role of local informal institutions,[1] including, but going beyond, the land tenure system, by considering institutions, such as social networks,[2] customs, and norms. It asks the question, How do local informal institutions mediate the relationship between society and the environment, and what effects do they have? It draws on data collected between 1995 and 1998 in eastern Burkina Faso, as well as on colonial documents from the first half of the twentieth century.

The second section reviews Malthus's and Boserup's theories and recent applications thereof to show how the role of institutions in affecting the relationship between population and the environment is either ignored or assumed to take on a specific form. It then argues the need to look explicitly at local informal institutions to inform population-environment debates. Moving down to the case-study region, the third section sets the context by describing population and environmental trends experienced in the region during the twentieth century. The fourth section focuses on the way local institutions have been adapted to enable the production system to respond in an environmentally sustainable[3] way to the changing context within which agriculture is practiced. The article ends with three conclusions about the relationship between population and the environment.

Institutions in Population-Environment Theories

Malthus (1803) argued that population, if left unchecked, grows more rapidly than food production, which ultimately leads to death from starvation. He did not consider the possibility of institutional or technical change that would allow the relationship between population growth and food production to change. Ricardo (1817) added the possibility of people expanding onto new land and then intensifying cultivation by applying additional labor but concluded that returns to labor and capital would eventually diminish owing to the finite quantity of land available. Thus, he, too, assumed that technologies and institutions would remain largely unaltered.

Boserup (1965), on the other hand, introduced the variable of technological change, to argue that food production is able to keep up with population growth. She implicitly included institutional change because for technologies to change, institutions need to be amended. But her theory does not explain how institutions change, and, furthermore, their direction of change is assumed to move along a path toward becoming institutions of a market economy.[4] Boserup's reasoning is as follows: as food and land grow scarce owing to population growth, new technologies are developed in which more labor is used in conjunction with land-improvement technologies. Land is cultivated more intensively; more investments are made in permanent land-improvement structures, and more careful husbandry is practiced. These

[1] *Informal institution* refers to social norms; customary laws and codes of conduct; and their enforcement mechanisms, such as social networks that together guide people's behavior within a society.

[2] *Social network* refers to relationships between people that facilitate cooperation and coordination among members.

[3] An *environmentally sustainable production system* "is the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources" (TAC/CGIAR 1988 in Reijntjes, Haverkort, and Waters-Bayer 1992, 2).

[4] A *market economy* is characterized by private ownership of land and other goods, in which production and consumption are determined primarily by prices set through free competition.

changes in technologies take place as institutions change. Such institutional changes take the form of land tenure shifting from tribal or feudal based to private property based and transport, labor and capital markets developing along the lines of a market economy. Each step of this development occurs at certain population thresholds when the demands of a population reach a peak and force a change in technology or institutions to occur. However, how or why institutions should develop along these lines and not others is not explained. Furthermore, studies have shown that even in highly populated areas, institutions, such as land tenure systems, have taken on various forms (Berry 1988; Downs and Reyna 1988).

Hayami and Ruttan (1985) provided an explanation of how institutions change in light of growing population through an extension of their widely used induced innovation model (Ruttan and Hayami 1972) to institutions. They argued that institutions develop and change according to a country's factor endowments. As one of these factors becomes scarce, prices for the scarce factor will rise and this rise, in turn, will create incentives for institutions to change and adapt. In the case of population growth, land becomes the scarce resource relative to labor, and as a consequence, land tenure institutions will develop into systems that "protect" land from becoming overexploited. The theory relies on the existence of labor and land markets. However, these markets often do not exist or exist only partially in many parts of Africa. In such cases, local institutions, like customs, norms, and networks, that guide how input factors are valued become central to determining whether environmentally sustainable land-use practices will be developed. For example, in the absence of labor markets, labor intensification depends on the customs and networks governing and providing access to labor.

Hayami and Ruttan (1985) share Boserup's (1965) optimism because the induced institutional innovation theory explains the creation of "efficient" institutions that safeguard scarce resources and allow the use of plentiful ones. However recent studies have cast a shadow on such optimism. Cleaver and Schreiber (1994) maintained that shifting cultivation and transhumant pastoral systems have not been adjusting to rapidly increasing populations, resulting in soil degradation and deforestation. Speirs and Olsen (1992) argued that inappropriate institutions can evolve as a consequence of population growth and that the mixed farming system evolving in many parts of the Sahel leads to overgrazing and environmental degradation. Others have contended that mixed farming systems may increase competition for resources among different ethnic groups and may not be as environmentally sustainable as is often hoped (Savadogo 2000; Slingerland 2000). Clay, Guizlo, and Wallace (1994) argued that with a tightening of the resource base because of population growth, the distribution of these resources becomes a key issue. Rental and share arrangements may evolve that take away the incentive to make long-term investments in land, again leading to land degradation. Furthermore, if population growth is not met by a concomitant growth in income, people will become poorer. Poverty has been cited as the cause of degradation because the poor are not able to make land-enhancing investments and because they cannot postpone production if their day-to-day livelihoods depend on that production (Dasgupta 1993; Ehrlich, Ehrlich, and Daily 1993; Hudson 1991). Finally, it has been suggested that an influx of people into an area may cause people to have inappropriate knowledge of and practices for the agroclimatic conditions in the new area and to cultivate on marginal lands, and traditional land tenure arrangements may prove to be inadequate for protecting land that is not already in the farming cycle from these new groups (World Bank 1991).

Case studies designed to test Boserup's thesis directly have also revealed a more nuanced picture. Hyden, Kates, and Turner (1993) studied five African coun-

tries and concluded that population growth drives agricultural intensification, but whether intensification leads to increased well being and environmentally sustainable practices is ambivalent. On the basis of six African case studies, Lele and Stone (1989) argued that public policies are fundamental in shaping the effects that higher population densities have on agricultural change. Without appropriate policies, higher population will lead to degrading trends.

At the same time, some studies have presented optimistic scenarios in which local populations have been able to counter degradation trends. Afikorah-Danquah (1997), Fairhead and Leach (1996, 1998), and Kepe (1997) documented cases in South Africa, Guinea, and Ghana in which landscapes over the past century have gained in tree cover owing to local land management. Other recent studies (see, for example, Adams and Mortimore 1997; Tiffen, Mortimore, and Gichuki 1994) have supported Boserup's (1965) thesis that population growth spurs a chain of developments that lead people to practice land-enhancing technologies. Taken together, these studies, showing evidence of both Malthusian doom and Boserupian optimism, highlight that rather than there being a universal relationship between population growth and environment, this relationship depends on *how* people adjust to an increase in their numbers. This adjustment depends on both external factors, such as policies, markets, and official research and development organizations, and internal factors, such as migration, the diversification of livelihood, capital investments in agriculture, adoption of modern technology, and local, informal institutions that either hinder or aid people in making adjustments that lead to environmental sustainability. However, although external factors have been covered comprehensively by the literature on population and the environment, local, informal institutions, aside from land tenure, have tended to be left out of analyses of internal factors (see, for example, Bernstein, Gow, and Martin 1990; Cleaver and Schreiber 1994; Hayami and Ruttan 1985; Lele and Stone 1989; Pingali, Bigot, and Binswanger 1987; Turner, Hyden, and Kates 1993).

We maintain that local informal institutions, in the form of customs, norms, and networks, affect the way resources are valued and allocated and, as such, are the most immediate mechanisms through which people mediate their relationship with the environment. The mediation role that local informal institutions have implies that the effects of population growth on the environment can be fully understood only by taking local informal institutions into consideration. It also calls into question whether population levels are indeed the driving force behind the relationship between the environment and society.

The Context: The Population and Environment in the Research Area

The eastern region of Burkina Faso lies approximately between 0°20' West and 2°20' East and between 11° North and 13°30' North (Fig. 1). With its largely savanna vegetation and annual rainfall averaging between 600 mm in the north and 900 mm in the south, the region is part of the Sahelian and Sudano-Sahelian ecological zones.

Information was collected in two villages: one in the northern Gnagna province and one in the southern Gourma province. Historical data and information were collected through aerial photographs; colonial documents from archives in France, Burkina Faso, and Niger; 25 life histories collected in both villages; various interviews with two key informants who were employed by the national extension service since the 1960s; four monographs on the region written in the 1960s and 1970s; agricultural statistics published since the 1960s; and structured interviews on vegetative and land use changes in 27 farming areas covering almost the entire territory of the two study villages.

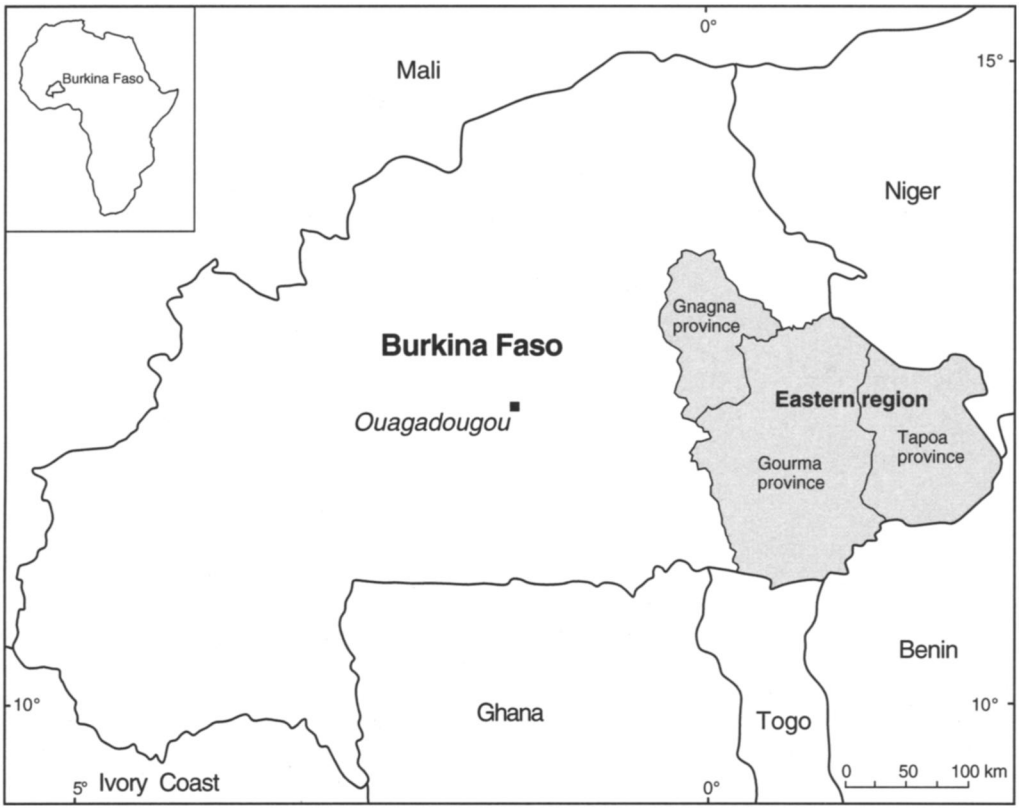

Figure 1. Burkina Faso and the eastern region. *Source:* Map 1 in Mazzucato and Niemeijer (2000b).

Data and information on the livelihood and agricultural systems were collected during three years of fieldwork between 1995 and 1998. The following were conducted: a village census; a village survey; a technology survey; and an agricultural study on soils, labor input, land tenure, landraces grown, and crop sequencing for all plots cultivated by 25 married individuals and plot sizes and yields for them and their 43 children. Cultivation histories were also collected for the married individuals. In addition, structured interviews were conducted with groups of farmers in both villages to compile a list of landraces grown and how and when they were introduced in the villages. Finally, a budget study was conducted with 35 male and female married individuals from the two research villages, including those with whom the agricultural study was done.

Strong Growth of Human and Livestock Populations

The region has experienced strong population growth in the course of the twentieth century, as can be seen in Figure 2. Although the population was remarkably stable during the colonial period, with an average annual growth of 0.5 percent, a strong average annual growth of 4 percent can be observed after independence in 1960.

Population densities in the region also rose steeply, from some 3 inhabitants per square kilometer in 1903 to some 18 in 1996 (Mazzucato and Niemeijer 2000b).

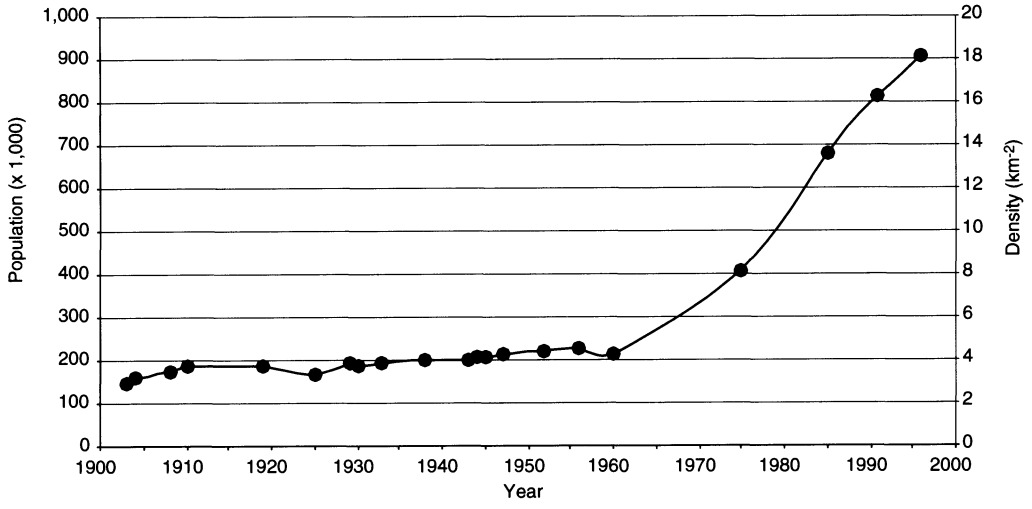

Figure 2. Total population in the eastern region of Burkina Faso (1903–1996). *Source:* Fig. 4.1 in Mazzucato and Niemeijer (2000b).

The 1996 population density may seem low, but it does not take into consideration the large proportion of area that is protected and/or covered by soils that cannot be cultivated and does not reflect the fact that population is not equally distributed over the area. Once these factors are taken into account (see Table 1), Gnagna province has a real population density of almost 47 inh. km^{-2}. Even when these factors are not taken into account, the Gnagna's rural population density of 35 inh. km^{-2} is still above the national average of 30 rural inh. km^{-2} for the Sahelian ecological zone (although not as high as some provinces on the Central Plateau, such as Yatenga, with 45 inh. km^{-2}). In contrast, Gourma province, with its rural population density of 13 inh. km^{-2}, is relatively sparsely populated, compared with the national average of 34 rural inh. km^{-2} for the Sudano-Sahelian ecological zone (Mazzucato and Niemeijer 2000b).

The growth in rural population densities has also differed greatly between the two provinces. Figure 3 presents a comparison of rural population densities in 1933 and 1996 in the two provinces. It shows that while the densely populated areas were in the eastern part of Gourma province in 1933, in 1996, some of the most densely populated areas were in Gnagna province. Thus, during this period, there was a strong

Table 1

Population Density for the Eastern Region in 1996

Province	Rural Density	Total Density	Real Total Population Density[a]
Gnagna	34.5	35.5	46.7
Gourma	12.9	14.0	20.3

Source: Agricultural statistics, Table 4.1 in Mazzucato and Niemeijer (2000b).

[a] Real total population density corrects for protected and uncultivable areas.

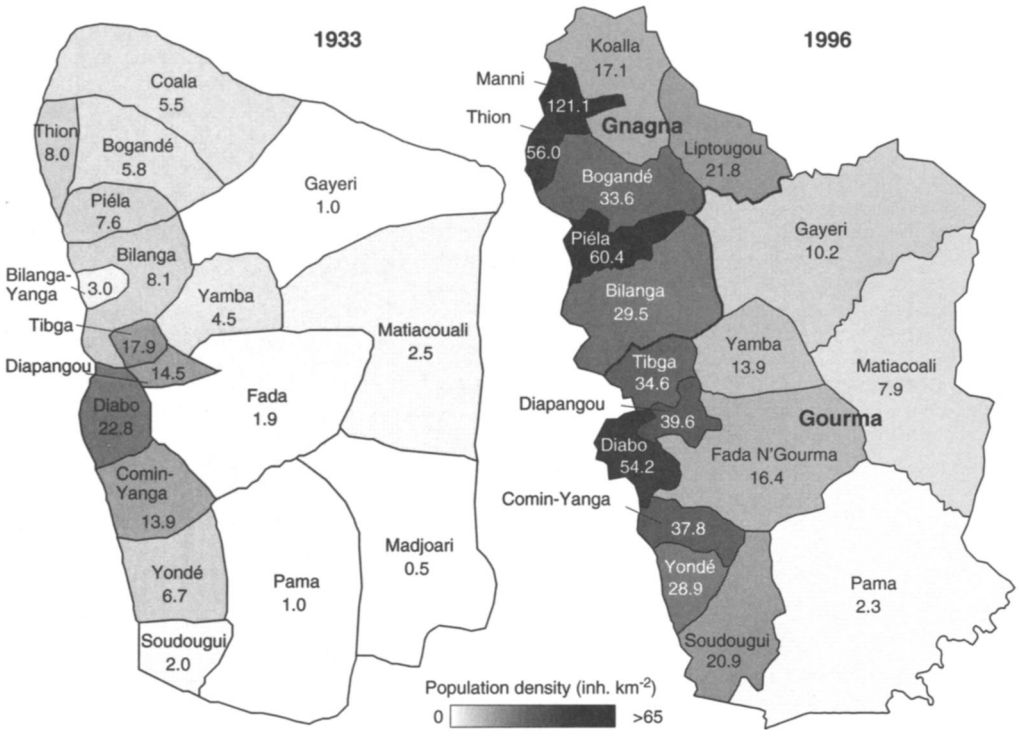

Figure 3. Rural population densities in 1933 and 1996 for the departments of Gnagna and Gourma province. *Source:* Fig. 4.2 in Mazzucato and Niemeijer (2000b).

population growth, especially in the northwestern part of Gnagna province.

Livestock numbers, although surrounded by uncertainties (since a full count is practically impossible), have also experienced strong growth in the course of the twentieth century. Figure 4 shows that in 1994, cattle population in the eastern region was more than 20 times higher than in the 1920s, raising the density from less than 1 head km^{-2} in 1923 to around 14 heads km^{-2} in 1994. The number of heads per capita grew from 0.15 in the 1920s to some 0.7 to 0.9 for the period of 1969 to 1994. The growth in other types of livestock was similar to that of cattle.

Like human population densities, livestock densities vary within the region. As can be seen in Table 2, Gnagna province had an average tropical livestock unit (TLU) density of almost 34 km^{-2} in 1994, while Gourma province averaged 12 TLU km^{-2}. In comparison, only 4 out of 30 provinces had higher livestock densities than the Gnagna in 1994, and the national average was 19 TLU km^{-2}.

In addition to population growth, the region has also experienced a steady decline in rainfall (see Fig. 5), amounting to a decrease of about 200 mm between 1950 and the late 1990s. This pattern is similar to patterns found in the rest of the country (Mazzucato and Niemeijer 2000b).

Environmental Sustainability

The different trends just described could have had a degrading effect on the environment, as they are said to have had in other regions of Africa (Cleaver and

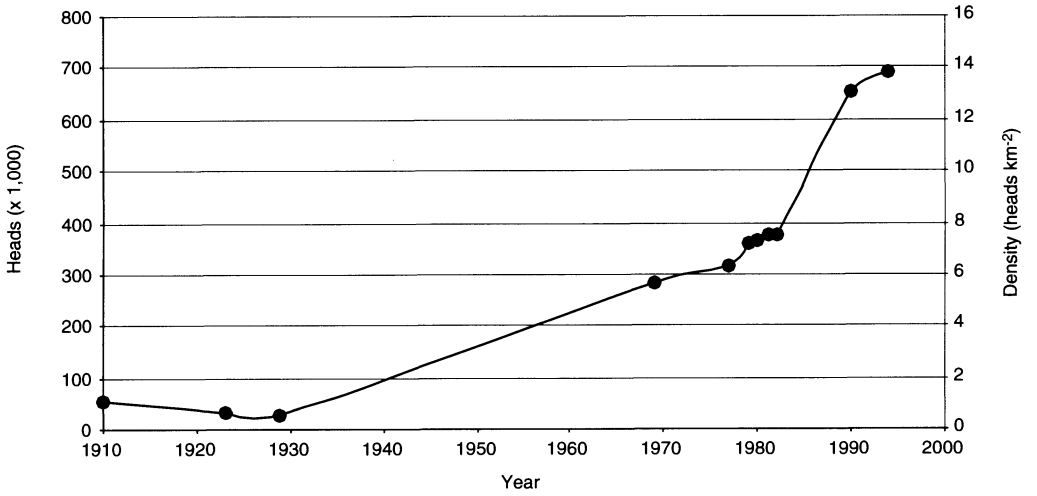

Figure 4. Cattle population in the eastern region of Burkina Faso (1910–1994). *Source:* Fig. 4.5 in Mazzucato and Niemeijer (2000b).

Schreiber 1994). However, on the basis of analyses of long-term agricultural statistics, aerial photos, soil fertility data, field observations and interviews, no evidence of land degradation was found in the study region. Since these analyses were discussed in detail in Mazzucato and Niemeijer (2000b), as well as in less detail in a few other publications (Mazzucato and Niemeijer 2001; Niemeijer and Mazzucato 2002), only the main findings are summarized here. Yields, which are often used as proxies of a degrading environment, actually rose during the past 25 years. Yields of the main staples, millet and sorghum, as well as of other important crops, such as groundnuts and maize, grew approximately by a factor of 1.5, which corresponds well with national level figures (Mazzucato and Niemeijer 2000b; Niemeijer and Mazzucato 2002). An analysis of aerial photographs, in conjunction with interviews

Table 2

Livestock Numbers and Density in Gnagna and Gourma Provinces in 1994

	Gnagna		Gourma	
Animal	Number of Animals (Heads)	Density (Heads km^{-2})	Number of Animals (Heads)	Density (Heads km^{-2})
Cattle	265,000	30.8	294,900	11.1
Sheep	241,200	28.0	289,800	10.9
Goats	426,400	49.6	367,300	13.8
Other[a]	15,208	1.8	36,410	1.4
TLU[b]	289,048	33.6	320,220	12.0

Source: Agricultural statistics, Table 4.4 in Mazzucato and Niemeijer (2000b).

[a] This category includes pigs, donkeys, horses, and poultry.

[b] TLU stands for tropical livestock unit and is calculated as follows: 1 dromedary = 1.1 TLU, 1 horse = 1 TLU, 1 donkey or cow = 0.8 TLU, 1 pig = 0.2 TLU, 1 sheep or goat = 0.1 TLU (Williamson and Payne 1978).

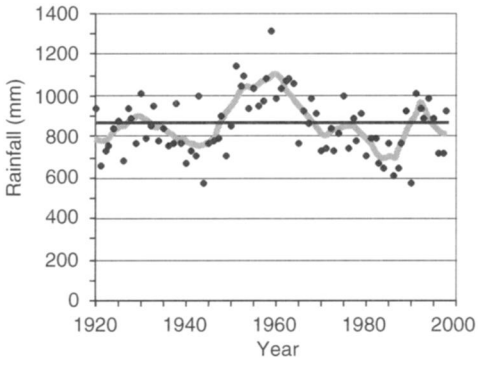

Figure 5. Annual rainfall, Fada N'Gourma (1920–1998). *Source:* Fig. 5.4b in Mazzucato and Niemeijer (2000b).

for the study villages, did not reveal a simple pattern of vegetation and tree cover loss but, rather, a dynamic landscape with a fluctuating land cover and species composition. This finding is supported by a number of recent remote sensing studies (Nicholson, Tucker, and Ba 1998; Prince, Brown de Colstoun, and Kravitz 1998) that found no evidence of a gradual deterioration of the vegetative cover in the Sahel but, rather, fluctuations following rainfall oscillations. No evidence was observed of increased gully formation except in localized spots, nor was there any visible evidence of excessive rill or sheet erosion.

Spatial and temporal analyses of soils also did not reveal any evidence of land degradation. When recent soil samples were compared with a 1969 French soil survey, no significant difference was found in the characteristics of soil chemicals (available potassium and total carbon, nitrogen, and phosphorus content). In addition, when cultivated land was compared with longtime uncultivated land, either no significant differences in chemical soil fertility were found or cultivated land was found to be more fertile as a result of land-improvement practices. Similarly, Prudencio (1993), who compared cultivated with uncultivated soils in the central part of Burkina Faso, found cultivated soils to be at least as fertile as old fallows.

Agronomic and biological land-improvement practices, such as manuring, crop rotation, and mulching, as well as mechanical practices, such as stone lines and grass strips, play an important role in maintaining and improving field fertility.[5] While the large majority of these practices were known and used even before colonial times, the frequency with which they are used and the surface covered has increased in recent times (Mazzucato and Niemeijer 2000b). New technologies introduced within the past 50 years are the donkey-drawn plow and new crop and landrace varieties brought to the village through various formal and informal channels.

These findings suggest that the production system has been able to remain environmentally sustainable with the increasing scarcity of natural resources (land and rainfall). Furthermore, the main technological changes that took place were in the form of using and adapting existing technologies more frequently, applying them to different areas in reaction to changing environmental conditions, and the introduction of the plow and new crop and landrace varieties. These technological changes could take place only within the framework of changing and adapting informal institutions because they require greater access to productive resources. In the next section, we look at the most important changes or adaptations made to the production system within the past century, with a specific focus on how institutions have enabled these adjustments.

Institutional Changes as Adjustment Processes

There are four domains in which institutions have been modified or changed to enable the production system to adjust in an environmentally sustainable way to a context

[5] For a full list of land improvement and conservation practices, see Mazzucato and Niemeijer (2000a, 2000b).

of growing natural resource scarcity: spatial organization, labor access, diversification of livelihoods, and use of technology.

Spatial Organization

Two important institutional changes regarding the spatial organization of production have occurred within the past century in reaction to the changes discussed in the previous section: an increase in bush camps and the rise of land-borrowing agreements. We argue that these institutional changes have allowed the population to deal with the increased scarcity of natural resources in an environmentally sustainable way.

Bush camps (*kuadabili*) consist of a single, but most often several, bush compounds (*kuadiegu*) that are inhabited during the 6- to 7-month agricultural season. Bush camps increased in the course of the twentieth century initially as a reaction to colonial policy and later as a way to adjust to changing population densities, the variability in rainfall, and increased market integration. At the turn of the twentieth century, wars between different kingdoms made it necessary for all villagers to stay close together for security. However, relative peace brought by colonialism, and repressive colonial policies of recruitment and taxation encouraged people to spread out in the hinterland so as not to be found by colonial authorities. This spreading out of homesteads resulted in an increase in bush compounds. As early as 1936 and 1937, censuses report 22 bush compounds for Bilam-Perga (an agglomeration of villages, including the northern study village) and 12 bush compounds for the southern research village (Mazzucato and Niemeijer 2000b).

The growing scarcity of resources in the latter half of the twentieth century, characterized by growing population and declining rainfall, made suitable land close to the village center scarce. Cultivating far from the inhabited center, however, has high labor demands in travel time to and from one's fields. In a context of production units decreasing in size and therefore labor being a scarce resource, bush camps provided an institutional solution to the problem of the growing scarcity of resources by making it possible to cultivate land farther from the village center (see Fig. 6) while minimizing travel between home and field.

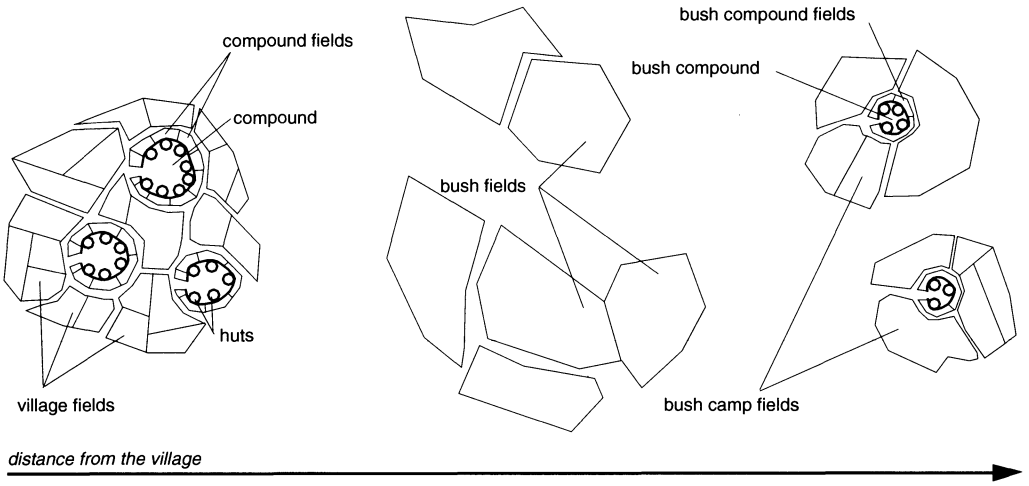

Figure 6. Schematic map of the spatial organization of the most important types of fields. *Source:* Fig. 4.3 in Mazzucato and Niemeijer (2000b).

Bush compounds also allow people to deal with the increased spatial variation in rainfall that accompanies a decline in rainfall (Sivakumar 1991). Through bush camps, households from one village compound can spread out to different locations so as to minimize the risk of all being in an area in which there is a shortage of rainfall in any given year.

Finally, increased market integration, which was stimulated by colonization and further spurred starting in the 1970s by greater contact with development projects and a globalized world economy (Mazzucato and Niemeijer 2000b), created advantages to an individualized accumulation of surplus production. Bush compounds seem to be a socially acceptable way for household heads to separate their production from the communal compound-based production of the past because a household head's desire to be independent of a compound head can be camouflaged by the need for space and for insurance against a shortage of rainfall. A village survey revealed that in 1996 there were 25 and 39 bush compounds in the northern and southern villages, respectively, amounting to 31 percent and 39 percent, respectively, of the total inhabitants who lived in bush camps for part of the year.

Borrowing land has also been on the increase, given the rise in population density. Borrowing land is part of the customary land tenure system. Within this system, cultivation rights are obtained by clearing a piece of land that has never been cultivated before. Within a bush-fallow rotation system, in which people cultivate land until it needs to be left fallow, land is progressively cleared and therefore "claimed," while fallows are allowed to regenerate. This system means that early settlers of a village will have cleared and claimed more land than recently settled villagers. As more people inhabit an area, borrowing fallow land from people who have "claimed" lots of land increasingly becomes an option for people who have "claimed" less land (such as latecomers or newcomers).

Borrowing has also facilitated the greater use of bush camps. Land far from village centers that is appropriate for establishing bush camps may be located in areas of previous settlement or cultivation or on another village's territory. Thus, cultivation rights to that land have already been "claimed" or are under the jurisdiction of another village. To cultivate in these locations, it is therefore necessary to borrow land from those who have rights to that land.

How have these changes in the spatial organization of production affected the environment? First, both bush compounds and land-borrowing agreements have made the crop cultivation system mobile, even with the increasing scarcity of land. This mobility has given people access to land fit for cultivation while enabling them to leave land fallow where it needs to be left to regenerate, despite less land being available. These institutions have thus allowed the bush-fallow rotation system, a key soil conservation technology used in the area, to continue to exist even under rising population densities.[6]

A further environmental consequence of field mobility has been the fact that people have been able to exploit different landforms according to the change in climate. As a result of the dryer climate since the wet 1950s, there has been a shift from high, sloping lands toward low, flatter lands.[7] A comparison of aerial photographs taken in 1955 with those taken in 1987 and 1994 for the southern and northern research villages, respectively, shows these trends (see

[6] As population rises even more, these institutional solutions to redistribute land will no longer suffice, and other solutions will need to be developed. However, the fact that these adjustments have taken place thus far gives us good reason to believe that further institutional adjustments can and will be made to face future changes in the context within which agriculture is practiced.

[7] This process was also noted by Swanson (1979) in this region and by Vierich and Stoop (1990) in other areas of Burkina Faso.

Table 3). An illustration comes from cultivation histories conducted with case study individuals in the southern village: during the wet 1950s, lower bottomlands were too wet to be able to cultivate even the local rice varieties, whereas in the dryer 1990s, they became ideal lands for rice cultivation.

Second, members of the same village compound access different farming locations through bush compounds and borrowing land and thus insure themselves against the risk of a production shortfall because of localized rainfall shortages. Rainfall can vary greatly between different farming areas, even those located within the same village territory. In the study villages, for example, rainfall recorded in 1996 and 1997 varied as much as 30 to 40 percent between farming areas located in the same village territory. These differences can be crucial for the growth of crops, given the low rainfall levels in the area. One way to avoid being in an unlucky area in a given year is for people from the same compound or household to cultivate in different areas contemporaneously. Both bush camps and borrowing land allow them to do so. Being in an unlucky area in a given year without also having a harvest from a more lucky area would mean incurring a production shortfall that could easily plunge a household into a vicious cycle of debt and debt repayment that constitutes the poverty trap, claimed to be one of the primary causes of degrading practices (Ehrlich, Ehrlich, and Daily 1993; Hudson 1991). Studies (see, for example, Dasgupta 1993) have found that the poor need to focus on their immediate consumption and cannot afford to postpone production to make land-enhancing investments. In southern Mali, for example, people were found to mine the soil of its nutrients to maximize their present consumption (van der Pol 1992).

Finally, although borrowing entails temporary rights to cultivate land, farmers do not perceive it as insecure. Six in-depth cultivation histories, conducted with some of the case study individuals in the two research villages, revealed no relationship between form of tenure (borrowed or ancestral land) and use rights (individual or household field), on the one hand, and agricultural decisions and cultivation practices, on the other hand. For example, in all cases, it was found that farmers applied soil and water conservation practices to adjust to the changing qualities of the soil that were due to cultivation. That is, the farmers often increased the amount of soil and water conservation activities toward the end of the cultivation period in response to a decrease in production in certain parts of the field (Mazzucato and Niemeijer 2000b). The fact that such a field would

Table 3

Changing Land Use Patterns in Northern (1955–1994) and Southern (1955–1987) Research Villages

	Northern Research Village			Southern Research Village		
	Total Area (Percentage of Territory)	Cultivated Area[a] (Percentage of Landform)		Total Area (Percentage of Territory)	Cultivated Area[a] (Percentage of Landform)	
Landforms		1955	1994		1955	1987
High or sloping land	26.9	17.4	16.3	45.2	2.1	4.8
Low or flat land	73.1	23.1	67.9	54.8	1.6	10.7
Total	100.0	21.6	54.0	100.0	1.8	8.0

Source: Aerial photo interpretation, Table 6.6 in Mazzucato and Niemeijer (2000b).

[a] Cultivated area includes recent fallows that cannot be distinguished from cultivated fields on the aerial photographs.

soon be left fallow or be used by someone else was never mentioned as a concern and is exemplified by the following comment made by a farmer: "If you know that you can use a piece of land that you borrowed from someone for more than two or three years, it is worth maintaining the land well (*ki kubi ki tinga*) by making stone lines, wood barriers, or planting grass strips. If someone lends you a piece of land, you are going to maintain it as if it were your own."

Labor Access

Changes in the constitution of production units have made these units experience an increased need for temporary labor. This section discusses three institutional adaptations that have allowed production units to meet their new labor needs. We argue that this access puts production units in a position to practice environmentally sustainable agriculture.

Colonial rule and market integration have both led to a reduction in the size of production units (for details regarding this process, see Mazzucato and Niemeijer 2000b). Smaller production units are at a greater risk of a labor shortfall because any event that takes members out of production, such as illness, death, or birth, means that a larger proportion of total family labor is unavailable for agricultural work than when production units were larger. Thus, although the population is increasing, labor is becoming a scarce resource at the level of the production unit. Consequently, small production units are in greater need of temporary labor. Three changes to networks and customs guiding access to labor have occurred within the twentieth century to enable production units to access additional labor: the use of work parties, composition of networks to access labor, and customs guiding women's role in agriculture.

Work Parties. Work parties, in which people are invited to work on a person's field in exchange for a meal and/or drinks, have two functions. The production function is evident: through the work party, a person is able to catch up on important tasks, such as harvesting, that, if not done in time, can make the difference between having a harvest and not having one at all. Richards (1986) even found that the major factor distinguishing farms with high and low yields in Sierra Leone was their access to work parties. However, there is also a social function to work parties in that the caller of the party exhibits and reinforces his social standing by having many people show up at his work party and offering lots of food, local beer (*dolo*), and tam-tam music to make it a festive occasion. Remy (1967), who studied Gourmantché villages to the southeast of the research area, pointed out that work parties were not always beneficial from an economic point of view: the offerings cost much more than the benefits of the work produced, which was done in a hurried manner and was thus of bad quality. Such large work parties had the effect of reinforcing the host's prestige and status within the community and thus had a political, more than a production, purpose.

Today work parties tend to be smaller and to be for production purposes, rather than for prestige. This change can be inferred by the high percentage of small work parties recorded for the case study individuals during the agricultural season and by the respondents' recollections. Furthermore, a village survey revealed that work parties are pervasive, since, on average, 1.6 and 1.4 agricultural work parties are called annually per household in the northern and southern villages, respectively. Table 4 shows that work parties called by case study individuals were relatively small, averaging 16 participants per party, which is considerably smaller than the marriage-related work parties that have a definite prestige component and range from 25 to 100 participants. These figures are similar to those of a village survey, which revealed an average of 18 and 21 participants per work party in the northern and southern villages, respectively. In addition, expenditures per individual present

Table 4

Agricultural Work Parties of Case Study Individuals, December 1996 to November 1997

Person[a]	Activity	Crop	Field Type	Total pp's[b] (no.)	Bush Neighbors (percent)	Kin[c] (percent)	Area pp^{-1} (ha)	Costs pp^{-1} (fcfa)
Bandia[d]	land clearing	sorghum	bush	22	9	95	0.109	186
Bandia	weeding	sorghum	compound	10	30	100	0.035	280
Bandia	cutting stalks	millet	compound	3	67	100	0.216	300
Piampo	weeding	millet	bush	50	0	0	0.069	217
Possi	weeding	millet	village	2.5	n.a.[e]	100	0.182	120
Possi	weeding	rice	bush	20	75	100	0.019	160
Djoulmani	weeding	rice	bush	8	50	50	0.222	250
Djoulmani	weeding	rice	bush	22	68	100	0.081	314
Djoulmani	cutting heads	rice	bush	17	29	71	0.105	353
Marhi	weeding	sorghum	bush	15	60	27	0.030	213
Marhi	cutting heads	rice	bush	9	67	22	0.104	222
Sambo	hoeing	sorghum and millet	bush	16	63	25	0.201	219
Noaga	second weeding	millet	village	15	n.a.	100	0.208	133
Average				16			0.122	228

Source: Agricultural study, Table 8.1 in Mazzucato and Niemeijer (2000b).

[a] Original names have been changed for privacy.

[b] pp = participant.

[c] Bush neighbors and kin are not mutually exclusive.

[d] The same person and crop do not mean it is the same field.

[e] n.a. = not applicable and applies to cases in which the person calling the work party did not have a bush field.

do not follow a clear pattern with the wealth of the person hosting the work party (thus no clear political-social significance). Indicative of the production orientation of labor parties is the fact that 8 of the 13 work parties were called by poor to middle-wealth families and that all but one of the people who called these different work parties were running behind in their cultivation tasks.

The respondents further confirmed this trend. Three men aged 40 to 60 who were interviewed independently on this topic concluded that work parties today, compared with 30 or 40 years ago, consist of fewer people, are more frequently called, and are less festive in that tam-tams are much less frequently played.

Composition of networks. A second change that has affected access to labor is the composition of networks used to access labor. Paid agricultural labor is virtually nonexistent in the area, so labor shortfalls are met by asking kin relations for their labor for short periods. The spreading out of cultivation farther and farther from the village center and ultimately into bush camps has meant that field neighbors have become an important source of temporary labor. Kin located in other bush camps or in the village would take too much time to reach the field, and because everyone has cultivation tasks that need to be done, spending one's time in traveling is not feasible. Since bush camp neighbors include nonkin relations, the new spatial organization of production has required networks from which one can access labor to extend beyond one's own kin.

The importance of bush camp neighbors, as well as the kind of composition of networks that bush camps entail, can be seen in the number of bush camp neighbors who participated in the work parties called by case study individuals (see Table 4) in the study villages over a one-year period. The only people who did not have any bush camp neighbors participate were those who did not cultivate on a bush camp

(Possi and Noaga) or the one person who had a marriage-related work party in which people from the suitor's village came to work (Piampo). In the case of the brothers Marhi and Sambo, who live in the same village compound during the dry season but cultivate in two different bush camps during the agricultural season, many of their neighbors who participated were not related by kin. They have a relatively small network of kin relations, so building networks with field neighbors seems to be all the more important. In fact, Marhi was difficult to locate during the rainy season because he was often working at his neighbors' work parties.

Role of Women. A third change is women's new role in agriculture. The increased need for the labor of small production units has necessitated women's involvement in the production process. While at the turn of the century women cultivated some sauce ingredients on the borders of the compound fields, they now dedicate much of their labor during the agricultural season to helping with agricultural tasks on their families' grain fields that are managed by their husbands. They also cultivate their own fields of millet or sorghum and groundnuts. The production from a woman's own fields can contribute to the production unit's food needs in case the family field does not suffice or can be sold to pay for things that are customarily a woman's responsibility, like clothes, kitchen utensils, and sauce ingredients. Women also contribute to the new demands of a modernizing society, such as school fees and hospital and medicinal bills.

The transition to women's active role in agriculture has been eased by an adaptation of customs that guide what women are and are not allowed to do, as well as the use of women's natal networks for agricultural purposes. Half a century ago, women in the northern village could grow Bambara groundnuts and okra only if one of their children had died. Only elderly women could cultivate tobacco because all other women would become blind if they did so. Gradually, customs changed so that women had to wait some time after their marriage before they could cultivate their own fields. For example, in the north, a newly married woman could sow neither sorghum nor cotton because she needed to have a grown-up son who could sow these crops for her. In the south, a woman could not cultivate millet if she did not have a child. She could have a personal field only if she had a child who was old enough to help her husband on the family's grain field. Later, a woman had to wait until the third year after her marriage before she could begin to cultivate a personal field. Progressively, the time that women had to wait to cultivate their own fields diminished so that today, both in the north and in the south, customs restricting when or what married women can grow are virtually nonexistent. In fact, today children, including girls, begin at around 8 years of age to cultivate their own groundnut fields and later also have millet or sorghum fields.

Women's ties with their natal families have also been used to provide them with starter seed for the first cohort of women who began cultivating their own grain and groundnuts. Interviews conducted with women aged 30 to 60, both in the north and in the south, indicated that they began cultivating their own fields with seed obtained from their natal families.

These changes to institutions that have allowed today's smaller production units to meet their new labor needs have important consequences for people's ability to manage the environment in a sustainable way. First, access to enough labor allows production units to move to new fields when the land they are cultivating needs to be left fallow because clearing previously uncultivated or fallow land is a highly labor-intensive task. A small production unit with few workers and many consumers cannot clear enough land on its own to feed itself and, without the additional labor, would be forced to remain on the same piece of land and ultimately overcultivate it.

Second, by completing agricultural tasks with work parties, time is freed for applying the largely labor-intensive conservation measures that farmers were found to use (Mazzucato and Niemeijer 2000a, 2000b). The additional time they gain allows farmers to use their knowledge of cultivation practices, their soils, and landraces on which these measures are based, to capacity. Thus, as a result of having enough labor available, farmers have been able to invest in land-enhancing measures, rather than have to cultivate more land per person to feed their families. In fact, area cultivated per person for the main staple crops during the period 1970 to 1996 remained virtually the same at 0.3 ha capita^{-1} in the eastern region (Mazzucato and Niemeijer 2000b).

Access to labor allows small production units to compensate for the dramatic shifts in household labor so as not to jeopardize production. As we argued earlier, reducing the risk of production shortfalls helps avoid the poverty trap that induces people to degrade the land. Finally, the increasing role of women in agriculture, enabled through a change in customs and new uses of women's natal networks, has given today's small production unit the labor base needed to perform agricultural tasks on time and in a sustainable way.

Diversification of Livelihoods

Livelihoods are diversifying in the study region, as has been found for other parts of Africa (Birch-Thomsen, Frederiksen, and Sano 2001; Mortimore and Adams 1999). Social networks are an important institutional form that has enabled people to take advantage of new livelihood opportunities brought on by increased market integration. In this section, we discuss three ways in which social networks allow people to diversify their livelihoods in the study region and, in certain cases, how these networks have changed in their form and use to provide access to these new forms of livelihood. We argue that new livelihood opportunities give people the room to maneuver in an increasingly resource-tight system in order to avoid degrading the environment.

One reason for accessing other people's labor is, as discussed above, to be able to free one's time to engage simultaneously in various income-earning activities. The example of a case study individual illustrates this point. Since his teenage years, Bandia had been involved in commercial activities, first by having his own petty commerce stand in the local market, then by importing goods from Togo and selling them in local markets, and most recently by trading in millet and livestock. In 1996 Bandia was at a difficult point in his life cycle when he had four children who were too young to be agriculturally active; one wife; a father who had just died, whose burial and funeral he had to organize and pay for; and a mother to care for. He also needed to move to a new field and leave the one he had been cultivating fallow. This could have been one of those years that can throw a person into a poverty trap. Field clearing is highly labor intensive. Not having access to temporary labor to clear a new field would have forced Bandia to stay on his old fields and overcultivate them, which would eventually have led to soil mining. Not having any additional hands to help him with agricultural tasks would have meant that he would have had to dedicate all of his own labor to these tasks and thus would have had no time for his commercial activities. Consequently, he would have earned less income, had to borrow money or food to make ends meet, and fallen into debt without any additional sources of revenue from which to pay back his debts: the poverty trap. Bandia, however, left his old fields fallow and set up a bush compound on borrowed land close to Piampo's bush compound. Piampo had three wives and various agriculturally active children. Piampo's daughter was often to be found in Bandia's compound helping with the household chores, thus freeing Bandia's only wife to work on Bandia's and her fields. The fact that his wife worked on the fields meant that Bandia could absent himself every once in a while to conduct his

commercial activities. It was advantageous for him to engage in his trading activities during the agricultural season when selling prices were high.

The example of Bandia illustrates how accessing temporary labor allows people simultaneously to conduct various income-earning activities and how the resulting diversification of sources of livelihood may help people avoid the poverty trap, even in years when their life cycles make them most vulnerable.

A second way in which networks provide access to new income-earning opportunities is the new ties forged between Gourmantché farmers and Fulbe, semi-sedentary, livestock herders. Greater market integration has made cattle a desirable form of savings among Gourmantché because it has a high market value; the demand for livestock is such that it is virtually always possible to find buyers in the region; and cattle reproduce, thus augmenting one's savings. There are, of course, risks involved in cattle rearing, such as epidemics that wipe out one's stock. However, given that when people have money, they usually invest in cattle, the rewards of cattle rearing are perceived to be greater than the risks it entails.

Gourmantché are able to engage in cattle rearing while maintaining their focus on crop cultivation because they entrust their cattle to Fulbe herders, as is commonly done in other parts of West Africa (see, for example, Breusers, Nederlof, and van Rheenen 1998; de Haan, van Driel, and Kruithof 1990; McIntire, Bourzat, and Pingali 1992). This system allows Gourmantché to keep their family labor for crop-cultivation tasks and have their cattle far from farming areas during the agricultural season so as to limit crop damage.

In areas where historical ties existed between the two groups, such as in the northern research village, farmers have relied on these relationships to initiate and maintain herding agreements. In areas where no historical ties exist between the two groups, such as in the southern village, villagers have developed a system of monetary loans through which they establish relationships of trust between members of the two groups. Market integration has made it so that almost everyone is either a potential lender or a creditor. Gourmantché have taken advantage of their relatively better-off situation with respect to Fulbe by giving loans of money or grains to Fulbe. First, small loans are made, and if the creditor repays his debt, the following loan will be a bit larger. In this way, a series of loan transactions are initiated that culminate with the Gourmantché entrusting his cattle to the Fulbe. Thus, in areas where social networks did not historically include Fulbe, these networks have been broadened to include Fulbe so as to engage in livestock rearing, and new ways have been developed (through monetary loans) to establish such networks.

A third way in which networks have adapted is by gaining access to cash for new cash needs created by market integration. Now ceremonies, such as funerals, require cash and can be costly. Furthermore, the availability of modern medicine can create a large and unpredictable need for cash. Forms of networking have emerged to deal with these new cash necessities in the form of self-help groups. Cash self-help groups function like *tontines*, which have been documented in other areas of West Africa (Lelart 1990; van den Brink and Chavas 1991; Webster and Fidler 1996). Life histories reveal that these forms of cash self-help groups have emerged within the past 20 to 30 years. By providing access to cash, self-help groups have the same effect as an income-earning activity in diversifying one's livelihood.

Access to income-earning opportunities outside crop production through social networks allows people not to degrade their environment, despite the increased scarcity of natural resources. The possibility of making one's living from more than just crop production means that there is less pressure on people to have to eke out everything they can from the land to ensure their livelihoods, as is characteristic of the poor (Dasgupta 1993).

Second, market incentives to engage in livestock activities could have easily led to land degradation at the village or watershed level because of overgrazing. However, the particular herding agreements developed with Fulbe and enabled through the creation of social networks between Fulbe and Gourmantché have avoided such a situation, since most cattle are grazed on transhumance routes.

Finally, networks allow people to take risks associated with an environmentally sustainable form of agriculture. For example, moving to a new piece of land involves some unknowns: one knows how one's own field produces, but one can never know exactly how a new field will produce. Furthermore, in the first couple of years, a newly cleared field produces less than its full potential because cultivating and mixing organic matter into the soil initially improves soil structure (Mazzucato and Niemeijer 2000b). Accessing income outside crop production allows one to take these risks that are necessary to practice sustainable land husbandry.

Use of Technology

With market integration and the development of research and development organizations, more technologies are available to farmers. In this section, we discuss the use of the plow and landraces, which are new to the region, to illustrate how farmers have adapted their use of networks to access these new technologies. Furthermore, we argue that these technologies enable people to practice an environmentally sustainable form of agriculture.

Networks are increasingly being used to access equipment for agricultural purposes. According to a national survey, only 3 percent of the agricultural population in Gnagna and Gourma provinces owns a plow (MARA 1996). However, this wide-scale survey, as well as smaller-scale studies on animal traction in the area (Barrett et al. 1982), focused on the ownership of plows and draft animals, ignoring the possibility of borrowing them. Such an omission can lead to conclusions that underestimate the actual use of technologies in rural African agricultural practices. In following farming practices in the study region, we noted, as did Hesse (1997) and Panin (1988) in northern Ghana, the frequent practice of lending and borrowing equipment, such as plows, draft animals, and carts, from one's network. Such borrowing does not involve explicit payment agreements. However, it is common for a borrower to offer a gift of appreciation to the lender. Both what is given and when are highly variable and dependent on the borrower's means. The respondents explained that receiving loans to purchase a donkey-drawn plow from the local extension office was not appealing, particularly because of the obligation that they would have to repay the loan within a predefined period and the high risk of events happening that would make them unable to meet their repayments. Borrowing equipment from one's network thus provided an institutional solution to gaining access to equipment.

A technology survey conducted with 47 married individuals illustrates this phenomenon. Ownership of plow and draft animals was virtually nil for women and 39 percent and 50 percent, respectively, for men (see Table 5). However, if one looks at the borrowing of plows, another picture emerges.

If one considers ownership and borrowing of plows together, then Table 5 shows that women use plows almost as much as men do (61 percent versus 71 percent, respectively). In general, the borrowing of equipment and draft animals is commonplace.[8]

[8] It is important to note, however, that borrowing plows usually entails accessing them late because the owner of a plow will first use it on his fields. Also, although borrowing equipment does not usually entail an explicit agreement for repayment, it does put the borrower under an informal obligation toward the lender. Finally, looking at the number of people who borrow says nothing about the amount of land that is

Table 5

Use of Agricultural Equipment in the Research Villages, 1996

Type of Equipment	Owns (Percentage)	Borrows (Percentage)	Total Users (Percentage)
	Women (N = 46)		
Plow	2	59	61
Draft animal	4	30	35
Cart	0	15	15
	Men (N = 28)		
Plow	39	32	71
Draft animal	50	25	75
Cart	14	32	46

Source: Technology survey, Table 8.2 in Mazzucato and Niemeijer (2000b).

Table 6

Provenance of Recently Introduced Landraces (ca. 1950–1998)

	Northern Research Village	Southern Research Village
Provenance of recently introduced landraces:		
Governmental agencies	9	11
Markets	7	1
Relationships with people		
Missionary	0	9
Villagers migrating out	8	1
Migrants coming to village	0	7
Family and friends	3	2
Do not know	0	5
Total introduced within the past 50 years	27	37
Total number of landraces currently grown	85	84

Source: Structured interviews on landraces, Table 8.3 in Mazzucato and Niemeijer (2000b).

Farmers also gain access to landraces of crops, such as sorghum, millet, groundnuts, and rice, and knowledge about them through networks. Table 6 shows that between 40 percent and 50 percent of recent landraces were introduced through relationships with people, such as a local missionary, villagers who migrate for some time and then return to the village with new landraces, migrants who come to the village usually to settle there and bring landraces with them, or family members or friends who live in other areas. Although both governmental agencies and markets also involve relationships between people, we make the distinction between the various categories because most extension work is done through official organizations or markets, whereas these results show how important informal contact between people can be for the propagation of technologies.

plowed. It may well be that the amount of land plowed with a borrowed plow is less than that plowed with an owned plow, given that borrowed plows are accessed late. This would make an interesting research question for an agricultural survey to address.

Borrowing equipment and accessing new landraces have made technologies available to facilitate a process of technological change and intensification to deal with the increasing scarcity of natural resources. Farmers' limited incomes have been repeatedly identified as a major impediment to the use of farm capital and therefore the productivity and environmental sustainability of African agricultural systems (de Graaff 1996; Reardon 1998). However, through networks, even those who cannot afford to buy equipment are able to use it. Networks allow people to access equipment without making a capital outlay and to pay for it through resources that they do have, such as labor and political allegiance. Thus, networks allow people to overcome the income constraint to practicing environmentally sustainable agriculture.

Another effect of accessing technologies on environmental sustainability is that adapting landraces to a changing climate and qualities of a soil is a form of soil and water conservation that was found to be widely practiced in the area (Mazzucato and Niemeijer 2000b). Farmers select the most appropriate landrace for soil and rainfall conditions at a particular point in time. As soil conditions change because of continued crop cultivation, farmers plant a different landrace to make more effective use of available soil moisture and to reduce the depletion of nutrients. If rainfall is late during a particular season and farmers need to resow, they change to a faster-maturing landrace. These landraces have also been fundamental to farmers adjusting to the decline in rainfall experienced since the wet 1950s (Mazzucato and Niemeijer 2000b). By giving farmers access to different landraces, networks contribute to the environmentally sustainable practices used in the region.

Conclusion

This article contributes to a growing body of case studies (Benjaminsen 1997; Fairhead and Leach 1996, 1998; Tiffen, Mortimore, and Gichuki 1994) that have questioned "received wisdom" or "orthodoxies" about environmental degradation. It explains an optimistic case in which rapid population growth has not produced any evidence of trends in land degradation, by focusing on the role of changing informal institutions in mediating the relationship between the environment and society. However, there are important differences between this study's findings and how institutions are treated in the optimistic theories of Boserup (1965) and Hayami and Ruttan (1985).

First, the case presented here indicates that people respond to more than just population densities in adjusting their interactions with the environment. Boserup's (1965) theory of technological change and subsequent applications thereof (for example, Tiffen, Mortimore, and Gichuki 1994; Turner, Hyden, and Kates 1993) grant primacy to population densities as the driving force behind the relationship between society and the environment. However, many of the institutional changes and adaptations discussed in this article were stimulated by increased market integration (see also Zaal and Oostendorp 2002 for a similar finding in Machakos, Kenya). Market integration did not only evolve as a consequence of higher population densities leading to reduced costs of communication, as stipulated by Boserup, but was also the outcome of colonial policies and increased contact with developed countries through trade, business, and development projects (Mazzucato and Niemeijer 2000b). Furthermore, changes in the spatial organization of production and in the use of technology have also been a reaction to a decline in rainfall experienced within the past 50 years. These various sources of change suggest, differently from Boserup's theory of population thresholds, that adjustment processes do not occur only at certain crisis points in which population levels have reached an unmanageable threshold, but continuously and in reaction to a multiplicity of factors.

Second, the effects of external changes, including population growth, on the environment depend on *how* people adjust. Thus, contrary to Boserup's (1965) theory, in which institutions are implicitly assumed to develop toward those of a market economy, and contrary to Hayami's and Ruttan's (1985) theory, in which factor markets are assumed to exist, this article has focused on how informal institutions change and how they affect the relationship between the environment and society. Changes in how production is spatially organized, labor is mobilized, different livelihoods are pursued, and technologies are accessed entail institutional adjustments that mediate the relationship between people and the environment. Land tenure arrangements are now being used more than in the past to allow people to cultivate in areas farther from the village center; customs have been modified to allow production units to split and to ease women into agriculture; and social networks have changed in their uses and composition to enable people to pursue their production goals, access technologies, and engage in a diversity of livelihood activities. All of these changes have allowed people to adapt to a changing context within which agriculture is practiced, while not degrading their environment. This article has thus highlighted the need to include the "missing link" of informal institutions in population environment debates to understand the diversity of institutional responses to the multiplicity of factors that influence people's relationship with the environment.

New solutions will need to be sought as the availability of natural resources and social and economic contexts change. However, the fact that substantial institutional adjustments have been made until now makes it reasonable to expect that further adjustments will be made to face new and changing contexts within which agriculture is practiced.

Finally, the emphasis of this article on adjustment processes makes us conclude, similarly to, but through a different analysis from, Cuffano (1997), that as far as population is concerned, the *rate* of population growth is more important than absolute figures of population densities. At fast rates of population growth, institutional adjustments may be difficult to make. For example, in a context of war or rampant levels of AIDS that can quickly decrease the number of people in a location and overwhelm local institutions, people may find it hard to adjust their local institutions to manage their natural resources under new conditions. However, our case study shows that even at relatively high rates of population growth in a fragile ecosystem, there can be processes of adjustment taking place through local institutions that positively affect the environment.

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