A Foundation for Coping with Environmental Change: Indigenous Agroecological Knowledge Among the Bambara of Djitoumou, Mali

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A FOUNDATION FOR COPING WITH ENVIRONMENTAL CHANGE: INDIGENOUS AGROECOLOGICAL KNOWLEDGE AMONG THE BAMBARA OF DJITOUMOU, MALI

William G. Moseley

Abstract

This chapter examines Bambara agriculturists’ perceptions of environmental change, their knowledge of microenvironments and associated management schemes, and their strategies for coping with environmental change. The chapter also explores development practitioners’ perceptions of this knowledge. In interviews conducted during the fall of 1992 with Bambara villagers in the Djitoumou agroecological zone of Mali, the author found that farmers had a detailed understanding of local microenvironments and associated management strategies. Villagers consistently identified ten different soil types which they managed for agricultural production in distinctly different ways.

This understanding differs dramatically from official reports that classify the area under a maximum of four different soil categories. Villager’s soil knowledge was reflected in their responses to environmental change. Farmers had switched from well-drained soils to water-retentive soils in order to cope with decreased rainfall. Villagers also began farming rice in areas where it had previously never been cultivated before.

Finally, the traditional land tenure system was flexible enough to accommodate dramatic shifts in land preferences. Discussions with development practitioners revealed that while many of these individuals believed that indigenous knowledge was once vital to the survival of Sahelian farmers, many suggested that the degree and rate of environmental change had been so great that this traditional understanding of the local environment was no longer viable. In contrast, the research revealed that grounded understanding of the local environment and associated social structures allowed for a flexible response to environmental change.

Such results suggest that the survival of local people afflicted by environmental change is not best promoted by totally new approaches and outside ‘expertise’ but by a more balanced process involving both international and local science.

Introduction

A good deal has been written over the past twenty years on the subject of environmental degradation in the Sahelian countries of Africa (World Bank 1989: 17; Harrison 1987: 17-19).
In part due to the failure of development efforts to address this dramatic rate of degradation (Hancock 1989: 191-192), there has been an increasing interest among development practitioners in participatory approaches (Korton 1990; Chambers 1989; Thomson et al. 1989). Within the francophone countries of Sahelian West Africa, the 'trendy' approach to participatory rural development in recent years has been the approche aménagement/gestion des terroirs villageois or community-based approach to local natural resource management (A/GTV) (Painter 1993: 1-2).

The underlying idea of this approach is that natural resources should be managed at the local level by local people. An integral component of the A/GTV is the incorporation of indigenous knowledge and practices into management strategies (Painter 1993: 3; Shaikh 1989: 13). Assuming that most rural communities seek to maintain or increase agricultural production in the face of environmental degradation, it is important to ask how indigenous knowledge might be helping people attain this goal given the change that is occurring? More specifically, are traditional and experiential knowledge of the environment and agricultural production strategies an asset of local people that can help them cope with environmental change? The author sought to explore this question in the fall of 1992 with Bambara villagers in the Djitoumou agroecological zone of Mali.

This chapter discusses the research methodology employed during the study and the importance of villager awareness of their own knowledge, villagers' perception of environmental change, some examples of the types of agroecological knowledge that villagers posses, and how villagers are using this knowledge to cope with environmental change. The chapter also discusses outside development practitioners' perceptions of indigenous agroecological knowledge and how this group's suggested environmental change coping strategies differ from those of villagers. The chapter concludes with policy recommendations.

Indigenous Knowledge is 'local knowledge – knowledge that is unique to a given culture or society' (Warren 1991: 1). This knowledge is often passed down from generation to generation or learned experientially from living in an area and interacting with the environment over an extended period of time. Indigenous agroecological knowledge pertains specifically to knowledge of local ecosystems and the management of these systems for agricultural production. Indigenous knowledge is different than international knowledge which is produced by universities, research institutes and private firms. Unfortunately indigenous knowledge has historically been undervalued by outsiders (Slikkerveer 1989; Warren 1989), which has lead to its exclusion from a great many natural resource management decisions. A more balanced combination of insider and outsider perspectives and ecological understandings may be a critical factor in sustainable natural resource management.

In general, indigenous knowledge has historically been characterised as static. 'Village level institutions and processes...are relatively static, at least the general pace of change is below that which is considered desirable today' (Wharton quoted in Todaro 1985: 305). Many development practitioners feel that while local knowledge may have been suitable to past situations, it is less and less viable in a period of rapid environmental change.
This is in fact the raison d'etre for a great deal of 'expert assistance' in the Sahel. "There was general agreement in...discussions that existing production systems were not simply outdated, but that growing demographic pressure and environmental crisis have created the need for entirely new land management strategies" (Shaikh 1989: 12). In contrast, other scholars have asserted that indigenous knowledge systems are dynamic (Warren 1991; Richards 1985: 86). Some research has indicated that local knowledge systems may be particularly rich and refined in marginal environments (Chambers 1983; Altieri 1990: 553). Given that the Sahel has a relatively harsh environment, the aforementioned research suggests that indigenous knowledge may currently, and should continue to, play a key role in the local environmental change coping strategies of this region. An exploration of indigenous environmental change coping strategies in this area will also add to the debate on the character of local knowledge.

The Study Area: Djitoumou, Mali

The Republic of Mali is completely landlocked and lies in the centre of the West African landmass. This country of 1,240,000 sq. km has a long history of empires built upon the trans-Saharan trade. The country is composed of a vast desert region in the north and a savannah zone in the south, with a Sahelian band transecting the two from East to West. The country's 8.2 million people comprise ten ethnic groups of which the Bambara are most numerous (48%), followed by the Fulani (15%), Senofo (12%), Songhay (7%), Kel Tamashak (5%) and others (15%) (UNICEF 1989: 32). Islam is the most predominant religious practice (75%) which has been noticeably influenced by now waning animist traditions. The French ruled Mali from 1916 to 1960 as part of the French Sudan. 81% of Mali's people live in rural areas. The economy is largely natural resource based with 87.3% of the labour force involved in agriculture, accounting for 50.4% of GDP (World Bank 1991: 196-197).

Djitoumou (Figure 6.1) is actually the traditional name for a geographically defined grouping of villages found in the present day Ouelessebougou Arrondissement. This traditional name continued during the colonial period when the French divided the country up into cantons (a county-like unit), incorporating most of the study area into the Canton of Djitoumou. It was at Independence when the name was officially dropped and the region divided up into arrondissements (smaller administrative units). While the traditional Djitoumou area only includes three of the six villages that participated in the study (Figure 6.1), the name has been used as the Djitoumou label has come to be associated with a much larger geographic area and agroecological zone (Diallo 1991: 1). Djitoumou is known to outsiders as one of the last strongholds of traditional religion and is one of the country's most productive agricultural zones.

The study area falls within the upper Banifing watershed. Its geology is characterised by granite bedrock underneath a sedimentary rock layer with occasional outcropping of dolerite. The area is relatively flat with gradual slopes, small hillocks, plateaus and shallows. (Diallo 1991: 3). Most of the region consists of semi-forested grassland with more heavily forested stream corridors.
Figure 6.1 Location of Study Area, Dijitoumou, Mali
The climate of the area is typical of the Southern Sahel. The average low temperature is 25°C (in January) and the average high is 32°C (occurring in April and May). Rainfall occurs between May and October, with the heaviest rain in August, and has averaged 900 mm per year in recent times.

Most Bambara villages in the area range in size from 100 to 900 people. On the outskirts of many of these villages, or in small hamlets, one finds the increasingly sedenterised Fulani who are traditionally semi-nomadic herders and relative newcomers to the area. If the swidden agriculturist is defined as one who keeps his/her land in fallow longer than in production (Ellen 1982: 35), then the Djitoumou Bambara could probably just barely be described as such. Staple food crops in the area are millet and sorghum. Other food crops (in decreasing order of importance) include: peanuts, rice, maize, cowpeas, hungry rice (Digitaria exilis), cassava and sweet potato. Important tree crops are shea (Butyrospermum parkii) butter, néré (Parkia biglobosa) and mangoes. The major cash crop grown in the area is cotton. Cattle are also becoming an increasingly important source of income.

The increasing problem of land degradation is qualitatively apparent to anyone who has lived and/or worked in Mali over the last several decades. Quantitative measures of degradation include an average annual net deforestation rate of -.5% per year between 1980 and 1985 as compared to -.3% for other low income African countries during this same period (World Resources Institute 1992: 286). This rate of deforestation is greater than that for Mali in previous decades. Using 1987 as the base year of comparison (1987=100), per capita agriculture production has also declined slightly from an index of 112.1 at Independence in 1960 to 108.2 in 1989 (World Bank 1991: 390-391). It is interesting to note that while crop production per hectare increased between 1980 and 1987 by 20.5%, the ratio of crop production to fertiliser inputs (kgs of crops/kg of fertiliser inputs) actually declined by 43% (Moseley 1992: 13). Given that both 1980 and 1987 were normal rainfall years, such a decline suggests a deterioration in the productive capacity of the land. The estimated annual rate of soil loss in 1989 for the country as a whole was 6.5 tons/ha/year, while that for the Djitoumou area was 15 tons/ha/year (Bishop and Allen 1989: 14, 38).

Research Methods

This chapter is largely based on a partial analysis of data that was collected in Mali during the fall of 1992 (Earl and Moseley 1992). The research methodology used in this study was largely qualitative and best characterised as a modified form of participatory action research (PAR). The basic principles of PAR found in this study are that: 1) the researchers and study participants are equal partners; 2) all information that is generated is shared with those who participate in the study (i.e. a non-extractive orientation); and 3) the study may be empowering for participants as they recognise the magnitude of their own knowledge (Patton 1990: 125, 129, 157). The format used for gathering data was semi-structured interviews using open and focused questions with individuals and groups. The majority of interviews were tape recorded with the permission of the participants.
Both members of the male/female research team were present at all interviews. Rural interviews were conducted in six villages located in the Ouellessebougou and Sanankoroba Arrondissements.

Villages were selected so as to represent a variety of the following criteria: population size, degree of remoteness (as measured by kilometers from a road), degree of development agency activity (as measured by the past or present intensity of non-governmental organisation (NGO) or government agency activity in the village), and the extent to which one of the team members had formerly worked in the village as a U.S. Peace Corps Volunteer. At least eight individuals were interviewed in each village. These included: two old women, two old men, two young women and two young men. These individuals were chosen by the villages themselves based on the gender and age criteria given to them by the researchers. Group interviews were also conducted in each village with the participants grouped by gender and by age as well when possible. In addition to the standard questions, the large group format was often used to further explore ideas that had been rarely mentioned or raised by happenstance in individual interviews. Walking tours were also conducted to identify landscape features and flora that had been described in stationary interviews. In all, 54 individual, six walking and 13 large group interviews were conducted with villagers.

Agency interviews were conducted in Ouellessebougou, Sanankoroba and Bamako with representatives of NGOs, government agencies and donors. Staff within these organisations were interviewed at the field, mid-management and top administrative levels. In total, 12 field, 12 mid-management and seven higher administrative interviews were conducted with organisation staff. Rural interviews were conducted in Bamanan. Agency interviews were conducted in French or English depending on the interviewee's preference. The villager and development community data was triangulated to compare and contrast responses among participants (Strauss and Corbin 1990: 57-176). Villager data on environmental change was compared with historical rainfall data and will eventually be juxtaposed with a time series of aerial photography and Landsat satellite imagery. Soil samples were also collected and analysed in order to reference villager soil taxonomies to an international system of classification.

**Importance of Villager Awareness of Their Own Knowledge**

Much of the literature on indigenous knowledge has emphasised that by working with local knowledge, decision-making systems and organisations, one can enhance participation, capacity-building and sustainability (Warren 1991). An often neglected point in existing development literature is that villagers are generally unaware of the positive value of their own knowledge. By helping villagers become cognisant of the character, origin and importance of their own local knowledge, cultural self-confidence can be enhanced, leading to an empowered and pro-active people. Paulo Friere (1982: 150) noted that those unsure of the value of their own culture often 'become convinced of their intrinsic inferiority'. Friere also felt that in order for development to occur a society must not be alienated from its own culture (1982: 160).

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Prayag Mehta (1988: 176) made very similar observations: 'The poor themselves have learnt over the years to doubt their own capabilities. They have internalised a negative self-image of themselves'.

Villagers have rarely been told that their input is valid and even more rarely come to the realisation that their knowledge is actually very sophisticated and complex. This is especially true in the francophone Sahelian countries. Through an educational system and bureaucratic structures, the French propagated the notion that Europeans were superior. The French attempted to replace everything native with things French and gained for the French the title of 'cultural imperialists,' for the wholesale attempt to impose an outside culture upon another people' (Buell quoted in Bodley 1990: 97). They instilled the notion that urban is better than rural and that worthwhile knowledge is found in books (Bodley 1990: 103). Unfortunately many of these attitudes were successfully inculcated among Africans and continue to survive within the educa-tional systems and government structures of post-Independence governments (Jiggins 1989: 76).

If development assistance is about helping people help themselves, then the sense of cultural pride and self-assuredness that could evolve from action-research on indigenous knowledge is not a trivial matter, but an essential component of the development process.

Villagers Perceptions of Environmental Change

As briefly touched on earlier, official statistics suggest that Mali has undergone a considerable degree of environmental degradation. Before one can assess villagers’ response to this degradation however, it is necessary to understand how villagers perceive the environmental change occurring around them. All villagers interviewed believed that the local environment has changed dramatically over the past 30 years. Among the changes they noted were those in: humidity, forest resources, agricultural lands and numbers of domesticated animals. The research team also questioned villagers on what they thought the causes of these changes were.

Nearly all of the participants indicated that humidity (sumaya), water and in some instances rainfall had decreased over the past 30 years. In analysing interview results the author initially interpreted all of these responses to mean a decrease in annual precipitation. While the historical rainfall record for Bamako (approximately 80 km north of the study area) corroborates the notion that annual rainfall generally declined between 1963 and 1985 (cf. Figure 6.2), it does not truly reflect the type of dramatic change that the villagers were describing.

Further examination of the data revealed that 15 of the 20 respondents who addressed this issue specifically said that there was more water and humidity during their grandparents’ time than today. The remaining five said that there was more rain in the past than now. No participants indicated that there was less water (in any form) in the past than today. While precipitation is in deed declining over time, villager responses indicate that changes on the ground have been more dramatic. When an older male participant was asked what it was like when he was young, he responded 'There used to be dense woods. There was lots of water.'
Figure 6.2  Rainfall at Bamako, Mali
There was water all of the time, the streams never dried up.' If ground cover and soil organic matter have decreased (as reported later in this chapter) then the vegetative and soil water storage capacity of the area has been inhibited. A degraded landscape will also lead to lower soil infiltration rates and greater runoff, leading to uneven stream flow throughout the course of the year (Brooks et al. 1991: 37-86). Both of these phenomena match villager observations.

When asked about climatic change over the past ten years, the majority of villagers responded that there was more water, humidity or precipitation now than at this time. This fits well with official reports indicating that rainfall levels have returned to relatively normal levels since the last drought in 1985 (Republique du Mali 1992: 3). The fact that 1991 was an extremely good year for rain may have affected informant responses.

In terms of forest resources many villagers noted that there were fewer trees than in the past. In some instances villagers made the point that the numbers of trees may not actually have decreased but that the composition of trees had changed dramatically. Villagers noted that the diversity of species had decreased. In many instances, participants were able to name tree species that were increasingly difficult to find and those species which were exceedingly rare or non-existent. Examples of species that were named as rare were Hyphaene thebaica, Entada africana, Combretum glutinosum and Carapa procera. Many villagers also noted that the amount of old growth trees had decreased significantly from in the past. Female participants often noted that they walked further distances to gather wood for cooking than in the past. This said, many also mentioned that the quantity of dead and dry wood available in the countryside was generally greater than in the past due to the drought and the fodder collection practice of coppicing branches from trees.

The perceived causes of change in the composition and extent of the forest were less rainfall and humidity, expanding agriculture and greater numbers of cattle and people. A few villagers specifically noted that decreased rainfall and humidity led to more destructive forest fires, the actual mechanism by which trees were destroyed. The ever increasing surface area used for agriculture was also cited as a major factor leading to deforestation. Villagers often attributed higher numbers of cattle to increasing presence of Fulani herders in the area. Villagers also mentioned that outsiders had historically come into the area to harvest particularly valuable species (e.g. Khaya senegalensis and Isoberlinia doka). While the villagers disapproved of this they felt disempowered to do anything about it. The author notes that wood cutting permits are issued by the national forest service and do not require the consent of the local community where the wood is being cut (Lai and Khan 1986: 8).

When commenting on changes related to agriculture, nearly all participants indicated that the area under cultivation has increased dramatically in the past 20-30 years. Villagers most commonly indicated that the cause of these changes was the introduction of plough, lower crop yields and increased numbers of people living in the area. Older participants noted that before 1960, all cultivation was done in the area with hand held hoes (daba). When the cultivation of cotton was introduced into the region it was accompanied by the oxen drawn plough. Villagers indicated that the number of ploughs grew steadily in the area to the point where nearly all
households own such an implement today. This same pattern seems to have been mirrored in the southern part of Mali as well (Serafini and Sy: 1992). Villagers stated that the plough allowed them to dramatically increase the number of hectares under cultivation.

When remarking on decreased crop yields, one middle-aged man specifically noted that it took four hectares today to produce what three hectares yielded ten years ago. Some older women and men specifically said that they felt the way the land was cultivated today (i.e. with ploughs) had led to a decline in yields. These participants indicated that most fields had traditionally cultivated with a short handled, shovel sized hoe (ntugu daba). A man/woman working with this hoe would overturn the earth in a circular fashion to create a mound. He/she would then continue until he/she had created a non-linear, but evenly spaced dispersion of such mounds throughout a field. Villagers mentioned a number of important effects that resulted from this strategy. The first was that it did not create the same opportunities for erosion that the long furrows of an oxen drawn plough does. Secondly, the plough tends to drag up subsoil (while the hoe method does not) which the villagers saw as detrimental to soil productivity. Thirdly, the hoeing technique effectively buried weeds and grasses upside down and under the soil, minimising their regeneration and detrimental effects on crops.

It is interesting to point out that this traditional practice is not significantly different from double-digging, a common soil enhancement technique used by bio-intensive gardeners. In spite of the benefits of the traditional technique, participants indicated that they preferred the plough as it so dramatically increased the number of hectares they could till. Older participants often joked that youth of their society no longer had the strength to farm as they once did. Farmers also consistently reported that they believed cotton and maize were very demanding on the soil. Their increased cultivation was often felt to have some linkage with higher rates of erosion.

Participants generally noted that the time frame in which a parcel of land was continuously cultivated had increased while the time it was let fallow had decreased. One young male villager explained that they were now pushing soils beyond the limits, as indicated by certain types of flora, they had followed in the past. 'We used to stop (farming a particular area of land) when we saw bad weeds. Now we stop after the weeds have come and only when the crops start go bad.' The most frequently mentioned weed was a Striga spp. The cause of shorter fallows was said to be increasing numbers of people and decreasing yields in conjunction with a finite quantity of arable land. Villagers saw this as an undesirable trend, realising that shorter fallows meant lower yields in the absence of fertiliser inputs.

The final environmental change theme mentioned by villagers was increasing numbers of cattle. Several older villagers mentioned that 30 years ago a typical village in the area owned ten head of cattle on average. Today most of the villages generally had 200-300 head of cattle and in one village a single family had this many head. When discussing the causes of this dramatic change most participants explained that cotton cultivation had led to higher levels of disposable income that were frequently invested in cattle. Villagers explained that cattle investments were now also more secure given that: natural predators of cattle in the area (lions and hyenas) were now virtually extinct, the current climate was less favourable to cattle diseases and veterinarians
were now more widespread and able to vaccinate their animals against most of the remaining, common diseases. Many participants also said that through increased contact with Fulani herders they had learned the value of keeping cattle. In contrast to the benefits mentioned in connection with cattle, many villagers also pointed out less desirable side effects. Many indicated that cattle slow down the recovery of fallows and that soil was degraded when trampled by these animals.

**Knowledge of Microenvironments and Associated Management Strategies**

A survey of villager knowledge of microenvironments and associated management strategies allows one to understand what types of information and technologies farmers have at their disposal to address environmental change. When questioned on their knowledge of soils, villagers consistently identified ten distinct agricultural soils. Consistency was established by the author through intra and inter-village comparison of participant responses. Some examples of these soils may be found in Figure 6.3. The villagers explained that these soil types were generally associated with different positions in the landscape. 'Bele dugukolo', for example, was found on hillocks and hillides while 'fugagwili' was located on plateaus. All soil types were not reported to be found in each of the six villages. 'Bogo dugukolo', for example was only found in villages where there were doleritic rock outcroppings. Another type of soil not included in Figure 6.3, 'balé' (a silty clay), was only found along the banks of the Banifing River, located in the Northwest corner of the study area. For each soil type, villagers described associated vegetative cover (both trees and grasses), as well as the types of crops cultivated in these areas.

Participants also described relatively distinct agricultural management strategies for each of the soil types including: average lengths of continuous cultivation, average fallowing times and tilling practices. As one might expect, villagers often stated that the length of continuous cultivation that a piece of land could sustain was dependent on the quantity of fertiliser used. Similarly, fallowing times were generally noted to be highly dependent on the amount of land available to a farmer. Farmers with less land were often unable to fallow land for as long as they felt was necessary for best results. Farmers also reported that varying soil types were cultivated in distinct fashions. In general, participants reported that coarser soils ('belé' and 'cencen dugukolo') tended to be cultivated by hand while finer soils were tilled with an oxen drawn plough. Villagers explained that the plough is particularly harmful to coarser soils as it tends to dredge up subsoil and rock in these shallower soils. The exception to this is fara dugukolo which is tilled by women in relatively small plot configurations. The small plot size in particular makes plough tilling difficult.

Farmers were also asked about how they knew when to bring a parcel of land out of fallow and about their knowledge of erosion on the different soil types. When determining if land was ready to bring out of fallow, farmers generally indicated that they waited for certain grass species to appear as well as a sufficient quantity of trees and shrubs. On finer soils, participants stated that the reappearance of *Andropogon gayanus* ('musowaga') indicated that the soil was once again ready to be cultivated. Likewise, villagers noted that the reappearance of a similar yet less substantial grass species, *Andropogon spp.* ('ci'), on coarser soils served the same role. Villagers
most commonly reported that erosion tended to be greatest on cencen dugukolo, a loamy sand. Others simply reported that it was greatest on slopes without indicating any particular soil type.

Villagers mentioned that historically there had been a number of traditional methods to combat soil erosion. These methods included rock lines and grass strips of *Andropogon gayanus*. Young and old participants explained that one could walk in the countryside over areas that had been farmed in the past and see the old rock lines. An older male villager stated that 'even today while cultivating we find old rock lines underneath the soil.' For reasons that villagers could not explain, this practice had been dropped until a German NGO reintroduced an improved, contoured version of the technique into the area. The author theorises that the practice may have met its demise as plough tillage became increasingly widespread, a practice which is somewhat encumbered by obstacles in the field. If such a scenario is true, it means that a traditional soil conservation strategy was dropped just as more erosion-prone tillage was adopted. Participants explained that grass lines became less viable with increasing numbers of cattle that roamed village fields during the dry season, eating everything in sight.

If one is to summarise the significance of the information presented in this section it is that Bambara farmers in Djitoumou have a very detailed understanding of a variety micro-environments within their area and that these environments are managed in different ways. The fact that villagers identified at least ten distinct microenvironments as well as associated management strategies stands in stark contrast to the national resource inventory (République du Mali 1990) that has mapped most of the villages in this study under one agroecological zone and the entire area under a maximum of four such zones. If sensitive agroecological management demands a thorough understanding of the environment (Pretty et al. 1992: 99; Altieri 1987: 93), then the Bambara farmers of Djitoumou have an important contribution to make to the process of ecologically sustainable development.

**Coping with Environmental Change**

Given that villagers perceive, and statistics confirm, that the natural environment of the Djitoumou area has changed greatly in the past 30 years, and that villagers possess a sophisticated understanding of their natural surroundings, the question arises as to if and how they might be using this knowledge to cope with the environmental change with which they are confronted? The research revealed that villagers have in fact changed their management practices a great deal and that in particular, they have used their knowledge of microenvironments and soil characteristics to adapt to microclimatic changes.

During questioning on soils and associated management strategies the majority of participants mentioned that they had historically cultivated on different types of soils than those they farm today. More specifically, villagers indicated that 30 years ago they cultivated a great deal on the coarser soils, 'bele dugukolo' and 'cencen dugukolo', while today they did so to a much lesser degree. Villagers indicated that these soils were ideal in the past as they did not retain too much moisture and weed growth was manageable.
<table>
<thead>
<tr>
<th>Ground cover</th>
<th>Soil</th>
<th>Indigenous soil name</th>
</tr>
</thead>
<tbody>
<tr>
<td>seasonal stream</td>
<td>silty clay clay loam</td>
<td>Fara dugukolo</td>
</tr>
<tr>
<td>Rice</td>
<td>sandy clay clay loam</td>
<td>Farada dugukolo</td>
</tr>
<tr>
<td>Cotton</td>
<td>loamy sand clay loam</td>
<td>Daba dugukolo</td>
</tr>
<tr>
<td>Sorghum</td>
<td>lateritic hardpan</td>
<td>Cencen dugukolo</td>
</tr>
<tr>
<td>Peanuts</td>
<td>loamy sand clay loam</td>
<td>Bele dugukolo</td>
</tr>
<tr>
<td>Fallow</td>
<td>shallow clay loam</td>
<td>Fugagwii</td>
</tr>
<tr>
<td>Rice</td>
<td>clay loam</td>
<td>Bogo dugukolo</td>
</tr>
<tr>
<td>Maize</td>
<td></td>
<td></td>
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<tr>
<td>Dolerite rock</td>
<td>clay loam</td>
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</tr>
</tbody>
</table>

Figure 6.3 Agroecological Micro-environments, Dijitoumou, Mali
Participants pointed out that today these soils simply did not have enough moisture retentive capacity to be viable in an era of decreased rainfall. In contrast to the coarser soils, villagers reported that they had greatly expanded cultivation on many of the finer soils (especially 'dabadugu' and 'fugagwili') due to their moisture retentive capacity. Figure 6.3 schematically depicts the geographic location of these soils within agroecological microenvironments. Villagers reported that while daba dugukolo, a sandy clay loam, was cultivated 30 years ago, it was less desirable to do so as weeding and tilling were much more difficult to perform when average annual rainfall was higher.

Participants also explained that they had begun to cultivate 'fugagwili', a clay loam, much more intensively than in the past. Villagers mentioned that they had historically grown cassava in these areas during severe drought times but that within the past five to ten years they had begun to cultivate a shorter season variety of rainfed rice. 'Fugagwili' is found on plateaus and is a relatively fine soil of limited depth laid upon a lateritic hardpan. Due to the fact that it is difficult for water to penetrate this hardpan, the area quickly becomes inundated during the rainy season and is ideal for rice cultivation. While villagers did not know who had originally introduced the aforementioned rice variety into the region, participants in all of the villages indicated that they had first seen this variety grown by farmers in one of the study villages. People in this village indicated that the practice was started by two of the more successful farmers in their community. One of these two farmers (who were cousins) indicated that he had seen the rice grown on 'fugagwili' when he went visiting a friend in another village about 60 km away. He subsequently bought some of the seed at a market in this other area and began experimenting with it back home (along with his cousin) during the following growing season.

What is remarkable is that during an eight year time period this form of rice cultivation went from being practised by two farmers to nearly every farmer in the area who had access to fugagwili. Participants explained that the practice spread exponentially as farmers observed the success of their neighbours and took up the practice themselves. The high degree of observability and trialability may account for the rapid rate of diffusion-adoption (Muth and Hendee 1980: 141).

Observability refers to the high visibility of this new practice as it spread among farmers and trialability to the ease and relative low cost of testing this rice variety in a new area. Rice is now only second to cotton as a source of revenue in the area and is the top cash crop in the first of the six villages where the practice was initiated. Given that a farmer's portfolio of agricultural soils is very different today than it was 30 years ago, it was asked how lands were redistributed when villagers transitioned from farming chiefly on coarser soils to farming primarily on finer soils. This question was based on the author's assumption that individual farmers or clans owned land in a permanent way and that a decrease in rainfall might benefit some villagers (those with a large quantity of 'daba dugukolo' for example) and be problematic for others (those with lands composed of coarser soils). What the author learned from the participants is that each village in
As a member of a particular village, a farmer obtains the usufruct rights (the rights to the products of the land) to any parcel of land that he/she clears for some productive purpose (assuming that it is not being exploited by another villager). If the farmer abandons this land and does not return to it within three to four years, then it is generally acknowledged to be available to any other interested party from that village. What this means is that when farming soil requirements changed, the land tenure system was flexible enough to accommodate a lot of movement.

When asked if the change in soil requirements was a problem one farmer responded 'There was no problem because those who possessed a lot of daba dugukolo could not exploit all of it,...they gave to the other farmers because they could not farm it all.' Interestingly enough, this flexibility does not extend beyond the village level. One village in the study group was particularly land rich in the coarser soils and deficient in areas with fine soils. While the village's traditionally established territory was quite large, it was actually experiencing a good deal of land pressure as productive farming was only possible in a few areas. This said, inter-village tenure flexibility is not completely rigid as some individual farmers did mention borrowing productive land from farmers in fine-soil-rich villages in order to meet their food production requirements.

It should be mentioned that the current system of land tenure in the Djitoumou area is probably in a period of transition. As described above, a parcel of land traditionally became open to exploitation by another member of the community three or four years after it was abandoned. As also detailed earlier in this chapter, villagers explained that periods of continuous cultivation were lengthening and fallow times were shortening. If it is increasingly the case that land is in fallow for less than four years, then it is unlikely to change hands (and consequently come under the continuous ownership of one farmer). While participants confirmed that this phenomenon is currently occurring on the best agricultural lands, they emphasised that individuals do not own land (i.e., have the right to sell it) as people do in Mali's larger urban areas. It will be interesting to see if Djitoumou follows land tenure trends in other parts of Africa and develops a more permanent, and unfortunately less flexible tenure system (Cohen 1980).

While the Djitoumou Bambara have been quite sophisticated in their response to environmental change, there are instances where cultural practices have not fully adapted to the changing environmental condition. One example of this may be bush fires. Fires have traditionally been used to clear fields for cultivation. The use of the resulting ash in agricultural production strategies has been well documented as a sound practice (Rice and Vandermeer 1990: 44-45; Altieri 1987: 78-80).

However, in addition to the burning of fields, villagers have historically burned portions of the forest (both intentionally or unintentionally through uncontrolled field burnings). Participants gave a variety of rationale for this practice. Women frequently mentioned that it made the collection of wood easier and removed the danger of snakes. Hunters mentioned that it cleared out the underbrush allowing them to better see game. Participants also mentioned that herders frequently burn in the early period of the dry season so that they can get a second growth of young grass for their cattle. Many villagers did mention that burning in the early part of the dry season was better than the latter half as fires would be less destructive at this time.
Women noted that a hot fire in the late dry season can destroy their shea nut (*Butyrospermum parkii*) crop. Such annual forest burnings, although less disruptive in the early part of the dry season, are unfortunately much more destructive today as scrub forests are often highly degraded and microclimatic humidity substantially less than in the past (Carroll 1990: 374, 376; Goodland *et al.* 1984: 195). The Malian conservation agency has historically taken a punitive approach to this problem as opposed to an educational one (Lai and Khan 1986: 5-6). As a consequence, a great deal of resentment has been engendered among villagers toward this agency resulting in predictably poor results.

This section described some examples of villager responses to changing environmental conditions. Chief among these was a switch from well-drained soils to water-retentive soils in response to decreased rainfall. Villagers also began farming rice in an area where it had previously never been cultivated before. Such responses were only possible because of participants detailed knowledge of soil types and their attributes. Furthermore, the traditional land tenure system was flexible enough to accommodate dramatic shifts in land preferences. Finally, while the Djitoumou Bambara have been quite perceptive in adapting their agricultural production strategies to environmental change, one should not assume that they have been perfectly adaptive in all instances. Seasonal bush fires are one example of this.

**Discussions with Professional Development Practitioners**

In this section, the author discusses development practitioners' views of indigenous knowledge as well as their thoughts on appropriate development strategies for the Djitoumou area. Of the development practitioners interviewed in this study most were surprisingly receptive to the notion of participatory development as well as the inclusion of indigenous knowledge in natural resource management decisions. Many field agents were familiar with traditional soil conservation techniques and had actively sought to build on these ideas in their field work. In spite of this receptivity to indigenous knowledge, a number of field agents felt differently about local knowledge when it came to the subject of the environment and environmental protection. For these individuals it was the outside development practitioner (who had the know how and technical expertise) who was in the best position to instruct villagers on how to manage the environment in a sustainable manner. One agricultural agent commented that 'It is the agents that give environmental knowledge that the farmers wouldn't otherwise know. We teach soil and forest protection.

These are themes that the farmers don't know.' A villager had an interesting comment related to this attitude. When this villager was asked what he thought the difference between an educated person's and a farmer's understanding of the environment, he replied 'There is a difference in knowledge. The educated talk about soil management but they don't practice it. They talk but they don't know anything about the bush.' Field agents working for NGOs generally appeared to be more sensitive to the value of indigenous knowledge and local participation than their counterparts employed by the state.
Upper administrative staff in the NGOs often indicated that they explicitly looked for field staff that embraced participation when hiring. While scholars have previously described a phenomenon known as brain drain wherein the best and the brightest are lured away from the developing world to jobs in the industrialised countries, this situation could be characterised as an 'attitude drain.' This is to say that trained development practitioners with more participatory orientations are being hired out of the Malian civil service to work for NGOs.

Upper administrative staff were very aware of the dialogue on the increased need for participation in natural resource management. Many non-Malian administrators admitted that they were not explicitly familiar with indigenous knowledge and natural resource management techniques but that they were generally inclined to believe such understanding was valuable. This said, both expatriate and national administrators often expressed the view that the rate of environmental degradation in the Sahel had been so tremendous in recent times that villagers' natural resource knowledge and approaches were quickly becoming out-moded. 'There is 20% less rain than in the 1960s but the villagers haven't adopted new agricultural practices.' For these individuals, participation was most often perceived as important for the long term continuation of a project, but not sound ecological management.

The government agricultural agency working in the Djitoumou agroecological zone states that its goals are to increase rural incomes and enhance food self sufficiency. The bulk of this agency's time and resources have been spent on the promotion of cotton production. Most employees of this organisation felt that the region's development was best promoted through the increased production of cotton. In contrast, a donor representative and key financial supporter of the agency stated that cotton production was becoming less and less viable.

In the fall of 1992, The Government of Mali was purchasing cotton from farmers at 400,000 francs CFA per ton and reselling it to France for 290,000 francs CFA per ton (Biladeau 1992). Given the financially strapped state of the Malian government, it is highly unlikely that such actions can be sustained.

One will recall that villagers remarked on a number of ecological consequences associated with the cultivation of cotton and the introduction of the plough. When extension agents were asked about the potential ecological repercussions of cotton cultivation in the area, none felt that this cultivar was responsible for any of the degradation they had witnessed. Some agents unfortunately had a very poor understanding of the ecology of the plant. One agent stated that cotton 'is like a tree that fertilises the ground. It fights erosion in the same way that trees do.' The truth of the matter is that cotton is known to be very hard on the soil and it is not a good cover crop for preventing erosion (Prentice 1972: 266). Given that villagers perceived such problems, extension agents and villagers are either not communicating or the latter not believing the assertions of the former. Unfortunately, cotton cultivation continues to be attractive to farmers as it is the only way that they can obtain credit to purchase inputs. This said, a number of farmers interviewed had either stopped cultivating cotton or were beginning to have second thoughts about it.
Policy Recommendations and Conclusion

The fact that villagers were often more in tune with environmental change and the ecological side effects of agricultural practices re-emphasises the notion that natural resource management needs to be a decentralised and collaborative process. It is unlikely that the sophisticated strategy of switching soil types in order to cope with decreased precipitation could have been prescribed by an outsider. Government agency and NGO staff need to get in the habit of openly discussing natural resource management strategies with villagers. Extension agents have traditionally sought to disseminate 'technical packages.' Agents are encouraged to be interactive but with the goal in mind of getting villagers to adopt an outside solution to a local problem. Extension agents are not typically interested in really learning and gathering information from villagers. A Malian research scientist probably summed it up best when he said 'What we need is an integrated research-development agent.' The historical separation of these two functions has impeded two-way communication. A state agricultural agency has the potential to be a depository of indigenous agroecological knowledge. This information could then be shared with other farmers as well as researchers. Such a truly interactive process would enhance the society's and villagers' appreciation of indigenous knowledge.

While donors, NGOs and government agencies now speak openly and with ease about the greater need for local participation in natural resource management decisions, fields agents continue to be trained at the secondary school and college level in traditional extension methods. It is not enough for agents to receive in-service training on participatory approaches. How can one expect a few days or weeks of training to change attitudes that were developed through years of education. Furthermore, many agricultural extension agents are typically trained in the technical aspects of crop production with little attention to the ecology of agriculture. Of the donors that the research team spoke with, none had plans to fund a study of the curriculum in Mali's natural resource and agricultural schools.

The results described in this chapter demonstrate that Bambara farmers in the DJitoumou agroecological zone of Mali were in fact very aware of the environmental change that was occurring around them. These farmers possessed a detailed understanding of their local environment and they used this knowledge to cope with changes in environmental conditions. More specifically, they began farming various soils at different intensities than they had in the past. They experimented with new crops in areas where they had never cultivated them before. The land tenure system was also flexible enough to deal with the changes in farming strategy. While outside development practitioners were aware off and had some appreciation for indigenous agroecological knowledge, they often questioned its applicability to environmental problems.

The author is not advocating a whole sale reliance on indigenous knowledge to solve Mali's agroecological problems, but rather a more balanced alliance between local and international science.
<table>
<thead>
<tr>
<th>Soil Name</th>
<th>Bele dugukolo</th>
<th>Cencen dugukolo</th>
<th>Daba/Bira dugukolo</th>
<th>Fugagwill</th>
<th>Farada/Tafa dugukolo</th>
<th>Bogo dugukolo</th>
<th>Fara/Fala dugukolo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse</td>
<td>⇒</td>
<td>⇒</td>
<td>Moderate</td>
<td>⇒</td>
<td>⇒</td>
<td></td>
<td>Fine</td>
</tr>
<tr>
<td>3Texture based on mechanical analysis</td>
<td>Loamy sand (with ferruginous gravel)</td>
<td>Loamy sand</td>
<td>Sandy clay loam</td>
<td>Clay loam (of limited depth)</td>
<td>Clay loam</td>
<td>Clay loam (of doleritic parent material)</td>
<td>Silty clay</td>
</tr>
<tr>
<td>Geographic Location</td>
<td>Hilllocks and slopes</td>
<td>Gentle slopes and flats</td>
<td>Relatively flat areas</td>
<td>Plateaus</td>
<td>Just beyond seasonal stream zone of inundation</td>
<td>Down slope of doleritic outcropping</td>
<td>Seasonal stream banks</td>
</tr>
<tr>
<td>4Common Tree Species</td>
<td>Detarium spp, Burkea africana, Pericopsis laxiflora</td>
<td>Detarium spp, Dichrostachys cinerea, Terminalia avicennioides</td>
<td>Butyro sperma parkii, Parkia biglobosa, Dichrostachys cinerea</td>
<td>Bombax costatum, Combretum micranthum</td>
<td>Mitragyna inermis</td>
<td>Butyro sperma parkii, Piliostigma reticulatum</td>
<td>Mitragyna inermis, Khaya senegalensis</td>
</tr>
<tr>
<td>Tropical crops</td>
<td>Peanuts, millet, sorghum hungry rice</td>
<td>Peanuts, sorghum, cotton, corn</td>
<td>Millet, squash (cassava historically)</td>
<td>Rice, sorghum, sweet potato</td>
<td>Sorghum, cotton, corn</td>
<td>Sorghum, cotton, corn</td>
<td>Rice</td>
</tr>
<tr>
<td>5Average Length of Cultivation</td>
<td>3-5 years</td>
<td>3-5 years</td>
<td>5-15 years</td>
<td>3 years</td>
<td>4-8 years</td>
<td>8-10 years</td>
<td>10-20 years</td>
</tr>
<tr>
<td>6Average Fallow Length</td>
<td>10-15 years</td>
<td>10-15 years</td>
<td>5-10 years</td>
<td>4-6 years</td>
<td>3-8 years</td>
<td>6-10 years</td>
<td>3-7 years</td>
</tr>
</tbody>
</table>
Notes

1 This research was conducted in collaboration with the Government of Mali's Institut des Sciences Humaines. Major funding was provided by the Population-Environment Dynamics Project, University of Michigan.

2 With the exception of the soil texture descriptions, all information presented in this table is based on villager responses. N = 50.

3 U.S. Department of Agriculture Classification System. For discussion see: Brady 1974.

4 Tree names were originally cited by villagers in Bamanan. The scientific nomenclature is from Maydell (1986), and Bailleul (1981).

5 Length of cultivation period varies with fertiliser (organic and inorganic) use.

6 Length depends on degree of land scarcity.