# Ethnopedology in Central Mali[1]

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## ABSTRACT

Research was done on local classifications of soils and conceptions of soil fertility management in Madiama, the SANREM-Mali site. While the local typology reveals a continuum between sandy, clayey and rocky soils, a typology of soils alone is insufficient in understanding the local classification system. Landscape and hydrological features, such as subtle elevation changes and type of water present (rain vs. river), affect understanding of fields and subsequent management strategies. Conceptualizations of soil fertility are based primarily on the application of animal manure, the quality of which varies with animals' diets and physiology. This in turn gives rise to a model of ecological process that considers interactions between humans, cattle, crops, trees, and abiotic elements within the landscape.

## INTRODUCTION

Demographic and environmental factors are changing the face of agriculture throughout Sahelian West Africa. Rapid population growth has promoted both the extensification and intensification of land use for agricultural purposes, often leading to decreased fallow periods and increased utilization of marginal and fragile ecological niches. Environmental change in the forms of decreased annual rainfall and desertification have compounded the acuteness of land shortages. One of the major symptoms of these changes is nutrient depletion in agricultural soils.

In response to widespread soil degradation, there is much research being done at the national and international levels on soil fertility management strategies. Most of this research, of course, is being conducted from the perspective of the biological and physical sciences. Science is an extremely powerful tool for understanding soil nutrient cycles and developing technologies to favorably influence these cycles. However, scientific measurements of soil fertility do not necessarily translate well into indicators of soil fertility that are useful for farmers. The identification of locally relevant indicators of environmental quality is essential for the development of sustainable and culturally-appropriate production systems. In order to make scientific research more accessible to farmers and to make farmers' practices comprehensible to scientists, it is important to develop means of articulating scientific and folk indicators of soil fertility.

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The purpose of this research is to articulate farmers' knowledge of soils in the Commune of Madiama, Mali. This can be subdivided into four interrelated categories: soil typology, soil fertility management practices, knowledge and beliefs about soil amendments, and explanatory models of soil fertility processes. Ethnopedology, like most ethnosciences, has traditionally focused on classification systems. Soil, however, often confounds clear classification because it is a non-discreet, continuous entity, without the clear organismal and special distinctions found in animal and plant kingdoms. This research starts with the premise that while classification is an important beginning, conceptualization of dynamic soil fertility processes of enrichment and degradation are of greater utility to applied agricultural research. Findings will expand the field of enthopedology toward greater consideration of local knowledge of processes rather than categories.

This research is relevant to social scientists interested in local environmental knowledge. Soil is the primary means of production in agrarian systems, both economically and ecologically speaking. Consequently, farmers' can be expected to have extensive and nuanced knowledge of soils, which, as previously mentioned, is fundamental in the rest of their environmental management practices. As will be discusses below, knowledge of soils cannot be entirely separated from knowledge of plants, animals or hydrology, as soil is ultimately a medium that integrates all of them all.

This research should also be of interest to agronomists and soil scientists researching soil fertility maintenance in the Sahel. I do not presume to quantify nutrient cycling in the Sahelian agropastoral ecological system, this research suggests that farmers' concepts of fertility maintenance extend beyond the boundaries of fields themselves and are inclusive of farmers' economic capacities and the inherent qualities of the "wild" ecological system. Understanding farmers' knowledge of ecological processes can inform agronomic research and help make its findings more comprehensible to farmers.

## METHODOLOGIES AND RESULTS

The findings presented here are the results of 23 semistructured interviews with 28 people (there were three group interviews), augmented by informal interviews with at least a dozen other people. No systematic sample frame was able to be used. At times I would only be allowed to interview the CCGRN representative. Othertimes, CCGRN representatives decided who it would be best for me to interview. Still other times I would interview whichever individuals invited me to come and view their fields with them. One of my best interviews began with a complete stranger approaching me at my house asking for aspirin. Due to the limited nature of study period it was not possible to determine the most highly revered farmers, thus this group of 'expert knowers' was not specifically targeted for formal interviews, though I referred to a few clearly innovative and communicative farmers as key informants in order to clarify observations made in formal interviews and to bounce ideas of off them. It seems probable that the sample of my formal interviews overrepresents more highly educated and socially central individuals and underrepresents the socioeconomically marginal people in the commune. I cannot speculate how this might affect the results, if at all.

As can be seen below, the sample is heavy on residents from the village of Madiama, primarily due to geographic convenience. Because agriculture is an overwhelmingly male domain, all but one of the interviewees were male. The exception comes with the inclusion of a woman in a group interview along with her husband and their son. The ages of interviewees ranges from 23 to 70 years, with an average age of 43. An effort was made to conduct interviews with people in all the villages of the Commune of Madiama. In the end interviews were conducted with people from the villages of Madiama (7), Toumadiama (5), Tougenie (3), Nerekoro (2), Siragourou (1), Tombonkon (3), Promanii (3), Torokoro (2) and Bangassi (2), leaving out Tatia, Nouna and Douceranie.

The basic methodology was semistructured interviews oriented toward knowledge of soils and soil fertility processes. In an effort to maximize the clarity of the questions, the bulk of the interview schedule was developed with the assistance of a trilingual (Bambara-French-English) language teacher in Bamako prior to my departure for Madiama. All interviews were conducted primarily in Bambara, though they slipped in and out of French intermittently depending on the preference of the interviewee. The interview questions were occasionally adjusted through the course of the research in order to accommodate the regional dialect, drop questions that were not working, and broaden the range of questions. A moderately confounding element to this linguistically-oriented research is that Bambara is a highly unstandardized language, which led to many different ways of referring to the same things. The words *bógóblen* and *bógówuliman* are ways of saying red clay, *blen* being Bambara in origin, *wuliman* being Mandé in origin.

The interview schedule centered around four topics: soil typology, soil management strategies, and knowledge of soil amendments and, later in the research, explanatory models of soil fertility. It should be noted that although the core interview schedule remained consistent, parts of it did change progressively through the course of the research, meaning that the number of respondents is not always the same for all questions.

**Soil Typology**

The interviews indicate that there is a large degree of shared knowledge regarding soils (*dugukóló*) among the interviewees. In an effort to localize findings, the question was phrased to elicit the types of soils found within the Commune of Madiama. Unsurprisingly, the primary categories offered by 100% of the interviewees are clay (*bógó*) and sand (*céncén* or *kénkén*). Seventeen (61%) interviewees cited another primary category, that of stone (*bélé*). The other 11 informants recognized stones as components in the other soils types, but because stones themselves are inert, they did not include it as its own soil type. Despite high agreement at the primary level, subcategories revealed a diminishing degree of agreement in names offered.

The basis for distinction of subcategories is based overwhelmingly upon color, occasionally on texture. Only six informants did not name any subcategories of clay. Subcategories of clay found the highest degree of agreement with eighteen informants naming *bógófin*, "black clay" as a type of clay, 12 of those 18 named *bógóblenman* or *bógówuliman*, different names for red clay, and 2 of those 12 named *bógóguema or bógójeman*, different names for white clay. No one named red clay without naming black clay, and no one named white clay without naming both black and red clay. It is telling that black clay, red clay and white clay always arose in a nested sequence. This indicates a clear pattern of relative salience, based on farmers' degree of interaction with the different types of soils. Red clay was described as occurring beneath topsoil, limiting farmer's encounters with it. White clay is described as being found only deep below the surface, making it of little importance to farming. The two people who name white clay explained their familiarity with it by their experience with digging wells.

Five informants, three of whom formed a nuclear family, provided subcategories of black clay that were specific to the river floodplains: *manama* (all 5) and *kirikiri* (2). *Manama* soils were characterized as being very fine clay with next to no sand which is sticky, rather than crumbly, when wet. *Kirikiri* is even finer, so fine that one will sink into it deeply if it is walked on when wet.

This distinction of specific floodplain varieties of clay is somewhat at odds with the majority of informants who said that highland clay and floodplain clay was the same sort of soil. Knowing that the Beni River floodplain is farmed in rice, whereas upland clay fields are farmed in sorghum, I asked informants how rice fields differ from sorghum fields if the soil is the same. Their responses uniformly indicated that the difference was found in the hydrology rather than the soil itself. Rice is planted in clayey places where water stands, whereas sorghum is planted in clayey places without standing water.

The other primary category of soil, sand, has a less developed nomenclature than clay. Only eight informants specifically named subcategories of sand, again primarily distinguished by color. The most frequently named subcategory of sand was *céncénfin*, black sand, named by five informants. Following this was *céncénblen*, red sand, named by three informants, then *céncénguema*, white sand, named by two informants. Red sand and white sand appear to be referring to the same thing: pure, loose sand that is not employed in agricultural production. This is reinforced by the fact that their use was mutually exclusive. The lack of explicit and well developed categories of sand is misleading due to the presence of mixed categories called *nyaami* or *nanga,* where varying degrees of sand, clay, and rock comprise a hybrid form of soil. For example, black sand was described as being where sand and clay mixed, meaning that a mixed sand and clay soil is the same thing as black sand. This was confirmed by several key informants. Considering this, 22 out of 23 informants can be said to agree on the existence of black sand as a soil type.

27 out of 28 informants indicated that soil types, such as clay and sand, mix together in the fields. Most informants, if asked, said that all sand in the commune had at least some measure of clay in it and that most clay had some measure of sand. Soil under the name *bélé* was rocky soil, though always mixed into a sand or clay base, usually sand. The widespread acknowledgement of mixed types exemplifies that although there are specific named categories for soil types, farmers understand soil as a three component continuum that is constantly varying through space rather than discreet plots of one type or another.

Distinct from, though related to soil types, hydrology and elevational changes within fields also play into field management. While walking transects of less than one kilometer with three different farmers, I observed that soil type can gradate across several categories in an elevational change of less than a meter. Five informants mentioned how low spots (*dinyé*) where water collects and high spots (*tintin* or *kulu*) where it drains off of play a role in their management of fields. Often, clay is associated with low spots and sand with high spots. The terms *dinyé* and *tintin,* however*,* are used more to describe landscape features of a field rather than soil type as such. Though conventional wisdom is that millet is grown in sandy soils and sorghum is grown in clayey soils, I found these "rules" to be widely broken frequently according to the presence of *tintin* or *dinyé*. For example, a low spot in a sandy field might be planted in sorghum due to the higher volume of water there.

When asked to rank the strength (*fanga*) of different soils, nine out of nine interviewees placed black clay first and black sand second. Other than crop health, the black color of soil is the most common indicator of soil quality, the darker the soil, the richer the soil. Interestingly, when asked which kinds of soil they liked best, three out of four informants said they prefer black sand to black clay. When it is wet, clay is very difficult to work, either with a plow or a hoe and several crops that prefer loose soils, such as peanuts and millet, cannot be grown in it. Although black sand is not seen as having as much strength as black clay, it has the valued qualities of versatility and workability. Black sand, being a composite type, combines the force of black clay with the workability of sand, allowing for a wider variety of crops to be grown there.

**Soil Fertility Management Techniques**

The SANREM soil fertility improvement trials in Madiama consists of rotation with legumes, intercropping with legumes, microdosing with chemical fertilizer, enclosing cattle in fields prior to growing season, and comparison of goat and sheep manure with cow manure (as will be discussed below, farmers widely believe that goat/sheep manure makes better fertilizer than cow manure). The purposes of these trials are to quantify the impacts of the techniques and to physically show the farmers of Madiama the efficacy of the techniques over the course of the growing season, as well as over several years.

My research indicates that all of these techniques are known and used by Madiama farmers, though to variable degrees. This is not at all to diminish the importance of the fertility trials, but to underscore how they are helping to methodically demonstrate the benefits of those techniques and more broadly disseminate the knowledge that already exists within the communities of Madiama. As one of the project agronomists pointed out to me, the primary problem is not that the techniques are unknown, but that they are not systematically applied by the farmers.

Microdosing is widely known and practiced in Madiama, but not for grain crops. The cultivation of watermelons as a cash crops appears to have been done with microdoses of chemical fertilizer for a long time. I asked one male in his mid-twenties how long he had used the technique, and he replied that he had learned it from his father who had been using it for a long time. It seems likely that microdosing with chemical fertilizer arrived with the introduction of watermelon as a cash crop. He and several other farmers explained that the reason microdosing is not used with grain crops is that 1. chemical fertilizer is expensive and grains, being subsistence crops, do not generate income, thus it is difficult to justify spending that much money on them and 2. the technique requires to much time, considering the size and number of grain fields. Three other farmers independently corroborated this information.

One pair of innovative farmers, brothers who farmed together, were experimenting with microdosing their watermelons and gourds with small ruminant manure after they had already sprouted. In their system, they dug small pits next to watermelon vines that were 0.5m long into which they mixed approximately three liters of small ruminant manure. They explained that the idea was that the pits would retain water when it rained and the gourds' roots would find their way to the enriched soil, bolstering the plants' growth while using valuable manure and rainwater more efficiently.

Intercropping or rotating grain crops with legumes, cowpeas or peanuts, frequently showed up in the interviews as a means of improving soils. One explanation offered for this by two different farmer was that peanuts and cowpeas improve the soil because they are low-growing and have lots of foliage which is good for the soil. Although intercropping can be widely found in fields, the benefit of intercropping cowpeas with millet and sorghum was most often expressed in terms of labor and space efficiency rather than soil management. By mixing beans in with grain seeds, the planting and harvesting of beans requires little extra time and energy, as well as no additional space. Ethnographic observations indicate that the intensity of the intercrop is low.

The use of cattle enclosures can be found in Madiama, but again, it occurs only at low intensity. Owners of goats, sheep cows, horses and donkeys were occasionally seen preferentially pasturing their cattle in their own fields in the weeks prior to plowing. This is done to harness the benefits of the cattles' manure. This technique was not systematically applied at a high intensity due to lack of sufficient grazing material in the fields.

**Soil Amendments**

The operative concept in farmers' conceptualization of soil fertility is *fanga,* which translates as "power" or "force". This is not, however, a concept that applies uniquely to soils and soil amendments. I heard it used in relation to medicine and food as well. Medicine has *fanga* if it cures quickly and thoroughly, food has *fanga* if it provides a lot of energy. For example, although rice is widely thought to be more palatable, millet and sorghum provide more energy for working, thus they were said to have more *fanga*. Soils and soil amendments (*nógô*) have variable *fanga* as well. As the application of *nógó* is the primary means of maintaining soil fertility, farmers' conceptualizations of *nógó* are essential to understanding their beliefs regarding the management of soil fertility.

Unsurprisingly, 100% of interviewees said that primary means of improving soil is through the application of fertilizer, *nógó*. When asked what things fall into the category of *nógó*, all respondents included the same list of manures; small ruminant manure, cow manure, donkey manure, horse manure. When asked, one respondent admitted that all manure is really *nógó*, observing that when a farmer defecates in his field, he may notice that the plants there grow a little faster and a little greener. However, he went on to say that non-cattle manures, such as chicken, human or dog manures, do not have enough *fanga* to bother with using them systematically.

All but two of the informants listed at least one form of plant organic matter as *nógó*. These took the form of leaves (*furaburu*), grasses (*binw*), crop residue (*kala*), and miscellaneous organic matter (*nyaminyami)* such as peanut shells or grain chaff. Six informants listed of compost (*sunógónógó* or "sleeping nógó"), which contains any or all of the previously mentioned organic matters and manure. The category of compost is somewhat difficult to handle in this comparative context because it is a composite category which has an inherently variable composition. The two informants who did not say that plant organic matter was *nógó*, reluctantly admitted that it is good for the soil, but did not have enough *fanga* to merit categorization as *nógó*. For them, only animal manures truly fell into the category of *nógó*. In addition to manure and plant organic matter, chemical fertilizers were discussed as forms of *nógó,* though it does not fit comfortably into that category for farmers.

For all farmers interviewed, both formally and informally, there is a clear and significant difference between the aforementioned sorts of *nógó* and *angéré*, chemical fertilizer. The first indication of this is that two primary categories are commonly used in conversation about fertilizer: *nógó farafin* and *nógó tubab*, African fertilizer and European fertilizer. When asked to list all forms of *nógó*, without using the modifiers *farafin* or *tubab*, farmers would frequently not mention *angéré*. When asked if *angéré* is a form of nógó, they would reluctantly tack it on almost as an afterthought. This might be partially attributed to the fact that it is too expensive for most farmers to buy, thus not in their regular cognitive repertoire of fertilizer options. However, the fact that *angéré* is widely used on watermelons, which appeared to be grown by many, if not most, farmers, would contradict this explanation.

When asked how *angéré* and *nógó farafin* are the similar, farmers all responded that they both help crops grow, the quality which appears unify the overall category of *nógó*. When asked how *angéré* and *nógó farafin* are different, four major themes arose. The first and universally expressed difference is that *angéré*, while powerful, is only good for one year. Its efficacy, its *fanga*, does not endure in the soil. Conversely, *nógó farafin* is seen as effective for anywhere from 3-10 years after application, depending on the type and intensity of application. This is highly connected to the second observation that while *angéré* helps plants grow, it does nothing to improve soil quality. This is significant because although farmers all say healthy-looking crops are the best way to tell the quality of soil, they still recognize that there is a difference between feeding crops and improving soils. A third quality which farmers use to distinguish *angéré* from *nógó farafin* is that *angéré* requires sufficient rain to be effective, without which it can actually harm crops. In contrast, *nógó farafin* works regardless of the amount of rain, and actually increases water retention in the soil. Finally, a distinction made by 5 informants is that *angéré* is made in factories and sold in markets whereas *nógó farafin* is produced by households and is not available for purchase. The question of fertilizer preferences versus availability is central to the issues of soil fertility maintenance, a point which will be discussed further below.

Half way through the research, I decided to have interviewees rank the *fanga* of the fertilizers. 11 out of 14 (78%) people ranked small ruminant manure first, which reflects what seems to be conventional wisdom. Informal interviews strongly support the idea that small ruminant manure has significantly more power than others. Two of the remaining interviewees ranked cow manure as first, with one ranking compost first. I allowed respondents free reign in deciding which *nógó*s to rank and found that only 3 out of 11 chose to put *angéré* anywhere in the scale without prompting. *Angéré* only earned one 2nd, one 3rd and one 4th place ranking. The modal response placed small ruminant manure first, cow manure second, followed either by horse manure or compost. As mentioned before, compost is by nature a composite category with high variability in its composition, which somewhat confounds consistent comparative ranking. Interviewees were generally disinclined to rank leaves, grasses and residue due to their insignificant *fanga*, preferring to attribute ranks only to the more powerful and salient manures.

Assessments of a soil amendment's power appear to based primarily upon the duration of its efficacy. Small ruminant manure was described as maintaining its *fanga* anywhere from 3 to 10 years, cow manure from 2 to 3 years, compost from 2-4 years, and *angéré* only one year. Horse and donkey manure are universally acknowledged to be very weak, and used only because they are widely available. This relative ranking held true for 100% of informants. The major differences were expressed in the speed of release. *Angéré* was always recognized as being very powerful, but, as previously stated, not enduring. The one person who ranked compost highest justified his choice by saying that although small ruminant manure endures longer in the soil, compost typically is stronger in the first year or two because it breaks down more quickly. No one cited small ruminant manure as having a dramatic immediate effect as its preferred quality. Instead, all farmers pointed to its slow release and durability in the soil. One farmer illustrated this point for me by digging two holes in his fields. One was a spot where cow manure had been applied at the beginning of the current season and another where small ruminant manure had been applied 4 years prior. The small ruminant site was still darker in color, the primary visual indicator of soil fertility (following crop health) according to farmers. When the informants who did not rank *angéré* at all were pressed as to why, they typically waffled and then referred back to the fact that *angéré*'s *fanga* is "different", apparently incomparable due to its short but intense duration in the soil.

**Conceptualization Of Soil Fertility**

Farmers describe *nógó* as being food for plants. People cannot live without eating, and likewise, neither can plants. As with human foods, some plant foods give more strength than others. What follows here is a sort of folk theory of veterinary and agricultural nutrition that begins to sketch out a folk theory of ecological energetics. Having identified that farmers perceive different fertilizers as having variable strength, the next question was their explanation of this variation. What makes sheep, goat and cow manure so much better than horse, donkey and other manures? What makes sheep and goat manure so much better than cow manure? If manure application is what makes the growth of crops possible, how is it that trees and wild plants can grow without the application of manure? These questions attempt to elicit farmers' understands of ecological processes related to soil fertility. Unfortunately, as these questions did not arise until late in the research, the sample size for them is limited to a maximum of ten informants, though the degree of agreement is significant. All ten informants agree that the goat, sheep and cow manures are stronger than horse and donkey manures because they are all ruminants and double chew their food. Two informants theorize that their digestive systems put vitamins into the manure. All ten informants also agree that goat and sheep manure is stronger than cow manure because their diet is different from cows diets. Where cows exclusively eat grasses and crop residues, the diet of small ruminants consists of a significant amount of trees and shrubs leaves, which are thought to endow their manure with more *fanga*.

The obvious next question is why the leaves of trees and shrubs should provide different quality fodder than grasses and crop residues? The few farmers who addressed this question cite two main reasons which pertain the spatial and temporal scales of the different plant types. Trees and shrubs, being perennials, have slower and longer growing cycles than annual grasses and crops. This requires them to be "harder", tougher, and stronger in order to endure the seasonal and annual fluctuations in temperature and rainfall. The second major difference that distinguishes trees and shrubs from grasses and crops is that they have deeper roots which draw on deeper *nógó* and deeper water systems in the soil. Farmers explained that trees and shrubs do not need the human application of manure *nógó* to grow because their slow growth cycles require less *nógó* to successfully function. Slow and weak decay of leaves and grasses into the soil provides sufficient *nógó* for perennials, whereas annuals, particularly crops, require intensive application. The reliance on deep *kólónji* (wellwater) enables perennials to endure droughts better than crops and grasses which are immediately reliant upon *sanji*, rainwater. Even within the categories of trees and shrubs, there are particular species that are widely recognized as providing superior fodder for small ruminants. The two general qualities of deep-rootedness and slow growth are what is said to give the leaves of trees and shrubs the greater strength which is passed on to small ruminants through leaves, and then passed on to the soil through manure. This points to a model of an ecological chain of causality for topsoil fertility that begins with roots of perennial trees and shrubs in the deeper layers of soil.

## DISCUSSION

The results of the soil typology research describe a fairly coherent and widely shared system of soil categorization, even if the names used are sometimes not the same. Informants displayed variable depths of knowledge, but the shape of the typology was consistent overall. I would like to suggest, however, that soil typology alone is an insufficient ending point for ethnopedological research. If two fields have the same kind of soils but the water is different, say one is rain fed and the other is river fed, than the management proscription will vary. This point is intended to illustrate that farmers' experience with and categorization of soils is necessarily situated in an agroecological landscape in which soil is but one feature among many. Instead of stopping at soil typologies, I propose that ethnopedological research, at least in this research context, is best conducted at the level of the field rather than soil. This shift in thinking will better take into account spatial variability across the landscape by incorporating the interactions between several variables such as soil, altitude, slope and hydrology to name a few. Research along these lines could not only generate crosshatches of variables through space, but it would also be able to better deal with change though time, an important issue in maintaining soil fertility in Sahelian Africa.

When it comes to soil fertility maintenance, farmers consistently express strong preference for the small ruminant and cattle manure, which releases slowly and endures the longest, over the chemical fertilizer, which has a strong but short lived impact. This indicates that they manage soil fertility with a long time horizon in mind and that they well understand the difference between building soil and feeding crops. In contrast, however, most farmers told me that if they had money, they would buy chemical fertilizer for their fields despite their overwhelming preference for manure-based fertilizer. I asked several farmers why someone would use *angéré* if small ruminant and even cow manures are so much better. They all gave the same response: there is simply not enough manure available to adequately maintain soil fertility. Farmers appear to use *angéré* not because they think it is superior, but because it is accessible through market channels, whereas there is no market for manure.

Because manure cannot be bought in the market, all manure must be produced at the household level. If a household's ratio of manure to fields is insufficient, it becomes necessary to either supplement manure applications with *angéré* or suffer decreasing yields. Farmers identified that this creates a situation in which better endowed families can maintain their soils fertility base and poorer families degrade their soil fertility base, leading to cycles that reinforce existing resource base disparities. In this context, I suggest that the market for chemical fertilizer should be seen not as a sign of "agricultural modernization" (as it often has elsewhere in the past), but as a symptom of ecological imbalance that may have a weak mutually reinforcing relationship with economic imbalance. Farmers have need of intensifying their efforts to maintain soil fertility, but are increasingly unable to do so using the preferred local resources.

Perceptions of the problem vary, however, depending on one's perspective. A Maraka farmer told me "There are not enough cattle and so not enough manure for the fields". A Fulani farmer/pastoralist described the same condition as "There are too many fields for the number of cattle." This underscores the importance of using holistic management across ethnicities and between towns in addressing the issue of soil fertility systemically.

This brings me to my final discussion point. By moving beyond static categorizations, the exploratory research on conceptualization of soil fertility began to reveal a picture of a folk theory of ecological process involving soils, non-domesticated plants, humans, domesticated plants and animals, as well as hydrology. This depiction closely resembles scientific representations of energy flows as used in contemporary ecology. The elaboration of farmers' notions of the chains of causality behind soil fertility indicates that their management of soil fertility begins outside (or under) the fields and even outside the human and domesticate dominated aspects of the ecosystem.

## POLICY IMPLICATIONS

Showing that farmers consider maintenance of soil fertility as a part of landscape-level agroecological system rather than something that is just done in the fields implies that they have knowledge to contribute to landscape level planning and management. In particular, the species of perennials that are prefered as fodder for the goats and sheep are under visible strain from heavy cutting of foliage. This could jeopardize their existence in the areas around villages and diminish the capacity of villagers to maintain healthy small ruminant herds which are recognized as important to maintaining soil fertility. Therefore, local policy initiatives regarding tree management may be in order, though further research determining the scale of the problem is necessary. Although trees are treated as common property, there is precedence for such initiatives. In 1999, the Mayor of the Commune placed a ban on the cropping of balanzan trees under threat of a 10,000 CFA fine, presumably to ease cropping pressure.

## TRANSFERABILITY AND INSTITUTIONALIZATION OF FINDINGS

While the specific results of local knowledge studies are rarely transferable to other locales, the methodological and theoretical angles are. The use of progressive elaboration of key concepts can be useful in identifying webs of causality and local conceptualization of ecological processes and functions. This focus on ecological processes rather than categories should be useful in moving toward desired long-term and landscape level goals that emerge from holistic management and future visioning.