Integrated Management of Agricultural Watersheds:

Land Tenure and Indigenous Knowledge of Soil and Crop Management

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Front cover photo: Threshing millet.

Back cover photo: "The land is old and tired", said a Zarma farmer.

Photo credits: A. S. R. Juo; A. Manu; R. Puentes; T. L. Thurow; and L. P. Wilding.

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INTEGRATED MANAGEMENT OF AGRICULTURAL WATERSHEDS:

LAND TENURE AND INDIGENOUS KNOWLEDGE OF SOIL AND CROP MANAGEMENT

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Foreword

Texas A&M University (TAMU), Soil Management Collaborative Research Program (TropSoils) in collaboration with Niger National Institute for Agronomic Research (INRAN) planned a joint project on Integrated Management of Agricultural Watersheds in Niger (IMAW). A major goal of the project is to improve agricultural productivity and enhance natural resource base through integrating indigenous knowledge with improved technologies for soil, crop, livestock and vegetation management within a well-defined watershed. In 1989, a proposal was submitted to the Agency for International Development Mission in Niamey for support and funding.

This report contains the findings of the on-farm survey on land tenure and land management. The complete report of the findings of soil, vegetation, hydrology and indigenous farming systems was published in a separate volume (TropSoils Bulletin No. 91-03, 1991).

The effort of many were required to complete the study. Dr. Ellen Taylor-Powell conducted the survey in 1989. Dr. A.S.R. Juo, Dr. R. Puentes, and Dr. A. Manu contributed to the planning, design and implementation of the project. Dr. S.C. Geiger and Mr. F. Adamou conducted the soil erosion assessment in the farmer's fields. Dr. Mamadou Ouattara whose earlier work in the watershed contributed much to the study. Ms. Ann Pfordresher helped with the base maps. Mr. Hama Yaye assisted with field interviews. Ms. Kati Ferrari and Ms. Peggy King assisted wit the editing and formatting of this report.

The continued support, interest and encouragement from the Office of the Director-General of INRAN, and from the administrative and technical officers of the USAID Mission in Niamey, Mr. George Eaton, Director; Mr. John Mitchell, ADO; Mr. George Taylor, ADO; Mr. Ernest Gibson, former ADO, and Mr. Flynn Fuller, former ADO, are gratefully acknowledged.

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Roger G. Hanson, Director
Soil Management CRSP
November 30, 1991.

EXECUTIVE SUMMARY

Less vegetative cover, declining soil fertility, increased erosion,and shorter fallows are consequences of the climatic changes and demographic pressures affecting the Sahel.

Past programs in the region have focused mostly on increasing food production through commodity improvements. The Integrated Management of Agricultural Watersheds (IMAW) project is a joint undertaking of the Institut National de Recherche Agronomique du Niger (INRAN), Texas A&M University, and the U.S. Agency for International Development/Niger. It seeks to sustain the productivity of land management units as opposed to merely increasing crop production. Small watersheds form the land use area within which sustainable management strategies can be established.

The project proposal called for a baseline assessment of social and cultural factors influencing land use, with a particular focus on indigenous knowledge related to soil management. To provide this information, a study was undertaken in a 500 ha pilot watershed east of the village of Hamdallaye, 30 km northeast of the national capital, Niamey, during October-December 1989.

The terms of reference included documentation of land history, assessment of land tenure, indigenous knowledge of soil and crop management, farmer perceptions of agricultural problems and solutions, and the historical and demographic description of the region. In-depth interviews were conducted with 42 farmers, plus village elders and chiefs having administrative responsibility over the territory. Major findings include the following:

1. Originally settled by Zarma farmers, land in the watershed is currently claimed by 41 families and is farmed by 56 different persons. Land holdings per household average 10.3 ha, ranging from 0.7 to 41.5 ha. Cultivated areas average 5.2 ha and fallow areas average 5.1 ha. Approximately half the watershed was in fallow during the 1989 farming season.

2. Nearly half of the cultivators are farming on borrowed land. Land tenure security appears to exist through established relationships and customary rules that allow borrowed land to pass to successive generations. Formal leases are being encouraged to guard against land claims by borrowing families. Women do not control land. They are allotted small plots on a temporary basis for cultivating peanuts and household gardens.

3. Of the 42 farmers interviewed, 32 are Zarma, 6 are Hausa, and 4 are Peul. Millet/cowpea intercrop dominates the cropping pattern. Improved varieties have been available since the early 1980s, but local varieties are preferred. Forty percent of the farmers reported never using fertilizer.

4. Nearly three-fourths of the households own livestock, principally mixes of goats, sheep, and cattle. Animals are an important source of investment for both women and men, and provide manure, pack/transport, and food. Zarma-owned cattle usually are entrusted to Fulani herders to spend the cultivation season outside the watershed, returning for crop residue grazing. Animals are kept from cultivated areas during the growing season on orders of the chef de canton. After harvesting, animals have free access to arable land. Planted cowpea forage and two native species, *Ipomoea involucrata* and *Merremia tridentata*, are cut and stored for dry season feeding or sold. The two native species offer multi-purpose possibilities.

5. Heads of households have a strong sense of land ownership, though land belongs to the lineage and is not to be sold. Management decisions and use of the land's production, including crop residue and other valuable plants, such as grasses and forage, fall to the field's cultivator.

6. Various tenures exist depending on use of the land and the user. Cultivators have exclusive use of cropped fields. Grazing land on the plateau is communal as is arable land after harvest. Tenure rules related to fallow land vary, depending on the season and whether the user is the landowner or borrower. Tenure rules apply to all permanent land improvements. Leaseholders are barred from digging wells or planting trees of economic value, such as citrus, mango, and baobab.

7. Fallow periods have reportedly shortened from 10 years to 3 to 5 years on family land and 2 to 3 years on borrowed land. The shortened fallow periods are blamed on population pressures, cultivation of larger areas to make up for decreased land productivity, seeding all land to minimize risk of a crop failure and to demonstrate use of land to keep others from using it, pressures to loan land with its being brought back into cultivation prematurely, and breaking up of family holdings resulting in greater farming intensification.

8. Farmers see their land base as degrading as a result of climatic changes and vegetation loss. Problems and concerns about poorer land productivity are most often tied to declining soil fertility. Wind that carries away topsoil and wind-blown soil that buries millet seedlings is considered more of a problem than water erosion. Sand deposits from water runoff that limit the cultivable area and bury the crop are considered more widespread and harmful than gully erosion. Farmers' perspectives and knowledge are empirically based. They plan for the short term and are concerned with minimizing risks in order to meet the food needs of the household.

9. Use of animal manure is seen as the primary method for sustaining production. The supply of manure, however, is limited by fewer head of permanent and migrating animals in the region since the droughts of the past two decades and by reduced vegetation to attract grazing animals. It is stated that few Fulani now own cattle so farmers must own animals to make manuring of fields possible.

10. Management of crop residues has reportedly changed over the past decade due to increased wind erosion. Some millet stalks are removed following harvest for construction, but most millet residue is left standing on the field to "hold the soil." After crop residue grazing, the stalks are uprooted and laid on the field, sometimes strategically on severely eroded areas.

11. Farmers in the watershed are attempting to lessen the risk of crop deficits by experimenting with various strategies such as multiple planting dates; mixing seed varieties; strategic farming in favorable microenvironments, priority weeding; and soil restoration techniques and wind erosion controls using crop residues and native woody species *Piliostigma reticulatum*, *Combretum glutinosum*, and *Guiera senegalensis*. Farmers have years of experience in adapting to an unpredictable environment. The existing wealth of indigenous technical knowledge when integrated with modern technologies should result in sustainable agricultural systems.

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INTRODUCTION

Soil degradation and the consequent loss of crop production potential is a widespread concern across the Sahel. Infertile sandy soils common to the region are susceptible to wind and water erosion particularly when the vegetation cover has been depleted. Population pressures and competing uses for land are resulting in reduced fallow periods and expansion of farming on marginal land.

Past activities in the region focused primarily on cropping system components with the objective of increasing production. The Integrated Management of Agricultural Watersheds (IMAW) project pinpoints the sustained productivity of land management units. Small watersheds with catchment areas of 2 to 6 km make up the land use area within which sustainable management strategies can be established.

The ways used by local farmers in conserving resources must be understood and integrated with modern technologies to bring about sustainable agricultural systems. An initial objective of the project was to conduct research on land tenure and indigenous knowledge related to land and soil management in order to get farmers' perspectives and document existing land tenure and conservation practices.

The terms of reference for this research called for three related activities to be conducted from October to December 1989:

+ Conduct interviews with village chiefs and elders to provide historical and demographic descriptions of the zone;

+ Identify all farmers within the watershed and document the land history of cultivated and fallow areas, and

+ Conduct individual farmer interviews to provide a general assessment of land tenure, indigenous knowledge of soil and crop management, and farmers' perceptions of problems and solutions.

Methods

The watershed selected for the IMAW project is 500 ha near the village of Hamdallaye, 30 km east northeast of Niamey, the capital of Niger. To identify persons farming or owning land, the researcher walked the watershed with knowledgeable farmers obtaining names associated with each cultivated and fallow field. Maps prepared from aerial photographs were used as the base of reference and served to stimulate a dynamic conversation with these nonliterate farmers. Of the 56 farmers identified, interviews were conducted with 42, a 75% sample. Several group interviews were held with village elders, and individual interviews were conducted with each of the three village chiefs having administrative responsibility over land in the watershed. A subsequent survey was conducted to determine the extent of wind and water erosion within 25 fields.

The exploratory nature of the research called for a naturalistic approach to data collection. Ethnographic techniques of informal interviewing and observation provided an opportunity to discover the variety in, and reasons underlying, farming practices. During the interview process the researcher walked with farmers over their fields asking for comments and seeking explanations related to soil management. Content analysis was conducted to categorize the field data into meaningful themes and patterns.

GENERAL SETTING AND DESCRIPTION OF THE PROJECT WATERSHED

Niger Context

The Niger Republic, covering 2,534,000 km, is the second largest Sahelian country. Its population is estimated at 7.2 million persons. A land-locked country, Niger has a semiarid and arid climate. Rainfall decreases sharply from south to north with high rates of evapotranspiration. More than 75% of Niger's landmass lies above the 300-350 mm isohyet where rainfed agriculture is untenable. The northern part of the country is entirely desert.

Agriculture, the primary economic activity, is concentrated in the southern part of the country where over 80% of Niger's population depends on the rural economy. Major cereal crops include millet and sorghum which cover 70% of the cultivated area. Other products include cowpea, onions, rice, cotton, peppers, peanuts, hides, and live animals. An annual population growth rate of 3.2% is moving counter to agricultural production, where increases of 1.5% each year over the past decade are largely attributed to an extension of the cultivated area rather than production increases. Droughts are a regular occurrence. The most recent droughts occurred in 1968-1974 and 1983-84.

IMAW Watershed

The 500 ha IMAW project watershed is located 2 km east northeast of Hamdallaye village in the Kollo Arrondissement, Tillabery Department (Fig. 1). The region was originally settled and claimed by Zarma farmers. An oral history of the area dates back to the mid-19th century. Immigration into the region and the watershed was stimulated by a desire to leave more populated areas to claim virgin land for individual families.

The watershed falls in the western Sahelian zone with a valley-plateau geomorphology characteristic of western Niger. Total rainfall in 1989 was 402 mm and 390 mm in 1990. Natural vegetation in the region is of the savanna-type. Soils are generally highly weathered.

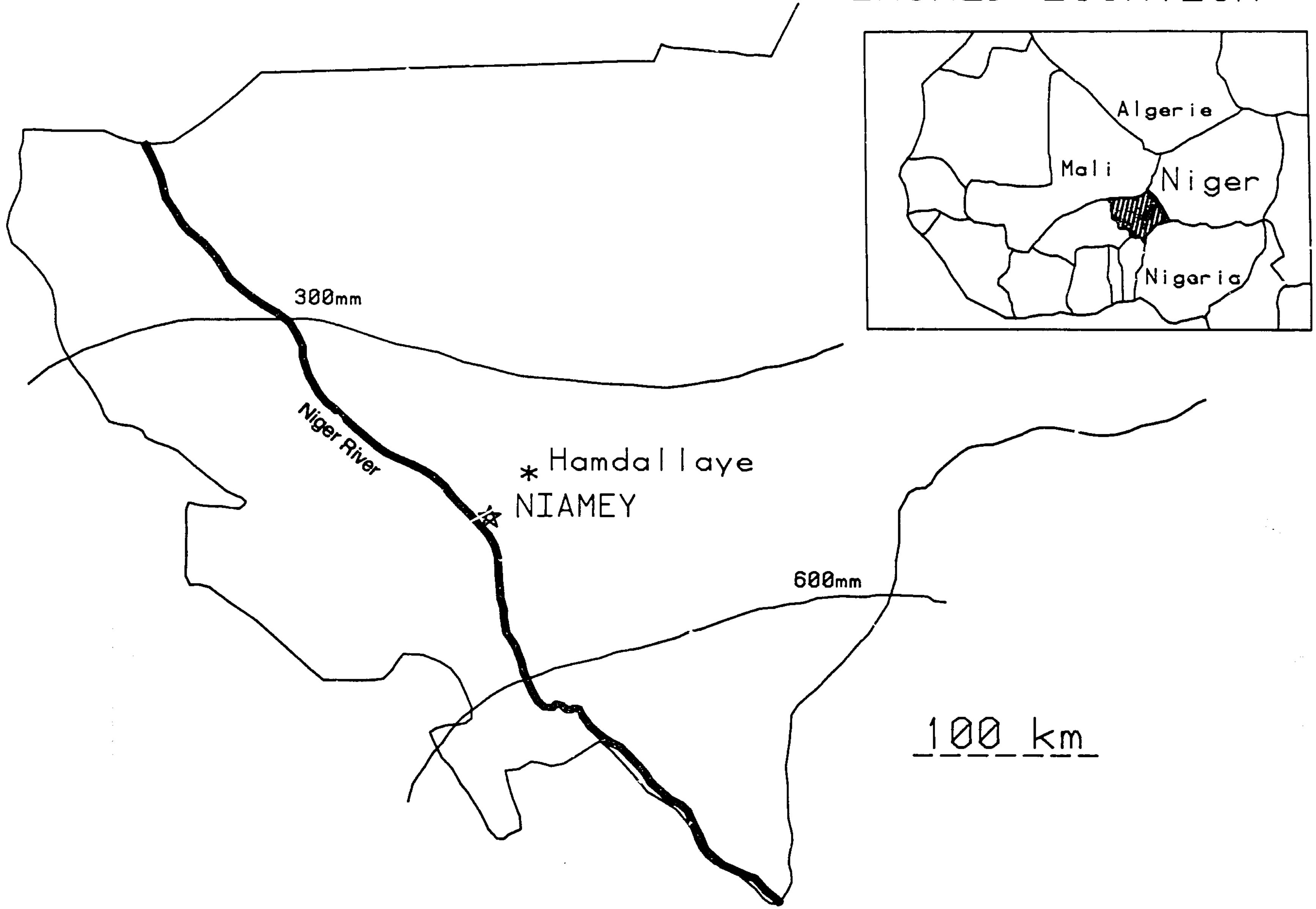
Development in the watershed region has been influenced by its proximity to Niamey, the capital. A major paved road connecting Niamey and Filingue passes through Hamdallaye. A system of secondary roads and paths link surrounding villages to Hamdallaye and its weekly Tuesday market. Other important markets in the region include Dantiandou, 30 km southeast; Baleyara, 65 km northeast, and Niamey, 30 km west.

Various public services and development assistance programs are centered in Hamdallaye, the chef-lieu de canton. There are two schools, a private Arabic school of 3 classes, and a public school with 7 classes. There is a private pharmacy and a government dispensary. The district agricultural officer is located in Hamdallaye. The agent has the responsibility for the entire canton.

Through the assistance of the Cooperative League of the USA, a local cooperative was established in 1986. In the early 1980s, the U.S. Peace Corps set up permanent training center at the edge of the village. Volunteers reside in Hamdallaye, resulting in some infrastructural development for village. A Seed Multiplication Center was established in 1978 with funding from the U.S. Agency for International Development (USAID) to provide seed and other agricultural inputs to area farmers. During the mid-1970s, the Sahel Vert program established a plantation near

Figure 1

MAP OF WESTERN NIGER SHOWING WATERSHED LOCATION



Hamdallaye which reportedly provided villagers with trees to plant.

Village Territories

Four villages have administrative territory within the watershed (Fig. 2). Approximately 13% of the land falls within the territory of Hamdallaye.

The village of Bokotchili Kaina, 4 km east of Hamdallaye by sand track, is outside the project boundaries but 56% of the watershed land area lies within its territory.

Falanke Kaina, a hamlet entirely located within the watershed boundaries, is about 6 km east of Hamdallaye. A quarter of the land within the watershed comes under the administration of the Family head of Falanke Kaina.

Outside the project area on the easternmost corner lies Falanke Beri whose administrative district covers about 6% of the watershed land. Land area falling within each village territory is reported in Table 1.

Table 1. Land area in each village territory

Village territory	Land area
Hamdallaye	71.6 ha
Bokotchili Kaina	308.7 ha
Falanke Kaina	137.8 ha
Falanke Beri	30.6 ha
TOTAL	548.7 ha

Village Histories

Hamdallaye. Two Zarma families are said to have been the first settlers in Hamdallaye. Originating from near Baleyara in the canton of Tagazar, they settled in N'Dounga before finally establishing themselves in Hamdallaye about 1854. The current chief, installed in 1988, is fifth in the patrilineal descent. The current population of Hamdallaye is about 1,200 households, predominantly Zarma. Some Hausa, Tuareg, and Arabs have settled in Hamdallaye. A settlement of Fulani, "Hamdallaye Fulani," is found on the southwest side of the village.

Bokotchili Kaina. The founder of Bokotchili Kaina originated from Bokotchili Beri in the canton of Koure. After settling and claiming land in Bokotchili Kaina, he moved on to settle the village area of Binni Bokotchili. Today, descendants from the same lineage claim land in all three villages. The current population of Bokotchili Kaina is about 800 Zarma in 88 households. Reportedly, the village population has decreased since the droughts of 1968-1974 and 1982-1984. Bokotchili Kaina has no governmental services or market.

Falanke Kaina. The history of Falanke Kaina dates back five generations, when a Zarma pioneer came from Allahoni to cultivate and claim surrounding virgin land. The hamlet consists of about 100 persons in 11 families. All are descendants of the original pioneer except one Fulani family who established herding relationships with the cattle-owning Zarma has settled permanently.

Characteristics of Farmers

Of the 42 farmers interviewed, 32 are Zarma (76%), 6 are Hausa (14%), and 4 are Fulani (10%). All are men except 2, one Hausa and one Fulani, who in the absence of husbands are de facto heads of households.[1] Age of the head of the household ranges from 22 to 70 years with an average of 42

[1] "Household" is defined primarily as a production unit: persons who work a common field(s) and share the produce. A household is a subgroup of a concession (residential dwelling unit composed of one or more conjugal units) which is a subgroup of a lineage.

years. Over half of the household heads are between 22 and 40 years with 12% over 61. Household sizes for the 42 farmers average 9 persons ranging from 2 to 20.

Traditionally, Zarma are agriculturalists with a production goal of meeting household cereal requirements and selling surplus grain to meet cash needs. Given recent droughts and unfavorable rainfall, producers have increasingly turned to off-farm work, particularly seasonal migration to coastal countries as unskilled laborers. Other activities include jobs in transportation (donkey and ox cart), petty commerce, crafts, tailoring, butchering, brickmaking, barbering, and herding (Fulani). Two of the 42 farmers have salaried employment. Other sources of household income include remittances from nonresident household members. Availability and allocation of capital and labor by households was not documented but is clearly diverse.

The Farming System

A millet-based mixed farming system characterizes the watershed's agricultural system. Demarcated land holdings fall under the control of household heads, but households vary in the way collective decisions are made about land management. Besides family fields, unmarried household men and women often cultivate individual fields, thereby establishing independent subeconomies within the household.

Cropping Pattern.

Millet (*Pennisetum spp.*) dominates the cropping pattern, generally as an intercrop with cowpea (*Vigna unguiculata*) (Table 2). Sorrel (*Hibiscus sabdarifa*) is often intercropped with millet and millet/cowpea combinations. More favorable microenvironments -- areas of favorable moisture and nutrient conditions within a field -- are cultivated to sorghum (*Sorghum bicolor*), maize (*Zea mays*), sorrel, and okra (*Hibiscus esculentus*). Women cultivate small plots of peanuts (*Arachis hypognea*) and tend rainy season gardens next to the household compound. Reportedly there is little dry season gardening due to the depth of the water table. A few manioc gardens are found in low-lying areas.

Table 2. Crop pattern in Hamdallaye watershed, 1989 (n = 46 fields)

Crop	No.	%
Millet/cowpea	30	65.2
Sole millet	7	15.2
Sole millet; millet/cowpea	4	8.7
Sole millet; sole cowpea	2	4.3
Millet/cowpea; sole cowpea	2	4.3
Millet/cowpea/sorghum	1	2.1
TOTAL	46	99.8

Besides planted millet, two other types of millet are important in the production system. *Diaraou*, volunteer millet (*mil savage* in French), competes with planted millet but ripens first and is therefore important in providing food during the "hungry gap." Diaraou residue is used in construction and fed to animals.

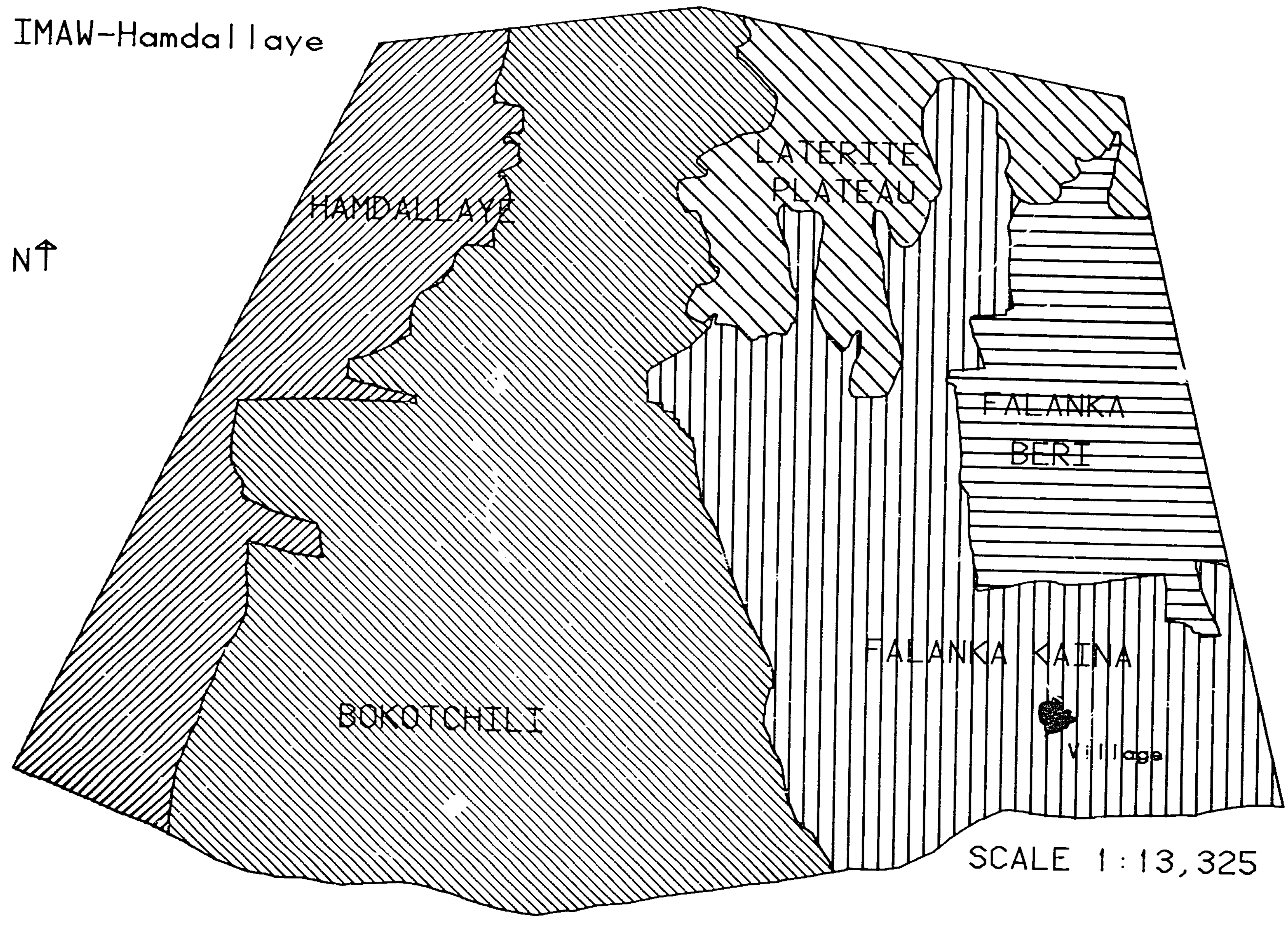
Sunne (*chibras* in *Hausa*) is undeveloped grain heads produced by local varieties. It is harvested, often by women, prior to the regular harvest and is also useful during the hungry season. *Sunne* not forming grain heads is weeded since it competes with planted millet.

Improved millet (HKP) and cowpea (TN578) varieties have been available in the region through the Seed Multiplication Center since 1982-83. Local varieties, however, dominate (Table 3). Two local millet varieties, *tchumo* (dark colored millet)

Figure 2

ADMINISTRATIVE BOUNDARIES

IMAW-Hamdallaye



and *drankoba* (light colored millet), are typically sown together and may be mixed with HKP to diversify and minimize risk.

Table 3. Millet and cowpea varieties used in Hamdallaye watershed, 1989 (n = 42 farmers)

Variety	No. of Farmers*	%
Local millets	35	83.3
Improved millet (HKP)	13	30.9
Local cowpea	39	92.8
Improved cowpea (TN578)	3	7.1

* Totals may exceed 100% since farmers may mix local and improved varieties

There are varying opinions about the productivity of improved versus local millet varieties. There are three main disadvantages with the improved variety, according to farmers:

1. Susceptibility to bird and insect attack due to its early maturity
2. Competition with other labor needs since it needs weeding sooner after planting because of its fast growth
3. Productivity depends on full use of recommended inputs. Prior to 1989, farmers reimbursed the Seed Multiplication Center with millet and cowpea grain at the rate of 2.5 kg for every 10 kg of seed obtained. Triple superphosphate and urea were available at a cost of 3,750 CFA and 3,250 CFA per 50 kg, respectively, or farmers could repay fertilizer in grain equivalents at the fair market price. Cowpea insecticide was free of charge.

Farmers' decisions in use of crop varieties and fertilizers were linked to a variety of variables: climate, availability of resources and inputs, and expected returns. For example, one farmer used a fast-growing improved millet variety when the rains were late. Another put off using fertilizer because a poor yield was expected due to lack of rain and his inability to reimburse costs.

Field Sizes.[2]

Field sizes in the watershed were calculated by the TropSoils staff using an electronic planimeter to measure fields identified on aerial photographs (1:5200) and verified on the ground. Fallow and cultivated fields averaged 10.3 ha per household, ranging from .7 to 41.5 ha.[3] The average cultivated area was 5.2 ha, with a range of 0.7 - 16.4 ha per household. The average fallow field was 5.1 ha, with a range of 0.2-41.5 ha. Of the households with land in the watershed in 1989, 62% had land in fallow and 83% were cultivating fields. A further breakdown of land areas by household is reported in Table 4.

Cropping Calendar.

Farmers in the watershed either dry seed or seed with the first sufficient rains in mid to late June. Reseeding is often necessary due to early season drought or the burial of seedlings by wind-blown sand. Planting can continue through July in some years. Two weedings are customary though dependent on the amount of labor available and an assessment of the potential crop yield. The first weeding of the millet crop occurs 10 days after planting. Harvesting is usually done in mid to late October. In 1989, harvesting began in the watershed during the week of October 16, 1989. The cropping calendar varies by year depending on the rainfall pattern.

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[2] Field is defined as contiguous land under household's control.

[3] These field sizes should not be equated with total farm size since some households have land outside the watershed which was not measured. Average farm sizes for two slightly more northern Zarma villages in 1982-1985 were found to be 10.1 and 15.3 ha (McIntire, Hopkins, Lamers, Fussel, 1989).

Table 4. Size of total area and cultivated area household, 1989

Size of area	Total area (n=53 hshld) No.	%	Cultivated area (n=44 hshld) No.	%	Fallow area (n=33 hshld*) No.	%
Less than 1 ha	1	1.9	1	2.3	3	9.1
1 - 3.99 ha	9	17.0	13	29.5	14	42.4
4 - 6.99 ha	16	30.2	15	34.1	7	21.2
7 - 9.99 ha	10	18.9	8	18.2	0	0
Over 10 ha	i7	32.1	7	15.9	9	27.3
TOTALS	53	100.0	44	100.0	33	100.0

* represents only households with cultivated/fallow land in 1989

Table 5. Livestock held by watershed cultivators (n = 41 farmers)

	No.	%
Households with no animals	11	26.8
Households with animals	30	73.2
Type of specie owned		
Cattle	15	36.6
Sheep	21	51.2
Goat	25	60.9
Donkey	9	21.9
Camel	1	2.4
Horse	2	4.9

Labor.

Hand cultivation using a long-handled hoe (*hilaire*) features surface rather than deep cultivation. The division of labor by gender is apparent. Field labor is typically done by the males of the household. Work is done first in family fields. Household members then work in individual fields. Zarma women in the region mostly assist in planting and harvesting on common household fields as well as postharvest work. They may cultivate small personal peanut plots and gardens near the compound; interplant sorrel into the main crop, and harvest *sunne* (undeveloped grain heads) and various native plants for home consumption and sale.

Only one farmer had used animal traction but reportedly uses the oxen more for transport. Two have used tractors - one to open new lateritic land near the plateau, another from Niamey who also used hired labor.[4] These two cultivators have the largest cropped areas in the watershed, 16.4 and 15.1 ha, respectively.

By household, field labor ranged from 1 to 7 persons, averaging 2.5 persons. During weeding and harvesting, households may participate in reciprocal labor parties, *bougou*. Food and drink are provided by women. Paid labor is rare. Only three farmers reported hiring labor in 1989. The minimum daily payment is 750 CFA per day, or by the job. During the 1989 harvest, laborers received 50 CFA per *botte*, a bundle of tied millet heads.

Livestock. Nearly three-fourths of the households own livestock, principally mixes of goats, sheep, and cattle (Table 5). Of the 30 households with animals, 60% own one or two species, 33% own three or four types of animals, and 6% own five or six species. Women own small stock as a more secure investment than having land allotted for their temporary use by men.[5]

A few small ruminants, donkeys, and horses are managed on farms by household members. Zarma who own cattle usually entrust them to Fulani herders. Cattle are either managed year-round in the watershed (3 cases) or outside the watershed during the growing season[6] and brought back to the owner's fields after harvest for crop residue grazing and manuring. For resident herds, animals are corralled close to compounds at night and moved to the plateau daily for grazing during the growing season.

Livestock are kept out of the cultivated areas during the cropping season on orders of the chef du canton. They are allowed to graze fallow fields, except those producing economic plants such as *Andropogon gayanus* and *Aristida sieberiana*. After the harvest, animals are given free access to all land. Thorny branches or fencing are used to protect edible material such as mats, granaries, and gardens from scavenging livestock.

Fulani farmers who maintain herds on their farms (two of the four resident Fulani in the watershed) profit from manure during the growing season but must balance labor between cropping and livestock. For these two Fulani, the cropped area is relatively small, 2.7 and 3.8 ha, respectively, but land productivity is relatively high.

All farmers interviewed report fewer livestock in the region since the drought ending in 1984, though numbers are said now to be increasing. Previously, the watershed was used by "etranger" Fulani herders both passing through during the seasonal movement of cattle and while setting up seasonal residences. Today few use the watershed.

Plate 1. A millet-cowpea intercropped field showing good crop establishment during a year with favorable rainfall distribution and reliability. The field received some manure and phosphate amendments.

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[4] Tractor rental available through the Seed Multiplication Center costs $0,000 FCFA per day or 10,000 FCFA per ha. [Dollar equivalent: about $160.00 per day or $40.00/ha. Dollar = 250 CFA]

[5] In two neighboring regions in western Niger, women are reported to won 74% of sheep and 77% of goats with flocks ranging form 1-41 animals; an average flock size of 5.6 animals per woman was found in two villages slightly north of the Project watershed (Taylor-Powell and Okali, 1990).

[6] Farmers reportedly pay 1000 FCFA per animal for the three-month sorjourn.

LAND TENURE

The land tenure system in the IMAW project watershed is based on the settlement history of the region. During the 19th century Zarma pioneers, usually single families, moved into the area establishing rights to virgin land they cleared. Villages gradually grew and holdings expanded until they reached borders of neighboring village land.

Customary Land Rights

Under Zarma land tenure, rights in the watershed rest in the lineage -- a group of people claiming descent from a common ancestor -- of the original Zarma settlers. Land passes from father to sons through patrilineal inheritance. When a son marries and establishes his household, he is allocated a portion of the family land. Through this process land has come under the management of individual household heads (*windi koy*) resulting in the breakup of the original tract.

These household heads have a strong sense of land ownership. Tenure is secure and management decisions are made by the cultivator for as long as the land is used, including fallow periods. The tract, however, belongs to the lineage and is not to be sold. Heads of extended families preside in the decision-making processes concerning the allocation and arbitration of family land. Land not yet inherited and land that has reverted to the family through disuse is under their control. In general women do not hold land, but receive rights to use the land through residence with their husband's family. They are allotted small tracts to use temporarily for their personal peanut crops or household gardens. In cases where a man has no sons, family land may fall to the daughter. Also, a woman may serve as the designated title holder at her husband's death until a son comes of age or in the absence of a husband or son.

Today all land in the watershed is claimed by 41 families originating from the early settlers (Table 6). Cultivable land is being farmed by 56 cultivators, 32, or 57%, of whom are farming family land. Six, or 15%, are nonresident landowners. Holdings are marked by trees or unweeded borders.

Table 6. Number of family land holdings and cultivators by village territory in the watershed

Village territory	Claimants #	Claimants %	Cultivators #	Cultivators %
Hamdallaye	7	17	9	16
Bokotchili Kaina	18*	44	23	41
Falanke Kaina	13	32	21	38
Falanke Beri	3	7	3	5
TOTAL	41	100	56	100

* Three of these claimants do not actually live in Bokotchili Kaina but in the villages of Binni Bokotchili, Fandougou and Bokotchili Beri.

Some expansion of the cultivated area has occurred in the past decade on marginal land near the plateau. One field, opened up in 1988, is situated on land previously used as a cattle marketing route and over which ownership is uncertain. The current farmer sees no problems in retaining land use rights as long as he cultivates the land. Once fallowed, however, it is felt that landowners of bordering fields will claim it.

Land on the plateau is said to be common land. It is unsuitable for cultivation but serves as a source of fuel, construction wood, and fodder. Farmers say if plateau land were made productive it would be claimed by bordering landowners. Unused land is not thought of as being vacant, available, or unclaimed. Except for these two recently opened-up fields, all other land in the watershed has passed through a succession of users.

Land Agreements

Besides inheritance, the principal way to acquire land is by loan. Forty-three percent of watershed farmers crop on borrowed land. Of these 24 farmers, 15 are landless, having moved into the area without original family claims. Nine have family land in the area but have sought a borrowed field in the watershed because of "insufficient family." "Insufficient" can refer to the quantity of the family land is insufficient to meet their production needs.

A borrower and a land proprietor usually reach a verbal agreement providing access to the land. There are no time periods. The understanding is that the borrower will use the land until the "field becomes too old and difficult to cultivate," at which point land is fallowed and the ownership reverts to the lending family. The borrower may then acquire another field from the same family, negotiate with another family, or subdivide the field into a rotation fallow system. Borrowing land entitles the cultivator to the field's harvest, including crop residues. But it does not ensure longterm rights. Thus, a borrower would not invest in long-term improvements such as digging a well or planting economic trees.

Few instances were reported where a landowner reclaimed land from a borrower. Tenure security of borrowed land appears to exist through established lender-borrower relationships. Several farmers were found acting as subleasers, allowing a third party to use parcels of their borrowed land.

For use of land, the farmer typically gives the lending household head a proportion of the harvest -- reportedly 10% of the yield -- though the amount varies according to their relationship and the crop's yield. No money is paid for land use. Land is not sold. A typical remark is that if one "sells land, the money will soon be gone whereas land lasts forever." In neighboring areas, however, land sales are reported.

The use of borrowed land passes in patrilineal succession to the borrower's sons, allowing use of loaned land to pass through multiple generations. This provides tenure security to nonlandowners. It also results in major land disputes since succeeding users develop a false sense of ownership. To prevent such misunderstandings, formal leases obtained through the chef de canton are being encouraged. If a land dispute occurs that the chef de village cannot settle, the chef de canton convokes knowledgeable elders to clarify the original settlement history.

Land Availability

Actual land availability in the project watershed is unknown. Surplus family land appears to exist in Falanka Kaina, but the elders of Bokotchili claim that village land is limited. Farmers contend land is available for anyone who wants to cultivate it. For example, " All the good, strong workers have left. They've gone elsewhere. They don't want to farm. They want to find work in the cities. All who are left are the old men. So, there is land here for anyone who wants to work." Such perceptions may be typical of the deep-seated belief over much of Africa that land is to be shared (de Wilde, 1967) or be subject to government policies that have encouraged the use of land by anyone willing to farm.[1]

Land availability is not synonymous with accessibility or quality of land. Much of the land in the watershed is distant from the village centers of Hamdallaye and Bokotchili Kaina. Farmers living in Hamdallaye travel 4 to 6 km to their fields. Women are granted small temporary parcels

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[1] Reports from Zinder suggest that this government intervention has resulted in the disruption of the fallow system and promotion of land degradation (Arnould, 1982).

and observations indicate that recent new residents are farming very marginal land.

Access to land is a function of the reputations of the lender and the borrower. Heads of families are known according to their temperament and generosity and are chosen for land negotiations accordingly. Borrowers are expected to be "serious farmers." It is said that land is only loaned to those who "want to work."

Use of Land Resource Base

The watershed serves various users both seasonally and yearly for multiple purposes. One person may own the land and another may farm it and have rights to the crop. Other persons may depend on the same piece of ground for dry season feed or as a seasonal residence.

Nineteen families live in the watershed using land as their residence including huts, gardens, livestock tethering sites, and granaries. A network of paths is used for transporting wood and to get to outlying areas. A livestock route dissects the watershed providing an important avenue for moving livestock to grazing during the cropping season. While actual monitoring of the watershed by its users was beyond the scope of this study, it is clear that land cannot be viewed from a single perspective.

Summary and Conclusions: Implications on Land Use and Management

Forty-one families claim ownership rights to the 500 ha comprising the watershed. Of the 56 farmers, 57% are using family land and 43% are farming on borrowed land. Under customary Zarma land tenure, land is inherited through the patrilineage and comes under the control of modern heads of nuclear households within the lineage. Household heads have a strong sense of land ownership, though the land belongs to the lineage and may not be sold. Women reportedly own no land.

Land holdings are identified with the head of the household using the land. However, nearly two-thirds of the fields are worked by more than one person. Often household members have individual parcels. Access to and tenure over individual plots within the household's holdings need further clarification. The person who cultivates the land is entitled to the harvest, including crop residue and valuable plants. A leaseholder is not permitted to dig a well or invest in improvements that hinge on long-term land rights.

Land must be used in order for the household to maintain possession and the right to transmit it to successive generations -- whether family land or borrowed. When the land becomes exhausted and uneconomic to cultivate, it is fallowed until the same or another cultivator needs it. Through this process most of the land has passed through a succession of different users. Many more farmers have various types of user rights to land and its resources than originally thought. Who uses the land and how and when become important factors in designing a watershed management strategy. Seasonal uses of the land, microenvironmental situations, and multiple users need to be considered.

Animals are typically blamed for promoting land degradation. Yet animals play an important role in the farming system as a source of investment, food, transport and pack, and manure. Monitoring animal use of the watershed during both wet and dry seasons would seem necessary.

Lack of land security is often cited as a major drawback to long-term investments in land improvement. Tenure security appears to exist for borrowers of land through established relationships and long-term leases that allow borrowed land to pass to successive generations. Falloux and Mukendi (1988) contend individual land ownership is an unnecessary prerequisite for encouraging land investments. Depending on the type of land investment, individual leaseholder arrangements and rights to crops may be sufficient. Willingness to invest in land improvements certainly depends on the nature and costs of the particular intervention.

What impact land investments might have on current tenure arrangements in the watershed is uncertain. Borrowers of land may be willing to invest in land improvements, but will landowners then cancel the agreements and reap the benefit of those improvements? Experience elsewhere indicates that as changes take place, land becomes more unequally distributed, both in quantity and quality, resulting in increased socioeconomic differences (Norman et al, 1982). Attention to these issues during program implementation will be necessary.

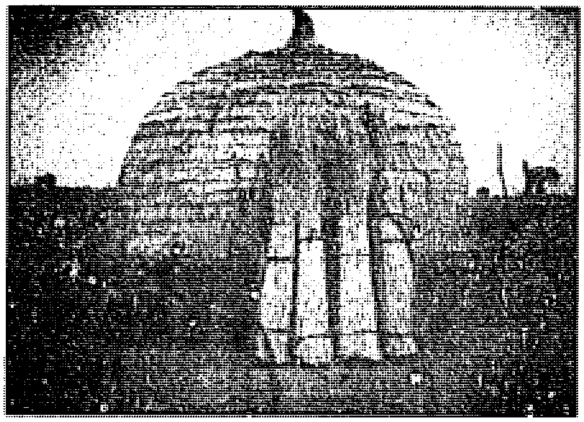

Plate 3. Bundles of *Andropogon gayanus* straw laid against a granary. This grass is used for making mats and as roofing materials.

Plate 2. Vines of cowpea and several native plants are harvested, stored or sold as livestock feed in the dry season.

Most development agencies consider the breaking up of land holdings and land fragmentation a problem in agricultural development. Increasing population pressure, emerging dominance of nuclear family units, and the observance of Malikite law providing inheritance to all sons as opposed to the oldest brother or son are identified with increasing land fragmentation (Dunsmore et al., 1976; Norman et al., 1982). Certainly all these factors are contributing to land fragmentation in the Hamdallaye region, though size of land holdings in the watershed is as diverse as are the differences in resources among households. In general, projects requiring cooperation among neighbors or the consolidation of fields have not met with success. Recognition of a trend from a community-oriented social interdependence to individually oriented economic independence is needed (Norman et al., 1982).

INDIGENOUS KNOWLEDGE AND CLASSIFICATIONS

Research on indigenous knowledge in the IMAW project watershed centered on farmers' understanding and experience about soil management. Interviews clarified local classifications of soils and landscapes and farmer perceptions of problems in order to incorporate and build upon this technical knowledge in designing appropriate soil conservation measures.

Land Types

By their position in the landscape, farmers characterize three major land types:

+ *Gorou* means valley floor or gully, but has various applications. It is also used to refer to gully erosion. Gorou also stands as a general designation for any low-lying land. It can mean the whole drainage basin, the lower portion of a field, or microdepression sites within a field.

+ *Fondu* refers to an upland area. Besides describing the entire region between a valley and a plateau, fondu is used to refer to elevated areas within a field, such as raised mounds of deposited soil or the upslope portion of a field.

+ *Tondo bon* refers to a plateau. In general, a plateau is viewed as nonarable and a communal grazing reserve. *Tondo kakasia* refers to land just below the plateau which is stoney and unproductive. Farmers state that tondo kakasia can be made productive through tractor cultivation.

General land quality is associated with these major topographical divisions. Typically, farmers classify higher elevations as less fertile because of water and nutrient runoff. Land closest to the plateau is considered the poorest in terms of soil structure. Farmers recognize, however, that management practices affect land productivity and they distinguish attributes of particular soils within a topographical sequence. Consequently, farmers tend to associate land quality more with cultivation and fallow practices than by topography. For example, recently cultivated marginal land near the plateau is considered more productive than downslope but older fields.

Field Classification System

The field classification system reflects the importance attributed to cultivation history by farmers:

+ *Sacara* - Land just returned to cultivation after a 1-year fallow

+ *Lalibanda* - First year of cultivation after sacara

+ *Kwarkwari* - Land under cultivation for 3 to 4 years

+ *Blanga* - Land under cultivation for 5 years or more

+ *Farezenou* - Land in fallow

Fields often include parcels of various fallow lengths. Within a single field, a farmer may distinguish a portion as sacara, another portion as lalibanda, and another portion as blanga. Productivity levels are equated with each.

Soil Classifications

Farmers distinguish three dominant soil types by color: *labu biri* as black soil; *labu kware* as white soil, and *labu kirey* as red soil.

Soil color is related to the presence or absence of organic matter, the process of soil erosion, and subsoil character. Black soil contains more organic materials and is considered more fertile. Through cultivation and erosion, valuable nutrients are depleted, leaving less productive white soil. Further degradation results in red soil. Within a class, farmers distinguish gradations in fertility. For example, a soil may be typified as a mixture of black and white.

The second major classification

system for soils is related to texture in three major types: *tassi*, sandy soils; *botogo*, soils with some clay content; and *gangani*, crusted, compacted soils.

Properties used to describe *tassi* soils include light weight, sandy texture, soft, porous, and dry. The botogo soils, in contrast, are said to be darker in color, heavier and retain water. They are described as being strong, more difficult to cultivate, but more fertile. Weeds grow faster in *botogo* soils, which also influences crop choice and its management. Because weeds inhibit growth, millet grown in *botogo* soils must be weeded more carefully than sorghum. Thus, extra labor is required. Also, *botogo* soils are particularly difficult to cultivate when dry, leading, at times, to an undesirable decision of delayed weeding. Small depressions within a field of *botogo* soils are often planted in sorghum or maize.

Within class distinctions are made relative to whether the soil contains some clay, sand, or laterite. Better quality land contains some clay. Soil that is too sandy is considered too light and more susceptible to wind erosion. By contrast, soils with some clay content are heavier and can trap and hold plant debris, leading to buildup in organic matter.

Gangani refers to denuded ground. Farmers typically listed *gangani* as land where plants do not grow. *Gangani* may be found over large areas or as isolated patches of bare earth within a field. Most farmers regenerate small patches of *gangani* found within fields. Over large areas, animal traction or tractor cultivation, along with additions of organic matter such as manure, chaff, and crop residue, are considered necessary to restore productivity.

The water retention capacity of soil is linked to length of cultivation as well as to clay content. Rainfall amounts are not considered critical to yields if fields are newly cultivated. Rain is not considered as much a problem on clayey soils as on sandy soils. In a few cases, farmers described a hardpan layer that restricted the infiltration of water and plant roots.

Farmers use sight and touch to determine the physical properties of soil, paying close attention to the top layer -- the rooting zone for millet and cowpea properties that farmers distinguish are color, organic matter, texture, drainage condition, and depth. Chemical properties seem not to feature in their classifications.

In evaluating soil fertility farmers commonly use the phrases *labu zenou* or *labu farga*, meaning the soil is tired. These soils have been cultivated too long, their fertility depleted. To restore productivity, farmers typically fallow or apply animal manure if possible.

Another phrase used to describe less common soils is *labu sida bani*, meaning the soil is not fertile. Farmers translate this to mean the soil is sick. They observe this condition by looking at millet roots soon after planting. If the new roots do not form and existing roots are dry and black, the soil is sick. Farmers say they are powerlessness to change this condition.

In general, soil types are classified according to topographical location. Low-lying land typically features loamy to clayey soils. Higher land is characterized by sandy soils. However, variability exists within fields. Different intercrop patterns maximize these microenvironments. For instance, sorghum, sorrel, okra, and maize may be grown in small water catchments with heavier textured soils. Sites with higher productivity potential -- areas where animals have been kept and at bonfire and grain pounding sites where litter has accumulated -- are similarly used.

Wind-blown soil forms a natural mound-gully cultivation system. Soil is deposited around plants, debris, and stumps. Also, wind may move soil from one of the field to another, resulting in high productivity on the lee side.

Higher productivity sites within a field are associated with ant (*n'kondo*) and termite (*tcharra*) colonies. Termite casts are considered rich in clay and plant nutrients, while tunnels loosen and mix the soil. During the dry season termites attack crop residues, resulting in decomposition and organic matter enrichment.

Classification of Vegetation

Various indigenous species are valued in the production system. Listed in order of priority in Table 7 are the principal plants and trees and their uses as identified by local farmers.

Plants.

Andropogon gayanus is widely found throughout the watershed. It is used for construction, principally in weaving large mats used in house construction, but an excess in fields lowers millet yields. Farmers contend hardier *andropogon* roots compete with millet, that morning dew on *andropogen* is too humid for millet, and that large plants shade the millet. Surplus *andropogon* is sold, but its income does not exceed that of millet.

Animals are kept from grazing fallow fields producing *Andropogon gayanus* and *Aristida sieberiana*, signifying their importance in the production system. Besides Aristida sieberiana, farmers use two other similar grasses in thatching roofs. *Bata-kirey* (*Heteropogon contortus*) is found on the plateau and *bata kwarey* (*Ctenium elegans*) is found in fields.

Trees.

Of the woody species found in the watershed, *kosey (Piliostigma reticulatum)* is given primary importance. Its impact on productivity occurs because its leaves contain nutrients that increase soil fertility and wind-blown soil collects around the base of the plant. The most productive millet occurs on mounds of raised earth at the site of kosey shrubs. *Kosey* rejuvenates land similarly to fallowing, farmers said. *Kokorbey (Combretum glutinosum)* has a similar effect on soil fertility.

Sabara (Guiera senegalensis)[1] is another very common woody specie found on cultivated fields. It grows on the harder, hotter, more lateritic soils closer to the plateau. Different parts of *kosey* and *sabara* are eaten by animals. *Guiera senegalensis* and *Combretum nigricans*[1] are considered good fuel.

On cultivated fields, shrubs are cut twice a year. This practice provides mulch to boost soil fertility and inhibit wide erosion, reduces shade which retards millet growth, and takes advantage of the high nutrient content of young foliage as animal fodder.

Few large trees are found in the watershed. Fruit trees around household compound and villages are few. Lack of water and roaming animals that eat seedlings discourage tree planting. Trees, however, serve to mark field boundaries. Farmers attribute the main benefit of trees to the shade they provide during fieldwork rest periods. The leaves and fruit of some trees are eaten. Higher soil fertility around the *zamturi (Prosopis africana)* is associated with leaf and bark decomposition and manure deposited by animals seeking shade. Nigerien law prohibits cutting trees.

Farmers indicate a preference for *gao (Acacia albida)* and *garbey (Balanites aegyptica)*. *Gao* enhances soil fertility. It is used in traditional medicines, and the fruit and leaves are fed to animals. However, *gao* needs water and is found near waterways but not on upland cultivated land *(fakara)*. *Garbey* also is linked to enhanced soil

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1 Guiera sengalensis, Combretum nigricans and Combretum micranthum are the three principal firewood species sold in Niamey (Hoermans, 1986).

fertility. Its fruit and leaves are used as livestock feed, food for the household, and sale.

Attitudes toward large trees are positive, but there is no custom of planting trees. Misgivings were expressed about small trees in fields because their shade hinders millet growth. A Zarma phrase indicates the importance of clean fields, "Da turi kaina go faro ra haino si kasu gumo," meaning, "If there are small trees in the field the millet will not grow large." The established practice is to cut bushes to make space for millet. In farmers' words, "Millet needs air and sun to grow."

Livestock feed.

Several plants are harvested and stored for animal feed in the dry season. Two are considered to be equal in nutritive value to the cowpea: *fugutu* (*Ipomoea involucrate*) and *kongo zara* (*Merremia tridentata*). *Fugutu* is found in fertile soils, whereas *kongo zara* grows on less productive soils. Only the farmer has the right to harvest these plants, indicating their importance in the production system. They are stored for dry season or sold. A third specie, *kullum* (*Eragrostis tremula*), does not have the same feeding value, and anyone may cut and use it. Branches of two large trees, *zamturi* and *farka hanga* (*Terminalia avicenioides*), are often cut and fed to animals in the dry season.

SOIL AND WATER CONSERVATION PRACTICES

In an uncertain environment where annual crop yields vary greatly, the objective is to secure a reliable food supply. Rather than speaking of changes or yield decreases, farmers view each year as different and unique.

Farmer Perceptions of Factors Determining Crop Production

Farmers consider rainfall the principal factor determining crop production. Low yields in 1989 were linked to late start of the rains, a drought period after planting, and too many rains in late July and early August, impeding grain development.

Early season rains are particularly critical because a rainfall of greater than 20 mm is considered necessary to established a successful crop (Sivakumar et al., 1981). For the Hamdallaye watershed, the first rain fell on June 25, but it was not until July 11 that a single rainfall of over 20 mm was recorded (Table 8). The amount of rainfall was adequate in 1989 but the overall distribution was a problem.

Rainfall/fertility interaction.

Farmers consider rainfall the principal factor determining crop production. In good rainfall years production levels are sufficient regardless of land quality. But under increasingly drier and erratic weather conditions, farmers stressed the combination of poor rainfall and soil fertility for reduced production. Rainfall patterns were considered a particular problem because the "land is old and tired." Soils, they said, were cultivated too long, the soil structure is weak, and rainfall infiltration is low. While farmers consider the start and pattern of rainfall of foremost importance, they appeared increasingly concerned about soil fertility.

Changes in Farming Practices.

Agricultural practices have changed in response to the environmental circumstances affecting the region. Farmers spoke of a seven to eight-month dry season

Table 7. Farmer listing of beneficial plants and trees in the watershed.

Zarma name	Scientific name	Use
	PLANTS	
Subu nya	*Andropogon gayanus*	mats; roofing; leaf sheath fed to animals
Bata	*Aristida sieberiana*	mats; roofing as underneath layer to Andropogon
Borboto	*Pennisetum pedicellatum*	animal feed; can replace Aristida in roofing
Ganda bani	*Cassia mimosoides*	soil fertility; mats; can replace *Aristida* in roofing
Haramdam	*Diheteropogon hagerupii*	animal feed; roofing as underneath layer to *Aristida*
Tutu	*Setaria pallide-Fusca*	animal feed
Fugutu	*Ipomeoa ivolucrate*	animal feed
Kongo zara	*Merremia tridentata*	animal feed
Kullum	*Eragrostis tremula*	animal feed
	TREES	
Kosey	*Piliostigma reticulatum*	bark used for cord; soil fertility; fruit, and new leaf growth as animal fruit
Korkobey	*Combretum glutinosum*	medicine; soil fertility
Darey	*Ziziphus mauritiana*	fruit; leaves as animal feed; thorny branches used to protect mats and granaries from animals
Zamturi	*Prosopis africana*	construction; soil fertility; cut branches for animal feed in late dry season; wood for mortar, daba, etc.
Sabara	*Guiera senegalensis*	medicine; leaves as sheep feed; firewood
Deli-nya	*Combretum nigricans*	firewood; consume and sell fruit
Gao	*Acacia albida*	enhance soil fertility; traditional medicine; fruit and leaves as animal feed
Garbey	*Balanites aegyptiaca*	enhance soil fertility; fruit and leaves as animal feed and human nutrition
Farka hanga	*Terminalia avicenioides*	animal feed

only three months of good rain. Most have in the past when they could count on for months of rain. Today they can depend onabandoned samno, late season millet, because of the shortened rainy season and insufficient soil fertility. Many farmers plant dry, mix varieties and follow varying management strategies to minimize risks.

Fallowing practices have changed because of uncertain yields and increasing pressure on the land. Farmers say fields cannot be left to regenerate while another field is cultivated. Farmers also noted increased wind erosion of valuable topsoil -- causing a change in crop residue management.

Farmers spoke about increased risks in agriculture. In the past they were assured an adequate harvest if a crop was planted. Today, even producing a crop is uncertain. In this setting, farmers were more concerned with minimizing risks, than with maximizing production.

Perceived Agricultural Problems.

Principal production problems expressed by farmers are related to the geoecological changes affecting the region: inadequate and irregular rainfall, low soil fertility, lack of animal manure, limited access to and money to purchase chemical fertilizer, labor shortages due to young men leaving home and the expense of hired labor, wind erosion.

Insect and pest damage were seldom mentioned in discussions of agricultural problems. This may be due to the variability in pest populations related to rainfall conditions. When inspecting fields, farmers quickly pointed to insect damage. In this context, farmers attributed 1989 yield losses to mice, a nocturnal millet beetle, grasshoppers, and various millet-eating worms.

Animal manure and chemical fertilizer were considered the primary means for improving productivity. In general, farmers reported shortages and higher costs of animal manure due to fewer numbers of permanent and nomadic cattle in the region. Changes during 1989 in fertilizer availability and costs appeared to limit its usage.

Farmer Perceptions of Land Degradation

Farmers refer to land degradation as the decreased production potential of the land. Most commonly, degradation was attributed to a loss of vegetation and an increase in wind. Declining land productivity was viewed as a self-perpetuating phenomenon over which farmers expressed little control. Decreased vegetation resulted in the loss of fertile topsoil and its capacity to support vegetation. Farmers attributed loss of vegetation to general climatic changes, the severe drought that ended in 1974, increased cultivation where more land is under the hoe, and shorter fallow periods. They also spoke of changes in the composition of plant species.

Farmers note an increase in the frequency and velocity of the dry season wind. These winds carry away topsoil, leaving unproductive gangani, literally meaning bare earth. Farmers further complained of millet damage when wind-blown soil buries seedlings. Farmers plant seeds amid millet residue to protect germinating seedlings.

Water erosion was seldom mentioned as a problem by farmers. Wind erosion emerged as a larger concern because all farmers fear its potential damaging effects. Water erosion, in contrast, depends on the location and slope of fields and is considered less severe. A representative comment: "Even with water on the field you can still get some harvest, but with wind damage you won't get anything." There appear to be differences in the ability to combat wind and water erosion. More techniques are used to control wind erosion. In contrast, farmers expressed an inability to combat water erosion.

Soil Management Practices

Fallowing.

Fallowing continues to be the principal management practice to restore soil productivity.

About half of the watershed was in

Figure 3

LANDUSE MAP

IMAW-Hamdallaye

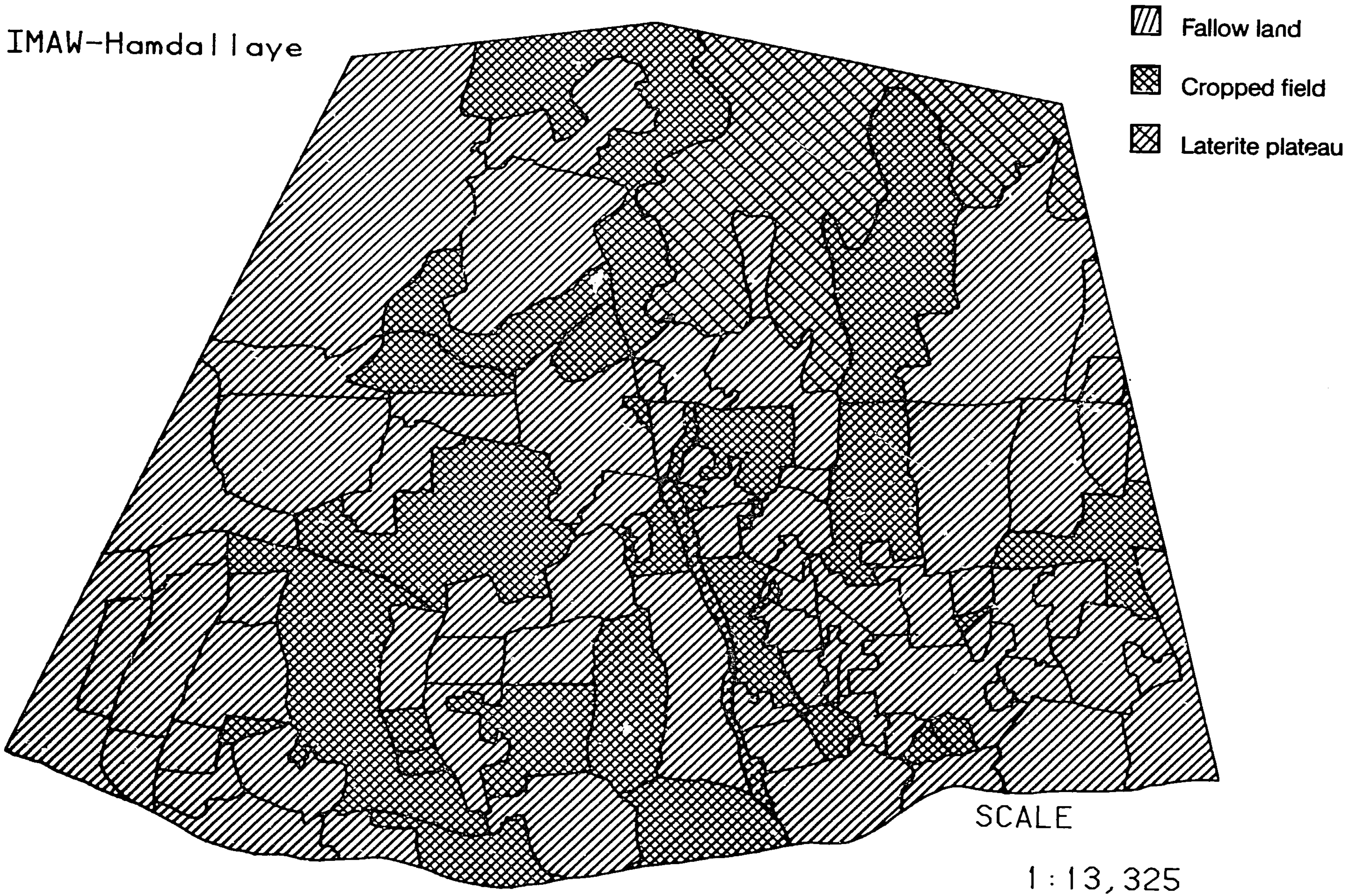

Table 8. Summary of rainfall data in the Hamdallaye Watershed for 1989 and 1990

	1989	1990
Date first rain	June 25	May 29
Date last rain	Oct. 6	Sept. 20
Total rainfall (mm)	402.4	390.1
Average rainfall/rain event (mm)	14.9	15.6
Range in rainfall (mm)	1.2-69.9	0.5-55.0
Total rainfalls	27	25
Rainfalls of 1-10 mm	14	14
Rainfalls of 11 - 20 mm	6	5
Rainfalls of 21 mm and over	7	6

Source: TropSoils data averaged for 8 rain gauges field.

Table 9. Fallow practices on fields currently under cultivation (n = 40 farmers)

	Number	Percent
Full Field fallow		
Fallowed within past 1-5 years	15	37.5
Fallowed within past 6-10 years	4	10.0
Fallowed over 10 years ago	7	17.5
Within field fallow	14	35.0
TOTAL	40	100.0

fallow during the 1989 cultivati n season (Fig. 3). The traditional practic of a long bush fallow, however, is breaki g down. Farmers reported that former fallow periods, generally 10 years or more, now do not exceed 3-5 years on land that is owned. On borrowed land, the fallow period is only 2 to 3 years. Otherwise, the land is considered unneeded and the owner loans it to someone else. One exception to short-term fallowing is a 24.3 ha block of land that has been in fallow for 10 years. The landowner reportedly refuses to loan this land, contrary to the custom. This may be a reaction to a 1975 presidential decree giving individuals who can establish they have farmed a piece of land secure access to it as long as it is farmed. Thus, landowners may be unwilling to loan land for fear of losing it. Organization of fallowing among farmers in the watershed is varied (Table 9):

Full-field fallow.

Land productivity declines to a point that further cultivation is uneconomic. The entire field is left fallow. The usual fallow interval is 2 to 5 years. Approximately 65%

of the interviewed farmers indicated that entire fields had been left in fallow. Leaving a whole field in fallow implies having access to another field to crop during the period. Fifty-seven percent of the farmers had more than one.

With-in field fallow.

Least productive areas within a field are fallowed. The remaining land is cultivated. With-in field fallowing implies having sufficient contiguous land to move cultivated areas around within the field. In this manner, a field can be composed of several parcels of varying fallow lengths. Usually the fallow interval is 2 to 3 years. Thirty-five percent of the farmers practice with-in field fallowing.

Emergency fallow.

A field or portion of a field may also be fallowed due to the illness of the farmers, lack of labor, or other circumstances that delay planting. Two farmers reported unintentional fallows in 1989 due to lack of labor.

Seven farmers reported no fallow practice. Cultivation periods ranged from 10 to 50 years with an average of 23 years. It is assumed some form of land regeneration management is practiced to sustain productivity. Three farmers, for example, use substantial amounts of manure. If the field or parts of it are uneconomic, it is left fallow. Farmers said that due to overall soil degradation, land takes longer to regenerate. They contend that the second year after a fallow is the most productive.

A common practice among Bokotchili farmers is a 3-year fallow followed by a 7-year cropping period. Farmers consistently said that a minimum 3-year fallow is necessary to regenerate soil productivity, but this may be shortened depending on how the rainy season unfolds. Late rains in 1989 brought fields back into cultivation prematurely. Soil characteristics, state of the land when fallowed, rainfall, family needs, and resource availability interact in determining actual crop and fallow intervals.

Another fairly common practice is to seed all land. Fields or portions of fields may be later abandoned if labor is unavailable to weed or if the chance of obtaining a harvest becomes low due to poor rainfall. Also, seeding all land is a way to spread out risks. Farmers evaluate fields and concentrate labor where it is likely to be most cost effective. Another reason for planting all land is to show use to preclude others from using it. Pressures exist to loan fallow land to family or outsiders. Land must be used in order to maintain land rights. At least 25% of the farmers in the watershed seeded entire fields but did not weed all or portions of those fields. Such land is called a "disguised fallow" (McIntire, et al., 1989) and does not benefit from being used.

Use of Animal Manure.

Farmers believe -- that if they have animals then crop production can be sustained. One Fulani, verbalized the importance of livestock to farming by saying, "*Bankan gonda kurgne* in *ganda ban kan sinda kurgne manta a fo*," meaning that the woman who has a husband and she who does not are not the same.

Animal manure is preferred to chemical fertilizer because it is said to last from 5 to 10 years, depending on the amount and type applied (goat, sheep, cattle or donkey), soil type, method of application (kraaling or hauling manure from the compound to field), and whether it is the rainy or the dry season. Eleven of 39 (28%) farmers with cropped fields reported applying animal manure during 1989, principally by kraaling animals on crop land (Table 10).

Manure application through kraaling is said to last up to 10 years as opposed to a 3-year impact on fertility with transported manure. Wet season kraaling is considered more effective because the rain leads to better infiltration of manure and urine.

Table 10. Methods of manure application for 11 farmers, 1989

	Number	Percent
Kraaling		
Wet season	4	36.4
Dry season	10	90.0
Transport	3	27.3

Often, however, animals are not available for wet season kraaling. Zarma typically entrust their cattle to Fulani herders. Cattle may be moved out of the watershed for the entire cropping season, returning to graze crop residues after the harvest. If cattle are kept close to cropped area and are available for wet season kraaling, (such was the case with 3 Fulani-managed herds during the 1989 cultivation season), it is the Fulani manager who reaps the benefit of the manure during the nighttime kraaling close to the compound.

Soil fertility from manure droppings during crop residue grazing is considered insignificant. Animals must be kraaled or significant amounts of manure must be hauled and spread to obtain an increase in productivity, farmers said. Often sites where donkeys and goats are tethered are planted to crops such as okra, lama, and sorrel, which require high levels of fertility. Fifteen of the interviewed farmers (37%) own cattle but the amount of available manure was not known. Several circumstances appear to limit the use of manure in sustaining land productivity. First, fewer livestock are found in the region since the droughts of the past two decades, although numbers are now said to be increasing. There has also been a reduction in transhumant herds using the watershed on a seasonal basis. In the past, Fulani herds would rest for several nights on farmers' fields or were available for longer kraaling. Second, farmers consider the costs of manuring to be high. Fulani reportedly receive a daily payment in grain -- a precious commodity for many farmers -- or 7,500-10,000 CFA a month, depending upon herd size. During the 1989-90 dry season, one farmers reported paying 2,500 CFA for each 10 days of kraaling. Third. it is generally said that Fulani are available to work as herders, but few own their own animals.

Thus, to ensure a reliable manure supply, farmers need to own their own animals, but are handicapped by lack of money and livestock feed.

Use of Fertilizer.

Nearly 60% of the farmers interviewed have used fertilizer (Table 11). Half discontinued use in 1989, apparently because of changes in terms and availability of credit.

Reported usage ranged from one 50 kg bag of either triple superphosphate or urea to 20 bags of phosphate and 14 bags of urea by one Niamey-based businessman (Table 12). Overall, fertilizer application rates were minimal compared to the total cultivated area per household. Timing of applications also varied depending upon when farmers obtained their supplies. In four cases, fertilizer was reserved strictly for crops of improved cowpea, TN578.

Use of Compound and Refuse Accumulation Sites.

Fulani living in the watershed move their family compounds within their designated land areas up to three times a year to take advantage of accumulated household

Table 11. Fertilizer use among 39 farmers, 1989

	Number	Percent
Used fertilizer		
in 1989	2	30.7
in previous year	11	28.2
Never used fertilizer	16	41.0
TOTAL	39	99.9

Table 12. Fertilizer use by 12 farmers, 1989

Fertilizer type/ amount (50 kilo bags)	Number of farmers
1 TSP	1
1 Urea	2
1 TSP and 1 Urea	4
2 TSP and 1 Urea	1
2 TSP and 2 Urea	2
4 Urea	1
20 TSP and 14 Urea	1
TOTAL	12

and animal refuse in improving land productivity. Relocation sites are purposefully chosen where fertility amendments are most needed. Three Zarma farmers who reside on their fields (as opposed to living in a village settlement) also move their compounds at least once a year to fertilize cropland.

Another practice to improve fertility is to cultivate sites previously used for pounding grain into meal. Some farmers burn accumulated grain refuse, which is thought to produce a particularly fertile area. Typically these sites are in the shade or on gangani where millet is dried. Reportedly, men may ask their wives to pound grain at the site of a particular *gangani* they want to restore.

Crop Residue Management.

Farmers report they have changed crop residue management over the last 10 years because of wind erosion. Previously, unused crop residue and debris was gathered and burned on the field. Now, crop residues and small bushes are left on the field. Said one farmer, "Before there were many trees. Now the wind carries the soil away. It is better to leave the stalks on the field to save the soil."

Grain heads and forages (cowpea and native species) are harvested as well as selected millet stalks which are used as construction material in building granaries, sun shelters and other enclosures. Reportedly, however, farmers in the watershed do not sell millet residue except in years when grazing resources are severely limited.

Crop residue remaining in the field after harvest is left standing for animals to graze. A general order from the canton chief (at the end of November 1989) grants livestock free access to cultivated areas. "Now the land is like the bush and animals can go anywhere," one farmer said. Animals strip the millet of edible leaf and sheath. The remaining stalk serves as a windbreak and holds the soil.

Thorny branches or wire fencing are used to protect mat enclosures, granaries, manioc gardens, seedlings, etc., from free-roaming livestock.[1]

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[1] In more southern locales where residue biomass is high and competition exists for access to crop residues, elaboarte herder-cultivator negotiations and systems of payments have evolved (Powell and Taylor-Powell, 1984; and Perrier, 1984).

Crop residue is returned to the fields in late December through January after crop residue grazing or in April during land preparation. This latter practice involves uprooting dead millet plants using a long-handled tool, called a some. The stalks are laid on the field, sometimes on gangani, to rebuild eroded soil.

Whether farmers uproot millet during the December-January period or later in April depends on their willingness to continue field work after the harvest and whether labor is available during the dry season. Uprooting millet after grazing is onsidered beneficial because the stalks attract termites, decompose over the dry season, and trap wind-blown soil. In addition to soil enrichment, uprooting millet prevents injury during weeding when the hoe could catch embedded roots. It also destroys insects that otherwise might live through the dry season in roots under the ground.

Mulching.

Mulching is practiced principally to build up eroded soils and to cut down on wind erosion. Various crop, plant, and household residues are used as mulch, including branches of native shrubs, kosey, korkobey, and sabara; millet stalks; refuse from old granaries; roof thatching from dismantled homes; fallen tree limbs, and cut grasses.

Typically, native shrubs are trimmed twice a year and used as mulch between December (after harvest) and April (before planting) and at the time of the second millet weeding. The last trimming provides space and sunlight for the millet.

Mulching materials may be distributed over fields or placed on severely eroded areas to trap wind-blown soil. This practice provides an adequate soil depth for plant growth without having to break up the lateritic crust. Mulch also is placed on the windward side of a field to cut down on wind erosion.

Other Soil Management Practices.

Other soil conservation measures are practiced on a more limited scale. For example, weeding operations may be suspended on unproductive areas to establish plant cover and trap wind- blown soil. Women may break up crusted patches of wind-eroded land, which, with additions of millet mulch and manure, can be made productive within one year.

Fewer practices exist to prevent water erosion. This is due to the difficulty in making improvements. Grass waterways were seen, but, in general, farmers said there was greater need to clear and cultivate all land for maximum production. A few farmers experimented with blockades made of branches or stones to combat gully erosion, or to keep water from gushing onto cropped area. Success in halting gully erosion is limited because of the high force of the water in comparison to the strength of the blockade. Contour plowing with a tractor is viewed as a way to slow deposits of sand and sheet erosion, but few farmers have resources to hire a tractor. Farmers mentioned dam construction as the only way of combating severe gulley erosion found on the eastern side of the watershed - an alternative not within local farmers' means.

Extent and Control of Erosion

A survey was conducted to measure the extent of wind and water erosional surfaces in 25 fields selected at differing toposequence positions and to ascertain farmer attempts to control the erosion.

Water erosion is associated with run off from the laterite plateau and lateritic outcrops and from large areas of exposed Bt horizons with surface crusts. Gullies are also common, but do not appear to cover a large part of the land surface. Farmers say they are relatively powerless to control water erosion, as runoff from the plateau and adjacent talus slopes will involve erosion control work away from fields and, therefore, is of little interest.

Wind erosion is seen by the gradual loss of the A1 horizon. In extreme cases, it leaves an exposed Bt horizon that is prone to surface crusting, which in turn can form a water erosive surface.

Five types of erosion were distinguished and are referred to by their Zarma names:

1. *Tassi gande*: Surface deposits of alluvial sand fans resulting from a decrease in slope at the end of a gully or rill. There is no growth due to high speed water flow during intense rains, which tends to uproot seedlings or cover them with sand. Generally there is good water balance for crop growth but the soil is sometimes depleted of nutrients and organic matter, depending on the force of flowing water. Farmers state that once millet is established, it grows well in these areas.

2. *Gorou gande*: A surface created by sheet erosion, as evidenced by stratification of the A1 horizon.

3. *Gorou*: The name for gully which results from the concentration of water from crusted or impermeable surfaces, such as those found on the laterite plateau and outcrops. *Gorou* areas are found only in areas with high slopes, and the walls of the valley bottom. As the slope decreases *gorou* become *tassi gande*.

4. *Gangani kware*: White *gangani*, a denuded soil resulting from wind erosion, where part of the surface soil is removed exposing the lower A horizon and sometimes the upper Bt horizon.

5. *Gangani kirey*: Red *gangani*, a denuded soil resulting from water and possibly wind erosion where the surface horizon is completely removed and the Bt horizon is exposed. This is generally crusted and is more difficult to regenerate than gangani kware. These areas may represent sites of old termite mounds, etc.

Of these types of water erosion, *tassi gande* was cited most frequently as a drawback to production because more fields are subject to sand deposits. Also, deep sand on fields is seen as an immediate problem because it limits the cultivated area and buries the crop. In contrast, gully erosion was seen as a long-term problem where "the water eats the field away little by little," thereby reducing the area available for future cultivation.

Results of an aerial survey, however, show that *gangani kirey* comprises the largest erosional surface within the watershed, followed by *tassi gande* (Table 13). However, less than 2% of farmers' fields are affected by *gangani kirey*. About 3.7% of farmers' fields was affected by one of the five types of erosion. Distribution of erosional surfaces was not uniform, as evidenced by the large standard deviations for each type of surface.

Erosion was most prevalent close to the laterite plateau at the upper part of the toposequence and in the valley bottom. However, *gangani kirey* was also associated with shallow soils at the second and third laterite outcrops. Farmers associated *gangani kware* with wind eroded surfaces. However, this surface is not very widely distributed in the watershed (Table 13). *Gangani kirey* may also result in part from wind erosion, so that the combination of the two *gangani* surfaces could indicate that both wind and water erosion contribute to the problems.

Farmer Practices to Control Erosion.

Several native plant species are used by farmers to control wind erosion, primarily on *gangani kware* areas (Table 14). Branches are generally cut twice a year and spread on the eroded surfaces to trap wind-born soil and build up the surface horizon.

Table 13. Frequency and standard deviations of surfaces within the watershed (n=25 fields)

Erosion type	% of field	Std Dev.
Tassi gande	30.73	2.07
Gorou gande	0.50	1.48
Gorou	0.25	0.58
Gangani kware	0.23	0.46
Gangani kirey	1.98	2.73
MEAN	3.69	

Guiera senegalensis is the dominant shrub of the semiarid savannah lands of West Africa, and it is not surprising that it is most used by farmers to control erosion. Both *G. senegalensis* and *Piliostigma reticulatum* grow throughout the watershed, primarily due to their unpalatability to browsing livestock.

Table 14. Native plants used for erosion control (n=25 farmers)

Scientific name	# fields used	% fields used
Guiera senegalensis	12	48
Piliostigma reticulatum	10	40
Combretum glutinosum	6	24
Cassia mimosoides	1	4
Combretum micranthum	1	4

Several other practices are used to control erosion (Table 15). Millet stalks on fields during the dry season are cut and laid on soil surfaces to act as mulches. They trap wind-blown materials. One farmer used millet chaff for this purpose.

Table 15. Different methods of erosion control practiced by local farmers (n=25 farmers)

Method	# fields	% fields
Millet surface mulch:		
stover	4	16
chaff	1	4
Animal manure	2	8
Animal traction	1	4

Two farmers used animal manure exclusively to combat erosion by spreading it on gangani *Kirey* soils to build up the surface. The manures were generally applied to the *gangani kirey* soils. ONe farmer used animal traction to break up the surface crust and loosen *gangani kirey* soil, applying manrue to prevent the crust from reforming.

Summary and Conclusions

Farmers in the watershed view their land as degrading as a result of climatic changes and loss of vegetation. Problems and concerns are most often related to lower soil fertility. Additions of manure and fertilizer are seen as solutions to stabilizing production. Wind erosion causing the loss of topsoil and burial of millet seedlings is considered more of a problem than water erosion. Water erosion that deposits sand on cropping areas and buries the crop is considered more widespread and harmful than gully erosion.

Traditional practices to sustain productivity -- fallowing and manuring -- are breaking down. Fallow periods reportedly have shortened; 3- to 5-year fallows on family land and 2- to 3-year fallows on borrowed land as opposed to 10 years previously. Numerous reasons are believed responsible: (1) cultivation of larger areas to compensate for decreasing land productivity; (2) seeding all land to cut risk of failure and to demonstrate the use of land to keep others from claiming and using it; (3) pressures to loan land so that it is brought back into cultivation prematurely; and (4) the breakup of family holdings leading to more cropping intensity. The supply of manure is limited by a decline in livestock numbers since the recent droughts and the loss of vegetation.

To compensate for these changes and to combat wind erosion, crop residue management has changed over the past decade. Farmers now leave residue on the field to hold the soil. The actual amount of crop residues over the dry season for field recycling, however, is uncertain. Observations during the early 1989-90 dry season suggest that millet roots and lower stalks remain standing in fields. The amount and variety of biomass is great, but often fields most in need of regeneration have little biomass available for agronomic recycling.

Farmers have developed a variety of soil conservation measures based on experimentation and observation. Clear opinions exist concerning the effectiveness and efficiency of installing conservation practices relative to household resources and priorities.

The use of native plant species known and used by farmers hold possibilities for improving land productivity, in particular *kosey, korkobey, sabara*, the forage species of *fugutu, kongo zara*, and the highly-valued cowpea.

No history of planting woody species exists given the problems of water supplies and grazing competition for seedlings. Some interest is expressed in trees, especially those requiring little water, to combat wind and water erosion. Possibilities exist for agroforestry programs that do not compete with land needs for growing subsistence food crops. Under temporary land rights, leaseholders cannot plant trees of economic value since they convey claims to land ownership.

Given the amount of land in fallow and the value attributed to fallowing, the watershed would seem a prime location for undertaking fallow regeneration techniques. The major drawbacks will be the current dry season grazing practice of free access to all land and competing labor priorities. However, there is some precedence in restraining animals from productive land, for example, cultivated fields and wet season fallows producing *Andropogon gayanus* and *Aristida sieberiana*. Also, farmers are acutely aware that the loss of vegetative cover is the cause of land degradation, so would value multi-purpose ground cover.

.te 4. A typical dust storm in the Sahel. Farmers perceive that wind erosion is a major constraint for crop production.

SUMMARY COMMENTS AND IMPLICATIONS

Farmers in the watershed are resilient and adaptable in responding to agroecological changes. They experiment in various ways to lessen the risk of crop failure by using multiple planting dates, mixing seed varieties, using favorable microenvironments, priority weeding, using soil restoration techniques, and controlling wind erosion by mulching with crop residues and native woody species.

Unfavorable rainfall patterns and declining soil fertility are considered the primary drawbacks to crop production. Farmers typically describe their land as "old and tired." Fallowing and use of manure continue to be the principal means of sustaining land productivity. However, fallow periods have gone from 10 years down to 2- to 5-year periods, depending on tenure security. Pressure to use land to maintain land rights discourages fallowing. Manure availability is limited because of a decline in livestock numbers and less fodder because of recent droughts. Animals are important in the production system -- for manure, transportation, and food -- so improvements in forage to provide a soil cover and as animal feed hold possibilities. Native plant species currently valued include cowpea, fugutu, and kongo zara.

Nearly half of the farmers are cropping on borrowed land. A certain degree of tenure security appears to exist through established lender-borrower relationships, and the custom of passing borrowed land to sons. As land becomes scarcer and values increase, however, it is likely these customary laws will change. Encouragement to obtain formal leases indicates change underway. Currently, leaseholders do not invest in improvements that rely on longterm land rights.

The watershed operates on a land system where a mixture of tenures exists, depending on the use of the land (cropping, fallow, or grazing) and the user (household, individual farmers - men or women). Farmers have exclusive use of their cropped fields, including various native species and crop residues. Grazing land on the plateau is considered communal, as is arable land within the watershed after harvest. Tenure rules related to fallow land vary, depending on the season and whether the user is the landowner or borrower. These multiple tenure arrangements need to be considered in watershed project design and implementation. Likewise, it will be important to recognize that land in the watershed falls under the jurisdiction of four villages which certainly will add complexity to issues of resource management and cooperation.

Subsistence economy households have short time views. Water erosion is not seen by farmers to be a major problem. A far more widespread concern is the loss of topsoil by wind erosion. Farmers see problems in terms of individual households and threats to their subsistence as opposed to community concerns or the long-term consequences of land degradation. They will participate in land conservation work when it is profitable from a labor standpoint and does not compete with subsistence food grain needs. The size of the land holdings and its quality vary greatly in the watershed, as does the ability of households to acquire and allocate other resources.

This research does not fully capture the diversity and complexity of these rural households. Information being collected in the region by the International Food Policy Research Institute of Washington, D.C., and the International Crops Research Institute for the Semi-Arid Tropics near Hyderabad, India, will contibute to the current understanding of Nigerien peasant economies and the effect household and production economies have on farmer decision making.

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