

Introduction

Mali is primarily an agro-pastoral country. National livestock numbers around 8 million cows, 22 million sheep and goats, 0.7 million camels, 0.07 million pigs. Despite this high production potential, herding does not meet expectations, as it does not satisfy food needs or aspirations for wealth creation.

This is due in part to poorly adapted production techniques and the poor organization of the producers. Herding relies on the use of natural pastures which are subject to climate changes and to the mismanagement of natural resources (brush fires, over-exploitation of resources, etc). Inappropriate production techniques (poor hygiene conditions, lack of supplements in most systems) and the weak gene pool of local breeds compound these issues.

In an effort to improve the herding productivity and the producers' revenue, IER, Texas A&M and Syracuse University, with financial support from USAID, have identified the research project Mali Livestock Pastoralist Initiative (MLPI).

This project proposes to bring appropriate solutions through study cases of the producers' organizations, production techniques and information management between producers themselves and between producers and businesses in different markets.

The goal of the project is to improve the productivity of herding and the revenue of producers. Specifically, it aims to reinforce the capacity of the actors and improve their access to improved production and commercialization technologies and information. Two grand hypotheses underpin the research activities:

- the existence of an appropriate management system has economic benefits for herders
- The existence of an appropriate management system has positive impacts on the environment.

This report presents the results of the studies carried out by the project on the livestock feeding systems. It has three chapters: the first discusses the methodology of the research, chapter 2 discusses the results and chapter 3 draws general conclusions about the study. These three chapters are presented below.

1. Methodology

1.1 Design of the collection plan

The study was conducted in several circles of the administrative regions of Mopti (Mopti, Djenné and Koro), Tombouctou (Goundam and Gourma Rharous) and Gao (Gao and Ansongo). The collection information chart used in the three regions is presented in Table 1.

Table 1 : Information collection chart for the study area

Regions	Circles	Communes	Villages	Observers
Mopti	3 (Mopti, Koro, Djenné (Sofara))	2-3	2-3	3
Tombouctou	2 (Niafunké et Gourma Rharous (Gossi))	2-3	2-3	2
Gao	2 (Ansongo et Gao)	2-3	2-3	2
Total				7

In the circles, the communes and villages were chosen based on the existence of a livestock market and the relative accessibility and security of the sites. The communes and villages chosen for the studies are given in Table 2 to 4.

Table 2 : Data collection chart for the Tombouctou region.

Circles	Communes	Villages/neighborhoods	Observers	Observer Base
Goundam	Tonka	Tonka	1	Tonka
		Atta		
		Guindigatta		
Gourma Rharous	Gossi	Gossi	1	Gossi
		Foulanes Gossi		
		Kel alhorma		

Table 3 : Data collection chart for the Mopti region

Circles	Communes	Villages/neighborhoods	Observers	Observer Base
Mopti	Fatoma	Fatoma,	1	Fatoma
		Niacoungo		
	Kona	Konna, ,		
		Konza		
		Sendégué		
	Mopti	Sévaré, Komoguel, Bargondaga		
Koro	Koro	Koro	1	Koro

		Dougouténé		
		Kenewé		
	Madougou	Madougou		
		Naye peul		
		Pourali		
Djenné	Sofara	Sofara	1	Madiama
		Kombaka		
	Madiama	Madiama		
		Nerekoro		
	Djenné	Djénné		
		Syn		

Table 4 : Data collection chart for the Gao region

Circle	Communes	Villages/neighborhood	Observers	Observer Base
Ansongo	Bara	Bara	1	Ansongo
		Tabango		
	Ansongo	Monzonga		
Gao	Soni Ali Ber	Magnadoué	1	Gao
		Forgho		
	Gao - urban	Gao		
		Bilalikoira		

1.2 Data Collection

The data was collected between August 2009 and June 2010. Two techniques were used:

- Collection of existing data : using data and maps available at IER and at regional government offices
- Interviews with agropastoralists at the commune levels. Four study forms were used for this.

1.3 Materials and collection tools

We used the following material and tools to accomplish the task:

- a data collection sheet on the livestock feed sources
- a data collection sheet on the production and processing of the fodder
- A data collection sheet on land use
- a data collection sheet on natural resource management
- a GPS
- a motorcycle

1.4 Data processing and analysis

The study data was first analyzed manually for quality control. It was then analyzed with SPSS using descriptive statistics. Analysis was done on three levels:

- At the communal level
- At the circle level for a comparative needs analysis

- At the regional level to compare regions in relation to their specific characteristics. The methodology used permitted us to come to the following conclusions.

2 Results

2.1 Site location

The study was conducted in several circles of the regions of Mopti (Mopti, Djenné and Koro), Tombouctou (Goundam and Gourma Rharous) and Gao (Gao and Ansongo). The collection information schema used in the three regions is presented in Table 1.

Table 2 : Data collection chart for the Mopti region

Circles	Communes	Villages/neighborhoods	Observers	Observer Base
Mopti	Fatoma	Fatoma,	1	Fatoma
		Niacoungo		
	Kona	Konna, ,		
		Konza		
		Sendégué		
	Mopti	Sévaré,Komoguel, Bargondaga		
Koro	Koro	Koro	1	Koro
		Dougouténé		
		Kenewé		
	Madougou	Madougou		
		Naye peul		
		Pourali		
Djenné	Sofara	Sofara	1	Madiama
		Kombaka		
	Madiama	Madiama		
		Nerekoro		
	Djenné	Djenné		
		Syn		

Table 3 : Collection Chart for the Tombouctou region

Circles	Communes	Villages/neighborhoods	Observers	Observer Base
Goundam	Tonka	Tonka	1	Tonka
		Atta		
		Guindigatta		
Gourma Rharous	Gossi	Gossi	1	Gossi
		Foulanes Gossi		
		Kel alhorma		

Table 4 : Collection chart for the Gao region

Circle	Communes	Villages/neighborhood	Observers	Observer Base
Ansongo	Bara	Bara	1	Ansongo
		Tabango		
	Ansongo	Monzonga		
		Ansongo		
Gao	Soni Ali Ber	Magnadoué	1	Gao
		Forgho		
	Gao urbaine	Gao		
		Bilalikoira		

2.2 Sources of livestock feed

In the study area, the livestock feed comes from various sources:

- Les parcours naturels exondés (herbacés et ligneux) ;
- The upland rangeland (herbaceous/grassy and woody)
- The flooded rangeland
- Fields and fallows
- Crop residue
- Supplements (forage plants, ABH, agriculture by-products)

These sources will be explained below.

2.2.1 The upland rangelands

For all the types of animals encountered in the upland rangeland (cattle, goats/sheep, camels, etc...) the natural tract is the principal source of food. According to various sources (Boudet G, 1972. ; Wilson R Trévior ,1983.), about 90% of the material consumed by the livestock comes from the rangeland that is made up of two elements: a herbaceous layer dominated by annuals, principally grasses and sparse woody plants of varied height and phenology (Hiernaux et col 2005).

The floral diversity is between 15 and 30 species, which is poor with often less than 5 species observed per m². (Bille JC.,1977).

The exclusive use of the natural rangelands at the beginning of the rainy season was noted in two circles: Goundam (17% of respondents) and Koro according to 33% of respondents (Table 5). In the middle of rainy season, because of the abundance and quality of the fodder, the livestock get essential nutrients from the natural pastures; this feed source was noted in the circles of Djenné (37.5% of respondents), Goundam (16.7% of rspondents) and in Gourma Rharous (37.5% of respondents). The exclusive use of the natural rangeland during the entire season was noted only in the circles of Gao and Goundam.

Table 5 : Period of use of the natural upland rangeland by livestock

Circle	Beginning Rainy season (RS) (% R)	Middle RS (% R)	End RS (% R)	Beg. Dry Season (% R)	End Dry Season (% R)	All year (% R)	Begin. RS/End DS (% R)	Begin/Mid/End RS (% R)	Respondent Total (%)
Djenné		37,5	37,5	25,0					100,0
Gao						33,3	33,3	33,3	100,0
Goundam	16,7		16,7	16,7	16,7	33,3			100,0
Gourma Rharous		50,0	37,5	12,5					100,0
Ansongo		100,0							100,0
Koro	33,3	66,7							100,0
Total	6,5	38,7	22,6	12,9	3,2	9,7	3,2	3,2	100,0

Nb : (% R)= percentage of respondents ; RS= Rainy Season ; DS = Dry Season ;

The use period and the role played by the two parts is different. The herbaceous layer is composed essentially of annual grains with low productivity and of phorbes, with an annual production varying between 1 and 1.5 tons of dry material par hectare (Wilson R Trevor, 1983). During the rainy season, it is the staple food for the

livestock and ensures milk production and appreciable daily weight gain. But its fodder value decreases during the growth season and at the end of the rainy season, it can no longer sustain the livestock who use different grasses rich in nitrogen to complete their rations ((Maïmouna S Dicko et col 2006).

In the dry season, straw is roughage but the livestock's nitrogen needs are fulfilled by eating the woody fodder (leaves and fruits). The woody layer of bushes is made up of several species (*Combretum sp*, *Acacia sp*, *Pterocarpus sp*, etc.) consumed in all areas where it is the main source of nitrogen, minerals and vitamins during the dry season. Its protein content is higher and less variable than that of the grassy fodder (Maïmouna S Dicko et col 2006). The duration of consumption varies from 3 to 12 months (Table 6). The consumption by goats and camels was mentioned by 100% of respondents in Goundam, Gaouma Rharous and Koro circles. For the circle of Ansongo, the same statement was made by 50% of respondents. It has been shown that goats can ingest up to 6.0kgMS/100kg PV per day. The high level of voluntary consumption by goats, especially in the dry season, can be explained by their preference for woody fodder. This fodder is easily accessible because fruits and leaves of certain trees and bushes fall and because certain woody species regrow their leaves.

The duration of consumption of the herbaceous layer by the livestock varies depending on the regions (4 to 8 months depending on the circle). In the circles of Djenné, Goundam, Gourma Rharous and Ansongo, the use of the herbs in less than 6 months, while in Gao and Koro, the livestock stay in the grassy tracts for 8 months of the year.

Table 6 : Length of use (in months) of different parts of the tract

Circle	Grassy	Woody	Flooded rangeland	Fields and fallow	Total
Djenné	4	3	3	3	3
Gao	8	7	4	4	6
Goundam	5	12	.	12	10
Gourma Rarhous	5	7	8	6	6
Ansongo	3	3	2	3	3
Koro	8	12	.	7	9
Group total	5	7	4	6	6

Slight differences are noticed for the same source of food depending on the animal species. For example, in the circle of Djenné bovine consumption of grassy fodder in the upland zone was cited by 33% of respondents as opposed to 40% for the total of animal species. In the Gourma Rharous circle, according to 56% of respondents, livestock consume grassy fodder in the upland zone (Table 7). In Djenné, Gao and Ansongo, the use of the flooded tract is higher than that of Koro, where they don't

use it. As noted in Table 6, the fields and fallow play an important role in the feeding the livestock in all of the circles.

Table 7 : Element used by animal species

Circle		Grassy	Woody	Flooded rangeland	Fields and fallow
Djenné	Bovine/sheep & goats	33,3 %		66,7 %	
	All species	40,0 %	20,0 %		40,0 %
	Group total	37,5 %	12,5 %	25,0 %	25,0 %
Gao	Bovine/sheep & goats			100,0 %	
	All species	42,9 %	28,6 %	14,3 %	14,3 %
	Group total	37,5 %	25,0 %	25,0 %	12,5 %
Goundam	Bovine/sheep & goats	50,0 %			50,0 %
	Sheep & goats/camels		100,0 %		
	Group total	33,3 %	33,3 %		33,3 %
Gourma Rharous	Bovine	55,6 %	11,1 %	22,2 %	11,1 %
	Sheep/goats				100,0 %
	Camels		100,0 %		
	Group total	33,3 %	26,7 %	13,3 %	26,7 %
Ansongo	Bovine/Sheep & goats	50,0 %	50,0 %		
	All species			50,0 %	50,0 %
	Group total	25,0 %	25,0 %	25,0 %	25,0 %
Koro	Sheep & goats/camels		100,0 %		
	All species	50,0 %			50,0 %
	Group total	33,3 %	33,3 %		33,3 %

NB. The percentages in this table and the following tables correspond to the percentage of respondents.

In all the areas there exists a food crisis during the dry season. This begins in March or April and reaches its height in May or June. With the start of the rains it subsides but the available fodder does not cover the needs of the livestock. In Gao and Grouma Rharous only 20 to 25% of respondents state that the food crisis is moderate in March (Table 8 to 13).

Table 8 : Degree of severity of the food crisis in the Gao circle

Month	None	Moderate	Severe
January	100.0 %		
February	100.0 %	25.0 %	
March	75.0 %	41.7 %	
April	58.3 %	8.3%	
May	33.3 %	25.0 %	58.3 %
June	16.7 %	16.7 %	58.3 %

July	50.0 %		33.3 %
August	100.0 %		
September	100.0 %		
October	100.0 %		
November	100.0 %		
December	100.0 %	9.7 %	
Group total	77.8 %		12.5 %

Table 9 : Level of severity of the food crisis in the Djenné circle

Month	None	Moderate	Severe
January	100.0 %		
February	100.0 %		
March	66.7 %		33.3 %
April	33.3 %		66.7 %
May			100.0 %
June			100.0 %
July	66.7 %		33.3 %
August	100.0 %		
September	100.0 %		
October	100.0 %		
November	100.0 %		
December	100.0 %		
Group total	72.2 %		27.8 %

Table 10 : Level of severity of the food crisis in the circle of Gourma Rharous

Month	None	Moderate	Severe
January	100.0 %		
February	100.0 %		
March	100.0 %		
April	60.0 %	20.0 %	20.0 %
May		60.0 %	40.0 %
June		60.0 %	40.0 %
July	40.0 %	40.0 %	20.0 %
August	80.0 %	20.0 %	
September	100.0 %		
October	100.0 %		
November	100.0 %		
December	100.0 %		
Group total	73.3 %	16.7 %	10.0 %

Table 11 : Level of severity of the food crisis in the circle of Goundam

Month	None	Moderate	Severe
January	100.0 %		
February	100.0 %		
March	83.3 %		16.7 %
April	50.0 %		50.0 %
May	66.7 %		33.3 %
June	100.0 %		
July	100.0 %		
August	100.0 %		
September	100.0 %		
October	100.0 %		
November	100.0 %		
December	100.0 %		
Group total	91.7 %		8.3 %

Table 12 : Level of severity of the food crisis in the Ansongo circle

Month	None	Moderate	Severe
January	100.0 %		
February	100.0 %		
March	100.0 %		
April	75.0 %	25.0 %	
May	75.0 %		25.0 %
June	100.0 %		
July	100.0 %		
August	100.0 %		
September	75.0 %	12.5 %	12.5 %
October	100.0 %		
November	87.5 %	12.5 %	
December	87.5 %		12.5 %
Group total	91.7%	4.2%	4.2%

Table 13 : Level of severity of the food crisis in the circle of Koro

Month	None	Moderate	Severe
January	25.0 %	75.0 %	
February	25.0 %	75.0 %	
March	50.0 %	33.3 %	16.7 %
April	41.7 %	8.3 %	50.0 %

May	25.0 %	16.7 %	58.3 %
June	33.3 %	16.7 %	50.0 %
July	33.3 %	50.0 %	16.7 %
August	33.3 %	66.7 %	
September	50.0 %	50.0 %	
October	66.7 %	33.3 %	
November	58.3 %	41.7 %	
December	58.3 %	41.7 %	
Group total	41.7 %	42.4%	16.0%

2.2.2 Naturally flooded rangeland

The consumption of fodder by the livestock in the flooded zone, especially by bovines, was noted in almost all of the circles except Goundam and Kora (table 7). Note that the pastures of the interior delta are not traversable during at least 5 months of the year. During times of high water, flooding prohibits their use which causes an exit of the delta for a long transhumance towards the Sahelian rangeland. It is worth noting that the naturally flooded tracts are only one of the elements of a group of resources that include: the Sahelian tracts, the fossilized alluvial plains to the west and North of Macina, all the way to the depression of Néma in Mauritania; in the east, there are the tracts of plateau of Bandiagara, the plained of Séno and Gourma; and in the south, there are the terroirs of the regions of Ségou, San and Koutiala that have rangeland and fallow, but also an abundance of plants residues and agro-industrial by-products (Hiernaux P, 2005).

Unlike the upland zone, the flooded zone fodder is made up essentially of highly productive perennial grasses with biomass that can exceed 10 tons of dry matter per hectare. The richest tracts, called bourgoutieres, have a production between 20 to 30 tons of dry matter per hectare, which is 10 to 20 times that of a good Sahelian pasture. In this respect, the delta is a unique space in West Africa in that it is the only place in West Africa that has this high of productivity spread over such a large space (Hiernaux P & Diarra L ,1983. Hiernaux P & Diarra L ,1986). These perennial grasses (or sedges) have four biomorphologic types:

- the upright bunchgrass (*Vetiveria nigriflora*, *Andropogon gayanus*, *Eragrostis barteri*, *Hyparrhenia rufa*)
- the grasses with floating stems (*Echinochloa stagnina*, *Voschia cuspidata*, *Brachiaria mutica*)
- the turf grasses (*Cynodon dactylon*, *Sporobolus spicatus*, *Sporobolus helvolus*, *Brachiaria mutica*)
- the rhizome grasses :(*Oriza longistaminata*, *Echinochloa pyramidalis*, *Eleocharis dulcis*, *Eleocharis dulcis*, *Scirpus brachyceras*, et la cypéracée *Cyperus maculatus*).

The length of stay of the livestock is also variable: it is 8 months in Gourma Rharous as opposed to 2 in Ansongo. In Djenné, the use of forage of the flooded zones by the bovines and small ruminants was expressed by 67% of respondents.

2.2.3 The plant residues

The residues from the harvests play an increasingly important role in feeding livestock because of the reduction of pastoral land and expansion of cultivated land. This consumption was noted in all locations. It was summarized in three types of residues: the millet and sorghum stalks, the rice stalks and the tops of cowpeas (table 14 and 16). The rice stalks mixed with the millet hulls was also noted in Ansongo (100% of respondents) and in Djenné (33% of respondents), especially for bovine feed. The millet and sorghum stalks and the rice stalks were given to herded cows, as well as feed and milk cows, while the cowpea stalks were given to small ruminants in Djenné (33%), Goundam (33%) and Koro (100%). They were consumed from December to May. According to 20% of the respondents, the harvest residues were consumed during the entire year in the circle of Gao.

Table 14 : Types of plant residues available in the circles of Djenné and Gao

Circle		Millet/sorghum stalks	Rice stalks	Cowpea stalks	Livestock feed	Hulls	Rice stalks/millet hulls
Djenné	Herding cows	66,7 %					33,3 %
	Feed cows	66,7 %					33,3 %
	Milk cows	33,3 %	33,3 %	33,3 %			33,3 %
	Herding sheep/goats		66,7 %	100,0%			
	Feed sheep/goats			21,4 %			
	Group total	35,7 %	21,4%				21,4 %
Gao	Herded cows		100,0%				
	Feed cows		50,0 %		50,0 %		
	Milk cows		50,0 %		50,0 %	50,0 %	
	Herding sheep/goats		50,0%			50,0%	
	Feed sheep/goats				50,0%	20,0 %	

	Group total		50,0 %		30,0%		
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Table 15 : Types of plant residues available in the circles of Goundam and Ansongo

Circles		Millet/sorghum stalks	Rice stalks	Tops of cowpeas	Livestock feed	Hulls	Rice stalks/millet hulls
Goundam	Herded cows	33,3%	66,7%				
	Feed cows		100,0%				
	Milk cows		100,0%	33,3%			
	Herding sheep/goats		66,7%	33,3%			
	Feed sheep/goats		66,7%				
	Herding camels		100,0%				
	Milk camels		100,0%	9,5%			
	Group totals	4,8%	85,7%				
Ansongo	Herded cows						100,0%
	Feed cows						100,0%
	Milk cows						100,0%
	Herding sheep/goats						100,0%
	Feed sheep/goats						100,0%
	Group total						100,0%

Table 16 : Types of plant residue available in the circle of Koro

	Millet/Sorghum stalks	Rice stalks	Tops of cowpeas	Livestock feed	Hulls	Rice stalks/millet hulls
Herding bovine	100,0%					
Feed bovine	100,0%					
Milk bovine	100,0%		100,0%			
Feed sheep/goats			11,1%			
Group total	88,9%					

2.2.4 Water sources

In the study area, there are various livestock watering sources: dams, pumps, wells, drainage wells, abandoned brick making pits, ponds and streams (Table 17 a, b and c).

In the dry season, livestock watering is done mainly at the river and at wells in the circles of Djenné, Gao and Ansongo. Several ponds were noted as sources especially in Goundam.

In the rainy season, bovine, sheep and goat watering occurs mainly at ponds. The use of pumps/wells or abandoned brick making pits was noted in Goundam. Watering at the river was not noted for bovines.

In the dry season, the river and wells are the primary watering sources for small ruminants.

These water sources are situated at varied distances depending on the circle and the season: between 2 and 40km in the dry season, between 1 and 30km in the rainy season. Generally, they belong to the community.

Table 17a : Water sources for bovine

		Djenné	Gao	Goundam	Gourma Rarhous	Ansongo	Koro
Water sources for bovines in the dry season	Dam			25,0%	40,0%		
	Well	33,3%	66,7%		60,0%		
	Pond			25,0%			
	River	66,7%	33,3%			100,0%	
	Pump/well/brick making pit			50,0%			100,0%
Total		100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
Water source for bovines in the rainy season	Dam			25,0%	25,0%		
	Well				50,0%		
	Pond	100,0%	100,0%	25,0%	25,0%	100,0%	
	Pump/well/brick-making pit			50,0%			100,0%
Total		100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Table 17b : water sources for sheep/goats

		Djenné	Gao	Goundam	Gourma Rarhous	Ansongo	Koro
Water sources for sheep/goats in the dry season	Dam			25,0%			
	Wells	33,3 %	66,7%	25,0%		100,0%	
	Ponds				100,0%		
	River	66,7 %	33,3%				
	Pump/well/brick making pit			50,0%			100,0%
Total		100,0 %	100,0%	100,0%	100,0%	100,0%	100,0%
Source d'eau pour les ovins/caprins en saison des pluies Water sources for sheep/goats in rainy season	Pond	100,0 %	100,0%	33,3%	100,0%	100,0%	
	Pump/well/brick making pit			66,7%			100,0%
Total		100,0 %	100,0%	100,0%	100,0%	100,0%	100,0%

Table 17c. Water sources for camels

		Djenné	Gao	Goundam	Gourma Rarhous	Ansongo	Koro
Water sources for dromedaries in the dry season	Pump	100,0%		25,0%	100,0%		
	Dam			25,0%	100,0%		
	Well		100,0%			100,0%	
	River	100,0%			100,0%		
	Pump/well/brick making pit	100,0%		50,0%	100,0%		100,0%
Total		100,0%	100,0%	100,0%		100,0%	100,0%
Water source for dromedaries in the rainy season	Pond	100,0%	100,0%	33,3%		100,0%	
	Pump/well/brick making pit			66,7%			100,0%
Total		100,0%	100,0%	100,0%		100,0%	100,0%

Certain precautions were taken to preserve the water sources. These include: local management conventions, tree planting, edging, awareness campaigns (table 18). The existence of local management conventions and awareness campaigns were noted in all the circles. On the other hand, tree planting and edging were noted only in the Koro circle.

Table 18 : Preservation acts at water sources

Circle	Local management conventions	Tree planting	Edging	Awareness Campaigns
Djenne				100,0%

Gao				100,0%
Goundam	100,0%			
Gourma Rharous	66,7%			33,3%
Ansongo	75,0%			25,0%
Koro	33,3%	33,3%	33,3%	
Group total	50,0%	13,6%	13,6%	22,7%

According to 100% of respondents, access to these water sources is free. The use of wells for livestock watering was not noted in Gourma Rharous. In Koro, access to pumps was mentioned by 67% of respondents but for 33% of respondents, access is controlled. It appeared in the studies that there are vast tracts of pasture unused by livestock because of the lack of water (25% of respondents). Despite the efforts by some, the water points of pastoral use are still insufficient in numerous rangeland zones. This insufficiency explains the large numbers of livestock around the water sources, which results in degraded areas of the pastures that get larger from year to year, as well as a decrease in productivity of the herds who are obliged to stay in these areas.

2.2.5 Fodder production and processing

The rangeland fodder is the base of the livestock feed. It exists in large quantities during the rainy season. This is not the case in the dry season. In numerous zones, the fodder produced in natural pastures is entirely consumed at the beginning of the dry season because of the surplus of animals. Additionally, certain tracts cannot be used during the dry season for various reasons. To maintain the livestock in the dry season, many agropastoralists produce fodder to feed the livestock (Table 19). The production of fodder was mentioned by 100% of respondents in Goundam, Ansongo and Koro. On the other hand, in Djenné, the percentage is only 33%. It is 80% in Gourma Rharous and 67% in Gao.

:

The species of fodder grown are:

- Fodder sorghum (Gourma Rharous) ;
- Bourgou (Gao, Goundam, Gourma Rharous and Ansongo)
- Cowpeas (Djenné, Gao, Goundam and Koro);
- Peanuts (Djenneé, Goundam and Koro).

Table 19 : Fodder species cultivated in the study zone

Circles	Fodder sorghum	Bourgou	Cowpeas	Peanuts
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Djenné			50,0%	50,0%
Gao		100,0%		
Goundam		37,5%	37,5%	25,0%
Gourma Rarhous	50,0%	25,0%	25,0%	
Ansongo		100,0%		
Koro			50,0%	50,0%
Group total	13,8%	34,5%	31,0%	20,7%

The largest areas were mentioned for fodder especially in Koro: peanuts (6.0ha) and cowpeas (8.67 ha). The sorghum fodder was noted in Gourma Rharous only, as for the bourgou, we note that it was not noted in Djenné, the areas cultivated varied from 1ha in Gourma Rharous to 5ha in Gao.

These fodders are produced in mono-cropping (34% of respondents) or in association with other plants (38% of respondents). For 28% of the agropastoralists surveyed, the production was done at the edges of the fields (Table 20).

Table 20 : Fodder planting system in the study area

Circle	Mono-cropping	With other plants	At the edge of fields
Djenné		50,0 %	50,0 %
Gao	50,0 %		50,0 %
Goundam	37,5 %	37,5 %	25,0 %
Gourma Rarhous	50,0 %	50,0 %	
Ansongo	33,3 %	33,3 %	33,3 %
Koro	42,9 %	42,9 %	14,3 %
Group total	34,4 %	37,5 %	28,1 %

Two storage techniques were used: sun drying and shade drying. The fodder treated as such was stored on porches or sheds, in warehouses, in grain silos or even in houses. In the three regions, the most stocked fodder was: bourgou (31% of respondents), cowpeas (21%) and rice stalks according to 19% of respondents (Table 21).

Table 12 : Preferred fodder species stored by agropastoralists

Circle	Cowpeas	Bourgou	Peanuts	Rice straw	Millet/sorghum stalks	Wild straw
Djenné	27,3 %	27,3 %	27,3 %	18,2 %		
Gao		50,0 %		50,0 %		

Goundam	27,3 %	27,3 %	18,2 %	27,3 %		
Gourma Rarhous	25,0 %	62,5 %			12,5 %	
Ansongo		50,0 %		50,0 %		
Koro	25,0 %		25,0 %		25,0 %	25,0 %
Group total	21,2 %	30,8 %	15,4 %	19,2 %	7,7 %	5,8 %

For 36% of the respondents, the fodder produced is used to “save the animals”. It can be sold (33%), distributed to feed animals (18%) ou serve to feed milk cows (table 22).

Table 22 : Use of fodder species

Circles	Feeding	Saving the animals	Support milk cows	Sale
Gao	28,6 %	28,6 %	28,6 %	14,3 %
Goundam		42,9 %		57,1 %
Gourma Rarhous	14,3 %	28,6 %	28,6 %	28,6 %
Ansongo		66,7 %		33,3 %
Koro	33,3 %	33,3 %		33,3 %
Group total	18,2 %	36,4 %	12,1 %	33,3 %

2.2.6 Hay storage

As mentioned above, in the study areas, there are large unexploited areas because of the lack of water spots. Because the nutritional value of the fodder decreases in the dry season, proper feeding of livestock in the dry season is difficult. To improve the availability of fodder in the dry season, numerous agropastoralists grow their own hay and fodder to store.

Table 23 : Hay storage by agropastoralists

Circles	Yes	No
Djenné	100,0 %	
Gao		100,0 %
Goundam	88,9 %	11,1 %
Gourma Rarhous	100,0 %	
Ansongo	18,8 %	81,3 %
Koro	44,4 %	55,6 %
Group total	60,3 %	39,7 %

In the Djenné and Gourma Rharous circles, hay storage was mentioned by all the respondents, in some circles people don't store hay and among these the largest number was identified in Gao (100%) and Ansongo (81%). In addition to the fodder species cited in the preceding paragraph, the rice stalks and wild straw were mowed and stored to feed livestock. If we consider the entire study zone, 60% of respondents store hay. Only in Gao is this practice not mentioned by the people surveyed.

2.2.7 Supplementing

Nutritional supplementing is practiced in all of the circles with various types of food. The supplements distributed include: wild straw, rice straw, the tops of peanut or cowpea plants, balanzan tree pods, millet and sorghum stalks, bourgou, the hulls of grains, salt and ABH (Table 24). ABH, hulls and salt are cited by the largest number of respondents (19%). Next is bourgou (14%), the tops of peanuts and cowpeas (13%), wild straw (11%) and millet/sorghum stalks (10%). Other supplements were mentioned by less than 10% of respondents. Supplements are either bought (37% of respondents), harvested (16%) or bought/harvested (47%).

Table 24: Supplements distributed by the agropastoralists

Circle	Wild straw	Tops of peanut/cowpea	Animal feed	Millet/sorghum stalks	Balanzan pods	Rice Straw	Bourgou	Hulls/salt
Djenné	18,2 %	18,2 %	9,1 %	18,2 %		9,1 %	9,1 %	18,2 %
Gao			16,7 %			33,3 %	33,3 %	16,7 %
Goundam		27,3 %	27,3 %	9,1 %			27,3 %	9,1 %
Gourma Rarhous		7,1 %	35,7 %		14,3 %		21,4 %	21,4 %
Ansongo	30,0 %		10,0 %	10,0 %		30,0 %	10,0 %	10,0 %
Koro	16,7 %	16,7 %	11,1 %	16,7 %	11,1 %			27,8 %
Group total	11,4 %	12,9 %	18,6 %	10,0 %	5,7 %	8,6 %	14,3 %	18,6 %

2.3 Natural resource management

For this study, natural resource management includes management of: the rangeland, the herds, the water sources, the land and fallows, the salt licks, the conflict zones as well as conflict resolution between different actors. These aspects are presented below.

2.3.1 The natural rangeland

Like all of the Sahel, in the study area, the natural rangeland is the principal source of food for the livestock. It is situated at varying distances which can exceed 40km in several circles (Table 25). According to 100% of respondents, the abundance of grass and the existence of water are the criteria that determine the herder uses to pick the pasture. The lack of water explains why certain rangelands are not used in the dry season. At any given moment, the limit of the pasture area is determined by the distance to food and water. The high variability of rain from year to year polarizes the area. High-traffic livestock areas are usually characterized by a network of water points that allow the surrounding pastures to be used.

Table 25: Location of the pasture areas

Circle	Less than 20 km	Between 20 et 40 km	More than 40 km
Djenné	36,4 %	9,1 %	54,5 %
Gao	37,5 %		62,5 %
Goundam	33,3 %	33,3 %	33,3 %
Gourma Rarhous	26,7 %	53,3 %	20,0 %
Ansongo	50,0 %	50,0 %	
Koro	33,3 %	55,6 %	11,1 %
Group total	36,9 %	36,9 %	26,2 %

According to 37% of respondents, the pasture zones are located less than 20km away. For food, the natural rangelands are used by all types of animals, even those from indigenous or foreign herds (Table 26). Only 12% of respondents mentioned that certain rangelands were used only by foreign herds in Djenné and Goundam.

Table 26: Herd origins for pasture use

Circle	Native	Foreign	Native and Foreign
Djenné	9,1 %	45,5 %	45,5 %
Gao			100,0 %
Goundam	66,7 %	33,3 %	
Gourma Rarhous	100,0 %		
Ansongo	37,5 %		62,5 %
Koro	44,4 %		55,6 %
Group total	47,1 %	11,8 %	41,2 %

Herders take animals to pasture for grazing. This is done during the day, at night or both night and day. Only feed animals are kept in stalls (cows, sheep/goats).

In the circles of Djenné, Gao and Koro, all the herding cows graze night and day. In other circles, only a portion of herding cows graze night and day (Tables 27a and b).

For feed cows, night pasturage was only noted in Gourma Rharous. In other circles, grazing was done day and night, but mainly during the day.

For milk cows, daytime grazing was noted in the circles of Goundam, Gourma Rharous and Ansongo. In other circles, the milk cows grazed night and day.

For the herding sheep and goats, grazing day and night was noted by 100% of respondents in Djenné, Gao and Goundam. In Koro, 100% of those surveyed mentioned daytime grazing.

Only 9.7% of respondents in the entire study area said that the livestock followed the natural rangeland in all periods (Table 5).

In the beginning of the rainy season, very few of the animals live exclusively on natural pastures. On the other hand, in the middle and end of the rainy season, the natural rangeland were the principal source of livestock feed (61% of respondents) because the fodder is widely available and of good quality.

Table 27a. Type of grazing practiced in the circles of Djenné, Gao and Goundam

Circle		Daytime grazing	Night grazing	Night and day grazing
Djenné	Herding cows			100,0 %
	Feed cows	66,7 %		33,3 %
	Milk cows			100,0 %
	Herding sheep/goats			100,0 %
	Feed sheep/goats	33,3 %		66,7 %
	Herding camels			100,0 %
	Milk camels			100,0 %
	Group total	17,6 %		82,4 %
	Gao	Herding cows		
Feed cows				100,0 %
Milk cows		50,0 %		50,0 %
Herding sheep/goats				100,0 %
Feed sheep/goats		100,0 %		
Group total		25,0%		75,0 %
Goundam	Herding cows		33,3 %	66,7 %
	Feed cows	100,0 %		
	Milk cows	100,0 %		
	Herding sheep/goats		33,3 %	66,7 %
	Feed sheep/goats	100,0 %		
	Herding camels		33,3 %	66,7 %
	Milk camels	100,0 %		
Group total	57,1 %	14,3 %	28,6 %	

Table 27b. Type of grazing practiced in the circles of Gourma Rharous, Ansongo and Koro

Circle		Day grazing	Night grazing	Night and day grazing
Gourma Rharous	Herding cows		100,0%	
	Feed cows		100,0%	
	Milk cows	100,0%		
	Group total	33,3%	66,7%	
Ansongo	Herding cows		100,0%	
	Feed cows	100,0%		
	Milk cows	100,0%		
	Herding camels		100,0%	
	Milk camels	100,0%		
Group total	55,6%	44,4%		
Koro	Herding cows			100,0%
	Feed cows			100,0%

	Milk cows			100,0%
	Feed sheep/goats	100,0%		
	Feed sheep/goats	100,0%		
	Group total	30,8%		69,2%

At the end of dry season very few animals live exclusively on natural pastures because they are of poor quality and because they cannot cover the daily needs of the livestock.

2.3.2 The land and fallows

The land is used during at least five years before being left to lay fallow. In certain areas, fields are allowed to lay fallow after 10 years of use (Table 28).

Table 28. Land use time before laying fallow

Circle	5 years	10 years	Over 10 years
Djenné	100,0%		
Goundam		33,3%	66,7%
Ansongo	25,0%	50,0%	25,0%
Koro			100,0%
Group total	30,8%	23,1%	46,2%

This is the case especially in Goundam (67% of respondents), Ansongo (25% of respondents) and Koro (100% of respondents). After use, the land is left to lay fallow for various periods depending on the zone: 5 years in Djenné and Koro for 100% of respondents, 10 years for Ansongo (75% of respondents)

2.3.3 The salt licks

The existence of salt licks was noted in all circles except Djenné and Koro. The studies revealed that the herds access the licks in all periods for all locations except Ansongo, where they go only in rainy season. They stay for no longer than 15 days in the rainy season, but for around 3-5 months throughout the year (Table 29).

Table 29. Length of stay (days) of herds at the salt licks

Circle	All periods			Rainy Season		
	Minimum	Median	Maximum	Minimum	Median	Maximum
Gao	7	7	7	4	4	4
Goundam
Gourma Rarhous	11	100	150	.	.	.

Ansongo	.	.	.	3	9	15
Group total	7	82	150	3	8	15

NB. The studies did not give information on the type of salt licks that exist in the study zone.

The salt lick is an important stage in the movement cycle of nomadic and transhumant herds. It corrects mineral deficiencies, it helps rid the animals of internal parasites because of its laxative effect. Few measures are undertaken to conserve the salt licks or to preserve the pastures in general. The reasons cited for this include the lack of financial means; others think it is not necessary to invest in public goods. But almost all respondents can agree to invest to improve the pastures to help with regeneration and the fight against desertification.

Opinions are divided concerning the advantages linked to pasture management. In Djenné and Goundam, all respondents think that certain management styles have advantages over others. In Gao, Ansongo and Koro, it is the opposite. Only in Gourma Rharous were diverging opinions recorded. It is worth noting that even if the majority of respondents acknowledge that certain management types have a negative effect on the environment, this impact has not been well defined. Studies have not clearly shown how agropastoralists assess the quality of the environment and the rangeland dynamic.

Over 60% of respondents think that fires are accidental, especially on the rangeland dominated by annual species. In Goundam and Gourma Rharous, according to those surveyed, the fires are accidental.

2.3.4 The herds

The animal species raised in the three regions vary. For example, in the Gao region, we find the following species:

- Bovines (Azawack zebu, touareg zebu, Bororo zebu, peul Gelgodji zebu)
- ovines (the big Sahel sheep, the Bali-Bali sheep, the Koundoum breed, the touareg sheep, et the wool sheep from Macina),
- Goats (the Sahelian goat)
- Donkeys (the small grey Algerian donkey)
- Horses
- Camels (the Sahelian variety and the Aïr dromedary)
- and birds (the Gao regional assembly, 2008).

The various livestock management methods are strategies developed to adapt the animal's feeding to the environmental conditions. Travel by the herd depends on the availability of pastures and water points. These trips can be planned with well-

defined itineraries or unplanned. This allows them to take advantage of the rangeland which, in this period, are good quality and free of insects and to allow them to take advantage of the salt licks. Three main management strategies are employed:

- Nomadism, which is the movement of the livestock (cows, sheep, goats, camels, horses and donkeys) by the nomads in search of pastures and water for the animals, often without a pre-defined destination or itinerary.
- Sedentary: the herding activities occur without great mobility, the livestock move around the village fields and comes back to the village in the evening with or without a shepherd.
- Transhumance : the cyclical and seasonable movement of animals under the supervision of shepherds following precise itineraries with the goal of exploiting the pastoral resources of a given territory. Traditional transhumance allows use of the forage potential of the region, the salt licks and ensures the livestock watering in the best conditions.

In the case of transhumance, only the herder or shepherd move with the herd, without the milk cows that stay at the place of permanent habitation. The start of transhumance to the north corresponds with the arrival of the rains to free up the arable land and to avoid flooding. The livestock return at the beginning of the dry season. The sedentary troop management concerns mostly small ruminants who are taken to the fallow fields or unfarmed land by a shepherd to graze or attached to a post to eat the grass around the family concession. In the dry season, grazing prevails.

2.4 Land use

In the three study regions, the studies show that the land is used for pastoral and agro-pastoral activities. Six pasture zones were identified at the time of the study. Grassy non-flooded savannas, grassy savannas of the interior delta, the side of the cliff, the edge of the river and lakes as well as the fallow land were used in different communities.

- In the Koro circle, 67% of respondents said that forests (grassy savannas) were the principal pasture zone whereas for 33% of respondents, the base of the cliff was the principal pasture zone. For 67% of agropastoralists, these zones are slightly far from the village, whereas for 33%, they are very close.
- In the Djenné circle, 75% of respondents said that grazing occurred mostly in the fallows of the commune. For 25% of respondents, the edge of the river and lakes were the principal grazing zone.

- In the Goundam circle, the animals graze along the river and in the lakes. According to 100% of respondents, these zones are relatively close to the villages.
- In Ansongo, 100% of respondents said that grazing happens along the river and lakes whereas in Gourma Rharous, the animals graze in the fallow fields of the commune, which can be far from the villages (50% of respondents).

Opinions differ about the quality of pasture from one zone to the next. In Djenné and Koro, 100% of the agro-pastoralists think that the quality of fodder is the same from one pasture to the next. Those in Goundam and Ansongo think otherwise. In Gourma Rharous, 60% of agro-pastoralists surveyed think that the quality of the fodder differs from one zone to the next, the contrary is noted by 40% of respondents.

The choice of pasture zone is essentially determined by the abundance of fodder and the existence of water (100% of agro-pastoralists surveyed). With the exception of Djenné, there are some unused pastures in the circles. These pastures are not exploited for four main reasons:

- Insecurity (20% of agro-pastoralists surveyed)
- The state of degradation (20% of agropastoralists)
- The extension of agricultural land (35% of agropastoralists)
- The lack of water (25% of agropastoralists)

These reasons also explain the changes in boundary areas of the study, but do not carry the same weight in the circles. In Ansongo, the last two reasons are equally important, but in the Koro circle, the lack of water is noted by only 14% of respondents as opposed to 43% for the extension of the fields. Insecurity was noted only at the circle level in Gourma Rharous.

2.5 Conflict zones

The Sahelian rangelands are expansive and represent the main source of food for livestock. However, the extent of the pasture zones can decline for various reasons, such as: the existence of conflict zones (65% of respondents). There exist problems related to land or planted areas. Problems can occur between herders (21%) around water points for watering animals and or for the use of certain pasture zones. The conflicts between farmers and herders are most frequent (46% of respondents). The causes of these problems stem from damage done in the fields by the movement of the animals, the planting of the pasture area or the transhumance routes. Disputes, sometimes violent, arise between pastoralists in regards to the appropriation or use of pastoral resources (Marie J., 2000). Conflicts were mentioned between farmers (21%) and between herders and fishers (12%). Mediation between actors typically

resolved the dispute, but according to 37% of respondents, the justice system is often needed to resolve the conflict.

Conflict management strategies differ from one circle to another. In Djenné, 100% of respondents say that the conflict management style has not changed while in Goundam, the opposite is noted. In Koro, no strong tendency was observed as the results for each question were 50-50. Resorting to the justice system and the presence of a management and oversight committee contributed to the introduction of new modes of conflict management.

The results of the studies do not clearly demonstrate whether the nature of the conflicts has changed with time. Similarly, little information was collected on the precise location of conflict zones. It seems that the incivility of populations (50%), the excesses of power (17%) and misunderstandings between socio-professional groups (33%) are at the origin of this change.

3 Conclusion

At the end of this study, a certain number of observations can be made :

- in all regions, the forage of the rangelands is the largest sources of livestock feed. Access to pastures is free even for foreign herds. The upland rangeland routes have two parts: one part is herbaceous, mainly grasses and a woody part dominated by Combretaceae and legumes. The biomass of the herbaceous layer varies by region, and in the region, it can vary depending on the plant species. In general, this level of biomass can sustain an animal during the rainy season, but not in the dry season, when animals lose weight.
- the woody strata of the rangeland is consumed in all areas as it represents a principal source of nitrogen, minerals and vitamins for the animals during the dry season ; it is consumed during all 12 months in certain locations.
- in the study area, because of the extension of planted areas, the harvest residues play a large role as a food source for the livestock. Three types of residues were found: millet/sorghum stalks, rice straw, and the tops of cowpeas.
- the pastures of the flooded zones, much more productive than the upland tracts, are exploited by all the cows in the dry season. Perennial grasses are found there.
- Vast pasture zones are still unusable during the dry season because of the lack of water ; others rest untouched because of conflicts of various origins
- each region, including marginal zones, noticed an increase of agricultural activity in the pastoral zones. With the increase of the animals, the

“narrowing” of consecutive pastures, pastoral land becomes increasingly limited for the herds.

- in all regions, there is a more or less severe food crisis that starts in March and peaks in June – July.
- supplementing is practiced all over the zone, to combat the food deficit, numerous agropastoralists produce forage, several species are used, but the largest areas produced cowpeas and peanuts.
- Rangeland degradation linked to deforestation in all directions in order to meet the firewood needs of the increasingly large population is pronounced in all areas.

All of these observations show that the current resource management has a harmful influence on the environment and animal productivity. The major problems remain feeding livestock, especially in the dry season, as well as the degradation of the environment. Several solutions are available.

- The forage deficit can be combated by an increase of available stock during all seasons. For this, the highly productive forage species that exist in research can be made available to agro-pastoralists to cultivate. First, a training in forage production techniques should be given to a large number of agropastoralists.
- To slow down the environmental degradation, the ancient practices of woody fodder use should be strengthened; the rangeland restoration techniques, the installation of woody and grassy forage grain bank techniques and woody species management methods should be made available to agropastoralists; training the agropastoralists in fodder production and rangeland restoration will be necessary.
- The current limits of the pasture zones are not well defined, making defining the carrying capacity difficult. A detailed cartography of the plant groups would allow the management of pastoral resources. Updating the land use map in the region would contribute to improved conflict resolution between herders and farmers. But it is essential to organize the responsibility of the herders around pastoral land management. This would allow them to align their practices with objectives they themselves choose.
- The intensification that allows agriculture to settle into one place can exacerbate the competition between herders and farmers. If non-intensive grain monocultures rapidly exhaust the soil, forcing the farmer to move his parcels often, the rotations and their associated cultures that necessitate legumes are often more beneficial in that they are more productive and allow the parcels to remain in one place for a longer time.
- To increase the performance of feeding, the food rations studied by researchers should be transmitted to a large scale and accompanied by a recommendation that was made at the time of the workshops of the project GL CRSP MLPI in Mopti and Gao.

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