



## Characterization of the Fodder Resources of the Upper Valley of the Senegal River (HVFS)

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### Abstract

The present study is devoted to "the characterization of fodder resources in the transhumance terroirs of the Upper Senegal River Valley". It was conducted in the Pastoral Unit of Malandou which straddles the Valley and the Ferlo and in eleven (11) sites of the ISRA Program, all located in the regions of Matam and Tamba (North- East of Senegal). It focused on the characterization of the herbaceous stratum based on grasses of the genus *Aristida spp.*, *Chloris spp.*, *Schoenefeldia...* and that of woody whose most fodder species, are *acacia albida* and *seyal*, *pterocarpus érinaceus ...* Grassproduction has been linked to the rainfall recorded and it has been found that the most representative herbaceous species are annual grasses such as *Aristida spp.*; *Chloris spp.*; *Schoenefeldia gracilis*; *Cenchrus spp.*, with a carpet that can be sparse or continuous, a height of 50 - 60 cm and a covering that can vary, depending on the level of rainfall, from 10 to 8 As for woody fodder, namely, trees, shrubs and bushes, the floristic composition is characterized by the relatively large presence of woody, some of which are, *Acacia seyal*, *Ziziphus mauritiana*, *Balanites aegyptiaca*, *Adansonia digitata...*, are fodder and has more than twenty (20) species of trees and more than twenty species of shrubs and bushes inventoried. The landscape has a lower and lower density of woody trees as we move north. The counts and calculations made show average densities over all sites, about 41 trees/ha and 209 shrubs/ha, with variations of 20 to 82 trees/ha and 22 to 334 bushes and shrubs per ha,

**Keywords:** Forage Resources; Transhumance; Upper Senegal River Valley; Floristic Composition; Grassland Biomass; Woody Fodder

### Introduction

This study takes stock of the results recorded in the work undertaken to assess the forage potential of the Upper Senegal River Valley (HVFS). The main characteristics of the forage resources studied are thus reviewed, namely

- The herbaceous pathways, of which the floristic composition and the production of biomass will constitute the two axes

- Les woody fodder, for whom, the floristic composition, density and height of canopy and leaf biomass of trees and shrubs that develop in the study area.

After reviewing the materials and methods used for this study, we will work in this chapter to make an inventory of herbaceous plants, to establish the floristic composition of woody trees and to determine their density.

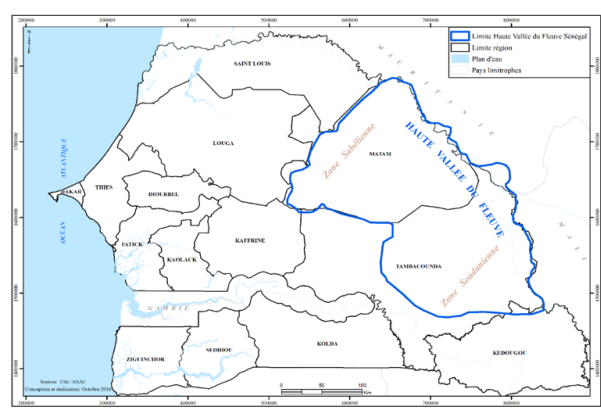
## Presentation of the study area

The study was carried out as part of programs initiated and implemented in the Administrative Region of Matam at the level of the departments of Ranérou - Ferlo, Kanel and Matam and in that of Tambacounda which covers the departments of Goudiry and Bakel. The administrative situation, zonal division and socio-economic activities of the populations residing in the study area will be addressed.

## Administrative situation of the HVFS

The Senegal River valley stretches from Bake1 to Richard-Toll, forming a 10 km wide arc and nearly 400 km long depending on the location. It is a land of flooding of the river which imprints on this ecological zone, a particular personality linked to its hydro geographical characteristics. The Valley, overall, includes (i) on the right bank: the regions or *wilaya* of Trarza, in particular: the departments or *mouqhataa* of Keur Macène, Rosso and R'Kiz), Brakna, Gorgol and Guidimakha and, (ii) on the left bank: the region of St Louis (departments of Dagana, Podor and Matam), the department of Bakel and a fringe of the department of Goudiry, in the Tambacounda region.

The Upper Valley of the Senegal River is located upstream of Bakel and extends along the said River, to the Malian border and the left bank of the Falmé. It covers most of the Matam Region (shown in the map in Figure 1 below).



**Figure 1:** Map of Senegal with "The Upper Valley of the Senegal River" (circumscribed in bold).

## Biophysical characteristics of HVFS

The characteristics of the Upper Valleys of the Senegal River (HVFS) are assessed from the geographical position occupied by the study sites, the climatic conditions prevailing there as well as its hydraulic, soil and edaphic resources.

## Geographical position of study sites

The first phase of the study was hosted by the departments of Ranérou - Ferlo, Kanel and the north of the department of Matam, belonging to the region of the same name.

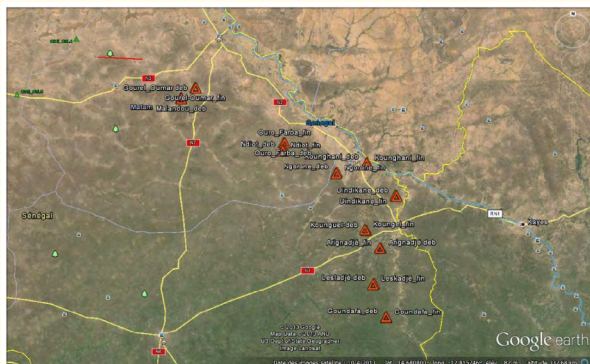
Matam is an agro-sylvo-pastoral region consisting of part of Ferlo, Dieri and Walo which extends to the south by the Boundou area (East of the Tambacounda Region).

The sites that have been used for this study in this area are in the pastoral unit of Malandou which straddles the areas covering the two agro-ecological areas that are: (i) the "Ferlo", located in the south and having a preponderant pastoral vocation; (ii) the "Diéri", in the North of "Senegal", is marked by its commercial and intermediation activities.

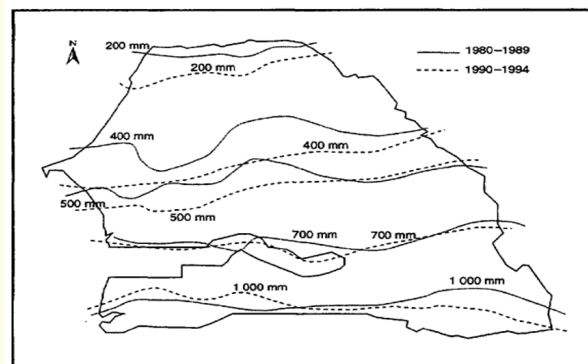
The northern part studied is inside the so-called Senegalese "sylvopastoral" zone, which is located in the Sahelian domain and covers about 70,000 km<sup>2</sup>, or a little more than a third of senegalese territory.

The U.P. Malandou, which centralizes the northern part of the study area, is located in the administrative region of Matam between latitudes 15° and 16° 30 North and longitudes 13° 30 and 16° West.

The 2<sup>nd</sup> phase of the study extended into the area between 15° and 17° north latitude. The valley is entirely located in the Sudano-Sahelian climate zone which is characterized by a short rainy season. This part of the Senegal River Valley covers the departments of Bakel and Goudiry (Tambacounda region) as well as the south of the Matam region. As part of this study, 11 sites were identified that are crossing points for local and foreign shepherds in transhumance. The pastoral routes that are the subject of our study belong to the traditional natural region of "Boundou" which occupies the north-east of the Tambacounda region and the southern part.



**Figure 2:** Position mapping of the 11 pastoral resource monitoring sites (Google image).



**Figure 3:** Translation of isohyets between 1980 and 1994, (Source: Fall, *et al.* 2001).

## Climate data

Senegal straddles the isohyets 200 and 1200 mm with a rainfall irregularly distributed in the space and in time. Indeed, climate change has led to an interannual irregularity in rainfall, but also to a decrease in precipitated volumes which has resulted in a remarkable shift of isohyets to the south in an "almost inexorable process of desertification and economic poverty" linked to the decline in the performance of production systems [11].

The climate is sahelian and includes three main seasons: wintering or rainy season (July to October), the cold dry season (November to March) and the hot dry season (April to July) or (lean season) difficult for herds due to the scarcity of food. The rainfall is characterized by light, irregular rains, spread over 3 months between July and September. Overall, the number of rainy days decreases from south to north. Also, climatic variations are noted but they are an inherent characteristic of the Sahelian perimeter and do not represent an exceptional situation. The dry season is marked by the harmattan, a hot, dry, dust-laden wind that results from the continentalization of the trade winds from the Azores Anticyclone. Its impact on evaporation is notable. It is this wind that justifies the wearing of turbans by the populations of the area to protect themselves from the heat.

## Rainfall

The rainfall of the Valley and delta is characterized by low, irregular rains (intra and interannual) and distributed over a short

period between mid-July and mid-October. Annual averages vary from 200-300 mm in the delta and lower valley, 300 to 400 mm in the middle valley, 500 to 600 in the upper valley.

The study area is thus characterized by a relatively limited rainfall average of (400 mm) and fairly high temperatures.

It should be noted that between 1970 and 2000, the countries of the Sahelian zone were confronted with a high rainfall deficit which, combined with a strong anthropogenic pressure, which shape the facies of the vegetation of the area.

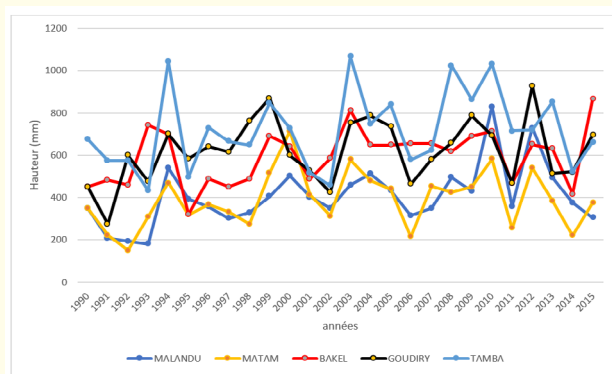
In the "Boundou" part of the Upper Valley (South Matam and East Tamba), the month of August receives more than 60% of the total annual rainfall.

Over the entire area, the distribution of rainfall is very irregular and capricious both in time and space and shows an increasing gradient from downstream to upstream, ranging from 200 to 700 mm/year.

From 1990 to 2015, over more than 25 years of regular monitoring, rainfall was measured and rainfall records were recorded daily. Then, they were compared with the data of the National Meteorology, which made it possible to arrive at the synthesis of results presented in the x graphs of Figures 2, 3 and 4 below

Results Sites	HVFS: NORTH ZONE		HVFS: ZONE SUD		
	Malandou	Kill	Bakel	Goudiry	Tamba
AVERAGES	400 mm	391 mm	595 mm	619 mm	717 mm
Medium/Zone	399 mm/an		644 mm/an		
Deviation- Type	145 mm	133 mm	132 mm	151 mm	184 mm

**Table 1:** Summary of average rainfall in the North and South Zones of the HVFS.



**Figure 4:** Rainfall 1990 to 2015: Summary of records recorded at targeted stations.

It appears, on the basis of the results of 26 years of monitoring, illustrated by the graphs shown in Figures 3 and 4 above, that

- For the Matam Station, it was recorded, for an average rainfall of 391mm/year, 14 years deficit and 11 surplus.
- The Malandou site, which averaged 400 mm of rainfall, has 15 years in deficit and 10 years in surplus,
- In Tamba Counda, for an average rainfall of 711 mm/year, it was counted, 15 years in surplus and 10 years in deficit
- The Bakel station has an average rainfall of 595mm/year and has recorded 15 surplus years and 10 deficit years and,
- Goudiry, with an average rainfall of 619 mm/year, counts 13 years in surplus and 12 years in deficit

For the northern zone, covering the Departments of Ranérou Ferlo and Kanel, the data concern the stations of Malandou and Ma-

tam, show averages of about 400 mm/year over the thirty years, with maximums of 829 mm (in 2010) and minima of up to 151 mm (in 1992).

### Soils

The morpho-pedological division can be presented in two large sets: the *waalo* and the *diéri* with a transition zone, in the valley, named *diediegol*.

First of all, the settling basins near the river, called *hollaldé*, are devaste flat depressionary and clayey areas. They form the walo with the levies flooded fluvio-deltaics called *founded*. Note here the salty character of many depressions of the *waalo*, in particular, downstream (up to 200 km from the mouth). Finally, the *dieeri* corresponds to non-floodable dune zones.

### Vegetation

The vegetation is that of the Sahelian domain, but the valley is influenced by the flood that determines the presence of a pseudo-climate.

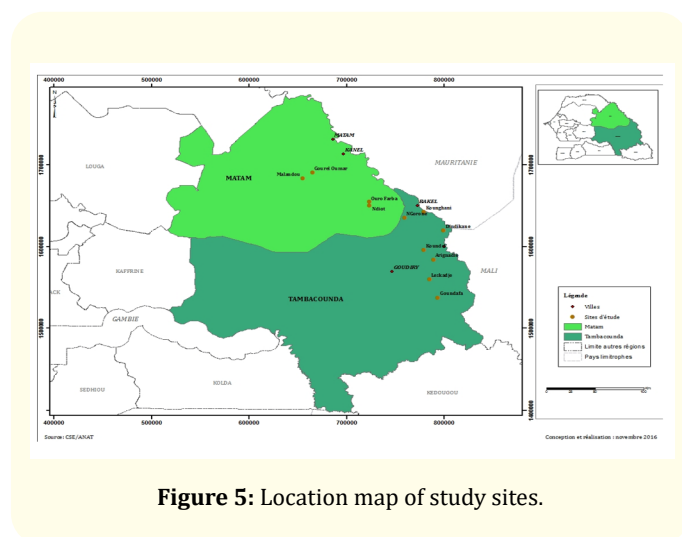
Although the topography is small, we have microreliefs that influence the floristic composition. This perfectly adapted vegetation has various characteristics which are correlated with it. The vegetation is characterized by a predominance of *Acacia nilotica* (Gonakier) in the Walo on the soils "Hollaldé", *Balanites aegyptiaca* (Soump) and *Acacia senegalensis* on the soils "founded" with sometimes a shrub stratum consisting of *Acacia seyal* (Sourour), *Boscia senegalensis*, *Ziziphus mauritiana* (jujube) etc.

### Decoupage zonal DE LA HVFS

Based on considerations related to the approach and relying on eco-climatic data, our study area can be subdivided into two areas that are distinguished by the contours of the 2 traditional natural regions that compose it.

The northern part, which includes the departments of Kanel and Ranérou (in the middle of Ferlo) to which is added the north of the department of Matam, represents the typically Sahelian part of the Matam region that hosted the Vegetation Monitoring Program developed by the Ecological Monitoring Center (CSE) in the UP Malandou, over the period 1994 - 2014.

The southern zone is the part crossed by the departments of Bakel, Goudiry and Matam (in part), covers the area of the Senegal River Valley, including the traditional regions of "Walo" (South of the department of Matam and "Boundou" (Northeast of the region of Tambacounda).



**Figure 5:** Location map of study sites.

### The population and its socio-economic activities

It appears that irrigation has a contrasting impact on the Senegal River Valley. It represents a real agrarian revolution, both in agricultural, technical, economic, social and institutional terms. The spread of irrigated culture has two divergent economic effects.

Men: the population is divided into fairly homogeneous ethnic groups.

The whole valley is occupied by the Toucouleurs of Fouta Toro "Halpularéen" except at the extremities where we find Wolof in the West and Soninke in the Southeast.

In the distant Jeri, the Fulani group marks an essentially pastoral existence, while the group of Black Moors (haratines) also called "Narebe" is scattered around the hydraulic boreholes. The

Senegal Valley has three large groups of peasants. The Wolof are concentrated in the lower valley (district of Mbane) and are scattered in isolated villages, even in the district of Ourosogui (department of Matam).

The "Soninkés" occupy the upper valley and form high concentrations in the district of Semmé. Further downstream, they gather in neighborhoods in toucouleous villages. Finally, located in between, the Toucouleurs constitute the vast majority of the settlement of the valley. All these populations have production systems traditionally based on rainy and low-water agriculture, and the breeding of cattle as small ruminants. In addition, the use of emigration is throughout the valley a widespread and ancient means of compensating for the irregularity of income.

The drought of 1972 marked the beginning of a radical change in village production systems in the valley. The decrease in the area under rain and in decline has gone hand in hand with a sharp decrease in the number of herds now dominated by sheep.

### Animal resources

#### Livestock in the upper Senegal river valley

The herd consists mainly of cattle (*Zebu Gobra*, *Zebu Moor*), sheep (Fulani-Fulani, Tuabir), goats (mostly Sahelian goat), horses, asins and camels.

The results taken from the statistics of the National Field Agency. The Statistics and Demography [2], crossed with the figures of the Regional and Departmental Inspectorates, have been confirmed by the surveys that nsteams have had to carry out on the upper valley of the Senega Riverthe account of large numbers distributed in the 6 departments it crosses according to the following table 2.

The bulk of this herd consists of cattle (54%) and small ruminants (40%) (See photo). Pigs are absent in this area. Asins, horses and camels are very little represented (6%). Camels are found only in the 3 departments of the Matam Region. The numbers recorded by the ANDS show for the whole area: 838,305 head of cattle and 2,902,492 small ruminants including 1,622,724 sheep and 1,279,768 goats [2].

Based on these considerations, the number of livestock enumerated can be converted and would thus count for the equivalent of 1,167,800 UBT distributed among the numbers of the herd shown in Table 2 below



Departments	Cattle	Sheep	Goats	Horses	Blood	CAM	Surface. km <sup>2</sup>	Total (UBT)
Tamba	289502	722300	537103	8 762	9249		20.328	
Bakel	159923	156162	216203	4585	12967		22.378	
Goudiry/K	195496	190880	264402	5603	15803		17.000	
Kill	101592	186411	99802	9475	12 126	91	5 729	
Cinnamon	72632	179282	66180	6520	7497	61	8 766	
Ranérrou F	19160	192189	96 078	11716	10029	71	15 101	
TOTAL	838305	1627224	1279768	46661	67671	223	89.322	
Conv rate	0,75	0,16	0,16	1	0,4	1	_____	
EQU. UBT	628728,75	260355,84	204762,88	46661	27068,4	223	_____	1.167.799,9
Percent.	53,84%	22,30%	17,53%	3,99%	2,32%	0,02%	_____	-----

**Table 2:** Number of pupils in the study area by department (in Number of heads).

**Sources:** Results of the National Census of Agriculture and Livestock (ANSD 2013).

**Totals:** Number of head of cattle and total area in km<sup>2</sup>

**Equ. UBT:** Number of livestock expressed in UBT

**Rate conv:** Conversion of the number of head of cattle into number of UBT.



**Figure 6:** Photo - Small ruminants in a tree-lined route at the end of SS- Lescadje 2014.

Wildlife is also present but remains marginal in the areas intersecting our study.

### Breeding practices in the upper Senegal river valley

With DIA Ibrahima in "Terroir Management, we know that for ruminants, raised in the extensive study area, most of the feed comes from fourrage (spontaneous or cultivated), depending on the production systems [7]. In extensive systems based on the exploitation of spontaneous fodder, itinerant grazing is the main mode of exploitation of space by animals. This mode of exploitation requires large areas of land well supplied with plant biomass. However, the aridity that characterizes the environment is a determining factor in the degradation of the livestock's food stock. Added to this is the combined pressure of animals and humans on natural resources that are weakening over the years.

In addition to the effect of ruminant pressure, these rangelands are exposed to the exploitation of wood (coal, firewood, building materials, etc.). There are also bushfires that give rise every year to many initiatives on the part of the actors, to limit the possible damage. In addition, the devastating practices of some users who collect bush straws in order to market them as livestock feed at the

expense of transhumant herds. This kind of practice also causes divergences between users in addition to destabilizing the already fragile balance between local livestock and available pastoral resources.

On the other hand, landscapes further north are less endowed with cultivated spaces. With a Population with a Fulani majority, the upper valley of Senegal and the outskirts of the Falemé are characterized by frequent movements of cattle throughout the year with variations in these movements largely dependent on the seasons. As a result, some researchers only support transhumance outside the area of residence, is less and less practiced in years of normal rainfall [9].

In normal rainfall years, herds, depending on their location in the Delta, alternately exploit natural parklands and by-products.

From February, the herds of the Haut and Moyen-Delta do not have a flood course nearby, except, the western bank of Lake Guiers at the end of the dry season, are led to the rice racks where they consume rice straw, the basis of their food ration. The herds of the breeders residing in the Bas-Delta and in the area of the Djoudj Park exploit the flood courses of the basins not yet developed and are only driven on the rice traps at the end of the dry season. In the future, when all the bowls are developed, by-products and mainly rice straw will probably form the basis of the feed ration of the Delta herds in the dry season.

### Water requirements of livestock

The water needs of irrigated crops, livestock, fish farming and forest plantations have been calculated by 2025. Assuming a crop intensity of 160%, Phase I of the Master Plan for the Development and Management of Water in the Senegal River (SDAGE) estimated in 2009 the current total water needs for livestock in the Senegalese part of the Senegal River basin at 14,797,830 m<sup>3</sup>/year on the basis of the following consumptions: 48 l/day/for camels; 21 l/day/for bovine animals; 12 l/day/for asins; 2 l/day/for goats and sheep. On the same basis and, considering the annual growth rates of the herd in the basin (0.7% for Camelins; 1.4% for cattle; 5% for small ruminants); the water needs of the herd would be 20,834,728 m<sup>3</sup> in 2025.

Overall, the satisfaction of these needs does not pose any particular problems, given the availability of water in the area, but the

further away from the river, the more water becomes scarcer, thus justifying the displacement of many pastoralists in transhumance.

### Study Materials and Methods

The present study was conducted thanks to two research programs, one of which was initiated by the Centre de Suivi Écologique (CSE) from 1994 to 2014 and the second of which made it possible to continue the work begun, within the framework of ISRA's RIVERS Project, carried out between 2013 and 2015.

The first phase, which took place (1994 - 2000 and 2005 - 2014), was limited to monitoring the quantities of biomass produced in the northern zone of the HVFS, precisely, at the level of the UP Malandou, extended to the north of the department of Matam, thus straddling the Ferlo and the valley. After evaluating the results achieved, over ten - seven years, the need to redeploy the program was felt in order to improve a little more, the knowledge acquired on the forage resources of our country. It is in these circumstances that a new program started in 2013 - 2015, was added to the first and was developed around 2 axes consisting of an extension of the program (i) in terms of widening the study area that integrated the south of the HVFS, corresponding to the Boundou region but also, (ii) in terms of raising the range of activities, by taking charge of the floristic inventory, and the study of fodder woody.

The work focuses on forage resources, which for the most part consist of natural rangelands, which account for the bulk of pastoral livestock feed. In the characterization approach that we are working to undertake here, the components of natural rangelands, namely, (i) herbaceous pastures and (ii) woody forages will be studied.

The methodological approach adopted in this study is based on:

- General provisions and a number of materials intended to be used in the performance of targeted tasks
- Amethodology that is based on several acts

To carry out this various works, the necessary equipment and the methods implemented are described as follows.

### Equipment used

To carry out this work, the following material was used

- A GPS (Global Positioning System) to find the plots.

- Milestones to delineate plots and allow for sightings.
- Lab materials (ovens, test tubes, reagents, craft paper, marqueurs)
- Material used to weigh samples: a digital scale, a spring loaded peson
- Vegetation index maps to compare results.
- Self-closing plastic bags, Zip lock dimensions: 17 x 25 cm.
- Agricultural equipment (shears and sickles, to cut grass in the squares; mower, fork, rakes ...)
- Measuring equipment: Rubans - meters of 30, 50 and 100 meters; Altimeter for heights
- Rain gauges in some villages

In addition to this material, records of woody and herbaceous surveys were used for the purpose of recording data and information relating to the various species identified.

### Study methods

In the context of the characterisation studies, after the identification of the sites, the results of the surveys carried out as well as the work of inventories carried out were used.

Rainfall surveys were collected at the Meteorological Stations of the targeted regions The National Geographical Service and the Directorate of National Meteorology were also asked to search for additional data.

Our study is part of applied research, initiated in collaboration with the Faculty of Science and Technology of the Cheikh A. Diop University (UCAD/FST) of Dakar, the ISRA - LNERV of Hann - Dakar, the Center for Ecological Monitoring (CSE) and the Higher Institute of Agricultural and Rural Training of the University of Thiès (UT/ISFAR).

It was based, in part, on the results of the monitoring of natural rangelands, conducted by the Centre de Suivi Écologique (CSE) in Dakar. This monitoring makes it possible to evaluate both the quantity (primary production) and the quality (floristic composition) of the fodder available in the different ecological zones of the country. It is therefore an essential element for the proper management of natural resources and, taken in its context of long-term monitoring, it makes it possible to understand the process of evolution of ecosystems [18,19].

On the basis of the expected results, the studies for the characterization and evaluation of forage resources were carried out on the basis of an approach encompassing the following steps

- Field studies: choice and delimitation of sites, sampling, measurement of production quantities,
- The collection of data and information from structures and institutions such as the DRDR, Projects operating in the area, the services of the National Meteorology.
- Analyses carried out in the laboratories of ISRA - LNERV, ENSA Thiès
- Surveys of populations in general and breeders or agro-breeders belonging to the identified sites.
- The exploitation of the data and the computer analysis of the recorded results

All this was based on a choice of well-targeted sites, and surveys of the populations, in particular, the herders living in the area.

### Identification of study sites

The first phase of the study, carried out between 1994 and 2014, required the choice of 3 Soil Control sites installed within the Pastoral Unit of Malandou and its immediate surroundings and which made it possible to measure directly, to evaluate the herbaceous production on the northern part of the HVFS. A site is considered to be a portion of a variable territory belonging to the same group defined by Toutain [24]. In UP Malandou, 3 ground control sites were selected (S CS1, 2, 3) and their coordinates are given in Table 3 below.

The acquisition and processing of this field data and the determination of the correlation between the Decade Vegetation Index (NDVI) and total production, results from the work carried out in the field. The vegetation index expresses the chlorophyll activity of plants.

In the same vein, for the purposes of the implementation of the 2<sup>nd</sup> stage of the study, carried out over the period 2013 - 2015, a series of pastoral sites along the transhumance axes used by pastoralists in eastern Senegal (Matam, Bakel, Kidira) were identified and described. The sites are crossing points for local and foreign shepherds and constitute an international corridor of transhumance. Indeed this corridor is the place of passage of Senegalese



Sites	Coordinates		Placette number	Placette Name	Coordinates	
	X	And			X	And
SCS1	656880	1679687	MAL02E	FCU02E	658930	1687080
SCS 2	649122	1677980	MAL02N	FCU02N	657930	1688080
SCS 3	1688322	635182	MAL02S	FCU02S	657930	1686080
			MAL02W	FCU02W	656930	1687080

**Table 3:** Location/coordinates of the U.S. P of Malandou.

breeders but also Malian and Mauritanian. Stage lodges characterize these passages and serve as a temporary parking area for pastoralists and cattle for whom makeshift pens are sometimes set up. They are most often close to a village or at least a water point allowing the herds to drink and the breeder to camp for a while before taking the road to the banks of the Falmé.

The results recorded at these sites made it possible to characterize the herbaceous stratum and woody stands of the study area.

Thus, four clusters of sites were identified along the transhumance axes, namely: the Matam cluster (4 sites), the Bakel cluster (3 sites), in the two clusters of Kidira and Sadatou (4 sites), for a total of 11 sites presented in table 3.

Photo 5 below, shows the axes of passage, different infrastructures ... which justify the choice of a study site.

Departments	Sites	Beginning of the axis			End of axis		
		Marks	At the tiude	Longitude	Landmark	Latitude	Longitude
Kill	Gourel Oumar	Adansonia Digitat	15,287	-13,463	Was	15,293	-13,469
	Malandou	Termite hill	15,223	-13,553	nothingness	15,225	-13,548
	Ndiot	Adansonia Digitata	14,912	-12,92	Acacia seyal	14,904	-12,925
	Farba Gold	<i>Sterculia Sétigéra</i>	14,954	-12,921	Termitiere	14,954	-12,912
Bakel	Dindikane	-----	14,63	-12,22	<i>Sterculia sétigera</i>	14,634	-12,227
	Kounghani	-----	14,836	-12,403	<i>Balanites aegyptiaca</i>	14,829	-12,407
	NGorone	<i>Sterculia</i>	14,775	-12,588	nothingness	_____	_____
Kidira	Arignadie	-----	14,313	-12,319	nothingness	14,312	-12,324
	Koundel	rônier	14,42	-12,407	nothingness	14,42	-12,407
Sadatou	Goundafa	<i>Balanites</i>	13,893	-12,285	nothingness		
	Leskadje	<i>Sterculia Sétigéra</i>	14,096	-12,359	Tamarindus Indicates	14,092	-12,367

**Table 4:** Location of the survey axes of the different study sites.

The North of the Upper Senegal River Valley with the departments of Matam, Ranérou - Ferlo and Kanel, covering the sites Gourel Oumar, Malandou, Ndiote and Ouro Farba hosted the biomass studies of the first phase. The other sites are located in the southern part of the HVFS.

### Population surveys

In the northern sites, the questionnaire was administered at the "Gallé" level. According to Barral, quoted by Thébaud, "Gallé (plural "gallédji") can be defined as the socio-economic unit that lives on a herd and it therefore represents, from a pastoralist perspective, the most relevant level of investigation [3,25]. The Gallé generally consists of the head of household of the "Diom gallé" (head of galle) with his wife or wives and often the household or households of one or more of his married sons, to which are frequently added relatives, among whom divorced women, widows ... Interviews and surveys were conducted in all 15 villages of the U.S. P. and 112 "gallédji" where the leaders were subjected to a questionnaire on the management of pastoral resources and the management of herds. The choice of this target was guided by the representativeness of these Leaders in the village. Interview guides used in some cases have been processed to collect information from privileged partners: Technical Services Managers, Projects/Programme Managers, local authorities, etc. A total of 121 breeders, partners and collaborators were surveyed.

The following table lists the 15 villages in which different Diom Gallé were investigated.

The village of Oudalaye, which is the largest agglomeration, capital of a rural community, has not been the subject of a Gallé survey, given its status as a religious village. In this country, the only voice allowed is that of the Religious Guide, which is why he was interviewed on the recommendation of the President of the UP, as well as the only eco-guard trained by the project. It should also be noted that all village chiefs and privileged partners of the project (eco-guards and nurserymen) of the UP villages were systematically investigated.

Among the "Diom Gallé" (or Heads of Household) surveyed, all are of the Fulani ethnic group, 66.7% are over 50 years old and the average age is 55.14 years. Only 30% of them are monogamous. Surveys also reveal that among the "Gallédji" (or concessions/

UP	TP	Village	Nombre de Gallé	Observations
Malandou	Gourel	Wouro Sébo	1	Investigated
		Wouro Sékourou	1	≠
		Gassel Hotels	1	≠
		Mboulidow	1	≠
		Wouro Mamoudou	4	≠
		Gourel	6	≠
		Thiéwélé	10	≠
	Malandou	Malandou	15	≠
		Hop on Tokossel	4	≠
		Naiki Mango	6	≠
		Niarwel	8	≠
	Fété Fowrou	Namari	22	≠
		Fété Fowrou	22	≠
		Loughéré Mbaba	11	≠
	Oudalaye	Oudalaye	115*	Not investigated
	TOTAL	15	(-115) = 112	

**Table 5:** List of villages surveyed in UP Malandou.

families), interviewed, 70% have more than five children under the age of 8 while 44% have more than five children over the age of eight.

During the 2<sup>nd</sup> phase of the study (2014 - 2015), concerning the host villages hosting the Boundou sites, the investigations were carried out using the same questionnaire which made it possible to collect data and information on the conduct and use practices of the forage resources of the area. They mainly concern production systems with the aim of identifying the potential and constraints relating thereto. On the basis of the census carried out in the villages - sites, a list was drawn up taking into account the criteria of ethnicity and dominant activities (agricultural, agropastoral and pastoral). Survey sheets were developed and administered to a total of 103 producers, randomly selected by sampling in each of the villages - centres of each of the study sites. Focus group interviews were also carried out at the level of the 11 host villages hosting the biomass sampling sites. The questionnaire covered conduct, resource use practices, access conditions, among others.

Focus group surveys have thus made it possible to gather different opinions from farmers and resource persons in the same place and to address the target group, in this case breeders, directly. The questions focused, mainly, on pastoral activities, but also on other production activities, which influence livestock.

The information and data collected were supplemented by focus group interviews. This is a method that is the most suitable for collecting opinions from breeders and resource persons in the same place. Indeed, the focus group has the advantage of addressing directly to the group concerned, in this case, the breeders. It also presented an opportunity to gather different positions in a single session. The target group interviews were also a good opportunity to get general information but also to highlight particularities insofar as everyone can express their point of view. Indeed, group discussion allows to have a richer information and facilitates the cross-checking. In total, about thirty people per site residing in the 11 host villages were interviewed.

In relation to the biomass sampling of these villages, the questionnaire concerned the conduct, the practices of use of the resources, the conditions of access, among others.

The administration of a questionnaire was followed by the characterization of forage resources. This activity concerned the holdings of the persons who were interviewed by questionnaire.

### Sampling of herbaceous vegetation

In each of the selected sites, the samples studied relate to biomass measurements made by sampling and cutting. Observations and measurements were carried out in the 11 sites targeted for sampling, collected using the systematic sampling method. On a 1 km long transect, stratification was carried out on different levels of production of the herbaceous stratum. It is a question, on squares of one meter side, so it, an area of one square meter (1 m<sup>2</sup>), with five (5) repetitions, to take samples every 25 meters along the axis of the survey.

Forty samples were taken and were intended either to be inventoried or to be evaluated to determine the quantities of biomass production.

### Study of herbaceous and woody vegetation

The samples collected are taken and then identified by manual sorting in the laboratory and the phenological stages determined.

At the sample level, the dominant species were identified. The herbaceous plants have been with the following works: "Flora of Senegal [4]", "The adventitious of Sudano-Sahelian Africa [16]"; "Guide des weeds d'Afrique de l'Ouest [20]" and "Nom en langues nationales des principales plantes spontanées et subspontanées rencontre dans le bassin arachidier du Sénégal [27]".

On all samples from each site, a classification is made according to the presence and rank assigned to the grass in each sample, to determine the dominance of species in each site. The characterization of the productivity of the rangelands was supplemented by an estimate of the load capacity of the areas studied. Among the parameters for the improvement of the overall value used for the purposes of this study, density was targeted as one of the determining characteristics in the forage representativeness of woody trees.

Since density is the count of the number of individuals (trees, shrubs) per unit area, the systematic inventory method was used. It consisted in listing and fully inventorying all woody species along a marked axis of 1000 meters. The names of the species present and the number of feet per species were then noted. The name of the species was based on the Catalogues of Vascular Plants of Senegal [17] and the illustrated flora of Senegal [4], before the nomenclature of species was updated. The methods of floristic inventory and vegetation surveys proposed by Gounot (1969) are used to establish the list of woody species present in the various Community rangelands.

The status of each of the forage woody species was determined on the basis of the results of their frequency in the area, their evolution and their use by livestock farmers as revealed by the information collected at the time of the surveys. To determine the stocking densities, an exhaustive count of trees and shrubs is carried out and a calculation based on the data collected, made it possible to find the desired results. Several species have been identified but only woody fodder are the subject of additional specific studies.

### Data processing

The results recorded in the context of the operations described above have been processed at various levels and have made it possible to carry out (i) the characterization of herbaceous biomass (floristic and productivity study); (ii) the assessment of the biomass production of wood forages (density, foliage depth or crown height studies of trees and shrubs) and (iii) the determination of the bromatological value of certain woody forages.

## Analyses quantitative et qualitative

The data and information from the focus group were processed by the software "The Sphinx plus". The qualitative data were also processed using this software by text study, which made it possible to analyse the assessments made by farmers of their own situation but also to collect their opinions on the prospects for improvement.

Another part of the data was processed using the *Excel spreadsheet*, in particular, for the preparation of tables and graphs. It also made it possible to carry out statistical analyses (classifications, distributions, etc.), in particular, by cross-tabulations. Finally, the mapping of the sites was carried out by the technical services of the CSE and using a software of "geographic information system, Quantum GIS (QGIS version 1.7.4)" and GPS data provided by ISRA.

## Results

The population surveys, inventory work, sampling, measurements and weighings carried out as part of our study, made it possible to record results in terms of the floristic composition of herbaceous and woody plants as well as the density of trees and shrubs identified in the different sites hosting the study.

### Characterization of herbaceous

It is a question of highlighting the floristic composition that marks the courses of the targeted area. The relatively advanced study period in the dry season, for reasons related to the objectives pursued, did not allow a systematic inventory of herbaceous plants to be made.

However, on the basis of the measurements, observations and weighings carried out in this context, a number of observations have been noted, in particular (i) the most representative herbaceous species are annual grasses such as *Aristida spp.*; *Chloris spp.*; *Schoenefeldia gracilis*; *Cenchrus spp.*; etc. (ii) These germinate from the first rains in June - July and dry on their feet from the end of September. (iii) This carpet is closely dependent on precipitation and can be sparse or continuous, with a height of 50 - 60 cm and a covering that can vary, depending on the level of rainfall, from 10 to 80.

### In the northern part of the HVFS

The herbaceous stratum is composed mainly of *Aristida mutabilis*; *Cenchrus ciliaris*, *Pennisetum pedicellatum*, *Chloris prieuri*,

*Schoenefeldia gracilis*, *Dactyloctenium aegyptium*, *Cassia obtusifolia*, *Zornia glochidiata*; herbaceous plants, the most common are *Brachiaria mutica*, *Chloris pilosa*.

Floodplain pastures are important in the region and are found all along the Senegal River between Gandé and Ambidédi, as well as along the Falémé and Karakoro rivers because these environments are less risky than those farther from the river. The density of human population and livestock is very high, resulting in the degradation of this resource in some areas. These regions naturally support perennial herbs such as, *Andropogon pseudopricus*, *Schoenefeldia gracilis*. The degradation of pastures decreases in proportion to the distance from the river, which indicates the importance of water for livestock.

On all the sites visited, the inventory made it possible to establish a list of several species divided into eleven families. The family Poaceae is the most represented. It is followed by *Acanthaceae*, then *Fabaceae* and *Cyperaceae*. Tables 6 and 7 below give details of these results presented in the form of an exhaustive inventory and classification of the dominant species.

### Floristic list of herbaceous rangelands

Identified species	Genres	Families
<i>Andropogon pseudapricus</i> ;	<i>Andropogon</i>	Poaceae
<i>Eragrostis tremula</i>	<i>eragrostis</i>	
<i>Chloris prieuri</i>	<i>Chloris</i>	
<i>Schoenefeldia gracilis</i> ;	<i>Schoenefeldia</i>	
<i>Schizachyrium exile</i> ;	<i>Schizachyrium</i>	
<i>Pennisetum pedicellatum</i> ;	<i>Pennisetum</i>	
<i>Andchinochloa colona</i>	<i>Echinochloa</i>	
<i>Blepharis maderaspatensis</i> ;	<i>Blepharis</i>	Acanthaceae
<i>Lepidagathis anobrya</i>	<i>Lepidagathis</i>	
<i>Peristrophe bicalyculata</i>	<i>Peristrophe</i>	
<i>Cassia obtusifolia</i> ;	<i>cassia</i>	Cesalpiniaceae
<i>Cassia mimosoides</i>		
<i>Dipcadi longifolium</i>	<i>Dipcadi</i>	Liliaceae
<i>Corchorus tridens</i> -	<i>Corchorus</i>	Tiliaceae

<i>Boerhavia diffuse</i>	<i>Boerhavia</i>	Nyctaginaceae
<i>Zornia glochidiata</i> ;	<i>Zornia</i>	Fabaceae
<i>Tephrosia bracteolata</i>	<i>Tephrosia</i>	
<i>Indigofera dendroides</i>	<i>Indigofera</i>	
<i>Fimbristylis sp</i> ;	<i>Fimbristylis</i>	Cyperaceae
<i>Polycarpaea linearifolia</i>	<i>Polycarpaea</i>	Caryophyllaceae
<i>Borreria stachydea</i>	<i>Borreria</i>	Rubiaceae
<i>Phyllanthus amarus</i>	<i>Phyllanthus</i>	Euphorbiaceae

**Table 6:** Floristic procession of herbaceous plants in the Northern Zone of the HVFS.

In the UP of de Malandou, twenty-two (22) species belonging to 21 genera, have been identified. They are divided into eleven families, of which the Poaceae are the most represented. The count

shows: *Cyperaceae* (2), *Fabaceae* :{3}; *Acanthaceae* (3); *Poaceae*: (4) and *Cesalpiniaceae* :{1}

The following families: *Rubiaceae*, *Euphorbiaceae*, *Caryophyllaceae*, *Liliaceae*, *Tiliaceae*, and *Nyctaginaceae* are represented by a single species.

On all forty samples from each site, the classification according to the frequency and rank assigned to the species in each sample, made it possible to establish a classification that highlights the dominant species in each site.

Table 7 gives at the level of each sampling site, the species considered to be the most present and most frequent in the area.

#### Dominant herbaceous species in the natural ranges of the northern zone

Sampling sites	Coordinates		Identified Dominant Species
	X	And	
SCS 1	656880	1679687	<i>Pennisetum pedicellatum</i> ; <i>Andropogon pseudapricus</i> , <i>Schoenfeldia gracilis</i> ; <i>Zornia glochidiata</i> ; <i>Eragrostis tremula</i> ;; <i>Cassia obtussifolia</i> ; <i>Chloris pilosa</i>
SCS 2	649122	1677980	<i>Zornia glochidiata</i> ; <i>Pennisetum pedicellatum</i> ;; <i>Schoenfeldia gracilis</i> ; <i>Cassia obtussifolia</i> ; <i>Eragrostis tremula</i> ; <i>Andropogon pseudapricus</i> ; <i>Chloris prieurii</i> ,
SCS 3	1688322	635182	<i>Andropogon pseudapricus</i> , <i>Zornia glochidiata</i> , <i>Schoenfeldia gracilis</i> , <i>Pennisetum pedicellatum</i> , <i>Andropogon gyanus</i> , <i>Cassia mimosoides</i> ; <i>Fimbristylis sp</i>

**Table 7:** Dominant species identified in northern zone sites.

#### In the South Zone of the HVFS (Boundou Zone)

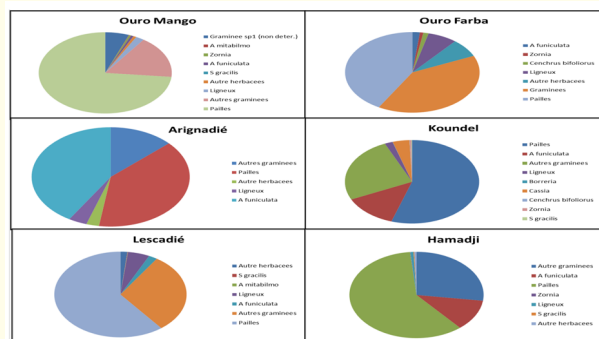
Manual sorting of samples made it possible to distinguish some species but many other individuals could not be identified at the phenological stage of their collection. Indeed, difficulties have been encountered in the identification of a few individuals, because of the loss of essential parts in the nomenclature or because of a more or less homogeneous mixture of several subjects reduced to small pieces. Where appropriate, they are classified as "other grasses" if it is established with certainty that they are largely grasses. If not, they are placed in the "straw" category. The distribution of species in the rangelands was thus made.

This region, along the Senegal River between Gandé and Ambidédi, as well as along the Falémé and Karakoro rivers, naturally

supports perennial grasses such as *Andropogon pseudapricus* and *Schoenfeldia gracilis*. In total, half a dozen species represented mainly by grasses, have been identified. The graphical representations in Figure 13 below give an idea of the representativeness of the vegetation components. It can be seen that of the 6 sites which have been the subject of an inventory, several species have been identified. The results have been listed in the graphical representations in figure 7 below.

On the various sites, we realize that the pastures are not mono-specific; in other words, most environments are populated by a mixture of several species, under the name of "straws" (in Koundiel and Arignadié) or "other grasses" (in Lescadié and hamadji) where they represent nearly 50%, or even more, in some cases. There are





**Figure 7:** Vegetation components in the sites (in bold) studied.

some species whose presence is marked in Arignadié, Hamadji, Ouro Farba. This is the case of *Aristida funiculata* and some species with relatively low representation, among which, *Zornia glochidiata*, *stylosanthes gracilis*, found in most of the sites studied.

Grasses are present in well-identified forms (*cenchrus biflorus*, *schoenefeldia*, *aristida*) or in bulk (under the name "grasses" and "other grasses") at all sites.

Grasses can thus be considered dominant in the HVFS courses. Various herbaceous plants are also found, in all sites, under the terms of "straws" or other "herbaceous", just as it has been common to encounter leaves of woody mixed with certain samples.

We also note the presence of *Aristida funiculata* on all 6 sites studied, while *Schoenefeldia gracilis* and *Zornia glochidiata* are each found in 4 sites; *Aristida mitabilimo* is identified in 2 sites.

Among legumes, only *zornia* has been clearly identified and marks its existence in 66% of the sites.

### Characterization of forage woody

Trees, shrubs and bushes offer by their foliage, in particular, high-quality green aerial fodder, and it becomes interesting to try to characterize them to have data and information elements to better value them.

The purpose of the chapter is to present the results of studies on plant composition, canopy measurements, and leaf biomass weighings on woody forages in the study area.

### Floristic composition

The 3 studies on woody trees were conducted at the 11 SITES of the RIVERS programme. In said area, the landscape is characterized by the relatively important presence of woody including some such, *Acacia seyal*, *Ziziphus mauritiana*, *Balanites aegyptiaca*, *Adansonia digitata* ... are fodder and are particularly exploited by livestock, therefore, are under strong pressure from livestock farmers. As part of the present study, more than twenty (20) species of trees and more than twenty species of shrubs and bushes, some of which are fodder (used to feed domestic ruminants), have been inventoried in the area covering the departments of Tambacounda, Bakel and Matam.

### Species inventoried

The most represented species remain the thorny, more adapted to the conditions of the environment. *Acacia seyal* is the most present and used species by breeders. Other woody species included in the diet of ruminants on range are *Acacia nilotica* (high density in Kounghany on flood zone); *Balanites aegyptiaca* and *Bauhinia rufescens* which are particularly appreciated by goats and cattle, especially since *bauhinia* has the double advantage of offering leaves and pods in the dry season. The areas south of Kidira have a greater specific diversity, with *Sterculia setigera*, *Ziziphus mauritiana*, *Adansonia digitata* and *Pterocarpus erinaceus* (vène) being among the most commonly used in animal feed. Moreover, leaves of *Pterocarpus* (young branches), are sometimes marketed in urban centers for small farms (sheep and goats).

However, not all species present are consumed by animals. Indeed, *Boscia senegalensis*, *Calotropis procera* or *Combretum sp.* are not widely used. It should also be noted the existence of pastoral ranges characterized in places, by plant species considered toxic. Some woody and herbaceous plants have been identified by breeders as toxic to livestock. This is the case of the species called *Cassia sieberiana* or "Samba Sindi" in pular. *Combretum glutinosum* is a woody tree very present in the area but it contains tannins, polyphenols, vitexin, proanthocyanidols, other phenolic compounds, quaternary amino acids, sterols and Triterpenes. It has a high level of lignin and an alkaloid compound that makes it toxic to animals. As for the woody *acacia seyal* and *Balanites aegyptiaca* type, they are particularly exploited for breeding, while *Ziziphus mauritiana* and *Adansonia digitata* were leafless or at the beginning of foliage at the passage of the team (month of April). It has been observed that leaf renewal takes place as the rainy season approaches.

### Representativeness of woody species

Of the fifty woody species identified, nearly half are under strong pressure from breeders who do not hesitate to prune them (disconnect, prune) for the benefit of small ruminants. Cattle also consume it in times of scarcity of herbaceous biomass. Woody trees have the characteristic of having a fairly high level of total nitrogenous matter (on average 35%) with variations resulting from species, organs consumed, vegetative stage and time of harvest. It has also been found that protected areas offer a greater amount of woody biomass. This is the case of the Boundou Community Nature Reserve (RNC) which straddles the departments of Goudiry and Bakel. It is also a fact that the density of woody trees decreases steadily as they move from the Sudanese zone (Boundou) to the Sahelian zone (Ferlo), with trees getting bigger and bigger. The sites of the Bakel department (Hamadji, Kounghany and Gourel Alassane) are characterized by more vigorous trees than that of the Kidira sites. With the cessation of the rains at an early stage, there has been a drop in the levels of delimbing in *Steculia setigera* (mbepp), *Balanites aegyptiaca* and *Acacia seyal*; the animals that have transhumed very early, *Boscia senegalensis* and *Calotropis procera*, permanently maintain their state of greenery in dry periods, but unfortunately, they are not appetized. Species such as *Guiera senegalensis* which has low palatability and *Boscia senegalensis*, are very adapted to drought and are found practically in all the sites visited.

It has been found that only certain species are grazed. There are those that are particularly sought after by at least one of the domestic ruminant species; there are others that are consumed occasionally and finally some are refused regardless of the season and the animals involved.

In the end, we will remember, from the point of view of floristic composition of woody fodder, that the species most represented in our study area, remain the thorny, more adapted to the conditions of the environment. *Acacia seyal* is the most present and used species by breeders.

To the south, in the localities of Bancouba, Lescadié and Arignadié there is a clear diversity of species with a relative abundance of combretaceae and thorny. There are also trees with high forage values such as *sterculia setigera* (mbepp).

Finally, the sites near the Ferlo (Ouro Mango, Ouro Farba, and the Ngourone area) are characterized by a strong presence of *Lep-*

*tadania hastata* that adapts easily to the sandy desert and produces fodder even in the dry season. Ubiquitous species such as *Guiera senegalensis* very adapted to drought as well as *boscia* that can be found in almost all the sites visited are also very present. Unfortunately their palatability is not very high.

### Density of woody trees in the HVFS

Generally speaking, the landscape has an increasingly low density of woody trees as we move north. The sites of the department of Bakel (Hamadji, Kounghany and Gourel Alassane) are characterized by more vigorous trees because they have not been subjected to pressure similar to that exerted on the sites of Kidira. There are *Sterculia setigera* (mbepp) as well as *Balanites aegyptiaca* and *Acacia seyal*.

Following the counts and calculations made on the trees and shrubs, the results recorded are presented in the following table

The average densities over all sites are approximately:

- 41 individuals/ha in terms of trees and
- 209 individuals/ha, in the case of shrubs and bushes.

It appears that all pastoral sites are wooded with a density of trees that varies from 20 to 82 trees per hectare, accompanied by a density of low bushes and shrubs, much more variable from one site to another (22 to 334/hectare) and a total of woody individuals varying from fifty on Sites of Kounghani (49.5); Gourel (61.5) at more than 350 per hectare in the sites of Dindikane (352), Lescadje (375) and Malandou. (393).

Figure 8 below shows the density of trees and shrubs at the different study sites.

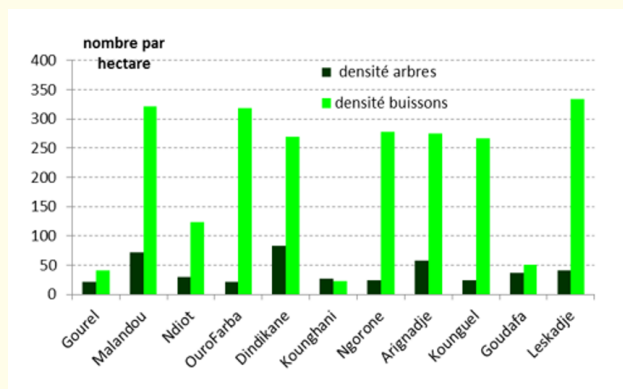
Counts made in the study area give totals of 50 to 393 woody individuals per hectare. It also emerged that pastoral sites are forested with densities that vary from 20 to 82 units per hectare for trees and from 22 to 334 units per ha, for bushes and shrubs. These densities do not adapt with latitude and therefore not with average annual rainfall. Hiernaux explains this state of affairs by deep clay soils (Ndiote, Kounghani) which tend to carry lower densities of trees and bushes, especially when subjected to temporary submersion (case of Goundafa) [13,14]. On the other hand, the shallow depth of the loose soil does not reduce the densities of trees and bushes (cases of Malandou, Koundel and Lescadjé) which do not seem to be influenced by the apparent grazing pressure.

Categories	Trees		Shrubs and Bushes		Total woody	
Sites	m	s. e	m	s. e.	m	s. e.
Gourel	20,7	3,4	40,9	6,6	61,6	10
Malandou	71,7	11,6	320,9	52,1	392,6	63,7
Ndiot	29,4	4,8	122,9	19,9	152,2	24,7
OuroFarba	20,8	3,4	318,5	51,7	339,3	55
Dindikane	82,4	13,4	269,2	43,7	351,6	57
Kounghani	27	4,4	22,4	3,6	49,5	8
Ngorone	24	3,9	277,6	45	301,7	48,9
Arignadje	57,4	9,3	274,6	44,6	332,1	53,9
Kounguel	24,2	3,9	266,3	43,2	290,4	47,1
Goundafa	36,6	5,9	51,2	8,3	87,8	14,3
Leskadje	41,3	6,7	333,8	54,1	375,1	60,8
AVERAGE	41,48	-----	208,9364	-----	248,5364	-----
ECART Type.	2,71	3,4905	123,04256	19,977	132,99331	

**Table 8:** Density (in number of individuals per hectare) of trees and bushes at pastoral resource monitoring sites in the HVFS.

**m:** medium or median

**s. e:** standard error ou erreur standard.



**Figure 8:** Tree and shrub density measured at study sites.

## Discussion

### Floristic composition of herbaceous plants

Our study found that half of the sites studied resulted in low to negligible herbaceous biomass production. The Kidira area shows the best production despite the traces of fire on the Bancouba site.

The impact of the fencing introduced in the Boundou Community Nature Reserve (RNC) has also had a definite positive effect on the preservation of the herbaceous carpet.

In the department of Matam, the level of production recorded was increased by the production of biomass obtained in Ouro Farba (south) while in the north, the quantity taken was almost zero due in particular to environmental conditions (lithosols, leaching and strong wind erosion). This is also the case in Kounghani in the department of Bakel, where the site is characterized by a flood substrate that does not promote optimal development of the herbaceous carpet.

On analysis, it appears that the levels of productivity of grassland biomass are very variable from the Sahelian zone (Ferlo) to the Sudanese zone (Boundou). These variations, depending on the site, can go from single to double. Rainfall is more favourable to the production of herbaceous plants in the Sudanese zone than in the Sahelian zone, so that Toutain noted that in the Sudanese zone live-stock have green fodder twice as long as in the Sahel [24]. Comparing the production of grassland biomass in the Sahelian part with

that of the Sudanese domain of the upper Senegal River Valley, although almost equivalent, nevertheless offer quantities of consumable fodder whose variability is related to the usable proportion.

Floristically, the courses studied are composed mainly of grasses. In the samples, however, it is common to encounter legumes in small proportions including *Zornia glochidiata* in a state of drying out. This is explained by the physiological state of the vegetation during this period of advanced drought.

It is also proven that before the drought of the 1970s, perennial graminoids such as *Panicum turgidum*, *Cymbopogon schoenanthus*, *Cyperus jemicus*... were relatively frequent and their recovery could reach 20% [5]. Zoungrana even found through a study carried out in the South Sudanese zone on 15 stations, values of 2.4 to 8.4 T MS/ha depending on the quality of the soils [29].

The loss of diversity observed in natural rangelands is mainly favoured by exploitation by animals. Most often, there is an accelerated grazing of the appetized species, resulting in a depletion of their reserves, jeopardizing the progress of the fruiting process. They are then replaced by species with a very short vegetative cycle, with zoochore dissemination that leave little straw in the dry season (*Zornia glochidiata*) and offer a reduced resistance to erosion agents.

If before the drought that has plagued tropical Africa since the 70s, perennial Graminoids (*Panicum turgidum*, *Cymbopogon schoenanthus*, *Cyperus jemicus* etc.) were not uncommon and their recovery could reach 20%, today they have practically all disappeared, giving way to annual herbs [26].

These same studies have established a relationship between the importance of rainfall and the types of plants present, which has led to the following findings: (i) with abundant rainfall, the most hydrophilic plants (legumes in general) will grow better; (ii) if rainfall is limited, plants that are not water-demanding (genus *Aristida*, *Cenchrus*, *Schoenefeldia*) will be dominant. They correspond to grasses that are not very palatable, once dry. In addition, depending on their degree of hydrophilia, certain species specific to a type of relief will only be found at the bottom of depressions according to Rouveïrolles, (2007). This is *Brachiaria mutica* or *Panicum lineatum*. Conversely, *Cenchrus biflorus*, a grass with little hydrophilicity, will only be found on sandy dunes.

It is therefore understood that the most popular herbaceous species for Ferlo are (i) for cattle: *Brachiaria hagerupii*, *Zornia glochidiata*, *Schoenefeldia gracilis*, [7]; (ii) in small ruminants, *Zornia glochidiata* is the preferred species.

On the other hand, 30% of the species recorded are said to be "without pastoral value", because they have a specific index of zero quality [19].

Surveys of livestock farmers have revealed that climate change, which has been marked by very difficult and severe rainfall conditions, has resulted in

- The disappearance of some species yet abundant on certain types of course until 1970/1971 such as *Dihetropogon hagerupii*, *ionurus elegans* and *Andropogon gasyanus*.
- The replacement of some species by others, less appetized, in particular, of *Aristida mutabilis*, *Schenfeldia gracilis* and *Chloris prieurii* by *Centiw biflorus* and *Dactyloctenium aegyptium*.
- The replacement of these same species by *Zornia glochidiata* which undergoes a strong exploitation of the rainy season and remains only a short time on the ground, after the end of the rains, leaving it naked trop tôt.

The results of Hiernaux' work reveal that perennial herbaceous plants are confined either to regularly flooded plains, or to depressions in the southern Sahel, or on the contrary, to dune or rocky reliefs in the northern reaches of the Sahelian zone [13]. The perennial formations of the southern Sahel mainly composed of *Cymbopogon giganteus* or *Panicum subalbidum* are similar to the savannahs that extend further south into the Sudanese zone.

### Floristic composition of woody fodder

Our results show a presence of woody of the genus, *Acacia seyal*, *Ziziphus mauritiana*, *Balanites aegyptiaca*, *Adansonia digitata* ... which are fodder *AcaciaAcacia nilotica* (high density in Koung-hany on flood zone); *Balanites aegyptiaca* and *Bauhinia rufescens* Towards the south of the HVFS there is a great specific diversity, with *Sterculia setigera*, *Ziziphus mauritiana*, *Adansonia digitata* and *Pterocarpus erinaceus* (vène), *Pterocarpus lucens*... According to Hiernaux, these same species are found in areas that do not go beyond the sahel centre [13]. He also noted that among the most frequent species are *Ziziphus mauritiana*, *Acacia seyal*, *Anogeissus leiocar-*

pus, *Acacia nilotica* and *Mitragyna inermis*. The physiognomic types of aquatic vegetation in the mountains, floodplains and lakes, numerous in this region, are very diverse but occupy only small areas except for the large floodplains (Senegal Valley, Macina in Mali, Daldols in Niger, Lake Chad, South Sudan). At the southern edge of the Sahel, the author found species such as *Leptadenia pyrotechnica*, *Calotropis procera* and *Acacia raddiana*. Ickowickz showed that, among domestic ruminants on the course, only sheep, goats and camels, significantly consumed *Acacia Seyal* fodder [15].

The same author also reveals that the removal of woody trees occurs mainly at the end of the dry season (between April and June), when pastures are lacking [15].

Ndiaye, et al. who worked in a portion of our area, found that the inventoried woody flora of Ferlo, is rich in 35 species, divided into 27 genera belonging to 19 families [20]. Among them, the families Combrétaceae (7 species), Mimosaceae (6 species), Caesalpiniaceae (3 species), Apocynaceae, Asclepiadaceae and Rubiaceae (2 species) are better represented. The other families each have a species. These are *Anacardiaceae*, *Balanitaceae*, *Bignoniaceae*, *Bombacaceae*, *Burseraceae*, *Capparaceae*, *Celastraceae*, *Euphorbiaceae*, *Fabaceae*, *Menispermaceae*, *Rhamnaceae*, *Sterculiaceae* and *Tiliaceae*. The genera *Acacia*, *Combretum* and *Leptadenia* which are respectively, better represented.

Species known to be highly toxic have been identified. This is the case of the species called *Cassia sieberiana* or "Samba Sindi" in pular. *Combretum glutinosum* is also a woody very present in the area but contains tannins, polyphenols, vitexin, proanthocyanidols... It will be up to us to deepen the research on this subject.

### Density of woody fodder

Woody trees are of paramount importance in the feeding of ruminants in the Sahel. This assertion has been confirmed by several researchers and then by our observations in the field. According to an ISRA report (1984), the density of woody trees in the northern zone of Senegal is between 60 and more than 2000 trees/ha depending on the location (soil types, topography, etc.). In any case a high density of *Acacia nilotica* was observed in the great bed of the Senegal River in the locality of Kounghany (department of Bakel).

Yesterday confirms our density results by also finding that the population of woody plants of the vast majority of Sahelian plant

formations is extremely open with a density of less than 100 individuals per hectare and a crown cover of less than 1% in the north and central Sahel and less than 500 individuals and 5% in the southern Sahel [13]. These populations are associated with a stratum of herbaceous plants largely dominated by annual herbaceous plants among which grasses have the first place. Diouf et al, who worked in the middle Senegal River Valley, claim that *Acacia raddiana*, *Balanites aegyptiaca* and *Boscia senegalensis* are the most frequent species there [10]; the density of *Balanites aegyptiaca* is the highest but the terse surface and the covering of *Acacia raddiana* are greater [10]. Almost all the large individuals of the stand represented by *Acacia raddiana* confirm the observations of Akpo and Grouzis [2]. The presence of scattered or scattered individuals shows that the vegetation develops under difficult climatic conditions, and/or intense anthropogenic action.

Diouf also found that the young plants of woody trees such as *Boscia senegalensis* and *Balanites aegyptiaca* appear to be resistant to the stress conditions of the environment because they manage to survive after the rainy season [10]. The density and regeneration rate of *Balanites aegyptiaca* could be related to its high adaptability to drought conditions. These results corroborate those of his authors Floret and Pontanier [12]. In the context of this same work, the results are reflected in the wake of those of our work. They reveal: the density in the Ferlo is 149 individuals per hectare. It varies from 64 for *Balanites aegyptiaca*, 53 for *Boscia senegalensis*, to 28 for *Acacia tortilis*. The density of other species is of the order of 2 individuals per hectare; The average distance between two trees is 6.3 m with a coefficient of variation (Cv) of 54.7%. This important coefficient of variation certainly indicates that there are aggregates, that is to say that the vegetation is distributed in groves. Work carried out in the Rural Community of Lour Escle (by Kaffrine/Senegal), has shown that four species alone cover 2204.8 m<sup>2</sup>/ha or 98.5% (*Acacia tortilis* 65.2%; *Balanites aegyptiaca* 24.9%.. In this study, woody fodder represents 27 out of 51 species cited by the populations, i.e., nearly 53% [21,22]. They are the main recourse of livestock in dry periods.

### Conclusion

The present study reveals that the transhumance terroirs of the Senegal River Valley include two areas whose characteristics have remained very marked. This is the northern part and the one immediately to the south. In the northern zone, rainfall is around



an average of 400 mm/year, giving rise to steppe vegetation where the herbaceous carpet partially covers the ground in the rainy season. The grassy stratum is associated with thorny trees scattered throughout space. The carrying capacity is estimated at 0.18 UBT/ha, equivalent to 6 ha/UBT/year. In the "Boundou", in the southern zone, of the Senegal River Valley, the developments have restricted the grazing areas but the productivity is relatively adequate, with a load capacity of 0.24 UBT/ha, or 4 ha/UBT/year. From the point of view of the floristic composition of herbaceous plants, the study revealed that the production of herbaceous biomass in the different sites is low to negligible. Floristically, the ranges studied are composed mainly of grasses but it is common to encounter legumes in small proportions, in particular, *Zornia glochidiata* in a state of drying out. The most popular herbaceous species for Ferlo are: *Brachiaria hagerupii*, *Zornia glochidiata*, *Schoenefeldia gracilis* (i) for cattle and, *Zornia glochidiata* is the preferred species for small ruminants. 30% of the species recorded are said to be "without pastoral value", because of their specific index of zero quality. Some species such as *Dihetropogon hagerupii*, *ionurus elegans* and *Andropogon gasyanus* have disappeared and, some species have been replaced by others, less appetized, in particular, *Aristida mutabilis*, *Schenfeldia gracilis* and *Chloris prieurii* by *Centiw biflorus* and *Dactyloctenium aegyptium*, but also, the replacement of these same species by *Zornia glochidiata* which undergoes a strong exploitation of the rainy season. Regarding the floristic composition of woody fodder, it was noted, the presence of the genus, *Acacia* seyal, *Ziziphus mauritiana*, *Balanites aegyptiaca*, *Adansonia digitata* ..., which are all, fodder but also, *Acacia nilotica* (high density in Koungnyon on flood zone); *Balanites aegyptiaca* and *Bauhinia rufescens*. The physiognomic types of aquatic vegetation in ponds, floodplains and lakes, numerous in this generally endorheic region, are very diverse but reduced, with the exception of the large floodplains (Senegal Valley, Macina in Mali, Dallols in Niger, Lake Chad, Sudd in Sudan). In total, thirty-five (35) species of woody trees exist in the Ferlo, there are also species known to be very toxic: case of *Cassia sieberiana* or "Samba Sindi" in pular. *Combretum glutinosum* is also a woody very present in the area but contains tannins, polyphenols, vitexin, proanthocyanidols... From the point of view of woody density in the northern zone of Senegal, it is between 60 and more than 2000 feet/ha. These stands are associated with a stratum of herbaceous plants largely dominated by annual herbaceous plants among which grasses have the first place. *Acacia raddiana*, *Balanites aegyptiaca* and *Boscia senegalensis*, are the most frequent

species; Almost all the large individuals of the stand represented by *Acacia raddiana*, the density in the Ferlo is 149 individuals per hectare. It varies from 64 for *Balanites aegyptiaca*, 53 for *Boscia senegalensis*, to 28 for *Acacia tortilis*. The density of other species is of the order of 2 individuals per hectare; The average distance between two trees is 6.3 m with a coefficient of variation (Cv) of 54.7%. In the end, it was found that four species alone cover 2204.8 m<sup>2</sup>/ha, or 98.5%, with *Acacia tortilis* 65.2% and *Balanites aegyptiaca* 24.9%.

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