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ORIGINAL ARTICLE

Forage production, pastoral value and carrying capacity of the rangeland of Tahoua State in Niger Republic

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ABSTRACT

Herbaceous species plays an important role in the feeding of livestock. The knowledge on the production and quality help in the management of the rangeland. This study determined the productivity and pastoral values of the rangeland of Tahoua region in Niger Republic. Data on the livestock and the forage quality of the species were collected during the pastoral survey. Those on herbaceous were collected based on 10 sites of 3km*3km selected according to homogeneity of vegetation. The evaluation was carried out in 60 plots of 0.5m² in each sites. The herbaceous biomass within the quadrant of 1 m² yield squares were cut at 2 cm above ground. The species with good, average, low and no pastoral values represented 75.6, 14.17, 7.76 and 2.47% respectively in term specific contribution. The Good Pastoral Value was 87.6% and 84.8% for the Net Pastoral Value. The global quality index (GQI) was 84.8%. With ten species (*Cenchrus biflorus, Tribulus terrestris, Dactyloctenium aegyptium, Alysicarpus ovalifolius, Eragrostis tremula, Aristida mutabilis, Ctenium elegans, Cencrhus preurii, Brachiaria lata and Gynandropsis gynandra)* represented 95.8% of the total pastoral value of the rangeland. The average forage production was estimated at 1.190 t DM/ha qualified to support 0.23TLU/ha/year of load capacity. The forage produced covered by far the need of the animals with a percent coverage ranging from 175.59 to 412.66% according the departments. The results showed the absence of perennials plant species being replaced by replaced by shorter life cycle more resistant to irregular rainfall, such as *Cenchrus biflorus.* This study recommends having a pastoral management plan for the rangeland to ensure the appearance of perennial plant species and the sustainable management of plant resources.

Keywords: Pastoral Value, Carrying capacity, Forage, Herbaceous

I. Introduction

Niger republic has a long tradition of livestock production. About 87% of the population practices animal husbandry as a primary activity or secondary activity, often associated with agriculture and or trading (Ministère de l'Elevage et de Industries Animales (MEIA, 2012). Its contribution to the national gross domestic product in 2017 was estimated at 10% while the entire Agricultural domestic Product was 30% (Institut National de la Statistic INS, 2018).

The estimated livestock population in 2018 were 14,363,595 Cattle, 14,132,592 Sheep, 19 585,749 Goat, 1,882,961 Camels, 260,861 Horses, and 1,988,893 Donkeys representing respectively 31.13%, 25.72%, 35.64%,3.43%, 0.47%, and 3.62% of the total animal population MEIA, 2018.

The main husbandry system are nomadic, transhumant and agro pastoral, representing respectively 16%, 18% and 66% of the animal population (Recensement General de l'Agriculture et du Cheptel RGAC, 2008).

Natural pasture derived from enclave and pastoral zone constitute the main source of feed to animals to sustain the production of good and services. Tahoua State has 11,021,214 hectares of pastoral grazing land composed of 7,950, 800 hectares of pastoral land located in the northern part of the state, and enclaves (35, 023 ha) and fallow (3,035, 391 ha) both situated in the southern agricultural zone of the State(MEIA, 2018).

Despite the large size of the livestock, and availability of pastoral land and livestock route to facilitate the mobility of herders, the natural pasture is facing many challenges, mainly human and natural, which mostly lead to conflict between farmers and pastoralists (Bonnet, 2012). The challenges are demographic pressure on pastoral land and livestock corridors or route to facilitate mobility, encroachment of misappropriation practices for development of private ranches (Mary & Bonnet, 2006) and overgrazing (Blench & Marriage, 1999), climate change or changes in rainfall and temperature pattern, desertification, drought, directly affect the production of agricultural crops as well as forages and livestock (Birendra & Samisen, 2016). The consequences include severe loss of vegetation cover, above-ground plant productivity, and soil erosion, elimination of soil seed bank, and shift in species composition and density of palatable species replaced by unpalatable or less palatable species (Ahamad *et al*., 2012, Hiernaux, 1996). These resulted in less availability of forage for the animal in the last 10 years as shown by the annual evaluation pastoral campaign (MEIA, 2018).

The secondary cattle multiplication center of Ibecetan was established in the early 1975 with the aim of promoting selection and diffusion of Azawak zebu to traditional pastoralists and agro- pastoralists farms (FAO, 2002). Livestock productivity depends on fertility, health, genetic potential and on the availability of forage all year round (Saidou *et al*, 2010). Knowledge of the overall fodder balance ranging from the potential biomass production, pastoral value, production of qualified pasture, and carrying capacity) is of great importance for the effective management of the pastoral zone and decisions making.

This study seeks to evaluate the floristic composition and grassland quality in the various geomorphological units of the Center in order to provide a good management and improvement to the current prevailing rangeland conditions.

The main objective is to contribute in feeding high quality forage through the analysis herbaceous species of the center. Specifically, the study aim to quantify, the forage potential of the Ibecetan livestock multiplication center, estimate the pastoral value of herbaceous species present in the centre rangeland.

II. Materials and Methods.

Description of the Study Area

The study was conducted in the region of Tahoua, Republic of Niger which covers 113371 km^2 and is located between parallel 13°42'and latitude 18°30' N and meridians 3°53' and longitude 6°42' E (Figure 1). The State is divided into three agro ecological zones : saharo-sahelien or pastoral zone covering the northern and center of the local government of Abalak with an average annual rainfall ranging from 150 to 300 mm in the north; Western dune and Eastern plain zone occupying the southern Abalak, Northern Keita and Illela, western Tahoua and north-Eastern Bouza local government receiving an annual rainfall of 300 to 350 mm and lastly the Ader- Doutchi- Maggia and Tarka Valley zone in the southern part of Tahoua State having and an average annual rainfall of 350 to 450 mm. The mean annual temperature is 30°C with a maximum of 47°C in April and a minimum of 15°C in December-January (Conseil Regional de Développement 2016-2020).

Four types of vegetation were encountered in the zone and include the woody steppe composed mainly of epinous tree species; some palms and euphorbiaceous trees; shrubs steppe with some annual grass plants; herbaceous steppe with some vivacious grasses and absence of vegetation in extreme north of the state.

According to the results of the General Census of Agriculture and Livestock of 2007, three husbandry systems are practiced in the State: the sedentary or agropastoral system (52.11%), nomadic (31.07%) and transhumant system (16.82%). The projected animal population in 2018 mainly composed of cattle (2, 868,016), sheep (2,762,002), goats (3,220,409), camels (553,817), horses (30,689) and donkeys (484,217) (Ministère de l'Elevage et des Industries Animales MEIA, 2018). Tahoua State has 11,021,214 million hectares of grazing land composed of 7,950,800 million hectares pastoral land located in the north and protected by law since 1961, enclaves (35,023 ha) and fallow (3,035,391 ha) situated in the agricultural zone in the south (MEIA, 2018).

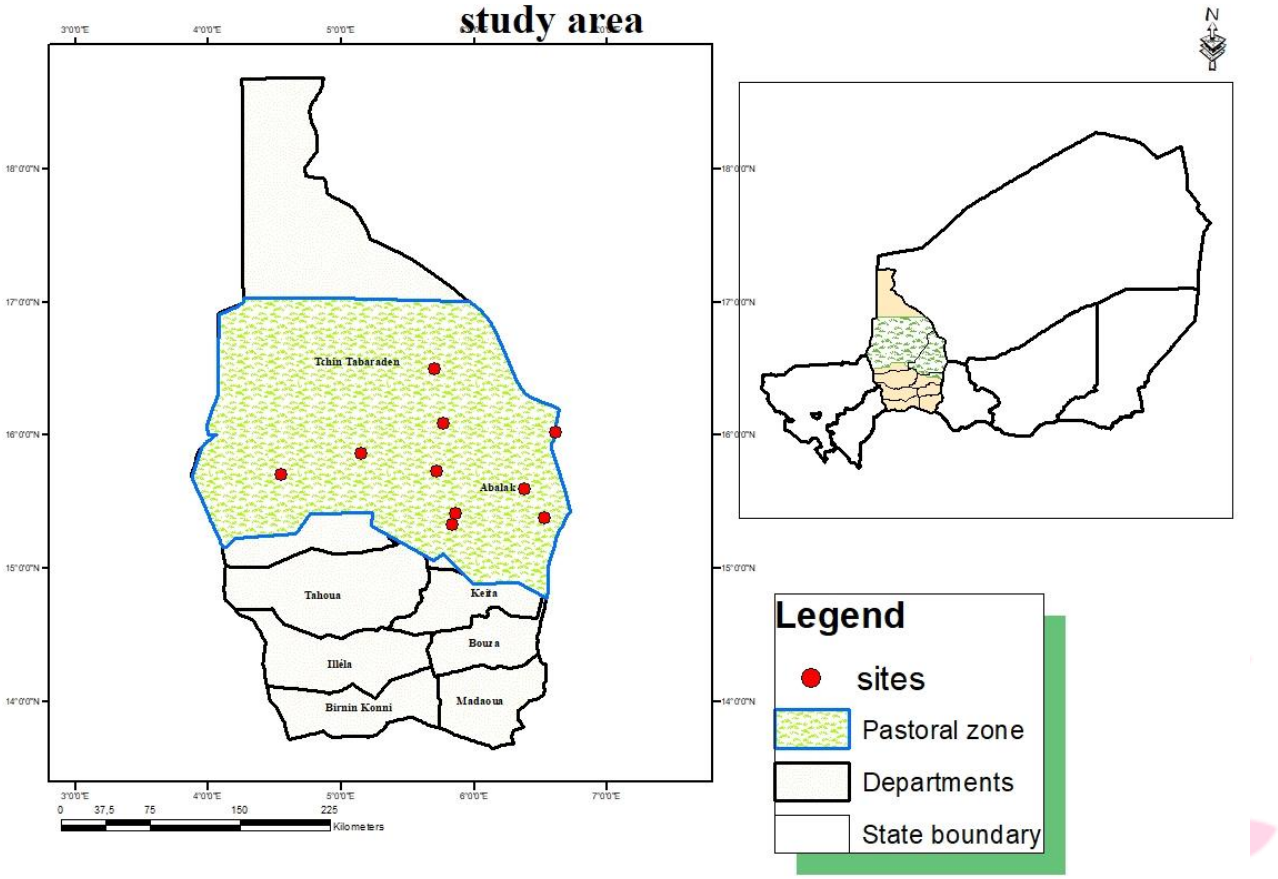

Figure 1. Map of Tahoua Showing the Departments, Pastoral Zone and

Data Collection

The double sampling method described by Cook and Stubendick (1986) was used to determine the floristic composition and productivity of pasture. The method combines visual estimation of biomass within the quadrat, cutting, weighing as well as the estimation of the production of herbaceous biomass and the determination of the floristic composition in percentage in the plots on sites of 3x3 km. It is a team work composed at least of four persons (the driver for setting the vehicule speedometer, one for estimating the soil herbage and identification of plants species, cutting and weighing) and moved in chronological order of the random chance. Measurement were taken at a predefined distance set by the random chance assigned to each site. There are 5 types of random chances for all sampled sites, numbered from 1 to 5. 10 sites of 3x3 km² were selected based on the homogeneity of vegetation to collect data at the late flowering –early fruiting stage (August and September). A tile was drawn to determine the plots to be cut and herbaceous species within the plots were identified using Niger vernacular name lexicon of Peyre de Fabregues (1979) in each plot. 60 plots were sampled and cut in each site making a total of 600 plots for the entire zone.

Statistical Analysis

Simple descriptive statistics of frequency and percentages were used for study. The parameters analysed include:

Specific frequency (Fsi) of (i) = cumulative sum of contacts of the species on the reading line;

The specific contribution: Csi (%) = (Fsi/ΣFsi)*100 where: Fsi is equal to specific frequency of the specie representing the sum of contacts of the species on the reading line; ΣFsi is the sum of contact of all species and Csi the specific contribution of specie i.

The quantity of useful biomass (Q) is obtained by multiplying the production harvested by the value of this synthetic index of pastoral quality (Akpo & Grouzis, 2002). Q (kg MS/ha) = P * Vp where P is the gross total production in kilograms of dry matter per hectare and Vp is the net pastoral value, MS is the dry matter. The vegetation growth was monitored during from the onset of rainfall to the time the evaluation was carried out. The Normalized Difference vegetation index images were downloaded, processed and then plotted to monitor the vegetation condition and growth. The maximum NDVI values extracted was regressed with the ground biomass production to elaborate in ArcGIS the biomass map production of the pastoral zone.

Carrying capacity: it will be calculated according to the method of Boudet (1991) on the basis of consumable biomass. The elements required include the usable biomass which is 1/3 of the produced biomass, and the daily consumption rate of the Tropical Livestock Unit (6.25 kg Dry matter/day). C.C = Biomass (Kg DM /ha)/Consumption (Kg DMS* /TLU/j).

III. Results.

Species composition of the rangeland of Tahoua State.

The botanical family of plant species identified can be grouped into three main groups. A first group of 15 families (Tiliaceae, Aizoaceae, Portulacaceae, Caesalpiniaceae, Rosaceae, Asclepiadaceae, Caryophyllaceae, Amaranthaceae, Asteraceae, Convolvulaceae, Scrophulariaceae, Pedaliaceae, Cyperaceae, Rubiaceae and Zygophyllaceae) represented by one genus only except the families Amaranthaceae and Convolvulaceae represented each by two and three species. The second group is composed of 6 families, among which the Capparidaceae, Cucurbitaceae, Euphorbiaceae, Fabaceae, Molluginaceae and Malvaceae, having each 2 genera. These families are composed of 13 species. The third and last group has 1 family only (Poaceae) with 10 genres and 14 species. The relative frequency of the first group is lower than 3% whereas those of the second group range between 4 and 7%. The Poaceae family is the most representative with 10 genera and 14 species and constituted 31% of the inventoried species, followed by the Malvaceae (2 genera and 3 species and represent nearly 7 % of the inventoried species. The frequencies and specific contribution of the species are presented in Table1.

Globally, the soil herbage is 96.7% while the percent soil coverage specific for all species was very low, less than 40%. Accordingly, species can be classified into two groups. The first group had a soil coverage higher than 10% and include *C. biflorus* (35.6%). *T. terrestris* (11.9%) and *D. aegyptium* (11.2%). while the remaining species composing the second group have less than 10% soil coverage percentage.

The global plants soil coverage of the rangeland was 96.7% and varied accordingly to the soil unit with 92% for sandy soil, 90.8% for mixt soil types and 82.2% on shallow limon-clays soil with a standard deviation of 8%. The

annual grasses of the *Poaceae* family are by far the most encountered on the pasture units with a specific contribution of 58.5%, 83.2%, and 71.8% respectively on shallow limon-clay (Table 2).The annual grass dominance could be considered as a pressure index. Since animals exert a selective consumption of phytomass, which favor the less consume species to dominate.

The pasture species identified can be regrouped into three family groups namely the annual grasses, legumes, and other families.

Table 1: Herbaceous species identified on the rangeland of Tahoua

Family	Number of genera	Specific importance	
		Absolute frequency (%)	Relative frequency (%)
Poaceae	10	14	31,11
Capparidaceae	2	2	4,44
Fabaceae	2	2	4,44
Cucurbitaceae	2	2	4,44
Cyperaceae	1	1	2,22
Pedaliaceae	1	1	2,22
Rubiaceae	1	1	2,22
Zygophyllaceae	1	1	2,22
Tiliaceae	1	1	2,22
Malvaceae	2	3	6,67
Convolvulaceae	1	3	6,67
Amaranthaceae	1	2	4,44
Asteraceae	1	1	2,22
Aizoaceae	1	1	2,22
Scrophulariaceae	1	1	2,22
Euphorbiaceae	2	2	4,44
Caesalpiniaceae	1	1	2,22
Portulacaceae	1	1	2,22
Caryophyllaceae	1	1	2,22
Molluginaceae	2	2	4,44
Rosaceae	1	1	2,22
Asclepiadaceae	1	1	2,22
Total	37	45	100,00
Connfidence interval (%)		0,95	

Table 2: Specific contribution of a family group on vegetation unit (%)

Statistical parameters	Vegetation units			Total samples
	Sandy soil	Shallow limo-clay soil	Mixt soil type	
Annual grass	83.2	58.5	71.8	69.6
Annual legumes	10.6	8.0	12.7	10.2
Others Specied	6.2	33.5	15.5	20.2

Forage production of Tahoua pastoral zone

Monitoring of Tahoua rangeland pasture: The NDVI images were processed to extract the digital number which is converted in reel NDVI reflectance value and plotted. It can easily be observed from Figure 2 that the rainy season

started on all the sites of pasture evaluation in the first decade of May. However, the vegetation growth as indicated by the rising in the NDVI value was not stable from May to the end of June and is shown by the rise (decade 2 of May) and falling (decade 3 of May to decade 3 of June) in the NDVI graph. With the regularity of rainfall from the first decade of July to the end of September, the NDVI registered an increasing trend to reach its maximum in September where it was quite stationary. By end of September, most of the plant species in the zone had reached their maximum growth and began flowering and producing grains. The pasture evaluation is generally carried out for and to second decade of October.

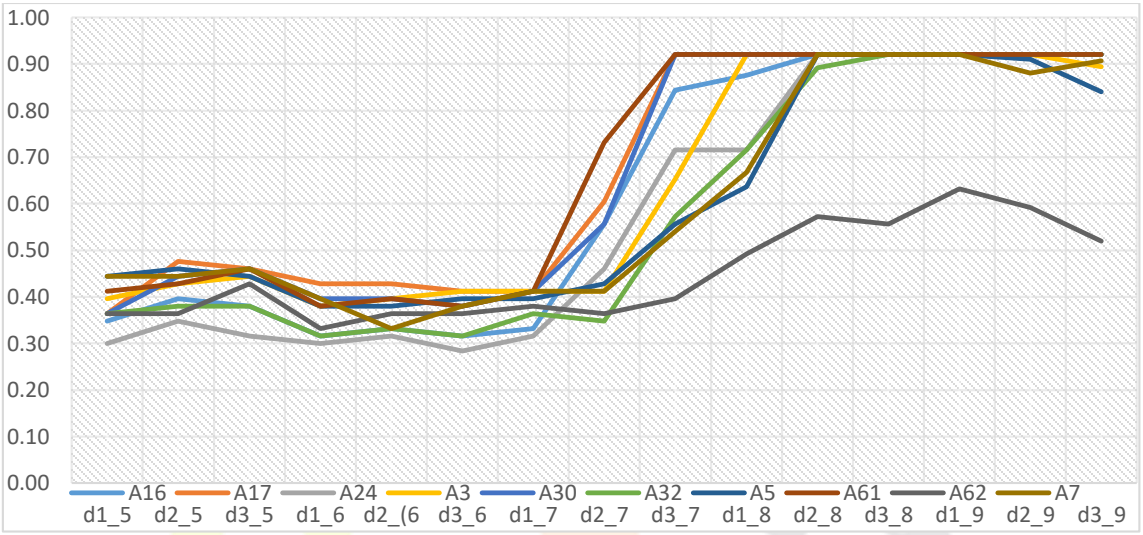

Figure 2: plotted NDVI during growing season

Evaluation of rangeland pasture: The evaluation of the pasture was carried out at the end of September and the beginning of October when herbaceous species are at maturity. The data collected are analyzed to obtain the ground biomass yield /ha /site presented in figure3.

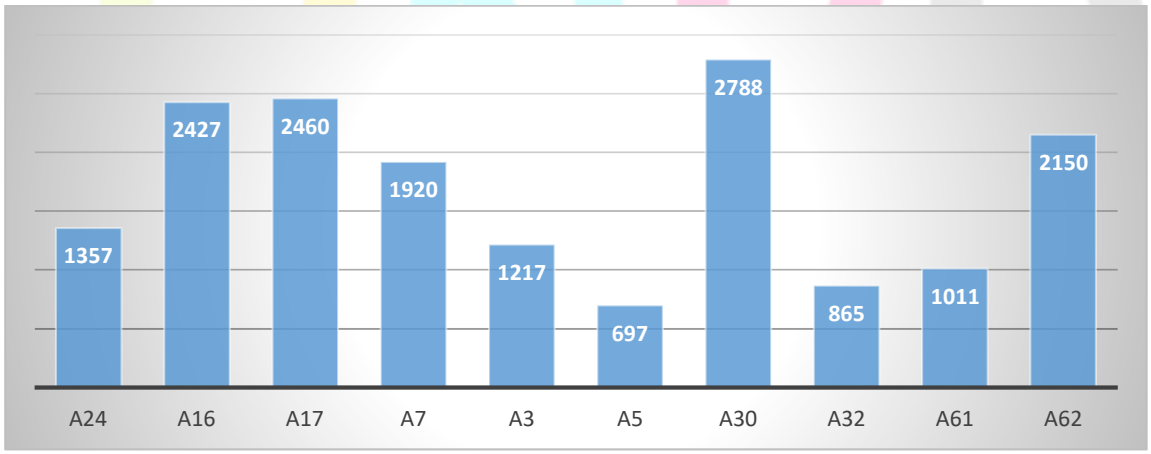

Figure 3: forage production in kg DM/ Ha /site.

As indicated by Bagoudou *et al*(1990) cited by Fodé (2010), a statistical analysis was performed through regression to determine the functional relationship between the average NDVI value and the ground biomass production obtained during the evaluation at the end of the rainy season. The regression equation obtained is **Y = 0. 0088 X + 164. 83, where** X is the integrated biomass and Y is the Average greenness NDVI value (Figure 4). The equation was used to determine the integrated productive average biomass distribution map in ArcGIS using the Raster calculator tool. This helped to produce a biomass distribution map across the pastoral zone and the entire region of Tahoua state. The biomass map produced is presented in Figure 5.

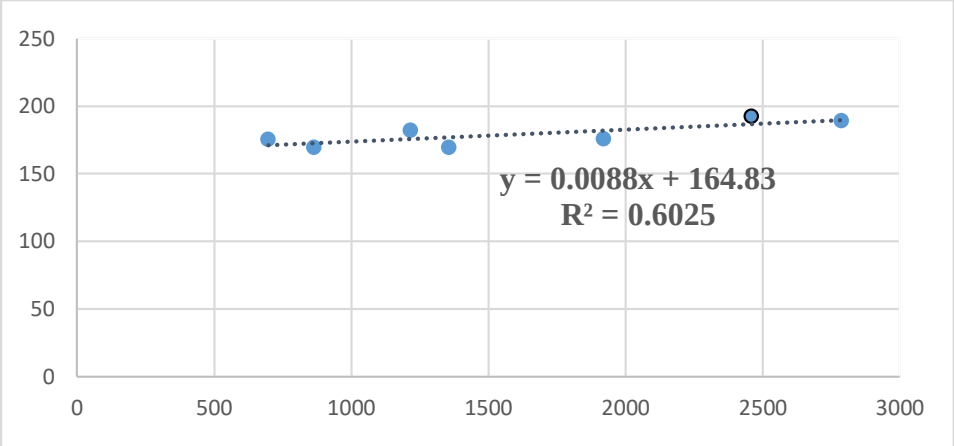

Figure 4: regression equation for ground biomass and NDVI Maximum values.

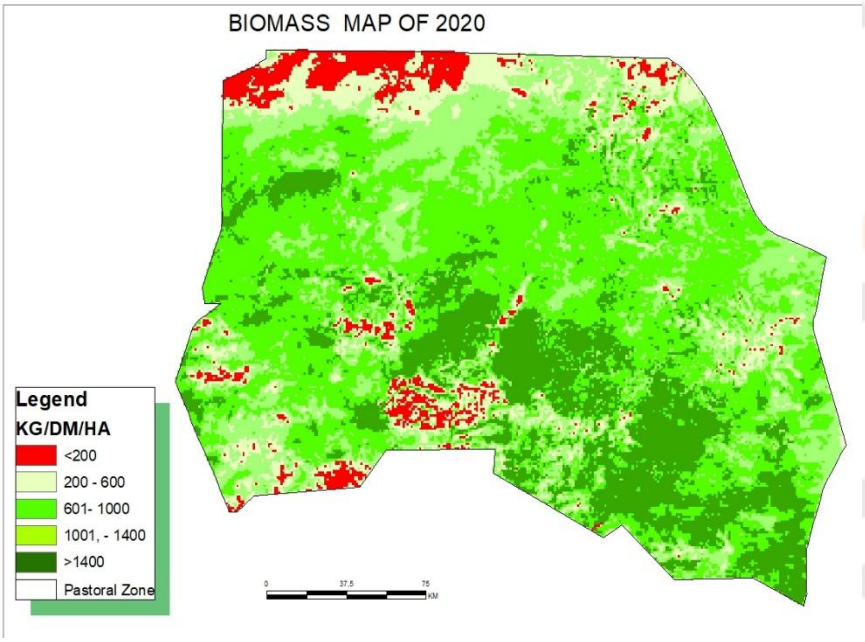

Figure 5. Forage productivity Map

Pastoral value

The relative values of species vary from low to medium as shown in Table 22. The species C. biflorus (36.9%), *T. terrestris* (12.3%), *D. aegyptium* (11.6%), *A. ovalifolius* (9.9%), *E. tremula* (5.2%), *A. mutabilis* (3.9%) and *C. elegans* (3.6%) have the highest relative values. The Gross Pastoral Value (Gvp) is 87.6% and the Net Pastoral Value

(Npv) is 84.8%. The Global Quality Index (GQI) is 84.8% and varies according to the different categories of herbaceous species. Species with Gpv and Apv participated respectively for 75.6% and 9.5% of the IGQ (Table 22). These two groups represent 85.1% of the value of the index. The Apv group has a high GIQ because *T. Terrestre*, which is part of this group, has the highest specific contributions. The gross pastoral value varied from 82.2% to 92.0% (Table 23). As for the net pastoral value, it varied from one vegetation unit to another from 75.5% to 96.4%. The analysis of this table shows that the most important pastoral value was noted at the level of Shallow lands followed by that of mixed soils with 82.4%. On average, the Pastoral value of the vegetation units of the zone is 84.8%.

Table 3: Overall quality index of fodder species of vegetation units

Species value appreciation	Vegetation unit			Global vegetation unit
	Sandy soil	Shallow zone	Mixts zone	
Gpv (%)	86.2	62.8	82.4	75.6
Apv	3.2	16.3	6.3	9.5
Lpv	2.6	3.0	2.1	2.6
Gpv (%)	92.0	82.2	90.8	87.6
Npv (%)	75.5	96.4	82.4	84.8

Gpv: good pastoral value; Apv: average pastoral value; Lpv: low pastoral value; Gpv: Gross pastoral value; Npv: net pastoral value.

Carrying capacity

Carrying or grazing capacity (CC) as defined by FAO, 1988 is the maximum possible stocking of herbivores that rangeland can support on a sustainable basis. It varies from year to year in the same area due to changes in forage production and therefore needs to be calculated every year. The Carrying capacity is expressed as the number of animal units that can be grazed for a specific time period Carrying capacity is expressed as the number of animal units that can be grazed for a specific time period. Thus for a Tropical Livestock Unit (TLU) of 250kg of weight requires a day 6.25Kg of Dry Matter which will represent 1.68 t of dry matter for 270 of the dry season(9 months). The amount of qualified (useful) fodder is about 1.69 t DM per hectare. Therefore, the carrying capacity (Table7) can be estimated at 63 TLU grazing days. We can then deduce the carrying capacity of the courses of the vegetation units. It is 0.23 TLU per dry season of 9 months or 270 days.

Table 4: Carrying Capacity of the rangeland on the basis of soil type

Statistical parameters	Vegetation unit			Pastoral Zone
	Sandy soil	Shallow limo-clay soil	Mixt Soil	
Phytomass production (t DM/ha)	0,697	1,862	1,011	1,190
Usable Biomasse (t MS/ha)	0,23	0,61	0,33	0,39

Number of grazing day (day)	37	98	53	63
Carrying capacity (UBT/ha/Dry season)	0,14	0,36	0,20	0,23

The feed balanced sheet calculated by subtracting the total animal needs of the area moins from the useful biomass pointed out that the need of the animals was coverered for the 9 months of the dry season. The map produced indicated that the animals need covered by more than 100% across the department of the pastoral zone (Figure6). The need coverage varied from 175.59 to 412.66%.

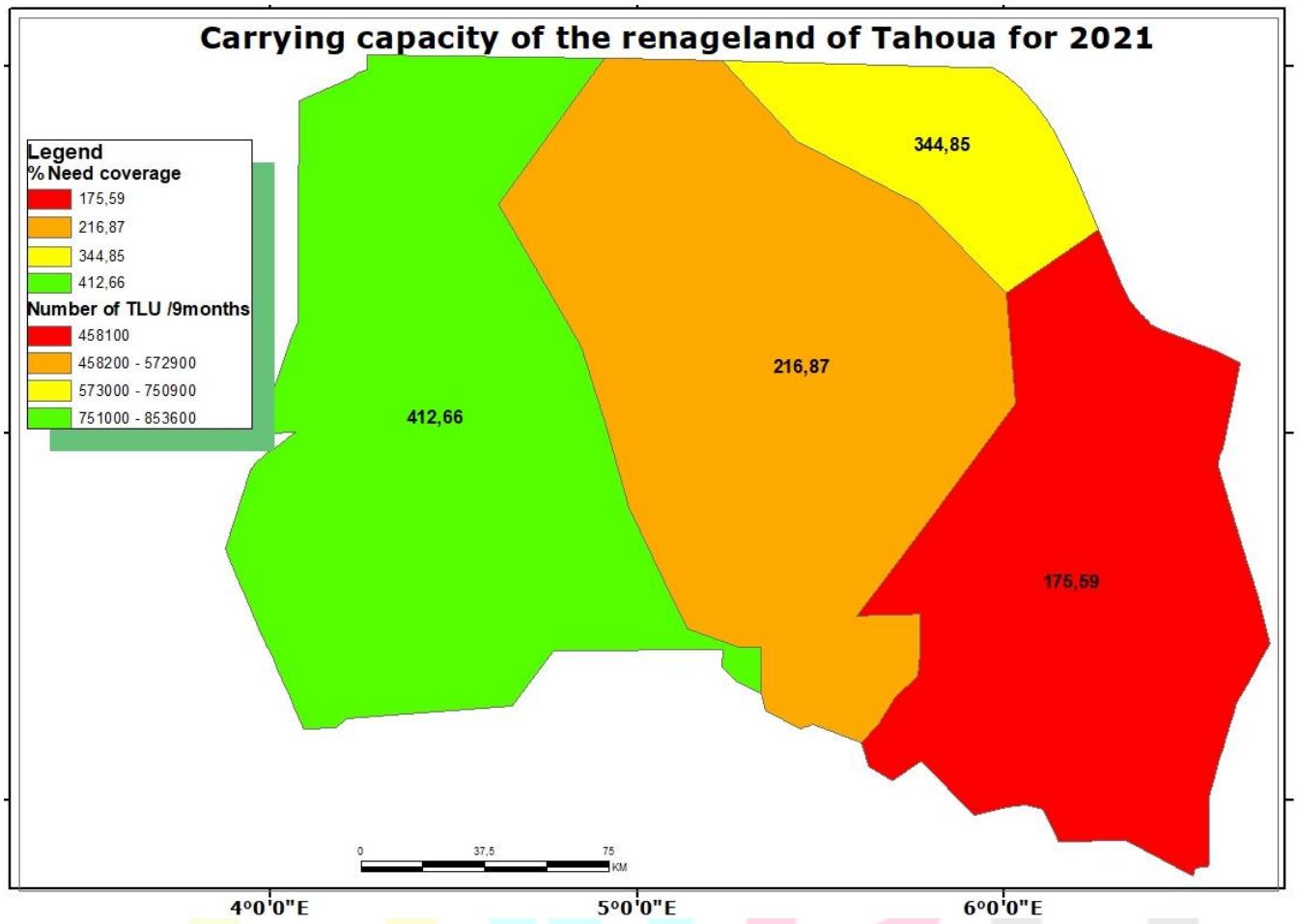

Figure 6: Carrying Capacity of Tahoua Rangeland.

IV. DISCUSION

The analysis of the Species floristic composition revealed that Poaceae family was the most represented, followed by Fabaceae/Malvaceae families. The high frequency of Poaceae family in all the pasture types could be attributed to its high tillering possibility and higher rate of regrowth after grazing. These findings were in line with the findings of César (1991) who, stated that Poaceae family species were the most commonly found, followed by those of legumes. The floristic composition results of the range were also similar to those obtained by Kouassi *et al*. (2014) in the grazed area of the Port-Bouët-Grand-Bassam coastline; Ngom *et al*. (2012) in the Ferlo biosphere reserve (Northern Senegal), and Soumana (2011) in the rangelands of the Zinder region. However, the number of species inventoried

in our study was lower compared to those obtained by Guisse *et al. (*2009) and could be explained by the difference in rainfall pattern and soil characteristics of the area.

Regarding the abundance of species found or species richness, the results indicated that the rangeland had an important diversity and richness of herbaceous plant resources. The herbaceous flora identified was composed of 45 species. The number was lower than the findings of Alhassane *et al*. (2017) who listed 134 herbaceous species on the natural range of the Maradi region.

The pastoral value was higher on dune plot (92%) than on mixed soils and lowlands soils with 90.8% and 82% respectively. The grasses group showed the highest pastoral value in dune soils (83.2%), while the legumes group remained higher in mixed soils with a pastoral value of 12.7%. This variation could be explained by the nature of the soil (César, 1994). The gross pastoral values of the three soil types are consistent with those indicated by Bakhoum (2013) for the pastures of the northern Sudanese zones.

The gross pastoral value varied from 82.2% to 92.0% according to the soil type. On the scale of vegetation units, it is 87.6% and could therefore be considered very high. Higher pastoral value is strongly dependent on the composition and the specific contribution present in the range. These results showed that the rangelands can be considered as good pastures because they have a gross pastoral value greater than 65%, which is the threshold value set by Daget and Godron (1995) cited by Bakhoum (2013), from which a grazing is considered interesting.

The carrying capacity corresponds to the number of cattle a pasture can accommodate or support and feed without deteriorating, is 0.23 TLU/ha/dry season. According to the vegetation units, it varied from 0.14 to 0.36 TLU/ha/dry season. The variation could be explained by the massive presence of animals on dune soils where there was a low carrying capacity value than on mixed in the Ferlo. This result was confirmed by *Kouassi et al*. (2014) who reported that it is important to respect the carrying capacity and setting up a system of regulation cattle grazing on the study on sustainable basis. This is low compared to the findings of Soumana (2011) who obtained a carrying capacity of 0.26 TLU/ha by studying the grazed plant groups of rangelands in the Zinder region

V. Conclusion

Results in the present study revealed that Tahoua rangeland had an important diversified forage species. Moreover, the composition of the herbaceous plant species in the study area includes predominantly grasses and legumes that have a great potential to be grazed. The rangeland had a great forage production potential with a very good net pastoral value used as a natural ecosystem for the survival of grazing ruminant animals. The rangeland pasture production can support during

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