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Land pressure on agro pastoral resources and impact on Forage availability in Tandjilé Province/Chad

Keiba Dar[1], Kabe Hinlibe Karka[1], Dougrigue Elie[1], Madji Magloire[2], Inusa S.K.[3], Moumouni Oussein[4]

[1] Higher National Institute of Agronomic Sciences and Agro-Food Technologies of Laï-Chad.
[2]Faculty of Agriculture / Abdou Moumouni University/Niger Republic.
[3]Bayero University, Kano (BUK), Centre of Dryland Agriculture (CDA), PMB: 3011. Garzo Road Kano Nigeria
[4]Direction des Statistique, Ministère de l'Agriculture et de l'Elevage (MAG/El, PMB 12091 Niamey- Niger

Abstract

The studies investigated the land pressure in agro pastoral resources in Tandjilé Province, Southern Chad. The supervised classification and Man Kendall trend analysis using Landsat 7 images and Normalized Difference Vegetation Index (NDVI) images series analyzed the land use land cover change and the degradation trend of the rangeland. The land use land cover analysis indicated an increase of 21.73% for cultivated areas, 12.60% for settlement and a decrease of 4.95, 14.22 and 46.49% for water ponds, forest and vegetation resource respectively.

Keywords: *Tandjilé, Vegetation, forest*

Introduction

The rural population in the Sudano-Sahelian zone of West and Central Africa has grown by more than 40 percent over the past 20 years, reaching more than 281 million people (Rust, 2018). Combined with a demographic explosion, these upheavals have favored the extension of cultivated areas and the political and socio-economic marginalization of nomadic and transhumant populations (Banoin & Jouve, 2000). Over the past four decades, cropland has doubled in area reaching nearly 25 percent of the total land surface, a trend that scientist's project to accelerate alongside population growth (Brottem, 2021). Pastoral land scarcity pushes herders into protected areas, such as national parks and classified forests, and increases their dependence on nominally illicit practices such as tree branch lopping (Brottem, 2021). It has become increasingly clear that human populations have a powerful effect on the environment. Yet the exact relationship between population dynamics and the environment is complex and not well understood (Hunter, 2000).

Livestock production is the world's dominant land use, covering about 45% of the Earth's land surface, and much of it in harsh and variable environments that are unsuitable for other purposes. Arable land resources also feel the squeeze of population pressure. Fulfilling the resource requirements of a growing population ultimately requires some form of land-use change, whether to expand food production through forest clearing, to intensify production on already cultivated land, or to develop the infrastructure needed to support increased population. Indeed, it is humans' ability to manipulate the landscape that has allowed for the rapid pace of contemporary population growth (Hunter, 2000).

Human influence on the land and other natural resources is accelerating because of rapid population growth and increasing food requirements (Radoslava, 2016). Agriculture and deforestation are two prominent forms of human induced land-use change. Deforestation is closely linked to agricultural land-use change, because it often represents a consequence of agricultural expansion (Hunter, 2000). Human expansion throughout the world caused that agriculture is a dominant form of land management globally, and agricultural ecosystems cover nearly 40% of the terrestrial surface of the Earth (Radoslava, 2016).

The encroachment of cultivated land into grazing areas deepens pastoralists' grievance that their rights to resources be it land, water, wood, or forage are weaker than those of farmers and consequently have been ignored. Pastoralists typically only need seasonal access to resources, so their land rights are often treated as secondary to those of farmers (Brottem, 2021). Due to unprecedented population growth in the South and non-existent land management in the North, farmers are expanding their fields in this contested pastoral space, while pastoralists are moving to agricultural areas in the south during droughts to find water and grazing points for their herds (PNUE *et al.*, 2011).

In search of land, herders are increasingly forced into forest reserves. Livestock is the most valuable resource across many rural communities and is a common target of thieves. Increased frequency and magnitude of livestock thieves is both a cause and effect of violent conflict (Brottem, 2021).

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Materials and methods

Studies were conducted from Tandjilé Province, South-West of Chad (GPS coordinates: 9° 24'N latitude and 16° 18' E longitude). It has a surface land area of 18,045 Km² (INSEED, 2014). A sample of 96 was interviewed and the interviewees were the household heads.

Statistical data were collected from the cadastral service of Tandjilé which help to understand the evolution of the city and determine its impact on the resources while Satellite derived raster image were collected freely via the United States Geological Survey (USGS) Global Visualization Viewer (Glo Vis): https://www.glovis.usgs.gov and https://www.diva-gis.org/gdata. Supervision classifications were used to assess and examine the patterns of land use. The NDVI of several types of land cover were classified into three periods of ten years (1999; 2011 and 2020 for analyses).

Result

According to information received from agro-pastoralists and official services such as the cadastral service of the province of Tandjilé, there were two periods of urban and periurban subdivision from 1962 to 2009 and 2009 to 2019. The first phase of extension of living spaces on the East side of the city concerned a distance of 1km from 1962 to 2009; approximately 900m on both sides. These extensions of residential areas have had an impact on agricultural areas and forced peri-urban agriculture towards open spaces considered as grazing areas.

From 2009 to 2019, the extension of the city on crop area was estimated on the East side and reached 1.7km; 1.6m on the South side and 1.5km on the North side. The west side of the department of Tandjilé East where this research work was carried out is occupied by the Logone River that is also under threat on its borders due to climatic and anthropogenic impacts (loamy soil taking and brick making). From 1962 to 2009, in 47 years the residential areas witnessed a subdivision of 90,000 ha and 408,000 ha in 10 years from 2009 to 2019. That is a total of 498,000 ha of residential land use in the study area. This demographic pressure has played a role in the disappearance of forage resources and influences the areas reserved for agriculture and livestock.

In Tandjilé province, availability of forage is most variable and is depending to climate and likely human anthropogenic activity (bush fire). The critical period of unavailability of forage has observed in March, April and May. This is due to the fire bush caused on early on December by herders and February by farmers, for different reason. The agro-pastoralists have observed climate variability over the years in forage productivity in the study area.

After flood there is another herbaceous carpet which colonizes the plain however the species which compose this flora are the aromatic species in majority not consumed by the animals. These species cover the ground and are heat resistant until the rainy season.

Generally in the province of Tandjilé there are early bush fires between November and December. These bush fires are caused by transhumant pastoralists who have come down very early in recent years, clamed 78% of agropastoralists.

According to those surveyed, these fires facilitate the passage of cattle in the grassy savannahs which hide poisonous reptiles but also cause the regrowth of new pastoral plants.

Part of farmers met bring back the residues harvest to store and feed their animals. Others burn the residues voluntarily to prevent access to the transhumant animals who was considered by farmer as crops destroyers and conflicting people.

After January, there are no more fodder plants available, so the period of shortage of pasture started in mid-February. Agropastoralists use the stored crop residues and stored rice straw to feed their animals and sell surplus. Transhumant herders are forced to resort to aerial pastures, i.e. woody species that cut down in an uncontrolled manner. During this critical period, there is also a rise in heat which causes a lot of losses.

According to survey of agropastoralists opinion, estimated the rate of loss of rice straw in the country at 2/4 by destruction of fires in Tandjilé Province.

According to the surveys carried out, the fodder deficit had three causes: flooding, the occupation of pasture areas by fields, the bush fires that farmers set to drive away rats and game and the fire set on the residues culture to voluntarily prevent breeders from having access to the residues.

"Residues were abundant in the past, but currently farmers collect and burn residues expressly to prevent our animals from consuming" hinted the agropastoralists during the focus group carried out in the ferrick of Milmil.

NDVI is an index to measure healthy green vegetation. Vegetation index are widely used on the one hand, to identify and monitor the dynamics of vegetation, but also to estimate certain biophysical parameters characteristic of plant cover, such as biomass.

Table 1 gave the descriptive statistic of the average NDVI value of the study area during the raining season months and the average annual value of the time series data.

The average NDVI varies to 0.63 in October to 0.89 in June. The month of October had the less NDVI value, this because of the flooding period impacting the pasture in august and September.

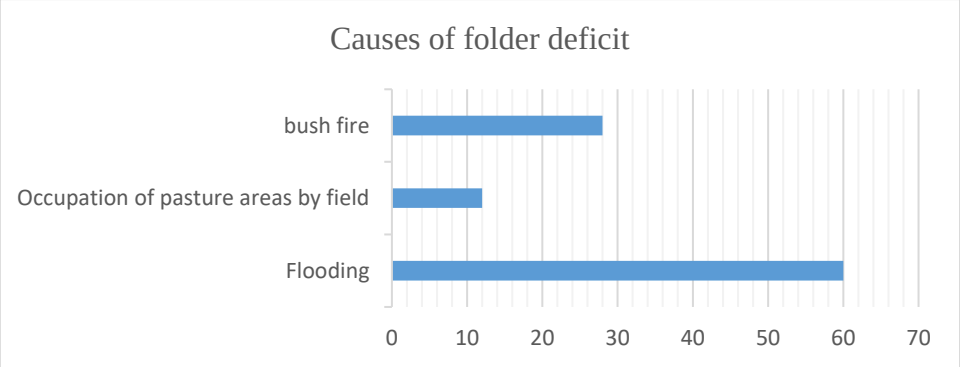

Figure: 2 causes of fodders deficit.

Table 1: Statistical parameters of NDVI.

Statistical parameters	*May*	*June*	*July*	*August*	*September*	*October*	*Average*
Mean	0.87	0.89	0.84	0.83	0.79	0.63	0.81
Standard Error	0.03	0.01	0.01	0.01	0.02	0.02	0.01
Median	0.92	0.91	0.84	0.84	0.77	0.62	0.81
Standard Deviation	0.13	0.05	0.04	0.06	0.09	0.11	0.03
Sample Variance	0.016	0.002	0.002	0.004	0.007	0.01	0.01
Kurtosis	3.17	2.13	-1.18	4.90	-0.37	0.56	0.25
Skewness	-2.21	-1.85	-0.22	-1.78	-0.49	0.10	-0.13
Range	0.37	0.15	0.14	0.26	0.31	0.43	0.14
Minimum	0.55	0.77	0.76	0.64	0.59	0.41	0.73
Maximum	0.92	0.92	0.9	0.9	0.9	0.83	0.88
Count	21	21	21	21	21	21	21
Coefficient variation %	14.83	5.40	5.40	7.15	11.09	16.83	4.18

Table 2: The Kurtosis and Skewness values show a normal distribution in the study area.

Parameters	*Z score*	*P-value*	*Kendall Tau*	*Variance*	*Slope*	*Confidence level*	*Interpretation*	*Trend*
May	-1.59	0.11	-0.22	795.53	0	0 0	Ho accepted	No trend
June	-1.06	0.29	-0.23	1938.03	-0.001	-0.0045 0.00	Ho accepted	Decreasing
July	2.023	0.04	0.32	1094.67	0.005	0.0001 0.007	Ho rejected	Rising
August	1.33	1.18	0.13	413.32	0.002	-0.003 0.006	Ho accepted	Rising
September	2.30	0.02	0.37	1091.00	0.007	0.001 0.012	Ho rejected	Rising
October	2.72	0.007	0.43	1095.67	0.011	0.003 0.012	Ho rejected	Rising
Annual	0.63	0.53	0.10	1096.67	0.0007	-0.002 0.004	Ho rejected	Rising

The annual value 0.63 for the Z score and 0.0007 for the Slope explains the positive trend (for the months of July, August, September and October). However, we observe deficits during certain periods, more particularly the month of June which shows a decreasing situation while the month of May shows a stable situation of the vegetation. The vegetation index for the month of May could be explained by the first rains recorded in the province.

Land Use Classification from 1999 to 2020.

Landsat satellites have the optimal ground resolution and spectral bands to efficiently track land use and to document land change due to climate change, urbanization, drought, wildfire, biomass changes (carbon assessments), and a host of other natural and human-caused changes. For this study we were focus on land use, urbanization and biomass. The images below show the different changing above 1999 to 2020.

The most pressure was observed in the decrease of vegetation in 1999 and 2020 (table 1) while crop farm pressure increase in 2020. These changes impacted negatively the transhumance mode.

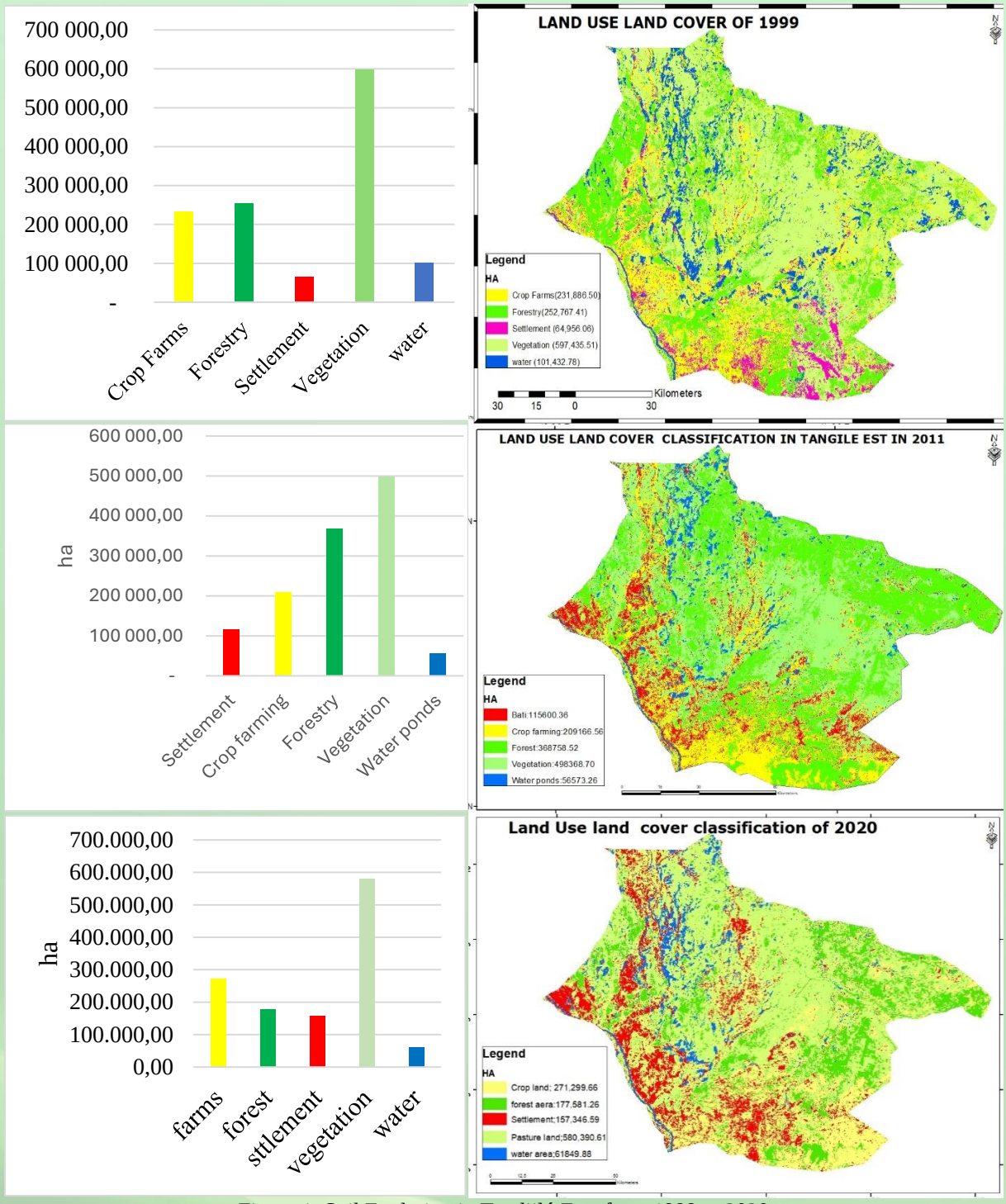

Figure 1: Soil Evolution in Tandjilé-East from 1999 to 2020

Table 1: Statistic of land use decade in Tandjilé-East

Designation	*1999*	*2011*	*2020*	*Variation*
Crop Farms	231 886,50	209 166,56	271 299,66	21.73
Forestry	252 767,41	368 758,52	177 581,26	-14.22
Settlement	64 956,06	115 600,36	157 346,59	12.60
Vegetation	597 435,51	498 368,70	580 390,61	-46.49
Water	101 423,78	56 573,26	61 849,88	-4.95

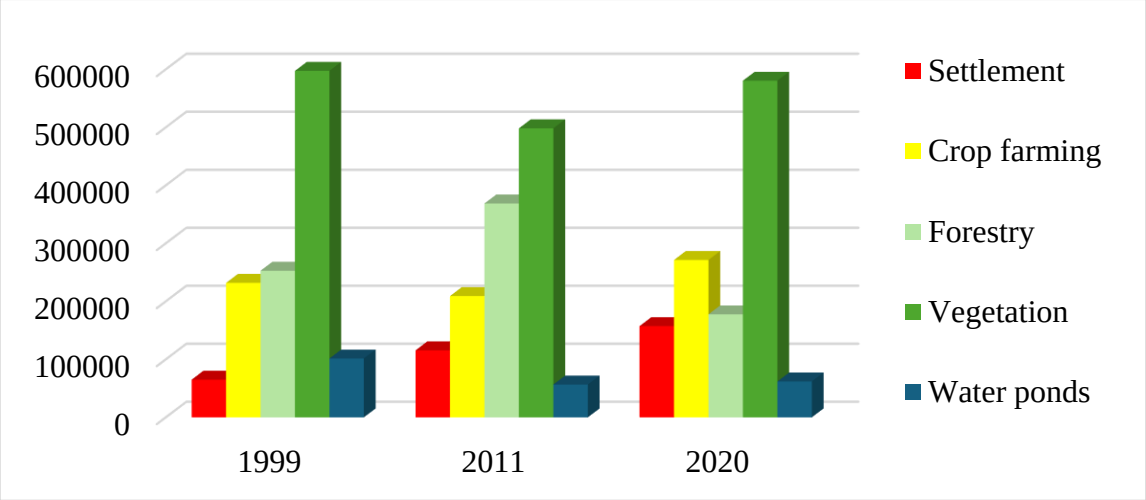

Figure 3: Proportion of occupancy over the last thirty years.

Landsat data from the province of Tandjilé made it possible to produce a land use map to examine the pressure on agro-pastoral resources in the study area. To this end, five entities were considered: settlement, fields, vegetation, forest and water.

In thirty years, we have noted an increase of 21.73% in cultivated areas, 12.60% in residential areas and a decrease of 4.95%, 14.22% and 46.49% in water, forest and vegetation.

Discussion

The soil pressure in Tandjilé province is reel. There was a land occupation of 90 000 ha from 1961 to 2009 against an occupation of 408 000 ha from 2009 to 2019. Between 2009, to 2019 we assist to the speed expansion of 82.92% of demographic pressure to the land. The results show a real demographic pressure on the soil. The report by Diogo *et al.* (2021) in Benin indicated that with the increase of mixed farming systems in many areas of the country, the use of pastoral lands has become more competitive. Akpan & Ebong, (2021), in Nigeria, revealed that agricultural land has continued to increase and currently averaged at 68.78%, indicating massive land expansion for use in farming. Furthermore, the findings showed that most arable crop outputs increase majorly from land expansion rather than land productivity. This situation cannot assure sustainable agricultural land use for food security in the near future. Besides, the country's agricultural land policies should focus on achieving land productivity and sustainable land-sharing strategies among major land users. The result show that the speed expansion of land uses in Tandjilé province is superior to the result obtained by Akpan and Ebong (2021) in Nigeria. The study of Hansen and Reenberg (1998), in Burkina has showed rather the fields expansion onto idle bush land. De Haan, (1998) clam that the reduction of grazing areas can be attributed to the expanding cotton cropping. According to Little & McPeak (2014), the loss of grazing land forces African herders to find new pastoral resources and increases the vulnerability of pastoralism. In Kétou (Benin), rangelands are contested by the sedentarization of herders and the yearly passage of many transhumant herds (Diogo *et al.* 2021).

Most interviewers (98 %) observed the forage deficit in Tandjilé province. The deficits sometime are caused by the farmers themselves who burn crop residues such as rice straw preventing the animals of the breeders from grazing in their fields. For Harouna *et al*., (2020) anthropogenic practices such as the collection of straw, which leads to a reduction in the edaphic stock of seeds, and the extension of crop fields to grazing areas, aggravate this degradation. These practices are the result of population growth and the decline in agricultural production. For Diogo *et al.*, (2021), the ecological processes leading to rangeland degradation are complex and cannot solely be attributed to cattle herding.

Most of transhumant herders and agropastoralists (88%) in Tandjilé Province have turned to aerial grazing, which is over-exploited during certain periods of the year between the months of February to May due to the low reconstitution of the herbaceous cover. Passage of the bush fire and the late arrival of the rainy season. This overexploitation of aerial pastures strongly affects the regeneration of certain species. *Faidherbia albida, Daniella oliveri, Zizyphus mucronata, Zizyphus mauritiana, Adansonia digitata* are highly threatened species in the area. This results confirm the study conducted by Dione et *al.*, (2020) in Senegal which showed that 82.14% of the woody species inventoried are considered fodder. These include *Adansonia digitata, Cordyla pinnata, Faidherbia albida, Ficus capensis, Ziziphus mauritiana* and *Sterculia setigera*. This observation shows the importance of the specific richness of the fields where all these species are found. Other respondents use these woody fodder for human food, pharmacopoeia, crafts, lumber, firewood, etc. This shows a strong pressure on these resources. According to Sarr *et al.*, (2018) trees are the main source of green aerial fodder in the Sahel in all seasons and are

found not only in agroforestry systems, but also in natural pastures. In pastoral areas, fodder supply during the dry season or in years of low rainfall is difficult with annual plants, and in these cases woody pasture becomes an important element.

Woody fodder species are much more exploited in the dry season when natural food resources become critical. This shows the importance of woody species in animal feed in the dry season. The survey results confirm those of many authors who noted the maximum use of aerial fodder by livestock during the dry season (Dione *et al.*, 2020; Bakaye, 2014), the dry season is the period during which woody plants are more exploited by agropastoralists. To access the different parts of the trees, breeders often practice cutting or pruning (Bakhoum, 2020). Diallo, (2019) in Mali confirm that the high demand for woody fodder crops leads to overexploitation of the most demanded. The consequence is the scarcity of these species in the harvesting areas. The results of the survey reveal the existence of overexploitation of woody fodder species which are consequently less and less abundant in the area. The overexploitation of species leads to the rarity or even the total disappearance of the species in the area.

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