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AN ASSESSMENT OF THE IMPACT OF HUMAN ACTIVITIES ON TABALAK WETLAND WATERSHED

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Abstract

The objective of this study was to assess how human activities affect Tabalak watershed dynamics. Data was collected from three sample sites along the Tabalak watershed to identify the morphological units and their socio-economic activities area. Satellite images and GPS coordinates were used and a Focus Group Discussion (FGD) was conducted. Our findings showed that in the last 40 years (1980-2020) there has been an increase in field surface areas and a decrease in the natural vegetation surface areas. The dynamics of the watershed reveal that the space occupied by vegetation was first transformed into crops and then evolved into other classes of bare soil and koris. It is therefore human who is responsible for accelerating the degradation of the environment. These actions are accentuated by the over-exploitation of vegetation, the best protection for soil against erosion.

Keywords: Wetland, Watershed, Land Use/Land Cover Maps and Tabalak.

Introduction

Sahel region of tropical Africa is increasingly facing harsh climatic conditions that aggravate food insecurity coupled with high population growth, with insufficient agricultural and pastoral resources due to soil fertility decline (Ichaou, 1996). Recent research by the United Nations (World Water Development, 2015) has demonstrated that some forces continue to seriously

affect the natural water resources in the Sahel (**Soro**, *et al.* **2014**). Over the last few decades, demographic growth has led to strong human pressure on the natural environment. The natural growth rate in the Tabalak community is 2.6 %. (CDPTabalak, 2010). This has resulted in the over-exploitation of natural resources in the municipality. Human actions in the watershed are contributing to the acceleration of land degradation. Indeed, land degradation, which reduces or destroys the capacity of soils for productivity, is both a cause and a consequence of poverty. In the absence of vegetation cover, soils are threatened by water and wind erosion and consequently become increasingly unproductive.

Material and methods

The study was conducted in the watershed of Tabalak wetland (figure 1) in the Tahoua region. The waterhole runs along the uranium road (Tahoua-Arlit road) for about ten kilometers, from the village of Kéhéhé to Tsaouna, passing through Tabalak. The waterhole is fifty (50) km from the town of Tahoua, around the geographical coordinates 15°05' North latitude and 05°39' East longitude (National Institute of Statistics NIS, 2012). The surface area of the water body varies according to the season from 50 ha to almost 1000 ha with an average depth of 2 m. The watershed is part of the Ader-Doutchi-Maggia plateau area. The average altitude of the watershed is between 300 and 500 m with a high point reaching 746 meters (CDP Tabalak, 2010).

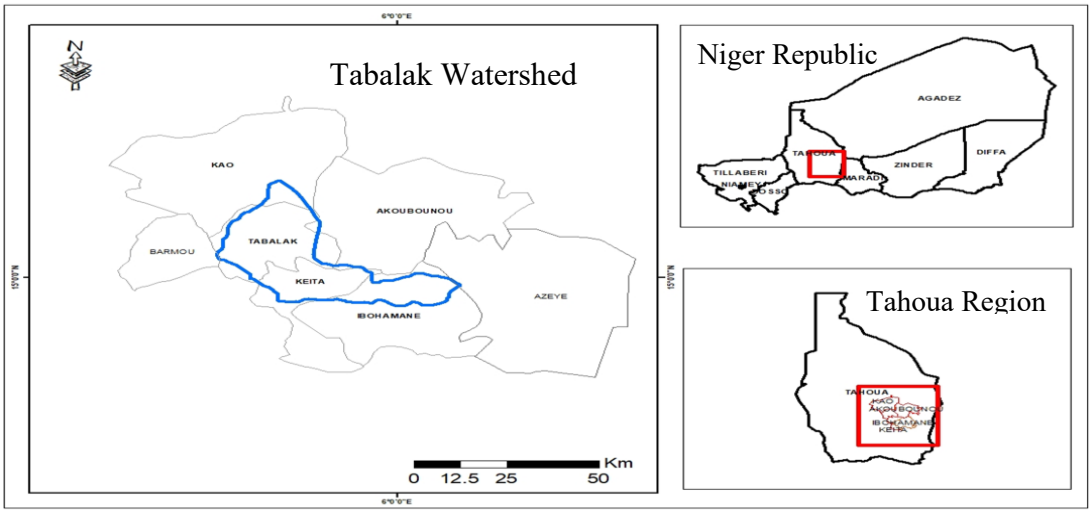


Figure 1: Watershed of Tabalak Wetland

Selection of the Study Area and Sampling

The locations for data collection (Figures 2 and 3) were selected through a literature review and field visits which made it possible to detect the major environmental issues due to land degradation and human activities in the watershed.



Figure 2: delimitation of the study area on the Landsat image

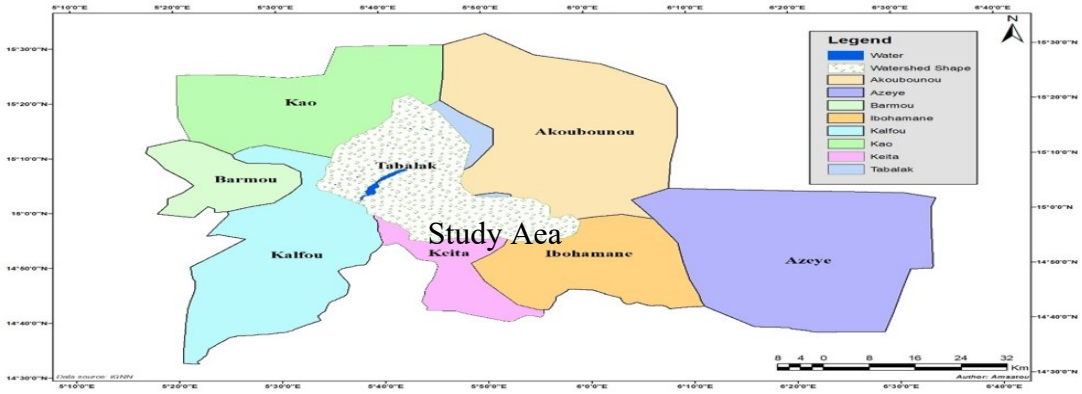


Figure 3: The study area in the Tabalak watershed

Method for Data collection

The checklist of different users and their activities was developed and Focus Group Discussion (FGD) was used to collect socio-economic pieces of information. The role and activities of each user were identified during the study. These materials were developed and used to interact with watershed users of the Tabalak Lake. These included: irrigation farmers, herders and livestock animal breeders, fishermen, gardeners, seasonal vegetable and grain marketers, etc. The population included: Men and Women; adults and old people who are either watershed land owners or users.

Material

The Landsat multi-spectral satellite images geo-referenced without cloud cover of the US Space Agency (NASA) operates at an average altitude of 705 km in near-polar circular orbits with an inclination of 98.2°, were used in this study. The land use/land cover map for the year 2021 from the sentinel imagery of 10 m resolution was also used as its table of statistics. Six sets of GPS readings of 5 points each (30 points in

total) collected in the field representative of each land use class, were used for the validation of the classification results.

2.3.Impact of Human Activities Data Processing and Analysis

a. Pre-Processing of Satellite Images

Before proceeding with the thematic classification of the satellite images, a series of pre-processing operations were carried out to facilitate their use. These include combining the bands to obtain a single multispectral image. The Landsat images are designed as individual grey level bands in Geotif format, all the bands were combined in ENVI software using the Layer Stacking module.

b. Supervise Classification

The method of classification by an object, put in place for this study, is a method of supervised classification under the image processing software ArcMap. The supervised classification is practiced if the class domains are known a priori. Supervised methods consist of two phases: the training phase and the classification phase. In the first phase, using samples of pixels including the membership class, training zones are established for each class. A training area is an area of the image with known ground cover of the user. In the second phase, the pixels of the entire image are classified by comparison of each pixel with known domains. The classes chosen are defined as follows:

- ✓ Water: Includes all water-covered surfaces at the date of acquisition image;
- ✓ Habitation: includes dwellings, Villages, markets, and any other construction,
- ✓ Vegetation: includes Natural or artificial vegetation;
- ✓ Fields: includes market gardening, arboriculture, park cultivation
- ✓ Bare soil: includes all surfaces with no vegetation (including rocky terrain, glaciers and dunes);
- ✓ Koris (Watercourse): includes all surfaces of dry, non-permanent, moving open water on the date of the image acquisition.

c. Post-Classification Processing and Validation

Once the classification was completed, processing was carried out to refine, evaluate the accuracy, and validate the results. The validation of classification is done by analyzing a confusion matrix

d. Statistical Analysis of Land Cover Change

The areas of different land use/ land cover classes were calculated from the intersection of the 1980, 1990, 1999, 2010, and 2020 land use/ land cover maps using the 'Intersect' function in ArcGIS 10.5 software. The determination of the nature of change by land use/land cover class was made from the transition matrix. It used to highlight the different forms of conversion that the land use/ land cover class underwent between 1980 and 2020. The number X of rows in the matrix indicates the number of land use

classes at time t0; the number Y of columns in the matrix is the number of converted land use classes at time t1 (t0 +10 years) and the diagonal contains the areas of the land use class that remained unchanged. The transformations are therefore row to column (Table 1).

Table 1: summarises the method for calculating the transition matrix.

	Category j at time t1			
Category i at time t0	Category 1 (j = 1)	Category 1 (j = 2)	Category 1 (j = 3)	Sum of Eit0 of rows
Category 1 (i = 1)	a(1,1)	a(1,2)	a(1,3)	Σ a(1,j), j = 1,n
Category 1 (i = 2)	a(2,1)	a(2,2)	a(2,3)	Σ a(2,j), j = 1,n
Category 1 (i = 3)	a(3,1)	a(3,2)	a(3,3)	Σ a(3,j), j = 1,n
Sum of Ejt1 of columns	Σ a(i,1), i = 1,m	Σ a(i,2), i = 1,m	Σ a(i,3), i = 1,m	ΣΣ a(i,j), i = 1,m

Source: Adapted from - L. Sintondji et al. (2013) and Ayena et al. (2017).

The conversion rate (CR) of a land use/ land cover class corresponds to the degree of transformation undergone by this class by converting to other classes. It therefore expresses the amount of change observed in a land use/ land cover unit between one decade and the next and thus measures the degree of conversion of a given unit to other land use/ land cover units. Indices of the transition matrix are obtained according to the Formula:

$$CR = \frac{Sit - Sis}{Sis} * 100 \qquad (I)$$

Sit Area of landscape unit i at the initial date t0;

Sis: Area of the same unit remaining stable at date t1

2.4.Rate of anthropogenic activities of Tabalak wetland

To measure the rate of anthropogenic activities the ecological disturbance index (U) was calculated. It represents the ratio of the total area of the so-called anthropogenic classes (in the context of this study, these are crops, bare soil, and dwellings) in the watershed to the total area occupied by natural classes or classes considered as very weakly anthropized (here, this is vegetation, koris, and water). When U > 1, the landscape is said to be disturbed.

Results

a) Level of Mapping Accuracy

The level of validity of these maps is expressed by the Kappa coefficient (KC) and the overall accuracy index (OAI) gives a measure of the level of reliability of these maps (Table 2**)**.

Table 2: Assessment of the level of validity of the mapping work

Years	**1980**	**1990**	**1999**	**2010**	**2020**
OAI (%)	70.14	61.08	73.25	78.31	90.05
K C (%)	85.1	63.45	70.34	66.62	89.3

Source: Calculated values, 2022

Overall, the maps show a statistically acceptable level of accuracy above 50%. The criteria used to select the satellite image scenes and the approach used in the production of the maps can be used as a basis for the analysis of landscape dynamics.

b) Ecological Processes Associated with Tabalak Watershed Dynamics

Figure 4 shows the evolution of land cover classes (vegetation and fields) from 1980 to 2020 in the Tabalak watershed. The curve adopts the same pattern suggesting a similar structuring of the watershed. It shows a phase of exponential decrease of vegetation class during the period 1980-1999 followed by a phase of relative constancy during the decades 2010 and 2020. From an ecological point of view, the major processes that can be associated with this spatial dynamic are: The phase of linear decrease of the vegetation class is consecutive to a process of creation of a new fields class. from the year 1980 onwards the classes vary slightly. This reflects the complete disappearance of vegetation on the sand dunes and rocky plateaus. These results are reflected in the watershed mapping which shows a quasi-stability in the land cover class ranges following the complete expansion of cultivation in the valley and the complete disappearance of natural vegetation on the sand dunes and rocky plateaus**.**

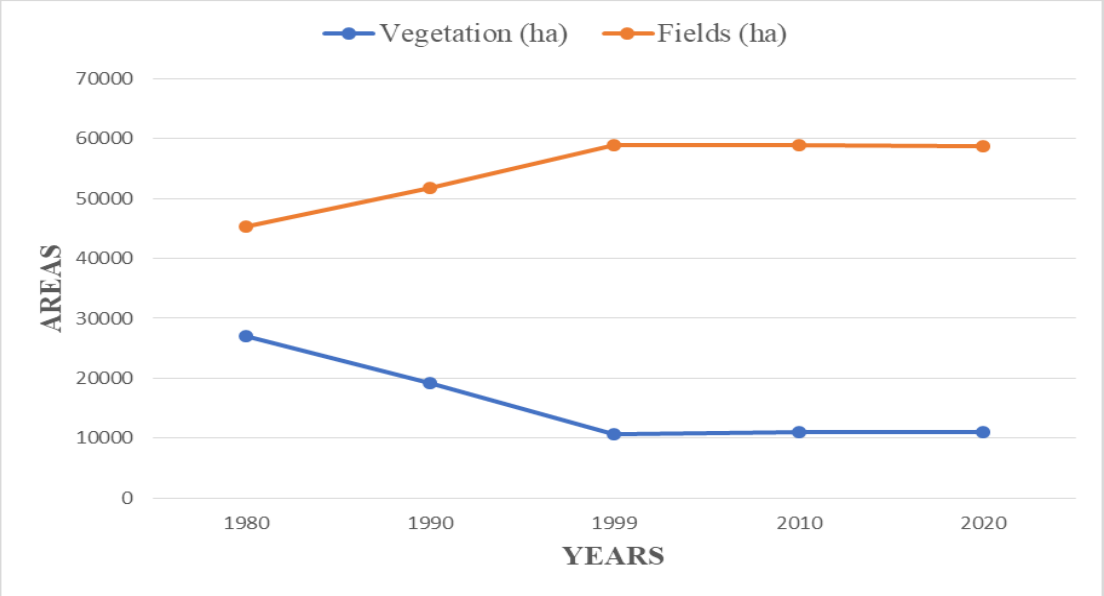


Figure 4: Evolution of land cover classes in the watershed from 1980 to 2020

The analysis shows an increase in the area of the fields and a decrease in the area of the vegetation class.

After this description of the evolution of the main land cover classes, it is important to understand the nature of the reconversion between the land cover classes to better understand the dynamics in its inter-class specificity. In this aspect, the transition matrices established at decade steps offer a great readability of the changes between

land cover classes. The results of the transitions expressed as a hectare are shown in Table 3

c) **Table 3:** Transition Matrix of land cover changes from 1980 to 2020

1980 -1990							
Area (ha) 1980	Area (ha) 1990						Total 1980
	W	H	V	F	BS	K	
W	-0,12	15,44	-92,79	-97,33	-95,51	-53,01	1379,64
H	-13,57	0,11	-93,77	-97,69	-96,11	-59,34	1193,81
V	1855,97	2160,65	41,06	-47,69	-12,04	820,25	27016,87
F	3178,05	3688,66	136,4	-12,35	47,41	1442,27	45278,09
BS	2016,67	2346,38	52,65	-43,4	-4,81	895,86	29236,54
K	112,36	145,44	-84,68	-94,32	-90,45	-0,09	2933,26
Total 1990	7149,36	8356,68	-41,13	-392,78	-251,51	3045,94	107038,21
1990 -1999							
Area (ha) 1990	Area (ha) 1999						Total 1990
	W	H	V	F	BS	K	
W	-1,94	15,7	-87,1	-97,65	-95,68	-52,78	1408,59
H	-15,16	0,11	-88,84	-97,97	-96,26	-59,15	1193,81
V	1259,72	1504,36	78,87	-67,43	-40,15	554,72	19153,05
F	3567,3	4227,1	382,44	-12,15	61,43	1665,84	51657,5
BS	2080,57	2472,89	186,86	-47,77	-4,01	949,97	31999,49
K	108,42	145,92	-72,58	-95,01	-90,82	0,36	2925,37
Total 1999	6998,91	8366,08	399,65	-417,98	-265,49	3058,96	107038,23
1999 -2010							
Area (ha) 1999	Area (ha) 2010						Total 1999
	W	H	V	F	BS	K	
W	2,09	17,99	-87,14	-97,61	-95,56	-51,54	1381,25
H	-13,47	0	-89,1	-97,97	-96,23	-58,93	1195,1
V	676,1	796,92	-2,241	-81,83	-66,21	268,38	10707,59
F	4162,19	4825,69	436,87	-0,19	85,56	1923,05	58803,37
BS	2219,39	2580,45	192,15	0,98	0,98	0,98	30715,54
K	112,04	145,05	-73,29	-95,035	0,64	0,64	2935,8
Total 2010	7158,34	8366,1	377,249	-371,66	-170,82	2082,58	105738,65
2010 -2020							
Area (ha) 2010	Area (ha) 2020						Total 2010
	W	H	V	F	BS	K	
W	8,69	15,57	-87,404	-97,65	-95,69	-51,59	1379,65
H	-13,47	-2,59	-89,1	-97,96	-96,27	-58,11	1193,81
V	693,89	817,48	-1,004	-81,33	-65,78	284,32	10952,99
F	4170,27	4835,02	437,89	0,45	84,05	1967,22	58914,83
BS	2196,98	10218,2	189,33	-45,97	-0,99	1011,96	31690,28
K	110,68	143,48	-73,46	-95,04	-90,92	1,99	2906,67
Total 2020	7167,04	16027,2	376,252	-417,5	-265,6	3155,79	107038,23

Source: Calculated values, 2022

Legend: W: Water**, H:** Habitation**; V:** Vegetation**; F:** Fields; **BS:** Bare Soil; **K:** Koris Table 3 shows that from 1980 to 1990, the natural vegetation suffered degradation of 7,863.82 ha, because of the 27,016.87 ha of the surface occupied by vegetation in 1980, 41.06 ha remained unchanged; 47.69 ha were transformed into crops, 820.25 ha converted into koris and 12.04 ha converted into bare soil.

During the decade 1990 - 1999 the area of vegetation decreased by 8,445.46 ha; of the 1,915.05 ha occupied by vegetation in 1990, 78.87 ha remained unchanged, 67.43 ha were transformed into crops, and 40.15ha were converted into bare soil. However, for the 1999-2010 decade, of the 10,707.53 ha occupied by vegetation in 1999, 81.83 ha were transformed into crops, and 66.21 ha converted into bare soil.

The area of bare soil increased from 29,236.54 ha in 1980 to 31,690.28 ha in 2010, an increase of 2,453.74 ha. This increase is also perceptible at the level of koris, which occupied 2,933.26 ha of land in 1980 and rose to 3,155.7 ha in 2020, an increase of 222.53 ha.

Being the result of the ultimate manifestations of water erosion, these koris have expanded considerably as a result of the degradation of natural resources, particularly the Vegetation on the top of the plateaus and sand dunes (Plates 1 and 2). This phenomenon is accentuated throughout the watershed, particularly on the upper slopes of the slopes that follow the plateaus and which are cultivated by the population. The widening of the koris is most often done by subsidence. In addition to this subsidence phenomenon, there are problems of regressive erosion leading to the silting up of the waterhole, and field observation shows that the left-hand slope is the most affected.

The dynamics of the watershed revealed that the space occupied by vegetation was first transformed into crops and then evolved into other classes such as bare soil and koris.



Plate 1: Plateau on the Eastern side of the Tabalak watershed



Plate 2: Sand dune in the Northern axis of the Tabalak watershed

C) Rate of anthropogenic activities of Tabalak wetland watershed

Table 4: The decadal changes of the Tabalak watershed

years	1980	1990	1999	2010	2020
U	2.42	3.56	6.12	6.02	6.05

Source: Calculated values, 2022

The analysis of Table 2 shows that the decade 1990 - 1999 is the most marked by human intervention in the modification of the watershed with a rate of anthropogenic activities that increased from 3.56 in 1990 to 6.12 in 1999.

Discussion

The analysis of the transition matrix shows that from 1980 to 1990, the natural vegetation suffered degradation of 7,863.82 ha, because of the 27,016.87 ha of the surface occupied by vegetation in 1980, 41.06 ha remained unchanged; 47.69 ha were transformed into crops, 820.25 ha converted into koris and 12.04 ha converted into bare soil.

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Conclusion

The Tabalak Lake is threatened by silting up due to the loss of vegetation cover in the watershed, which may eventually lead to its disappearance.

The land degradation analysis showed that the Tabalak watershed was in a considerably degraded state. Human activity has led to a considerable reduction in woody vegetation, and the disappearance of herbaceous vegetation and wildlife through logging and overgrazing, resulting in a drop in the water table and a decline in soil fertility.

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