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Research Article

Spatio-temporal mutations of land use in the rural commune of Tanda in Niger

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ABSTRACT

The spatio-temporal analysis of land use in the commune of Tanda shows that this commune, like many others in Niger, is experiencing significant changes in the evolution of its landscape, the main causes of which are anthropogenic and climatic factors. In the present study, the exploitation of multi-date Landsat satellite images and the use of Geographic Information Systems (GIS) made it possible to trace the mutations that occurred between 1985 and 2025 and identify the general trend of this landscape dynamic. The results obtained highlight the changes that the different land use units have undergone. Thus, the wooded-shrubby savanna, water bodies and flood zones have decreased in area between 1985 and 2025, while rainfed and irrigated crops, bare or degraded soils, and human settlements have marked a spatial extension for the same period. These spatio-temporal transformations of the natural environment of this administrative entity can impact local socio-economic conditions, in particular on the availability and access to natural resources on which the populations partly depend.

Understanding these dynamics is fundamental for the sustainable management of these (natural resources) and territorial planning adapted to the environmental, demographic and climatic realities of the commune.

Key words: GIS and Remote Sensing, Landscape, Mutations, Tanda.

1. INTRODUCTION

In Niger, changes in land use have been increasing for several decades, affecting ecosystems. The study of land use dynamics through diachronic analysis proves to be a privileged entry point in assessing the interactions between humans and their environment and in identifying appropriate strategies for planned management of natural resources [1], [2].

Indeed, the combination of the impacts of anthropogenic activities and climatic factors leads to a modification of land use, often with adverse consequences on ecosystems, especially plant formations [3]; [4]; [5]; [6]; [7]. Therefore, the vital needs of populations, especially local ones, are becoming increasingly important, one of the consequences of which is increased pressure on natural resources already weakened by physical factors [9]; [10], [11]. It is therefore judicious to provide decision-makers with information relating to the dynamics of territorial resources for a better knowledge and management of their territory. To do this, several methods have been invented and applied, with varying levels of effectiveness, including the joint use of Geographic Information Systems (GIS) and remote sensing to understand the evolution of the landscape [12]; ([13]; [14]; [3]; [15].

The Commune of Tanda, located in the Dosso region of southwestern Niger, has been facing a spatio-temporal dynamic of land use for several decades, which highlights a progressive transformation of land cover and use, largely the result of the action of natural factors, with a marked influence of climatic conditions. These changes are also amplified by anthropogenic pressures that intensify over time. All of these dynamics contribute to profoundly reshaping territories and their ecological functions. In this commune, climatic variations, combined with agropastoral practices that are not very respectful of the environment, continually shape the natural landscape. The study of these transformations has made it possible not only to assess the degree of degradation, extension or regression of the different land use units (rainfed crops, human habitats, vegetation, bare soils, etc.) but also to better understand the issues related to the sustainable management of these

resources. Based on a diachronic analysis of the natural landscape, based on remote sensing data, in particular Landsat images, this (analysis) has led to revealing the spatio- temporal trends of past and current environmental changes in the commune of Tanda.
This mutation thus expresses the very impact of the interaction between man and his environment.
The objective of this work is to conduct a diachronic analysis of the landscape in order to highlight the spatio-temporal transformations of land use that have taken place in the rural commune of Tanda from 1985 to 2025 via appropriate methods and data. It is a question in particular of carrying out the land use mapping of the commune over the three reference years (1985, 2005 and 2025) from Landsat 7 and 9 images in order to trace the spatio-temporal evolution of the landscape units. This will provide communal and state decision-makers with basic information for possible territorial planning and sustainable environmental management adapted to the ecological issues that emerge in a context of climate change and population growth.

2. MATERIALS AND METHODS

Study area

The rural commune of Tanda is located in the department of Gaya (Dosso region) in southwestern Niger (figure 1). It covers an area of approximately 343 km² with an estimated population of 49,890 in 2012, compared to 70,147 in 2021 and 81,604 in 2025, for an estimated average density of 196 inhabitants/km² [16]. The relief is characterized by three major units: the flat-topped plateau, the glacis, and the Niger River valley. The rural commune of Tanda rests on a substrate largely dominated by the clayey sandstones of the Middle Niger, and whose main types of soils encountered are raw mineral erosion soils, slightly developed soils, tropical ferruginous soils, ferralitic soils, and hydromorphic soils [17]. On the major bed of the river, there are alluvial deposits, while pseudogley soils and slightly leached ferruginous soils with mottling are found in the river terrace areas. The commune belongs to the dry tropical Sudanese climate zone located in the extreme south of Niger and is characterized by average rainfall of around 800 mm and can reach 1000 mm in years of good rainfall. On the phytogeographic level, the commune of Tanda belongs to the western North-Sudanese compartment. The main activities of the population are agriculture, livestock farming, fishing, beekeeping, and the marketing of forest fruits [19].

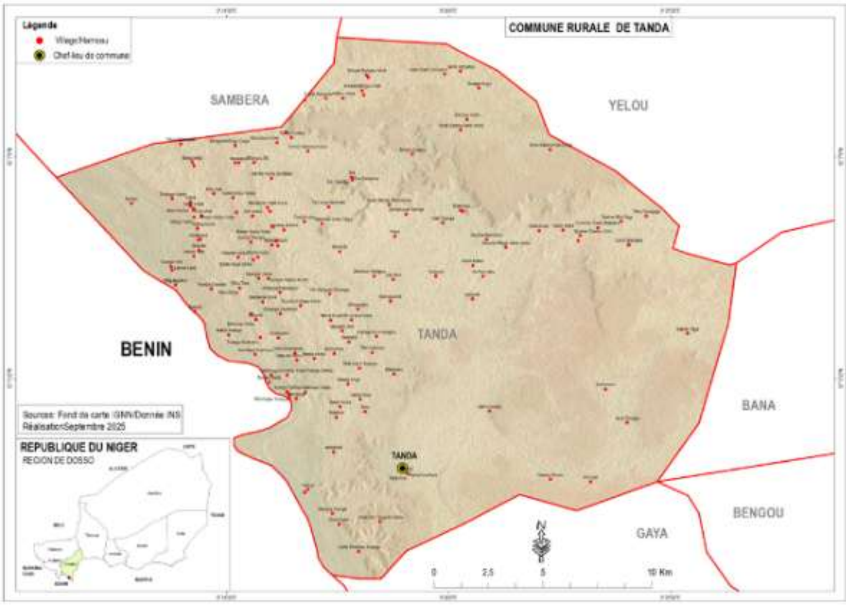

Fig. 1: Location map of the commune of Tanda

Material

To carry out the diachronic monitoring, the following materials are used:
-a GPS receiver to record the geographical coordinates in the field,
-image processing and GIS software such as ArcGIS 10.8 and QGIS 3.X.
-statistical analysis, data import and conversion software and the creation of graphs: Excel/SPSS spreadsheet and statistical processing, etc.

Basic data

The data used in this study consists, among other things, of georeferenced layers of administrative boundaries and localities of Niger from the IGNN. These served as cartographic support for the delimitation of the study area and the location of villages. Also, Landsat 5 TM, Landsat 7 ETM+ and Landsat 9 OLI -2 satellite images (Table N°2) were used to develop land use maps and spatio-temporal changes in the natural environment.

Methodology used

The methodology adopted to understand the spatio-temporal mutation of land use is mainly based on diachronic analysis from the processing of remote sensing data, mapping by supervised classification and the use of geographic information systems (GIS) techniques.

Diachronic analysis of land use

Identification of scenes and downloading of images of the study area

The first step in the development of land use maps of the study area was the identification and acquisition of image scenes at different dates via the Landsat grid (Path and Row), then their download from the USGS EarthExplorer site. After acquiring the scenes, the images were
subjected to pre-processing operations, including false color composite in the order 5-4- 3 (Landsat 5 TM and Landsat 7 ETM+) and 6-5-4 (Landsat 9 OLI -2); then a linear contrast enhancement to improve the visual appearance to facilitate interpretation. The advantage of using Landsat satellites with different sensors is that these (TM, ETM+, OLI) have the same spatial and temporal resolution as well as the same swath.

Table. 1: Characteristics of Landsat images used.

Image	Spatial resolution	Sensor	Acquisition date	Path& Row
Landsat 5 TM		TM	1985	192/05 2
Landsat 7 ETM+	30 m	ETM+	2005	
Landsat 9OLI -2		OLI-2& TIRS-2	2025	

Source: USGS/EarthExplorer, 2025 adapted

Image processing and analysis

For the identification of the different land use units, supervised classification was preferred to automatic classification, due to its reliability using the "Maximum likelihood" algorithm. The one calculates a multidimensional probability function to determine the probability of each pixel belonging to one of the categories corresponding to the spectral signatures [24]. Thus, based on the previously defined training sites which correspond to the different land use units (rainfed crops, bare soils, water bodies, etc.) and taking into account the knowledge of the field and with reference to the Land Use Nomenclature (NOT) of Niger, the image is classified in order to obtain the provisional thematic map.
To validate the accuracy of this classification through the confusion matrix, indices such as overall accuracy, Kappa coefficient, excess and deficit errors, user accuracy and producer accuracy were used to verify and evaluate the number of pixels correctly classified and those that are not. To do this, 65 control points previously chosen and supposed to be representative of each land use unit of the classified image of 2025 were compared to the reality of the field using a GPS receiver which was used to collect geolocated information. After integrating the field data and correcting the classification, a majority spatial filter *(Majority Filter)* was applied to smooth out any isolated pixels, before vectorizing the classified images and create the final land use maps with ArcGIS 10.8.3© software. Indeed, ground truth is a fundamental step in the development of maps, as it allows to verify the validity of the interpretation and its accuracy by comparing the results to the reality of the field.

Study of land use changes

These changes are understood through the evolution in time and space of land use classes towards a stage of degradation, improvement or more or less stable equilibrium, reflecting all spatio-temporal variabilities [20]. This dynamic makes it possible to synthesize the changes in land use classes that have occurred in the same landscape at different periods [20].
In the context of this study, the changes were analyzed from the evolutionary curves of the states and the comparison of variation of the surfaces of the units of land use at the different dates of analysis.
The global statistic (Global Rate GR) of the evolution of land use was calculated in using the equation proposed by Fund Agriculture Organisation (1996). Thus, the rate corresponding to the dynamics of each land use unit was calculated according to the formula: $\mathbf{Tg = (S_2 - S_1) / S_1 x100}$ [1]
Tg: Overall growth rate;
$\mathbf{S_1}$: the surface of a class of surface unit at the date $\mathbf{t_1}$;
$\mathbf{S_2}$: the area of the same class of surface unit at date $\mathbf{t_2}$.
The data from the results of the calculation of the rate of evolution of land use will be preceded by minus **(-)** or plus **(+)** signs to express respectively either a regressive or a progressive dynamic [22].
The annual rate of change (T)between consecutive dates was calculated according to the following formula from Oloukoi et al., 2007 [7].

$$T = \frac{(\ln S_{i+1} - \ln S_i)}{t \times \ln e} \times 100$$

Where:

Si = Area of the occupation class at the date i ;
Si+1 = Area of the occupation class at the following date;
t = Number of years separating the dates of observation **Si and Si+1;**
ln =natural logarithm and
e = **2.71828** (approximate value of **e** of Leonard EULER).
This formula measures the average annual rate of change of a surface or variable between two given dates [7].

Transition matrix

It makes it possible to highlight the different transformations undergone by the land use units between two dates t_1 and t_2. It describes in a condensed way the changes in state of the elements of a system during a given period [25], whose cells contain the value of a variable having passed from an initial class **a** to a final class **b** during the period from t_1 to t_2 [23. It is made up of **X** rows and **Y** columns. The number of rows in the matrix indicates the number of classes of land use at time t_0; the number **Y** of columns of the matrix is the number of classes of land use converted at time t_1 and the diagonal contains the areas of the plant formations remained unchanged. The transformations are therefore made from lines to columns [45].
In the context of this study, the transition matrix is obtained from the intersection of the land use maps of 1985, 2005 and 2025, using the *"Intersect polygons"* algorithm of the extension *"Geoprocessing"* of ArcGIS and their processing with the Excel spreadsheet after export.

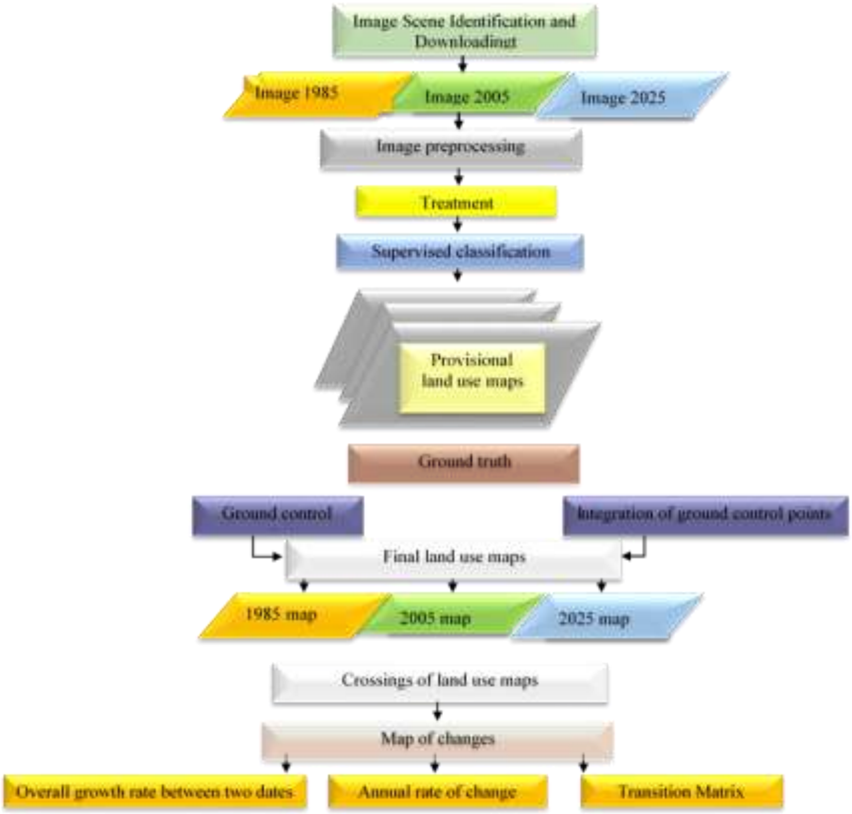

Fig. 2: Conceptual diagram for data processing and analysis

3. RESULTS

Accuracy of satellite image classification

Table 2 below presents the results of the accuracy assessment of the classification performed on the reference year images (1985, 2005, 2025) based on automatically calculated confusion matrices and the overall ground accuracy calculated based on the control points of the map with their correspondences on the ground.
Indeed, the confusion matrix allows us to know the level of accuracy of the processing, as it consists of comparing the results of the supervised classification with those of the ground truth. The classifications thus obtained are mostly excellent and reliable. This reliability is confirmed by the overall ground accuracies, which are validations by control points from the units of the provisional land use map of the year 2025 with the ground reality.

Table. 2: Validation index of the classifications of the municipality of Tanda in 1985, 2005 and 2025

Validation index	**1985**	**2005**	**2025**
Kappa coefficient	0.84	0.96	0.87
Automatic overall accuracy (%)	89.36	95.63	95.23
Overall ground accuracy (%)	82	80	84

Land use situation of the municipality in 1985, 2005 and 2025

The cartographic results of the land use units of the municipality of Tanda are given by Figures 3, 4 and 5 below. Overall, there is a regression of plant resources, both in agricultural areas (rainfed and irrigated), as well as bare or degraded soils increase in area.

In 1985, plant formations, including wooded-shrubby savanna and the Ripicoles cord, covered 16014.74 ha and 130.92 ha respectively, i.e. 35.66% and 0.29% of the total area of the study area. Rainfed and irrigated crop areas represent in order 48.19% and 4.03% of the studied sector with 21645.15 ha and 1812.52 ha, while bare or degraded soils have an estimated area of 545.56 ha (1.21%). Flood zones, bodies of water and the island represent 2283.37 ha (5.08%),907.41 ha (2.02%) and 835.67 ha (1.86%) respectively. Human Habitation (0.97%) and Kori (0.66%) cover less than one percent (-1%) each with 436.61ha and 298.14 ha respectively.

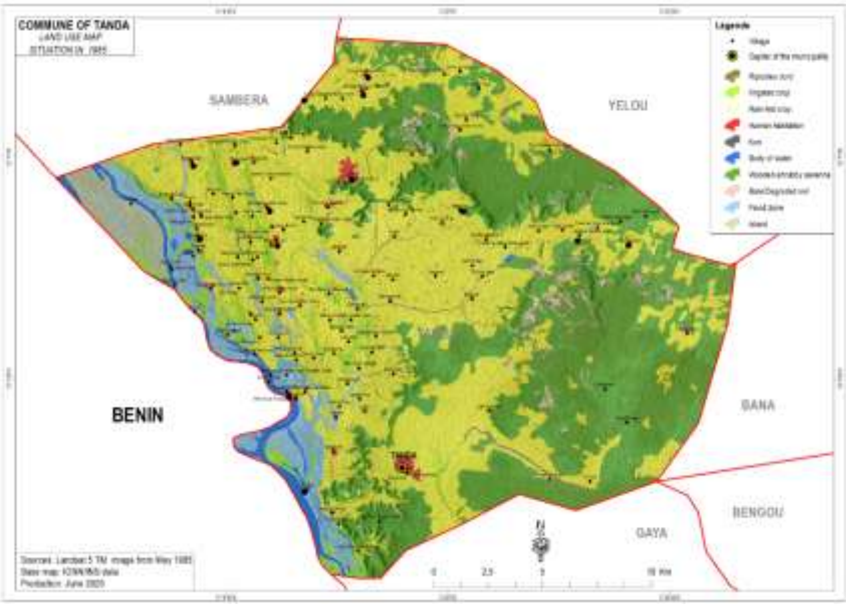

Fig. 3: Land use study map of the municipality of Tanda in 1985

The analysis of the 2005 land use map shows that 57.53% of the area of the municipality was occupied by rainfed crops with 25838.11 ha, compared to 11622.72 ha (25.88%) and 130.92 ha (0.29%) respectively for wooded-shrubby savannah and Ripicoles cord. The areas of irrigated crops, islands, flood zones and bodies of water are estimated respectively at 3017.31 ha (6.71%) 945.09 ha (2.10%), and 1041.91 ha (2.32%) and 832.69 ha (1.85%). As for Human Habitation, the Kori and bare or degraded soils each occupy in order 1.41%, (637.36 ha), 0.66%, (298.29 ha), and 1.25%, (545.70 ha) of the total area of the municipality.

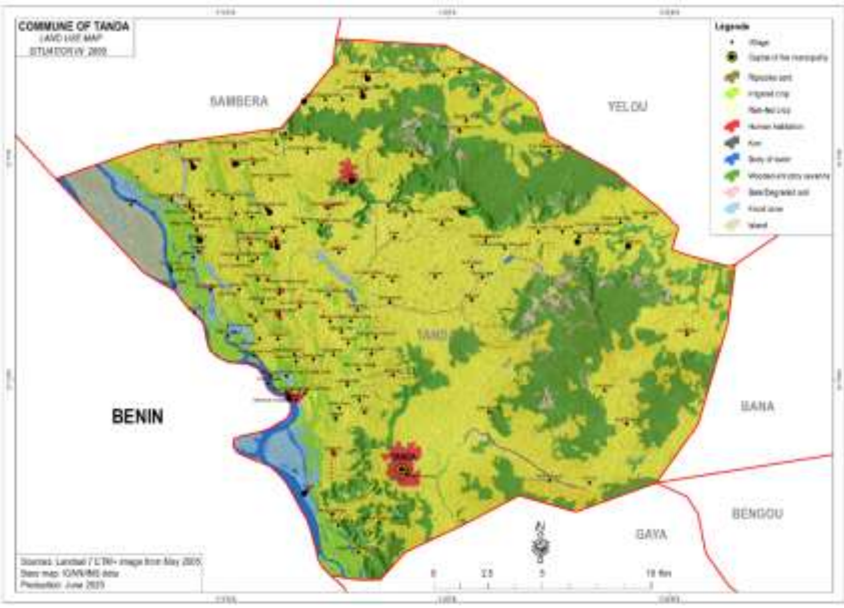

Fig. 4: Land use study map of the municipality of Tanda in 2005

In 2025, the landscape of Tanda is characterized by an extension of the areas occupied by rain- fed and irrigated crops, bare or degraded soil with respectively 27424.26 ha (61.06%), 3363.90 ha (7.49%), and 789.44 ha (1.75%). Conversely, the statistics show a regression of the areas occupied by plant resources, in particular the wooded-shrubby savanna and the Ripicoles cords with 9255.94 ha (20.61%) and 131.40 ha (0.29%) respectively.

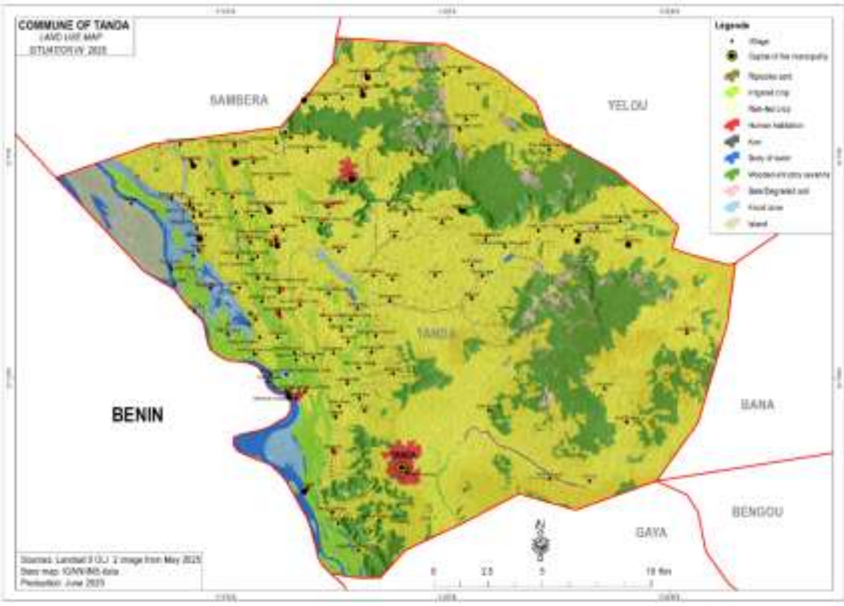

Fig. 5: Land use study map of the municipality of Tanda in 2025

Changes in land use from 1985 to 2025

The results of the spatio-temporal evolution of land use units show a decrease in the areas of wooded-shrubby savanna, which decreased from 35.66% in 1985 to 25.80% in 2005, then 20.62% in 2025. At the same time, those (areas) occupied by rain-fed and irrigated crops, bare or degraded soil have increased, rising respectively from 48.19%, 4.03% and 1.21% in 1985 to 61.06%, 7.49% and 1.75% of the total area of the study area in 2025. Detailed statistics are given in Table 3 below. As for Fig. 6, it illustrates the evolution in the form of a graph of each unit for the three reference periods (1985, 2005 and 2025) Tab. 3: Statistics of land use units in the municipality of Tanda in 1985, 2005 and 2025.

Table. 3: Statistics of land use units in the municipality of Tanda in 1985, 2005 and 2025

Units	**2025**		**2005**		**1985**	
	Area (Ha)	Percentage	Area (Ha)	Percentage	Area (Ha)	Percentage
Ripicoles cord	131.403	0.293	130.092	0.292	130.923	0.292
Irrigated crop	3363.902	7,490	3017.312	6.719	1812.520	4.036
Rain-fed crop	27424.260	61,065	25838.116	57.533	21645.154	48.197
Human habitation	637.362	1,419	634.245	1.412	436.611	0.972
Island	935.159	2,082	945.090	2.104	835.678	1.861
Kori	298.865	0,665	298.292	0.664	298.144	0.664
Body of water	979.475	2,181	832.696	1.854	907.412	2.021
Wooded-shrubby savanna	9255.946	20,610	11622.727	25.880	16014.747	35.660
Bare/Degraded soil	789.443	1,758	545.701	1.215	545.564	1.215
Flood zone	1097.433	2,444	1041.912	2.320	2283.378	5.084

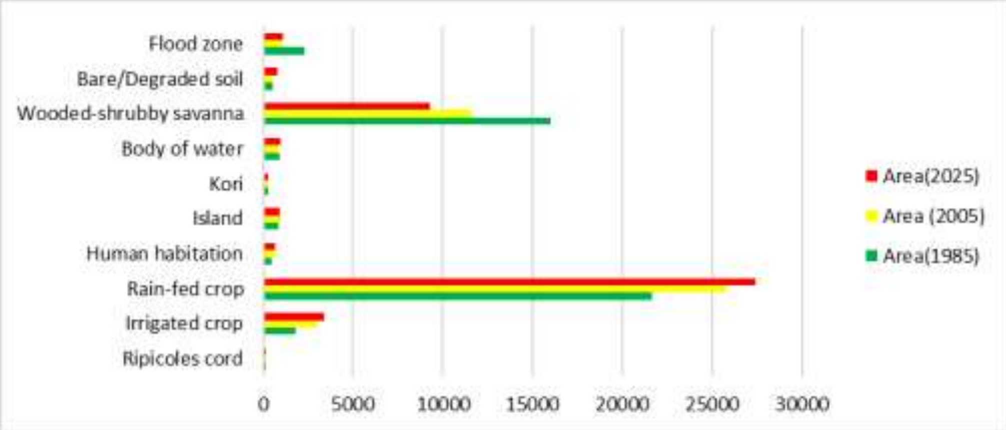

Fig. 6: Evolution of land use units in the municipality of Tanda in 1985, 2005 and 2025

The rate of spatio-temporal evolution of land use units shows a regression of the wooded- shrubby savannah, with a rate of **-0.00422 %.** The same applies to flood zones with **-0.00519%.** On the other hand, the other units have progressed with varying rates.

Table. 4: SRate of evolution of land use classes in the municipality of Tanda

Land use units	1985-2005	2005-2025	1985-2025	Nature
Ripicoles cord	0,00000	0,00004	0,00004	Progression
Irrigated crop	0,00665	0,00115	0,00856	Progression
Rainfed crop	0,00194	0,00061	0,00267	Progression
Human habitation	0,00452	0,00005	0,00453	Progression
Island	0,00131	-0,00011	0,00119	Progression
Kori	0,00000	0,00002	0,00002	Progression
Water body	-0,00082	0,00176	0,00079	Progression
Wooded-shrubby savannah	-0,00274	-0,00204	-0,00422	Regression
Bare/Degraded soil	0,00000	0,00447	0,00447	Progression
Flood zone	-0,00544	0,00053	-0,00519	Regression

The changes that occurred from 1985 to 2025

From the analysis of figure 7, it can be seen that between 1985 and 2025 the wooded shrubby savannah, the flood zones and partly the water bodies have marked a regression with values below zero. On the other hand, the units for which the rates are above zero record a progression.

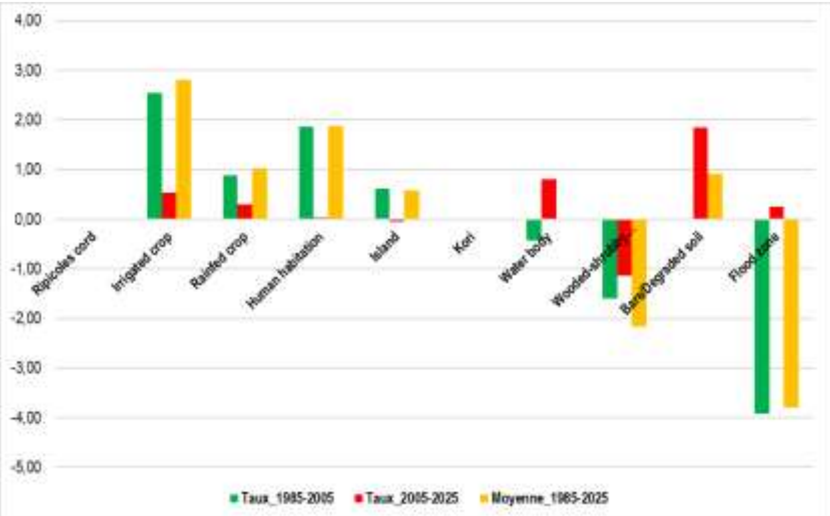

Fig. 7: Annual rates of change in land use classes in the municipality of Tanda between 1985 and 2025

Highlighting changes in land use classes from 1985 to 2025

To better understand the changes that have occurred within the land use units of the municipality of Tanda, the maps produced are cross-referenced two by two in order to obtain those of mutation (change) of each unit with reference statistics thanks to a transition matrix. Tables 5 and 6 present the percentages for the periods indicated.

Table. 5: Transition matrix of land use units between 1985 and 2005

Units	Ripicoles cord	Irrigated crop	Rainfed crop	Human habitation	Island	Kori	Water body	Wooded-shrubby savannah	Bare/Degraded soil	Flood zone	Total 1985
Ripicoles cord	0.29	4.04	48.20	0.97	1.86	0.66	2.02	35.66	1.22	5.08	100.00
Irrigated crop		3.68	0.11	0.01	0.00		0.02			0.21	4.03
Rainfed crop		0.12	44.56	0.46				0.31			45.46
Human habitation				1.02							1.02
Island					1.96						1.96
Kori						0.70					0.70
Water body		0.14					1.91			0.03	2.09
Wooded-shrubby savannah			10.62	0.00				26.93	0.00		37.55
Bare/Degraded soil									1.28		1.28
Flood zone		3.13					0.01			2.20	5.35
Total 2005	0.29	11.11	103.48	2.46	3.82	1.36	3.97	62.90	2.49	7.53	199.43

The analysis of Table 5 reveals that major changes have occurred within certain land use units, the most notable of which mainly concerned the wooded-shrubby savannah, with 10.61% of the areas transformed into rainfed crop areas and -1% into degraded soil. However, 26.93% of the areas of this unit (wooded-shrubby savannah) remained relatively stable. Also, the flood zones have undergone changes because 13% of the surfaces occupied by this unit have mutated into irrigated crop zone and 0.01% into water body. Of the other changes observed, we can mention those of the rainfed crop areas which mark transformations into irrigated crop (0.12%), into wooded-shrubby savannahs (0.31%) and occupation by human habitation (0.46%).

Table. +: Transition matrix of land use units between 2005 and 2025

Units	Ripicoles cord	Irrigated crop	Rainfed crop	Human habitation	Island	Kori	Water body	Wooded -shrubby savannah	Bare/Degraded soil	Flood zone	Total 2005
Ripicoles cord	0.292	6.719	57.533	1.412	2.104	0.664	1.854	25.88	1.215	2.32	99.993
Irrigated crop		0.000582	0.000013	0	0		0.000021			0.000092	0.000708
Rainfed crop		0.000116	0.005328	0	0	0	0	0.00005	0.000011	0	0.00550
Human habitation	0	0	0	0.000149	0	0	0	0	0	0	0.00014
Island					0,000211						0.00021
Kori						0.00007					0,00007
Water body		0.000012					0.000171			0.000007	0.00019
Wooded-shrubby savannah			0.00056	0.000448				0.002118	0.000047		0.00317
Bare/Degraded soil									0,000128		0,000128
Flood zone		0.000078					0.000024			0.000138	0.00024
Total 2025	0.292	6.71978	57.53890	1.41259	2,10421	0.6640	1.85421	25.88216	1,215186	2.32023	100.0033

Between 2005 and 2025, the most significant changes are observed in the wooded-shrubby savannah, rainfed and irrigated crops and water bodies. Indeed, these units have experienced minor changes in their areas, compared to those of the period 1985-2005. Thus, the wooded-shrubby savannah has been transformed into rainfed crop zone (0.00056%), into human habitation (0.000448%) and into degraded soil (0.000047%). The changes that have occurred within the crop unit concerning its transformation into irrigated agriculture (0.000116%), degraded soil (0.000011%) and tree-shrub savanna (0.00005%). As for irrigated agriculture, it has mutated into rainfed agriculture (0.000013%), water body (0.000021%), and flood zone (0.000092%), while 0.000012% of water bodies have been transformed into irrigated agriculture zone, then into flood zone (0.000007%). Overall, most of the mutations occurred between 1985 and 2005.

4. DISCUSSION

Tree-shrub savanna and Ripicoles cord

The tree-shrub savanna and the Ripicoles cord constitute the main plant resources of the study area. Indeed, the first unit (tree-shrub savanna) which occupied 35.66% of the area of the municipality (16014.74 ha) in 1985 decreased by .72% and increased to 25.88% in 2005 with 11622.72 ha, then 20.61% in 2025 for a covered area of 9255.94 ha. Indeed, the tendency to regression of plant formations in the municipality of Tanda observed in this study is observed elsewhere by other authors who have worked on the evolution of land use patterns. Thus, the works of [8] who studied the spatio-temporal dynamics of land occupation in the municipality of Simiri in western Niger observed a decline in vegetation from 493,528 ha in 1973 to 225,886 ha in 2020. Several others (authors) confirm the decline of plant formations, even their total disappearance [26]; [27]; [28]; [30]. In Benin, [29] who worked on the Classified Forest of Mékrou showed a regression of the area of plant formations which was 70.53% in 1992 to 39.33% in 2012, a decrease of 31.2% in twenty (20) years. As for [30], they showed that the proportion of shrub savanna in the municipality of Allada in southern Benin had gone from 11.47% in 1990 to complete disappearance in 2014. The results of studies conducted by [31] in the Tamou total fauna reserve (Tillabéri), those of [32] in the department of Gouré (Zinder), [18] and [15] respectively in the municipalities of Gabi (Maradi) and Gothèye (Tillabéri) in Niger, as well as the work carried out by [23] in South-East Togo, and [33] in the province of Bam in Burkina Faso show the same tendency to regression of plant formations. This regression can be explained by deforestation and cutting of wood for domestic uses, the extension of agricultural land, overgrazing which prevents the regeneration of young plants.

Unlike the tree-shrub savanna, the Ripicoles cord formation presents an opposite trend. This unit, composed of a mixed formation of tall and low woody plants, occupied 0.292% of the area of the municipality in 1985 and 2005, with 130.923 ha, then progressed to 0.293% in 2025 (131.403 ha). These results corroborate those of [35] who observed in the south-east of Burkina Faso an improvement in vegetation cover of 66.8% between 2001 and 2013. Other research carried out in the Sahel in general and in Niger in particular confirm the results of the present study, in particular a significant evolution of woody plants [36]; [37]; [38]; [39]; [40]. This is caused by excessive water withdrawals for irrigated agriculture and domestic uses, reducing the humidity necessary for these ecosystems.

Rainfed agriculture and irrigated agriculture

The areas occupied by rainfed and irrigated crops correspond to the agricultural areas of the municipality of Tanda. These represent respectively 48.19%, 57.53% and 61.06% for rainfed crops against 4.03%, 6.71% and 7.49% for irrigated crops compared to the total area of the municipality in 1985, 2005 and 2025. Indeed, this extension of rainfed and irrigated crop areas is at the expense of other land use units, in particular tree-shrub savanna and flood zones. This expansion is linked to the conquest of new crop lands, which would be due to the growth of the population of the municipality which increased from 49,890 inhabitants in 2012 to 81,604 in 2025 [16]. Many studies have shown that in the Sahelian zone or elsewhere, the impact of population growth on the expansion of cultivated areas, thus highlighting the progression of agricultural areas in connection with the increase in population [41]; [42]; [43]; [44]; [45]; [27]. Indeed, in the municipality of Tanda, the sown areas have experienced remarkable growth. Those of rainfed crops increased from 21645.15 ha in 1985 to 25838.11 ha in 2005 then 27424.26 ha in 2025. As for irrigated crops, they increased from 1812.52 ha in 1985 to 3017.31 ha in 2005 and finally 3363.90 ha in 2025. This increase in cultivated areas in the Sudanese zone is explained by the favorable availability of water and soil, but especially by the demographic and economic pressure that encourages the intensification and extension of crops.

Human habitation

The term human habitation encompasses hamlets, villages and urban centers such as the capital of the municipality. This land occupation unit has also undergone a spatio-temporal mutation that is related to the evolution of the human population at the municipal level. Indeed, the extension of this unit (human habitation) is generally at the expense of other land occupation units, with the exception of those whose natures are not favorable to human settlement (bodies of water, Kori, Ripicoles cord, flood zone). Between 1985 and 2025, the space occupied by the human habitation unit increased from 0.972% of the municipality in 1985 to 1.412% in 2005, 1.413% in 2025, an increase of 0.441% between the two extreme dates. These results confirm those of [43] who report that habitation areas increased by 81.6% between 1986 and 2013, then of [30] for whom the proportion of agglomerations increased by 2.71% between 1990 and 2014. These habitation areas are increasing mainly due to population growth, urbanization and economic development, often at the expense of natural areas.

Bare or degraded soils and the Kori

In the municipality of Tanda, bare or degraded soils and the Kori have experienced a dynamic, like other land occupation units. Thus, the areas occupied by bare or degraded soils increased from 1.21% of the total area of the municipality in 1985 to 1.75% in 2025. Regarding the Kori, their percentages in terms of occupied areas have evolved slightly, from 0.664% between 1985 and 2005 to reach 0.666% in 2025. Several factors are related to this evolution, including natural factors (effects of climate change and its corollaries), but also anthropogenic factors (deforestation, agricultural practices, etc.). According to [47], the decrease in vegetation cover exposes the land to the main erosive agents that are wind and water through rainfall, in the Sahelian context where

rainfall is variable and the soils are generally on aeolian sandy deposits. Indeed, several authors confirm this trend of progression of bare soils, including [28] who found that between 1972 and 2016, the areas of bare soils increased from 666 ha to 4,189 ha, in a study conducted in the northern part of the Dallol Bosso in Niger. Similarly, [46] found an increase in bare soils in western Niger, particularly in their work conducted in the municipality of Kirtachi, which states that
bare soils increased by 7213 ha (6.48%) between 2000 and 2020. In the Gouré region [48] found similar results in their work on the dynamics of silting up of the basins. Also, [8]
found that vegetation rates continue to decline from 1973 to 2020 while that of bare soil only progresses between these two dates in the municipality of Tondikiwindi in Niger.

Bodies of water, flood zone and island

Regarding bodies of water, they occupied 2.02% of the extent of the municipality in 1985, compared to 1.85% in 2005, then 2.18% in 2025. It is a saw-tooth progression, because the evolution of this land occupation unit, like that of flood zones, is linked to that of rainfall, but also to phenomena of silting up of watercourses. In 1985, 2005 and 2025, flood zones represent 5.08%, 2.32% and 2.44% of the municipal area. As for the island space (island), its evolution is almost similar to that of bodies of water and flood zone, and its area, compared to that of the total of the municipality, evolved from 1.86% in 1985 to 2.10% in 2005 and then 2.08% in 2025. The results of the present study partially corroborate those found by [15] where between 1984 and 2017, bodies of water regressed by -23.16% in Gothèye and by -11.67% in Torodi in Niger, but also by [43] who emphasize a regression of the surface area of surface water from 9.92% in 1987 to 0.98% in 2013, a drop of -8.94%. However, authors have shown, in their work, a progression of bodies of water, notably [49] in the municipality of Dogonkiria in Niger, where, according to these authors, the proportion of ponds had increased from 0.70% to 2.23% between 1973 and 2018. Similar results are obtained by [28], for whom semi-permanent ponds increased from a proportion of 0.09% in 1972 to 0.32% in 2016.

5. CONCLUSION

The diachronic analysis of the landscape of the Tanda commune, based on the use of Landsat satellite imagery and the use of Geographic Information Systems (GIS) techniques,
made it possible to capture the changes that occurred between 1985 and 2025, then analyze the evolution of the landscape. The results obtained reveal changes within the land use units with conversion rates that vary according to the unit (of land use) considered. Thus, the wooded-shrubby savanna, the flood zones and the bodies of water are the units most affected by this dynamic, characterized by the decline in their areas. On the other hand, other units have experienced an increase in their surfaces, in particular bare or degraded soils, rainfed and irrigated crops, human dwellings. Overall, the trend that emerges from this study is that of the continuous degradation of ecosystems, the reduction of the proportions occupied by plant formations being one of the characteristics of this landscape change. The statistics relating to land use units clearly illustrate this observation, because between 1985 and 2025, the wooded-shrubby savanna regressed by 4392.02 ha,
while rainfed crops and bare or degraded soils increased in area, revealing the nonconstancy of the dynamics of the natural environment in this commune.

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