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Mapping of the Dynamics of Land Occupation Units in the Municipality of Ouassa-Pehunco

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Abstract :- The rural environment has always served as a place of agricultural and animal production, refuge, recreation and leisure for riparian towns in sub-Saharan Africa. With the strong climatic variability and the demographic growth, natural resources undergo intense exploitation which lead to often irreversible ecological imbalances. Biodiversity is plagued by deforestation, wildfires, water pollution, poaching, extinction, the introduction of invasive alien species and overgrazing. This dynamic of agro-pastoral resources was carried out in the Municipality of Ouassa-Péhunco in Benin. The objective of this research is to analyze the mapping of the dynamics of land use units in the Municipality of Ouassa-Péhunco in a context of socio-environmental changes. To carry out this study, the phytosociological records were made. Remote sensing data (SPOT 5 images from 1990, SPOT 6 from 2005 and SENTINEL from 2020) made it possible to assess the various spatio-temporal changes in land use. The mapping of spatio-temporal changes in vegetation revealed that the area of natural plant formations in the Municipality has sharply declined by more than 38.17% between 1990 and 2020 in favor of mosaics of fields and fallows. Closed formations (gallery and riparian forests, dense dry forests and open forests and wooded savannas) fell by 32.95%. Land tenure and land use methods constitute the agricultural management methods among farmers in the Municipality of Ouassa-Péhunco. Cultural practices are based on the exclusive use of chemical inputs.

Keywords:- *Cartography, natural resources, spatio-temporal changes, terroir, agriculture, livestock, Benin.*

I. INTRODUCTION

In sub-Saharan Africa, the rural environment has always served as a place of agricultural and animal production, refuge, recreation and leisure for the neighboring towns. Most of the agricultural and animal production comes directly from this area where there are natural resources (water, vegetation and land). With high climatic variability and population growth, estimated at 3.5% in the Sahelian zone, these resources are subject to intense exploitation which leads to often irreversible ecological imbalances [1]. These imbalances frustrate the efforts of populations, weaken their relationship with the environment and contribute to the deterioration of the socio-economic situation in these areas.

In the municipalities of northern Benin, biodiversity is plagued by deforestation, wildfires, water pollution, poaching, disappearance, the introduction of invasive exotic species and overgrazing ([2] ;[3]. The growth Demographic growth and the strong monetization of markets have caused major socio-economic and environmental changes. This results in increased competition in the exploitation of resources, leading to conflict situations with serious consequences ([4] ; [5]). The state of flora and vegetation is extremely dynamic and sensitive to changes, particularly changes in land use [6]. The dominant forms of disturbance of the structure and physiognomy of vegetation within landscapes are wildfires, grazing, slash and burn agriculture and irregular rainfall ([7] ;[8] ;[9] ;[10]).

Natural resources experience variations (quantity and quality) and severe constraints linked to rainfall deficits which hinder the proper development of plants. They are still abundant in Ouassa-Péhunco and there are numerous behaviors harmful to their good management. Economic activities, population growth, the constraints of the natural environment are all elements that interact with each other and constitute a threat to the environment of the said Commune [11]. Added to this is the lack of rainfall coupled with the ever-increasing human needs for arable land, leading to a reduction in the surface area of grazed areas and often even their degradation [12]. The objective of this research is to analyze the mapping of the dynamics of land occupation units in the Commune of Ouassa-Péhunco

II. PRESENTATION OF STUDY AREA

A. Geographic framework and location of the study area

The Municipality of Ouassa-Péhunco is located in the northern region of Benin more precisely in the Department of Atacora. It is located between 10°03' and 10°45' north latitude then 1°45' and 2°15' east longitude and is limited to the north by the Commune of Kérou, to the south by the Department of Donga, to to the east by the Department of Borgou and to the west by the Commune of Kouandé (fig. 1). It has three (03) Arrondissements including thirty-five (35) administrative villages with an area estimated at more than 1956 km².

The climate of the Municipality of Ouassa-Péhunco is of the Sudanian type with a unimodal rainfall regime (a dry season and a rainy season). Precipitation, evapotranspiration and temperature are elements of the climate that can have an

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influence not only on plant formations but also on agriculture and livestock.

The relief of the Municipality of Ouassa-Péhunco is dominated by a peneplain which stretches in the watershed line of the Niger and Ouémé basins on the one hand and the sub-basins of the Mekrou and the Alibori. on the other hand. The inclination of the relief is pronounced in the south-north direction with an average altitude which oscillates around 350 m.

The hydrographic network of the Municipality of Ouassa-Péhunco is made up of numerous tributaries of the Mékrou in the districts of Péhunco, Gnèmasson and Alibori in the district of Tobré not far from the village of Ouassa-Kika.

Agriculture and livestock are the main economic activities of the populations of the Commune of Ouassa-Péhunco. Agriculture occupies 82% of the population and this also represents 77% of households according to [13].

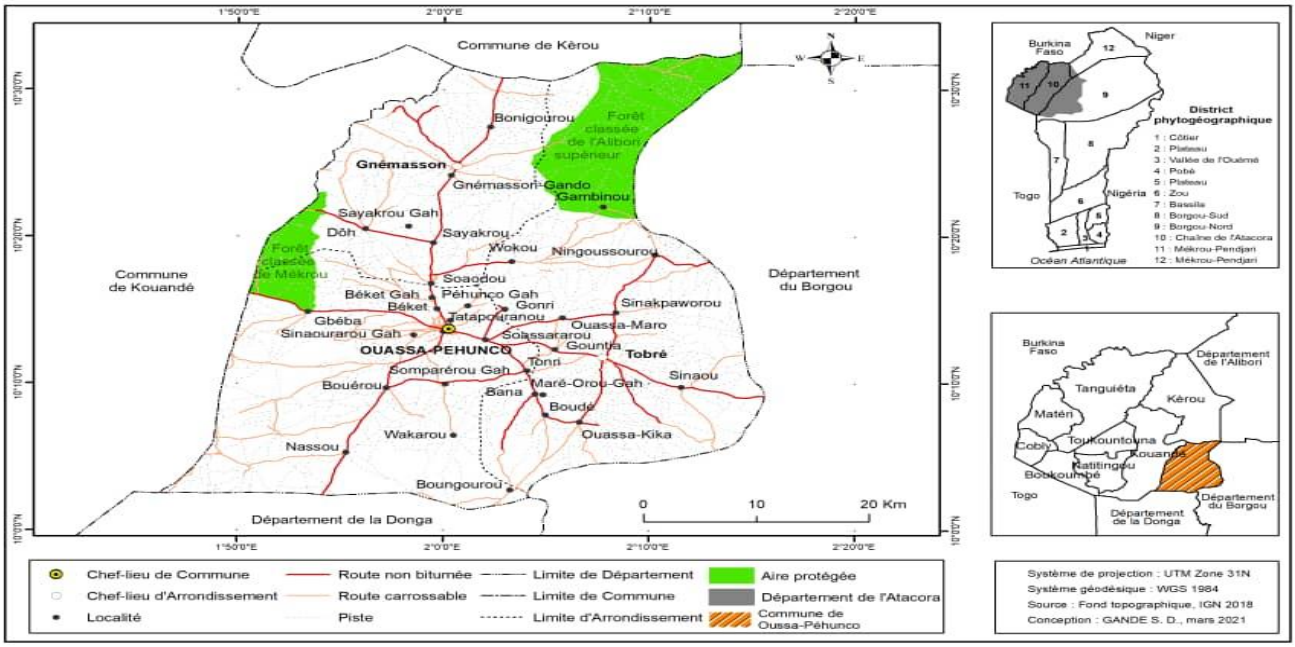

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Fig. 1 : Location of the Municipality of Ouassa-Péhunco

III. MATERIAL AND METHODS

A. *Material and equipment used for setting up the plots*

It was a question of the material used in the establishment of the plots in the different ecosystems. This material consists of:

- a GPS for the location and rallying of the sites operated from their geographical coordinates with an accuracy of 3 m;
- a 50 m long ribbon and a 100 m long roll of rope for the delimitation of the plots;
- a clisimeter for measuring the height of trees or, failing that, the lumberjack's cross;
- a π tape for measuring the diameter of trees (dhp ≥ 5 cm);
- newsprint for the conservation of unidentified botanical samples;
- 2 m wooden stakes to materialize the limits at the corners of the plots;
- a cutter, to make and install the stakes;
- survey sheets to record the data in situ.

B. *Methods*

- Satellite data collection method used

  To carry out this study, three types of landsat images were used, namely SPOT images from 1990; the SPOT images of 2005 and the SENTINEL images of 2020. Thus, Table I indicates the spatial coverage of the SENTINEL scenes of 2020.

Satellites	Spatiales resolutions	Acquisition dates
SPOT 5	10 m	1990
SPOT 6	6 m	2005
SENTINEL	10 m	2020

Table 1: Characteristiques of used pictures

The spatial resolutions of the SPOT 6, 5 and SENTINEL images are respectively 6 and 10 meters, UTM zone 31 N projection with WGS84 reference ellipsoid. These satellite images are acquired in the dry season over a period of maximum differentiation of land use elements (crops, woody). The year 1990 is considered as the reference year in this analysis. The quality of these images, in particular the absence of cloud cover, guided their choice. These different images were downloaded from the earthexplorer.usgs.gov site in GEOTIFF format. Secondary

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data such as old documents from the Beninese forestry administration, the ecological map of the vegetation cover from 1978, data from the National Forest Inventory from 2007, topographic maps at 1/200,000 (Leaf of Djougou) and geographical coordinates (GPS) sites observed directly in the field were a reference.

C. Satellite image processing method

The estimation of the spectral separability between the different units constituting the landscape for all the spectral bands of the SPOT 5, 6 and SENTINEL images is an essential procedure for choosing the optimal number of relevant spectral bands for a possible classification of the images, the visualization of the colored composition and the characterization of the land occupation spaces. The method of processing satellite images of the study area includes contrast enhancement, colored composition or combination of bands, visual interpretation, supervised classification and finally the analysis of the results resulting from the classification.

D. Contrast enhancement

It consists of making an image (colored composition) more interpretable/readable in relation to a given thematic image. There are several techniques to contrast an image. The contrast enhancement method used for this study is histogram equalization. With this method, image radiometric (DN) values are assigned to large brightnesses based on their frequency of occurrence, so that the highest brightness levels are assigned to image values that occur frequently.

E. Recon mission

The reconnaissance mission consists of exploring the study area in order to identify and locate the major elements of the landscape such as the types of relief, soils, plant formations and water bodies. Geographic coordinates (control points) will be recorded on different plant formations and other land cover units using GPS for ground truth and information collection on the study area. This phase makes it possible to assess the current state of land use and to collect qualitative information on land use on the one hand and to record GPS points for ground truth on the other hand. These control points made it possible to carry out the classification.

F. Choice of training areas

As a prelude to the extraction of the themes of land occupation, a visual interpretation of the images was carried out. This operation consists of displaying the image on the screen and identifying the objects and judging their meaning and importance. It considered not only the reflectance values of each of the pixels in the image, but also the spatial and spectral information of the images (shape, size, structure, texture and color), auxiliary information collected in the field, topographic maps and then the context. Some details were identified on the basis of an interpretation key (shape, pattern, color, texture, neighborhood, shadow) and especially the radiometric value of the image pixels. This interpretation key has made it possible to identify the major units of land use such as: gallery forest; dense dry forest; open forest and wooded savannah; tree and shrub savannas; mosaics of fields and fallows; agglomerations; saxicolous savannah and plantation.

G. Supervised image classification

In the context of the present study, the supervised classification is made using the Maximum Likelihood algorithm, or the Maximum Likelihood with the ENVI software (Environment for Visualizing Image). This method assumes that the statistics for each class of land cover in each band are normally distributed ([14] ;[15]). This algorithm calculates the probability that a given pixel belongs to a specific class. Each pixel is classified into a given category of land cover whose probability has been higher.Export to a Geographic Information System (GIS) and map layout.

After classification, each interpreted image was exported to a Geographic Information System. This involved converting the file from raster format to vector format. Cartographic editing includes a set of techniques for locating information relative to each other in a geographic reference system and requiring knowledge of the limits of human visual perception as well as mastery of a graphical language called semiology. The maps are therefore edited and laid out in a well-defined format and at a suitable scale. This skin also concerns the legend, the North direction, the data sources and the logos. This was done using QGIS 2.18 software.

H. Transition Matrix

The transition matrix makes it possible to highlight changes in land use during a given period ([16] ;[17]). The cells of the matrix contain the value of a variable having passed from an initial class i to a final class j during the period considered. The column values represent the proportions of areas occupied by each land cover class at time j and those of the rows at the initial time. It makes it possible to highlight the different forms of conversion that the plant formations have undergone between two snapshots. It consists of X rows and Y columns. The number of rows in the matrix indicates the number of plant formations at time t0; the number Y of columns of the matrix is the number of vegetation classes converted at time t1 and the diagonal contains the areas of plant formations that have remained unchanged [2]. The transformations are therefore made from the rows to the columns. The areas of these different vegetation classes were calculated from crossing vegetation maps of two dates using the Intersect function of the Arctoolbox toolbox of ArcGIS 10.3 software.

I. Calculation of the conversion rate of land occupation units

The conversion rate was used to measure the degree of conversion of a given unit into other land cover units. It is obtained from the transition matrix[16]. (Arouna, 2012) according to the formula: $Tc = [(Sit - Sis) / Sis] \times 100$ (1)

Sit = Area of land cover unit i at the initial date t;

Sis = Area of the same category of this unit i remained stable at date t1.

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J. Average annual rate of spatialexpansion

The average annual rate of spatial expansion expresses the proportion of each unit of natural vegetation that changes annually. This annual rate (Ta) is calculated using the following formula:

S1 = Area of a vegetation unit at date t1;
S2 = Area of the same vegetation unit at date t2 and
t = Number of years between t1 and t2.

IV. RESULTS

A. Cartographic analysis of the dynamics of land occupation units

The dynamics of the land occupation units of the Municipality of Ouassa-Péhunco was analyzed through the land occupation maps of 1990, 2005 and 2020. The evolution of plant formations between these three periods was then evaluated. and compared across the transition matrix, conversion rates and annual spatial expansion rates.

- State of land occupation in 1990

The physiognomy of the vegetation of the Commune of Ouassa-Péhunco in 1990 was largely dominated by wooded and shrubby savannahs, open forests and wooded savannahs which represented respectively 50.08% and 33.48% or 83.56% of the area. total (Fig. 2, Table I). There were also other formations such as gallery and riparian forests (4.67%), dense dry forests (1.12%), marshy formations (0.39%).

Most of the major rivers had gallery forests, notably the Alibori and the Mekrou. A small portion of dense dry forests was located north of the Commune. Open forests and wooded savannahs were found throughout the Commune; they were much more concentrated in the northern and eastern part. The tree and shrub savannahs were distributed almost uniformly over the entire territory. The mosaics of fields and fallow land evolve along the different roads throughout the municipal territory

Unités d'occupation des Terres	Superficie (ha)	Proportion (%)
Gallery forests and riparian forests	9281,43	4,67
Dense dry forests	2223,36	1,12
Open forests and wooded savannahs	66557,52	33,48
Tree savannas and shrub savannahs	99557,28	50,08
Swamp formations	782,82	0,39
Fields and fallows	19746,27	9,93
Plantations	15,84	0,01
Water places	3,60	0,00
Bare floors	172,71	0,09
Agglomérations	452,88	0,23
Total	**198793,71**	**100**

Table 2 : Plant formations and other land occupation units in 1990

Source: Interpretation of SPOT images from 1990

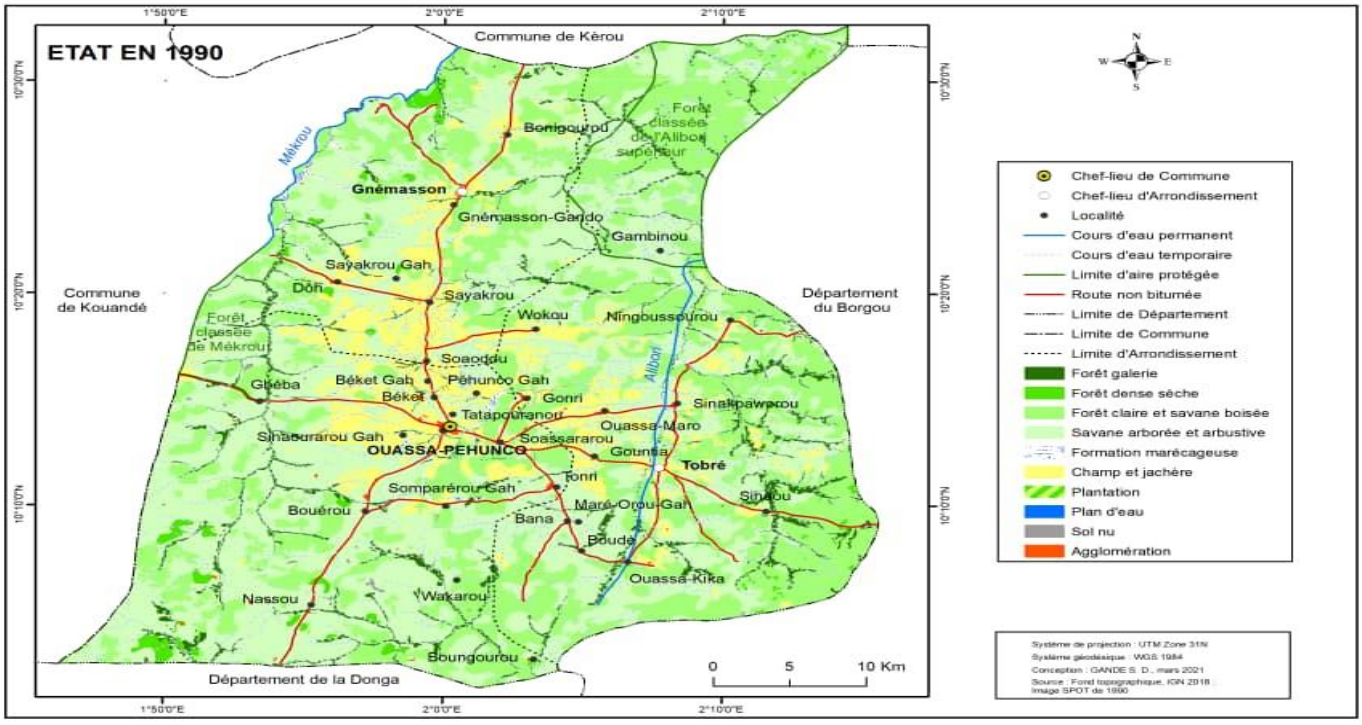

Fig. 2: Plant formations and other land occupation units in the Municipality of Ouassa-Péhunco in 1990

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- State of land occupation in 2005

In 2005, the landscape of the Municipality of Ouassa-Péhunco was dominated by wooded and shrubby savannahs and dotted with open forests and wooded savannahs (Fig. 3). The other plant formations (gallery and riparian forests, dense dry forests, wooded and shrubby savannahs, marshy formations, fields and fallow land, plantations, bodies of water, bare soils and agglomerations) observed in 1990 are also found in 2005 (Table III).

Wooded and shrubby savannahs occupied approximately 54.21% of the territory and were spread over the entire Commune (Fig. 3). Open forests and wooded savannahs were also observed in some places and occupied 7.26% of the Commune. Gallery and riparian forests (3.89%) were observed along the Alibori and Mekrou rivers and some of their tributaries. We are witnessing the evolution of the front of mosaics of fields and fallow land (32.94%), plantations (0.55%) and agglomerations (0.53%) towards natural plant formations.

Unités d'occupation des Terres	**Superficie (ha)**	**Proportion (%)**
Gallery forests and riparian forests	7726,50	3,89
Dense dry forests	305,73	0,15
Open forests and wooded savannahs	14427,18	7,26
Tree savannas and shrub savannahs	107757	54,21
Swamp formations	782,82	0,39
Fields and fallows	65480,58	32,94
Plantations	1087,02	0,55
Water places	4,23	0,00
Bare floors	172,71	0,09
Agglomérations	1049,94	0,53
Total	198793,71	100

Table 3: Plant formations and other land occupation units in 2005

Source: Interpretation of SPOT images from 2005

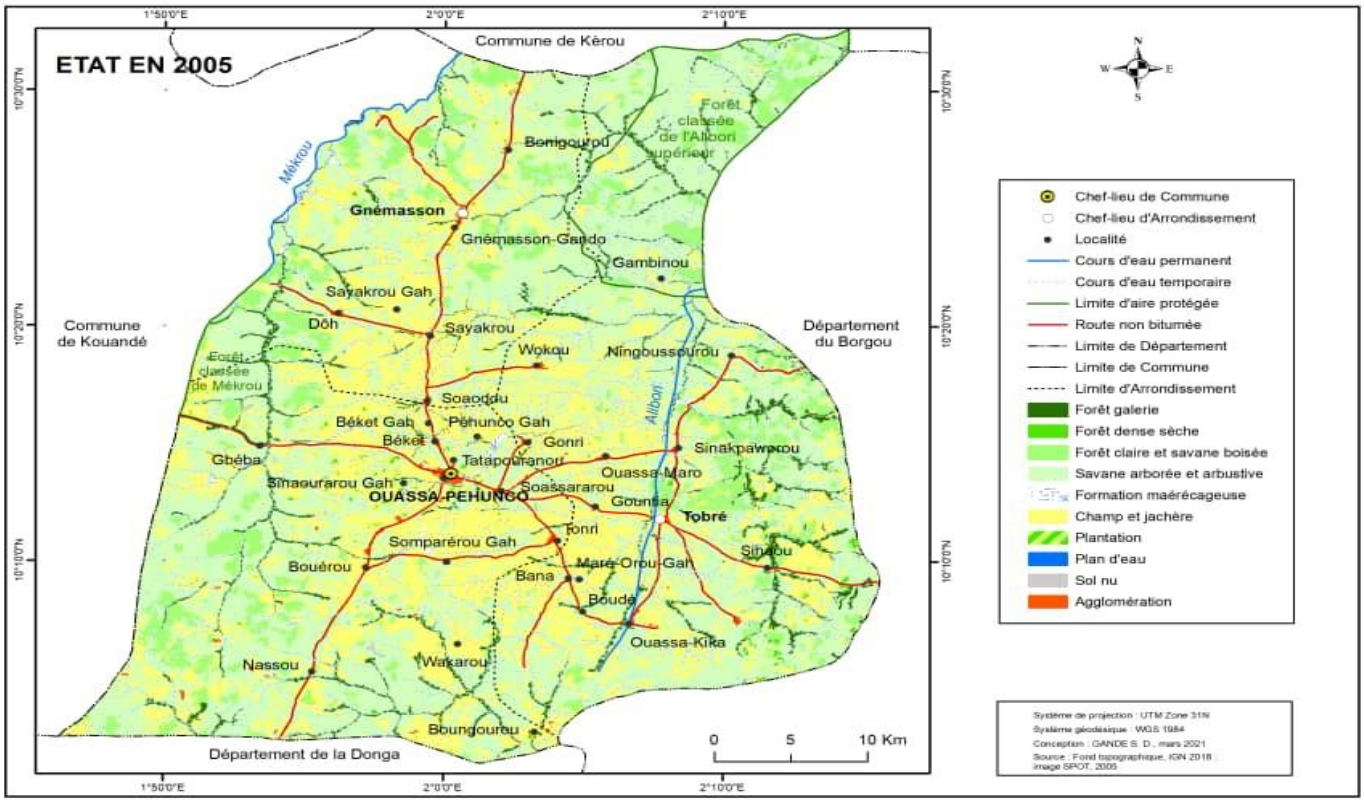

Fig 3: Plant formations and other land occupation units in the Municipality of Ouassa-Péhunco in 2005

- State of land occupation in 2020

The physiognomy of the Municipality of Ouassa-Péhunco is dominated by mosaics of fields and fallow land with 46.55% of the municipal territory in 2020 (fig. 4). Then come the wooded and shrubby savannahs with 44.87%. Note the residual natural plant formations which consist of open forests and wooded savannahs (3.18%) and gallery and riparian forests (3.10%) (Table IV).

The wooded and shrubby savannahs that constitute the dominant natural plant formations of the territory are found throughout the study area. The poorly represented

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open forests and wooded savannahs are observed in the northeastern and western parts of the Commune. Thin gallery and riparian forests are located along the Alibori and Mekrou and some of their tributaries. Dense dry forests have almost disappeared at this mapping scale. However, very small formations of 0.03% are observed on the ground.

Unités d'occupation des Terres	Superficie (ha)	Proportion (%)
Gallery forests and riparian forests	6156,18	3,10
Dense dry forests	64,46	0,03
Open forests and wooded savannahs	6330,50	3,18
Tree savannas and shrub savannahs	89196,69	44,87
Swamp formations	584,85	0,29
Fields and fallows	92534,42	46,55
Plantations	2249,72	1,13
Water places	30,68	0,02
Bare floors	172,71	0,09
Agglomérations	1473,51	0,74
Total	198793,71	100

Table 4: Plant formations and other land cover units in 2020

Source: Interpretation of 2020 SENTINEL images

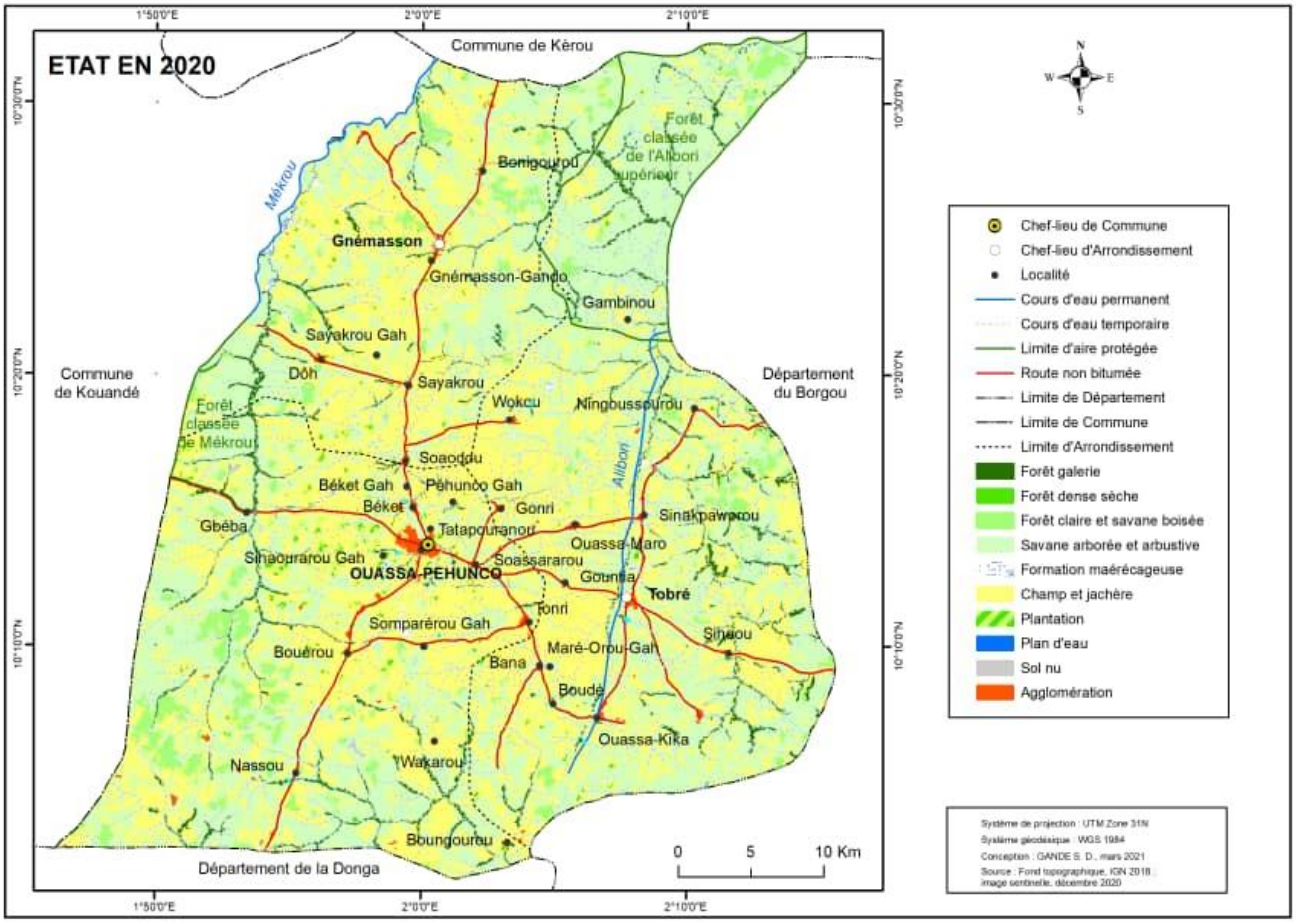

Fig. 4: Plant formations and other land occupation units in the Municipality of Ouassa-Péhunco in 2020

B. Dynamics of land occupation

The evolution of the dynamics of land occupation is analyzed successively from 1990 to 2005, from 2005 to 2020 and from 1990 to 2020.

- *Dynamics of land occupation from 1990 to 2005*

  The dynamics of land occupation from 1990 to 2005 is summarized by the transition matrix (Table V). In the row and column cells are respectively the vegetation formations and the other land cover units for 1990 and 2005. The conversions are made from the rows to the columns. Diagonal cells correspond to areas of units that remained stable from 1990 to 2005. Units outside the diagonal represent changes in vegetation and other land cover units. The average regression rate for the period from 1990 to 2005 is estimated at 23.85%.

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UOT en 1990	UOT en 2005										Total en 1990 (ha)
	FGFR	FDS	FCSB	SASA	FSM	CJ	PT	PE	SN	AG	
FGFR	7726,5	0	0	0	0	1554,3	0	0,63	0	0	9281,43
FDS	0	305,73	186,66	1035,36	0	695,61	0	0	0	0	2223,36
FCSB	0	0	14240,52	36218,52	0	16098,48	0	0	0	0	66557,52
SASA	0	0	0	70496,46	0	28813,68	0	0	0	247,14	99557,28
FSM	0	0	0	0	782,82	0	0	0	0	0	782,82
CJ	0	0	0	6,66	0	18318,51	1071,18	0	0	349,92	19746,27
PT	0	0	0	0	0	0	15,84	0	0	0	15,84
PE	0	0	0	0	0	0	0	3,6	0	0	3,6
SN	0	0	0	0	0	0	0	0	172,71	0	172,71
AG	0	0	0	0	0	0	0	0	0	452,88	452,88
Total en 2005 (ha)	7726,5	305,73	14427,18	107757	782,82	65480,58	1087,02	4,23	172,71	1049,94	198793,71

Table 5: Transition matrix of plant formations and other land occupation units from 1990 to 2005

Source: Interpretation of SPOT images from 1990 and 2005

FGFR: Gallery forests and riparian forests, FDS: Dense dry forests, FCSB: Open forests and wooded savannas, SASA: Tree and shrub savannahs, FSM: Marshy formations, CJ: Fields and fallow land, PT: Plantations, PE: Water bodies, SN: Bare soils, AG: Agglomerations, UOT: Land occupation units, ha; hectares, 7726.5: Area remained stable from 1990 to 2005

The analysis of Table V shows that the natural plant formations fell from 89.74% in 1990 to 65.90% in 2005, ie a regression rate of -23.85%. A large part of the gallery and riparian forests has been transformed into mosaics of fields and fallows (1554.3 ha) and water bodies (0.63 ha). The regression rate of gallery and riparian forests is 16.75%.

As for the dense dry forests, 1035.36 ha have been converted into tree and shrub savannahs, 695.61 ha into patchwork fields and fallows and only 186.66 ha into open forests and wooded savannahs. The regression rate of dense dry forests is 86.25%. This proves that this formation is endangered.

Open forests and wooded savannahs and wooded and shrubby savannahs are formations that have experienced strong anthropization. Thus, the areas of open forests and wooded savannahs fell from 66,557.52 ha in 1990 to 14,427.18 ha in 2005, ie a regression rate of 78.32%. For the area of wooded and shrubby savannas, they increased from 99,557.28 ha in 1990 to 107,757 ha in 2005, ie a growth rate of 8.24%.

- *Analysis of the evolution of plant formations from 1990 to 2005*

Most of the natural plant formations have experienced a decrease in their area apart from the tree and shrub savannahs which have undergone a gradual evolution. Closed vegetation formations consisting of gallery and riparian forests, dense dry forests and open forests and wooded savannahs fell from 177,619.59 ha to less than 130,216.41 ha, i.e. a regression rate of 26.69%. A significant part of these plant formations has been transformed into wooded and shrubby savannahs. Thus, wooded and shrubby savannahs became the plant formations with the largest area in 2005. It is also important to note that dense dry forests are threatened with extinction.

The balance sheet of changes in closed plant formations, namely gallery and riparian forests, dry dense forests and open forests and wooded savannahs, reveals that they have undergone transformations into mosaics of fields and fallows; i.e. a regression of 27.97%. This regression is due to logging which facilitates the practice of agricultural activities in these formations. While tree and shrub savannahs increased by 4.12%. This trend is largely due to the conversion of open forests and wooded savannahs into tree and shrub savannahs.

In addition, the mosaics of fields and fallows have been extended. Their area increased from 19,746.27 ha in 1990 to 65,480.58 ha in 2005. With a growth rate of 23.01%, these mosaics of fields and fallows constitute grazing areas in the dry season with the use of residues of crops. Land occupation between 1990 and 2005 essentially shows two phenomena in the study area: savanization and anthropization.

- *Dynamics of land occupation from 2005 to 2020*

The vegetation maps of 2005 and 2020 made it possible to analyze the evolution of vegetation in the Commune of Ouassa-Péhunco. Table VI summarizes the dynamics of occupationland from 2005 to 2020 by a transition matrix.

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UOT en 2005	UOT en 2020										Total en 2005 (ha)
	FGFR	FDS	FCSB	SASA	FSM	CJ	PT	PE	SN	AG	
FGFR	6155,55	0	0	0	13,81	1528,53	0	28,61	0	0	7726,50
FDS	0	59,85	78,27	163,01	0	4,60	0	0	0	0	305,73
FCSB	0	4,60	5810,25	6703,42	0	1908,90	0	0	0	0	14427,18
SASA	0	0	441,98	82328,73	23,02	24889,60	0	0	0	73,66	107757,00
FSM	0	0	0	0	548,02	234,80	0	0	0	0	782,82
CJ	0	0	0	0	0	63967,98	1162,70	0	0	349,90	65480,58
PT	0	0	0	0	0	0	1087,02	0	0	0	1087,02
PE	0,63	0	0	1,53	0	0	0	2,07	0	0	4,23
SN	0	0	0	0	0	0	0	0	172,71	0	172,71
AG	0	0	0	0	0	0	0	0	0	1049,94	1049,94
Total en 2020 (ha)	6156,18	64,46	6330,50	89196,69	584,85	92534,42	2249,72	30,68	172,71	1473,51	198793,71

Table 6: Transition matrix of plant formations and other land occupation units from 2005 to 2020

FGFR: Gallery forests and riparian forests, FDS: Dense dry forests, FCSB: Open forests and wooded savannas, SASA: Tree and shrub savannahs, FSM: Marshy formations, CJ: Fields and fallow land, PT: Plantations, PE: Water bodies , SN: Bare soils, AG: Agglomerations, UOT: Land occupation units, ha; hectares.

Source: Interpretation of SPOT images from 2005 and SENTINEL from 2020

The analysis of Table VI reveals that natural plant formations have fallen from 65.90% in 2005 to 51.48% in 2020, i.e. a regression rate of 14.42%. Most of the gallery and riparian forests have been converted into mosaics of fields and fallow land (1528.53 ha) and a tiny part into a body of water (28.61 ha) and marshy formations (13.81 ha). For the dense dry forests, 163.01 ha were transformed into tree and shrub savannahs, 78.27 ha into open forests and wooded savannahs, 4.60 ha into field mosaics and fallow land and only 59.85 ha remained stable. The regression rate for this formation is 78.92%. It can be deduced that the dense dry forests are endangered.

Wooded and shrubby savannahs and open forests and wooded savannahs are natural plant formations that have experienced strong anthropization with the respective proportions of 23.17% and 13.23% of their areas.In the study area, mosaics of fields and fallow land increased from 65,480.58 ha in 2005 to 92,534.42 ha in 2020; i.e. a growth rate of 41.32%.

➢ *Analysis of the evolution of plant formations from 2005 to 2020*

The analysis of the evolution of plant formations from 2005 to 2020 essentially shows two phenomena: savanization and anthropization. The gallery and riparian forests, the dry dense forests and the open forests and wooded savannahs have experienced both the process of savanization and anthropization. The rates of savannah in dense dry forests and open forests and wooded savannahs are respectively 53.32% and 46.46%. On the other hand, the anthropization rates in open forests and wooded savannahs, gallery forests and wooded and shrubby savannahs are respectively 13.23%, 19.78% and 23.16%.

The mosaics of fields and fallows are the only formations that experienced a strong extension between 2005 and 2020. These mosaics of fields and fallows constitute grazing areas in the dry season.

➢ *Dynamics of land occupation from 1990 to 2020*

The analysis of the evolution of the vegetation from 1990 to 2020 from the vegetation maps made it possible to deduce the evolutionary trend of the plant formations over a period of 30 years. This evolution is synthesized by the transition matrix (Table VII).

UOT en 1990	UOT en 2020										Total en 1990 (ha)
	FGFR	FDS	FCSB	SASA	FSM	CJ	PT	PE	SN	AG	
FGFR	6156,18	0	0	0	13,81	3084,36	0	27,08	0	0	9281,43
FDS	0	59,85	138,89	953,85	0	1070,77	0	0	0	0	2223,36
FCSB	0	4,60	5749,63	34818,96	0	25984,33	0	0	0	0	66557,52
SASA	0	0	441,98	53415,69	23,02	44578,01	777,78	0	0	320,8	99557,28
FSM	0	0	0	0	548,02	234,80	0	0	0	0	782,82
CJ	0	0	0	8,19	0	17582,15	1456,10	0	0	699,83	19746,27
PT	0	0	0	0	0	0	15,84	0	0	0	15,84
PE	0	0	0	0	0	0	0	3,60	0	0	3,60

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SN	0	0	0	0	0	0	0	0	172,71	0	172,71
AG	0	0	0	0	0	0	0	0	0	452,88	452,88
Total en 2020 (ha)	6156,18	64,46	6330,50	89196,69	584,85	92534,42	2249,72	30,68	172,71	1473,51	198793,71

Table 7: Transition matrix of plant formations and other land occupation units from 1990 to 2020

FGFR: Gallery forests and riparian forests, FDS: Dense dry forests, FCSB: Open forests and wooded savannas, SASA: Tree and shrub savannahs, FSM: Marshy formations, CJ: Fields and fallow land, PT: Plantations, PE: Water bodies , SN: Bare soils, AG: Agglomerations, UOT: Land occupation units, ha; hectares, 6156.18: Area remained stable from 1990 to 2020

***Source**: Interpretation of SPOT images from 1990 and SENTINEL from 2020*

Analysis of Table VII reveals that the land cover classes observed in 1990 were present in 2020. Indeed, natural plant formations fell from 89.74% in 1990 to 51.48% in 2020, i.e. a regression rate of 38.27%.

A large part of the gallery and riparian forests has been converted into mosaics of fields and fallow land (3084.36 ha), bodies of water (27.08 ha) and marshy formations (13.81 ha). This regression of gallery forests is due to logging which facilitates the practice of agricultural activities in these formations.

In the dense dry forests, 1070.77 ha have been transformed into mosaics of fields and fallows, 953.85 ha into tree and shrub savannahs and 138.89 ha into open forests and wooded savannahs. So dense dry forests constitute a plant formation that is on the way to extinction. In the open forests and wooded savannahs, 52.31% have been converted into tree and shrub savannahs and 39.04% into mosaic fields and fallows. While in the tree and shrub savannahs, 44.78% has been converted into mosaics of fields and fallows.

In addition, the mosaics of fields and fallows have experienced a strong extension. They increased from 19,746.27 ha in 1990 to 92,534.42 ha in 2020. The rate of increase is 36.61%. Natural plant formations are the most affected in this landscape transformation process.

- *Synthesis of land cover statements from 1990, 2005 and 2020*

From 1990 to 2020, natural plant formations (gallery forests and riparian forests, dense dry forests, open forests and wooded savannahs, wooded and shrubby savannahs) were mainly converted into mosaics of fields and fallows (fig.5) such that they have become the most dominant types of formations in the Commune in 2020. During these three decades, dense dry forests have almost disappeared. Fig.5 presents the summary of the land cover statuses for 1990, 2005 and 2020.

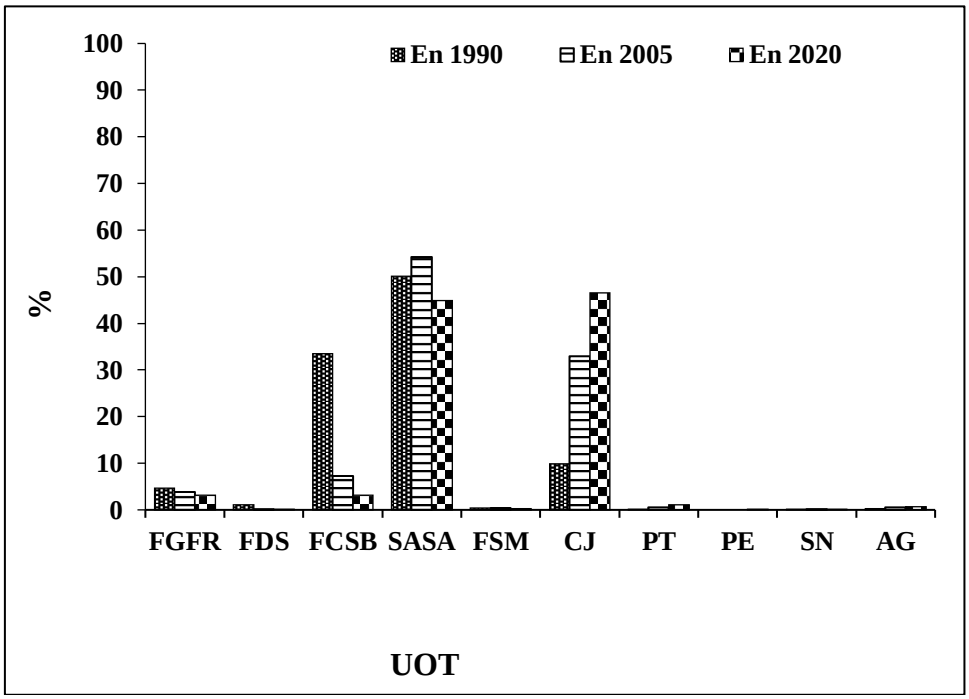

Fig. 5: Summary of land cover statuses from 1990, 2005 and 2020

Legend: FGFR: Gallery forests and riparian forests; SDS: Dense dry forests; FCSB: Open forests and wooded savannas; SASA: Tree and shrub savannas; FSM: Marsh formations; CJ: Fields and fallows; PT: Plantations; PE: Water bodies; SN: Bare soil; AG: Agglomerations; UOT: Land occupation units

From the examination of Fig. 5, we note a strong regressive trend of natural plant formations in favor of anthropogenic formations. But in the tree and shrub savannahs, a slight regression can be observed between 1990 and 2020. On the other hand, the mosaics of fields and

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fallows have experienced an exponential evolution between 1990 and 2020. They go from 9.93% in 1990 to 46.55% in 2020, an increase of 36.61%. We deduce that in the Municipality of Ouassa-Péhunco that natural plant formations are experiencing a regression in favor of mosaics of fields an.

V. DISCUSSION

The dynamics of land occupation units in the Commune of Ouassa-Péhunco was studied over three periods (1990, 2005 and 2020). Natural plant formations have experienced a strong regressive trend in favor of anthropogenic formations. Between 1990 and 2020, natural formations fell from 89.74% to 51.48%, i.e. a regression of 38.27% in three decades. Open forests and wooded savannahs are affected by this regression ([6] ;[18]). Thus, the area of this formation fell from 33.48% to 3.18%. This regression of natural plant formations has largely taken place to the benefit of mosaics of fields and fallow land. The same observations of regression of natural formations have been observed by several authors in their research ([19] ;[17] ;[20] ;[21] ;[22]). To this end, the mosaics of fields and fallows have generally experienced a strong increase in their area to the detriment of natural plant formations, whether around pastoral hydraulic reservoirs, in the Atacora massif, in the watershed of the Sota and in the Municipality of Djidja. The hypothesis which stipulates that "the various cultural practices listed contribute to the regression of land occupation units in the Commune of Ouassa-Péhunco" is thus confirmed.

In the Municipality of Ouassa-Péhunco, the lifestyles of farmers and breeders are undergoing rapid socio-environmental changes. The commercialization of agricultural products and the drought are the causes of the continual displacements of peasants in search of new wastelands [23]. The densification of human occupation and the gradual increase in pastoral charges leave in some areas very little leeway for the future of these extensive systems. The deterioration of agro-pastoral production potential in view of the increase in land pressure is one of these multiple problems [24]. The regressive dynamic is marked by a significant reduction in the woody and herbaceous specific diversity in this study area to the detriment of a certain homogenization, a reduction in pastoral resources. The modification of cultural practices with the use of chemical inputs have increasingly reduced pastoral areas and the erosion of floristic diversity. This practice has prompted herders to leave their homesteads in fallow land.

In addition, the plant environment is subject to permanent pressures linked to various activities (agriculture, logging and livestock farming) whose consequences take on a catastrophic appearance, especially for fragile ecosystems [25].

The comparison of demographic and economic variables highlights an imbalance between the needs of populations and available resources [26]. The result is a decrease in the productive capacity of the land from year to year. The extension of agricultural land in response to their decline in yield now affects grazing areas and corridors, classified and protected areas. The agro-sylvo-pastoral areas are thus subject to human and animal pressure resulting in the extension of cropland and overgrazing [27].

VI. CONCLUSION

The cartographic analysis of the dynamics of land occupation units in the Commune of Ouassa-Péhunco revealed that the natural plant formations have undergone profound physiognomic and floristic changes. Dense dry forests, gallery and riparian forests, open forests and wooded savannahs including wooded and shrubby savannahs have experienced a decrease in their areas in favor of mosaics of fields and fallow land (36.61%). In total, 38.27% of natural plant formations have experienced regression in this Commune. These natural plant formations have therefore undergone significant physiognomic changes which have had effects on the structure, the floristic composition and the biological and chronological characteristics of the vegetation.

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