Dynamics of land use in the Katiola area (Center-north of Côte d'Ivoire) using satellite imagery

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Abstract:

The degradation of the vegetation cover and the soils is being accelerated in the Katiola area. As a consequence, natural resources, in particular forests disappear in favor of naked grounds. It also causes the loss of fallow land resulting in arable lands infertility, the rarefaction of water resources, vegetation and aquatic species, and an increase in the flows on basin. The objective of this study is to evaluate the changes in land use between 1974 and 2000. The Methodology used is based on a multicriteria analysis and an interpretation of the air-photography. In 1974, the vegetation cover of the ground was diversified and abundant. However, in 1986, this cover regressed considerably in favor of naked grounds. In 2000, we can note a light resumption of the vegetation in some area in the South-east of the region. This light recovery is also due to a light resumption of precipitations in West and Central Africa, as a result of the abandonment of several arable lands exploitation and bush fire.

Key words: land use, multicriteria analysis, flow, Katiola

1. Introduction

The long drought which prevailed in West Africa in 1970, caused damages to natural resources, in particular on water and forest resources. This had as a consequence the fall of agricultural productions, the rarefaction of herds of breeding, and the degradation of vegetable cover. Côte d'Ivoire, from its geographical position, felt strongly these adverse effects at the agricultural, economic and social levels, especially in the Northern part of the country. This area has a dense population (20 inhabitants /km square) with rural majority (81, 2 % in 1996). The growth rate reaches 2, 9 %. This area which is with the door of the areas arid and semi-arid is touched by the phenomenon of climatic variability. The North of the country is a zone favorable to the agro-pastorals activities, with nearly 25% of the arable lands. The economy rests mainly on agriculture and the breeding and occupies nearly 80% of the population and intervenes for more than 40% in the PIB of the country. The majority of the most significant stoppings hydro-electric (dams Kossou and Taabo) take their spring in this northern part of the country. The agro-industrial activities rest on the production of the cotton which made its introduction into 1980s.

In addition, one observed on the basin, a very strong reduction in the flows of almost 80 % between 50 and 80 decades, a fall of rain of 25 % only (Paturel *et al.*, 1997). We can also notes the rarefaction of the water resources, the displacement of some villages in the search of generous grounds. The appearance attends stripped grounds, the loss of the fallow, and the disparity of the forests and species animals in favor of the grassy areas. The moving of farming seasons, the reduction of herds of breeding and water shortages exposing population to the hydrous diseases. . According to several studies, (Hughes, 2000; Lenoir *et al.*, 2008) the track race between climate change and vegetation is already launched. Many species looking for suitable habitats move towards the poles or upwards in elevation (Walther *et al.*, 2005) in (Vennetier, 2009).

Faced with that situation, it is essential to set up a policy of research which approaches the impact of the climate change on the natural resources and the activities of the population. This is why, we initiated this topic " Dynamic of land use between 1974 and 2000 in Katiola area (Center-north of the Côte d'Ivoire) "whose objective is to arise the causes and the effects of the climate change and to install a tool of decision-making aid for Katiola area.

2. Study Area

In spite of its character sahelian Katiola area located at the north of Côte d'Ivoire, conceals an important ground and water resources. This area of the country is favorable to agriculture, gold washing, the breeding and knows an intense activity of mobilization and water using: sugar perimeter of Ferké, (3 800 ha), rice perimeter (1 000 ha), 1 300 ha of hollows improved with Coreriz, the plain of Katiola (300 ha), rice perimeters of Niara (80 ha), Lopé (60 ha) and of Nabion (100 ha).These potentialities explain the great number growing of migrants on the locality where develop simultaneously various projects and activities without a prospective vision and coherence in installations. This involves a degradation of the grounds and strong streaming and deficits of flows. It is thus advisable to adopt strategies and techniques of protection and conservation of natural resources in order to guarantee an efficiency use of water resources. Katiola area (figure 1) is located between longitudes 5 and 6 West and latitudes 8 and 9 North, and is included in zone UTM 30.It is approximately four hundred (400) kilometers of Abidjan and with a hundred and forty (140) kilometers of Yamoussoukro. Katiola belongs to administrative area known as "Valley of Bandama" located in Center-North of the Côte d'Ivoire. It is limited by the areas of Bouaké and Béoumi to the South, Ferkessédougou in North, Korhogo in the North-West, Mankono in the West and Dabakala in the East. It covers a total surface of 9 452 km square.

II acts of a very monotonous area of plates whose average altitude is slightly higher than 300 meters with a light bending towards South-east in Katiola area where altitude is approximately 250 meters. The reliefs are here primarily remainders of lateritic armour. Only, in the North-East of Niakaramandougou, emerges the Niangbo mount which culminates to 694 m it is a granitic dome (Coulibaly, 2009). Lower center, in direction of the North-East, there remains an alignment of hills of an average altitude of 400 m (Geomines, 1982).

From its vegetation of savannah, this area is very sensitive to the streaming and with the phenomenon of armouring, its relief is thus marked by an alternation of glacis and zones depressed.

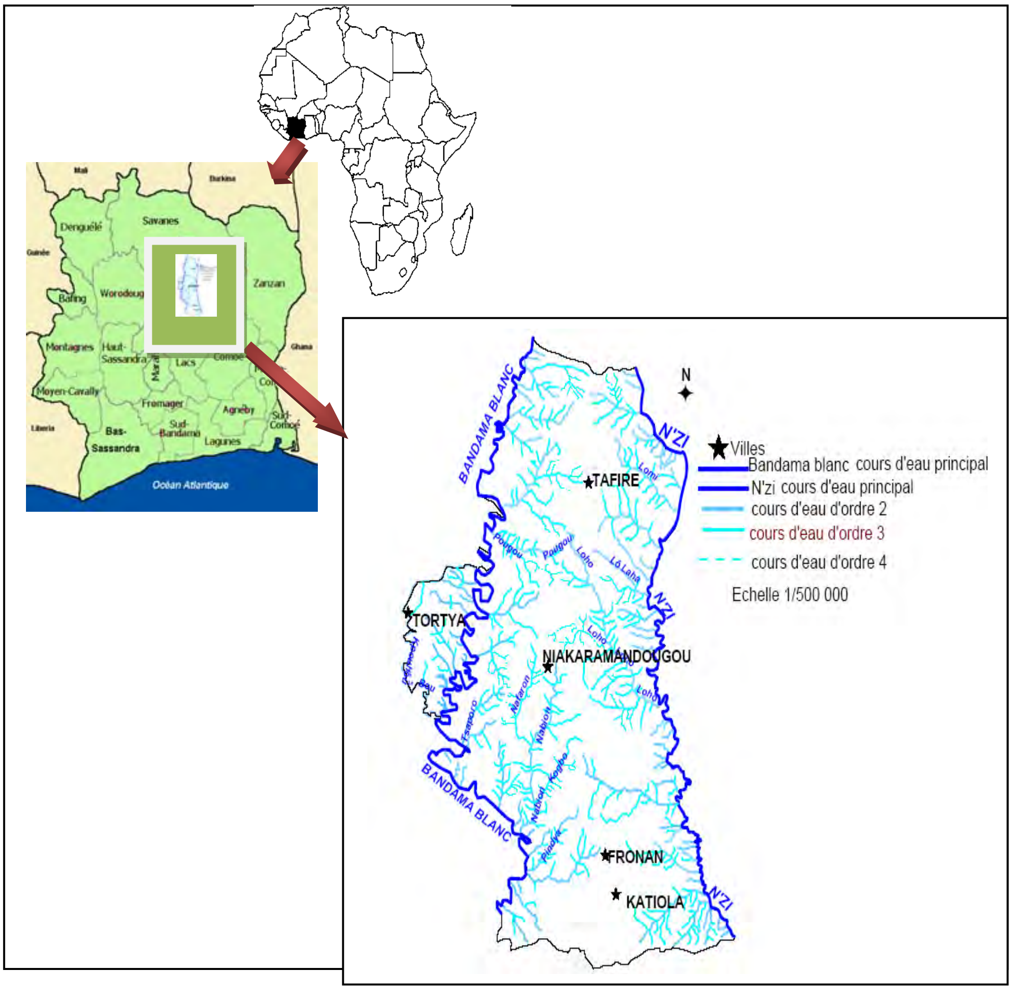


Figure 1: study area

3. **Grounds**

The regional cartography carried out according to the morphopedologic approach revealed that the evolution of the grounds at the square degree of Katiola depends on the following pedogenic processes: induration or armouring, rehandling, pedoplasmation, deterioration, impoverishment and hydromorphy (Editions of ORSTOM, Collection Conferences & Seminars Paris 1987).The induration seems to be the most significant process and is indeed very represented in the Northern part of Côte d'Ivoire. Four great strongly individualized sets follow successively from the West to the East. Inside the granites, some petrographical variations present a significant pedological incidence: the areas of embrechite and anatexite are related to abundant rock exposures on the slopes; the small granite hyperalcalin sprouting of the south gives a landscape to sandy grounds that are not deeper where the outcrops are noticed. In the center of the area, there is a set of a granite band with two micas. It is an intrusive granite tarditectonic which strongly compressed the compartments which border it (litage subvertical) (figure 2).The areas of edge are strongly heterogeneous and fractured (pollution and pressures during the increase), which led to the formation of many inselbergs and zones of outcrops. The Eastern limit is easily visual and shows us a difference of altitude with the close compartment (more than 50 meters on average).That is the same remark at the western edge in the north (valley of Bandama), but it goes down towards the south. This granite is characterized by the size of its quartz grains (strong proportion of the class 2-5mm) (Poss, 1982).

4. Climate

Katiola area is covered by the tropical climate and sub-sahelian. It is a one season climate characterized by a from 600 to 1100 mm on average and long dry season going from 6 to 7 months (December until June).The monthly average temperatures are about 30 °C. Annualrainfall is characterized by an important annual variability and a very bad space-time distribution (figure 2).

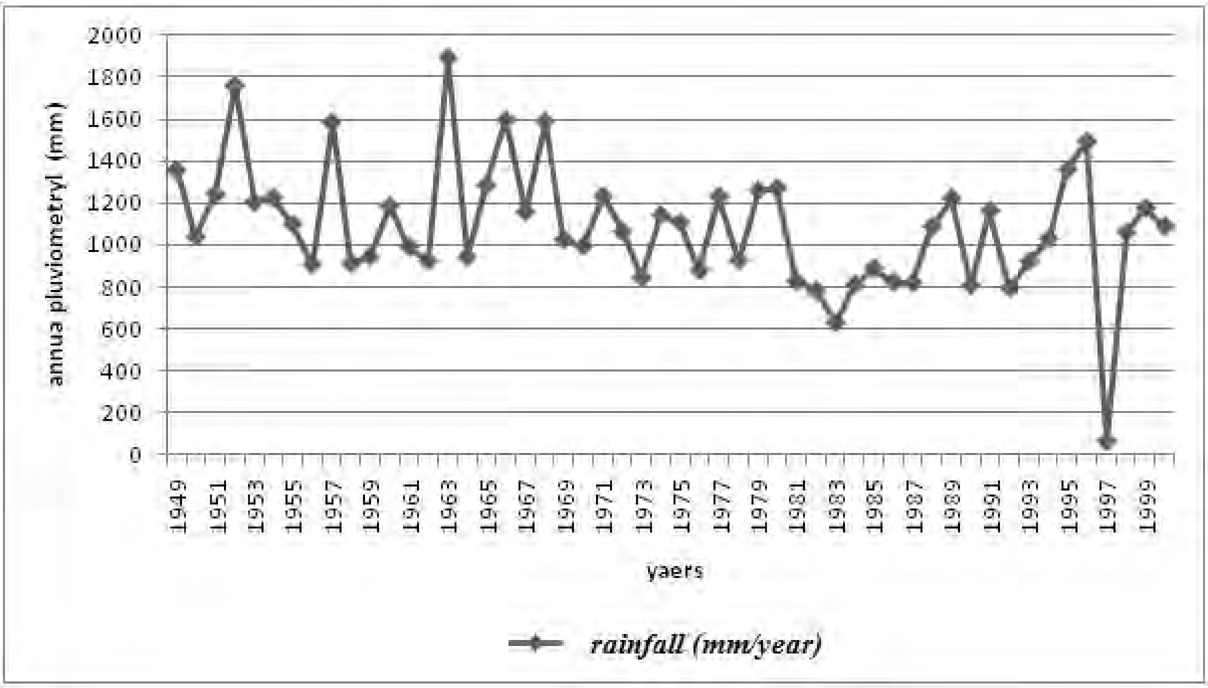


Figure 2 : Annual rainfall (mm) of Katiola from 1949 to 2000.

The tropical Africa climate knew an alternation of wet and dry periods, in response to changes of the total climate, on all scales of time. We can observe an increase by stages in the aridity since 3 million years. The changes observed imply interactions between orbital factors (solar activity…), conditions of surface of the oceans and vegetation (Gasse, 2006). West Africa east under the mode of monsoon. The drought in progress since the beginning of 1970s is characterized by a reduction in rainfall about 20 to 30% (Kamagate, 2006).The climate systems are an important in the total climate balance of our planet and condition the survival of populations living in the intertropical belt. This is particularly true for the African monsoon, which has known since thirty years a significant disturbance of its operation, with the visible consequences on the hydrological cycle and various types of resources such as subsoil waters. For the tropical modes, they present two characteristics. Firstly, their seasonal cycle is well marked and more stable one year to other; in addition, the rain is for most of the year lower than the evapotranspiration, in particular for the semi-arid areas located in subtropical. The annual rainfall total is very often comparable or higher on the whole rainfall of the moderate areas (Lebel, 2005).

The Katiola area profits to the Sudanese climate type which is characterized by:

- Only one very long rainy season of six (6) months going from May to September and a dry season which covers all the remainder of the year in North;
- In the South, we can observe two (2) seasons of rain and two (2) dry seasons. The first rain season begins in March and is completed in June while the second season lasts only two (2) months (from September to October);

Annual rainfall remains almost the same one on the extent of Katiola area with an average of 1200 mm rains and monthly average peaks of 120 mm between September and June (Monographie, 2003).

The dry season appears from November to February and is dominated by a very dry wind which is the blowing harmattan in the North-South direction in all the area of Katiola. This period is characterized by low temperatures the night being able to reach 15 °C and during the day they reach the order of 40 °C accompanied by dry winds and violent one. However, the remainder of the year i.e. the period going from March to October one observes monthly average temperatures varying between 25 °C and 35 °C.

5. Vegetation

The area is subjected to the sub-wet climate tropical and belongs to the southernmost part of the Sudanese field more precisely to the sub-Sudanese field what marks the presence of a much degraded forest due to the human activities. The essence of the vegetation thus makes up of raised and grassy savannahs, strewn with small islands batches of forests gallery especially along the rivers. However, we can notes sometimes the presence of some small islands of relatively deep forests in the Western part of the department and especially along Bandaman (Monographie, 2003).The principal small islands forest included in savannah are localized on the volcanogenic complex made up mainly of schist and basic rocks: it is the case of the small islands of Marabadiassa (ORSTOM, 1971). We can find the little degraded forest on both sides of Bandaman and especially in the Western part of the area with weak population between the sub-prefectures of Tortiya and Tiéningboué.

6. Hydrography

The affluent of two rivers go through the area which constitutes them the territorial natural limits. These rivers are: the N'zi in the East and the white Bandama in the West. The white Bandama and the N'zi flow from the North to the South. The most part of this zone we are studying is drained by the Bandama and its affluents (Bou, Nararnou, Nabion).

The hydrological mode is part of the equatorial type of attenuated transition (Girard, Sircoo' lon and Touche Beuf, 1971, Poss, 1982).The mode of the rivers reflects that of the precipitations. As for the significant basins, there is a unique increase of water in August, September and October followed by a fast drying up in November, December then a long period of low waters from January to May.

7. Material and Methods

7.1 Material

There are several tools we use for this study. Among which we can mention three scenes multi-dates (MSS 1974; TM 1986; ETM+ 2000), optical satellite images of very high resolution, in particular those of sensors MSS (Multi Spectral Scanner), TM (Thematic Mapper) and ETM+ (Enhanced Thematic Mapper Plus) of LANDSAT. The images of the sensors TM and ETM+ have the same space resolution that is 30 m except those of sensor MSS which have a resolution of 60 m in the beginning and which underwent a reechantillonnage in order to be brought back to 30 m.

For this analysis, the choice of the images is based on four criteria which are: the cover, the space resolution, years and seasons of catch of sight. The good space resolution gives a better flexibility in the choice of the scales of exit. The two dates, 1974 and 2000 are also justified by the interval of time which separates them (28 years) making it possible to appreciate well the evolutions of the landscape units in a climate change context. According to Robin, 2002 & Sarr., 2008 the more the temporal resolution is higher, the more the perception of the change is right.

The data of land, collected are saved in a software spreadsheet and are organized for data treatment. During the study of land, the localization of the landscape units, the roadway systems and the buildings are carried out thanks to a GPS Garmin Etrex Vista Hcx. In order to improve the quality and the precision of the geographical coordinates of the sites sampling, we used the differential mode between WAAS and EGNOS of the GPS. The EGNOS System **(**Service European of Navigation by Geostationary Covering), is based on a network on the ground of earth stations of reference making it possible to correct the signals of the positioning systems of the United States GPS and Russian GLONASS. Thanks to this interworking, it makes it possible to improve at the same time the reliability and the precision of the geographical coordinates of the samplings sites. The WAAS (Wide Area System Increase) is a system of assistance to navigation. The WAAS uses a network of stations of reference on the ground. Measurements of these stations of reference are intended to principal stations, which accumulate the corrections and send messages towards the geostationary satellites of the WAAS sufficiently less every five seconds to be able for use. These satellites send then these messages and corrections towards the Earth, where the receivers of the type "WAAS-enabled" can use them to improve the precision. The European system EGNOS, based on a similar principle, is interoperable with the WAAS (http://fr.wikipedia.org, 15/10/2010).

7.2 Presentation of the satellite images available

The satellite images used within the framework of this work make it possible to work out the land use map to follow the evolution of vegetable cover between 1974 and 2000 in Katiola area. With these data, is added climatic and hydrological data covering the period 1974-2000.The availability of these various data will make it possible to put in parallel the evolution of the occupation of the ground and the climate on the basin. The satellite images used for this purpose are images Landsat-1 MSS (Multispectral Scanner) of 1974, Landsat-5 TM (Thematic Mapper) of 1986 and Landsat-7 ETM+ (Enhanced Thematic Mapper Plus) of 2000 (Figure 1&2). The choice of the Landsat data excludes the possibility of having satellite images dating from the years 1960 because the program of the Landsat satellites started only in 1972.

The description of the spectral and space characteristics of the various images, the dates of acquisition as their origins is consigned in Tables (1&2).

Table 1: Spectral and space characteristics of the satellite images used

Spectral Bands	Spectral resolution (µm)	Spatial resolution (m)
Landsat-1 MSS (Multi-Spectral Scanner) 1974 Broke: 180 Km		
Bande 1= MSS Bande 4 (Vert, visible)	0.50- 0.60	60
Bande 2= MSS Bande 5 (Rouge, visible)	0.60-0.70	60
Bande 3= MSS Bande 6 (Proche Infra Rouge)	0.70-0.80	60
Bande 4= MSS Bande 7 (Proche Infra Rouge)	0.80-1.10	60
Landsat-5 TM (Thematic Mapper) 1986 Broke: 185 Km		
Bande 1 (Bleu visible)	0.45-0.52	30
Bande 2 (Vert visible)	0.52-0.60	30
Bande 3 (Rouge visible)	0.63-0.69	30
Bande 4 (Proche Infra Rouge)	0.76-0.90	30
Bande 5 (Proche Infra Rouge)	1.55-1.75	30
Landsat-7 ETM+ (Enhanced Thematic Mapper Plus) 2000 Broke : 185 Km		
Bande 1 (Bleu visible)	0.45-0.52	30
Bande 2 (Vert visible)	0.52-0.60	30
Bande 3 (Rouge visible)	0.63-0.69	30
Bande 4 (Moyen Infra Rouge)	0.76-0.90	30
Bande 5 (Moyen Infra Rouge)	1.55-1.75	30
Bande 6 (Proche Infra Rouge)		
Bande 7(Thermique)		

Table 2: Satellite images Landsat used

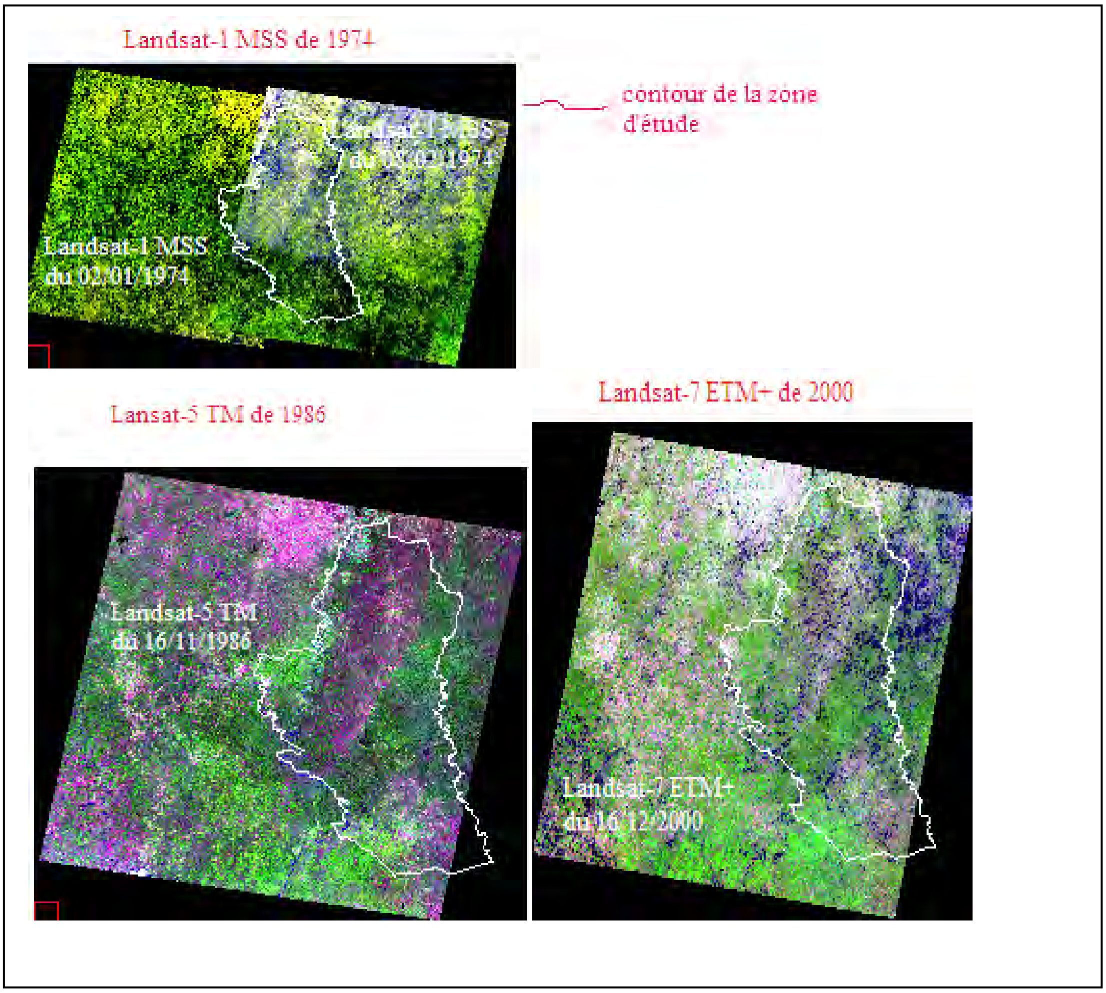
	Number of images	Date of acquisition	Source
Landsat-1 MSS	02(1974)	02 janvier 1974 (p211r54) 08 février 1974 (p212r54)	
Landsat-5 TM	01 (1986)	16 novembre 1986 (p197r54)	
Landsat-7 ETM+	01 (2000)	16 décembre 2000 (p197r54)	

All the images used within the framework of our work are from the same sensor but were taken on different dates. Each one of it underwent a visual examination which did not reveal any defect of chalk-lining and shimmer. However, one notices the presence of light cloudy veils on the image Landsat-1 MSS of January 02 19724 what is not the case of the second image Landsat-1 MSS of February 08 19724.However, these cloudy veils are corrected by a linear spreading out on the image concerned (MSS of January 02 19724) before its mosaic. Linear spreading out is a technique of treatment which makes it possible to raise desired spectral information, thus leading to a new image with the contents set of themes improved compared to the rough image (Diabaté, 1988).It makes it possible to be freed from a possible pretreatment aiming removing or at least at mitigating the cloudy effects on the numerical accounts of the images concerned.

The difficulty of any study lies in the availability and the reliability of the data used. Concerning this study, in certain cases, it was not possible to entirely cover the total surface of the zone of study for lack of images available (4 Figure).Alternative solutions were thus proposed in order to stage these insufficiencies. The images concerned with the lack of total cover of the zone of study are: images TM of 1986 and ETM+ of 2000. Three cases of figure arised :

A whole Southern part of the basin is not covered by the satellite image TM of November 16, 1986.The only image available covering this Southern part of the basin, dates from January 09, 1986.This image could not be taken into account because the evolution of vegetable cover during the eleven (11 months? 1 year) months passed between January and November proves very significant and the addition of an image of January 09, 1986 would skew the results. Indeed, for a good follow-up of the dynamics of vegetable cover, the interval of the most suitable time is the decade or the month. Missing surface relatively underwent a study based on work recent and passed. We thus had resorts to various studies which were undertaken on the same zone of study and by several authors (Coulibaly, 2009; Doumbia & Pouclet, 1997; Roland & Christian, 1983; ORSTOM, 1983**)** to supplement the missing part.

A very small portion (less than 0,6 %) is a piece of 12 hectares of the South of the basin is not covered by image ETM+ of November 16 with 2000 used. The image available which covers this part goes back to 2002.The year 2002 is too distant from 2000 and cannot not take into account in our study. Therefore, we are to satisfy with the only image of 2000 for this work which made it possible to do the sampling of zone of drive on the ground (reality ground).To supplement our study, we based ourselves on the recent work and passed already completed on our zone basin. The figure 3 presents the various satellite images used within the framework of our study.



Figures 3 : 1, 2, 3: satellite images (MSS 1974, ETM 1986 & ETM+2000)

7.3 Methods

The various collected data made it possible to set up a methodology. This methodology consists in making a diachronic analysis of vegetable spaces and the other systems of land use. Taking into account the whole source of data (general statistical data, topographic charts, various charts sets of themes of land use), results of land study and the analogical and digital processing of satellite images of the years 1974, 1986 and 2000.The analysis of land use evolution was done by the method of supervised classification. The classification of an image in remote sensing consists in an automatic recognition of reflectance. The process used for this study comes from Fosting's model (1998) (figure 4). It is about a hierarchical classification. The method consists at first level, in classifying the stages, the bands which are used in classification. Secondly, to choose the pixels of sample in the whole of the image from the bands chosen to create areas of interest for classification. Finally, the number of classes, the maximum number of iteration and the limit value of distance between classes is done.

The method of maximum of probability is selected to make our classification (Tabopda, 2005). From the interpretation of the satellite images and work on land, it was possible to define landscape units and to study their evolutions at different periods (1974, 1986 and 2000).

The typology of the physical environment points out seven classes in the Katiola area. The seven main units are: the deep forest, the destroyed forest, clear shrubby raised savannah, the water resources, wetlands, fields and grounds naked. The study of the evolution of the land use is a multicriteria analysis of the satellite images which presents three steps of analysis. It deals with the modifications, transforming and no modifications. A crossing study of the three land use maps for the three years has been done in order to better apprehend the spatial-temporal evolution of the seven landscape units.

The "**modification**" shows that changes are noticed inside a same category of land use. For example, the shrubby savannah which becomes clear raised savannah or vice versa**.** While, the **"transforming»** which is the passage from a category to another one such as wetlands becoming grown up fields. The term "**conservation**" refers to the whole of the stages which are remained in the same stage between the two dates of the study, that is to say, having been affected neither by the modifications, nor by transforming.

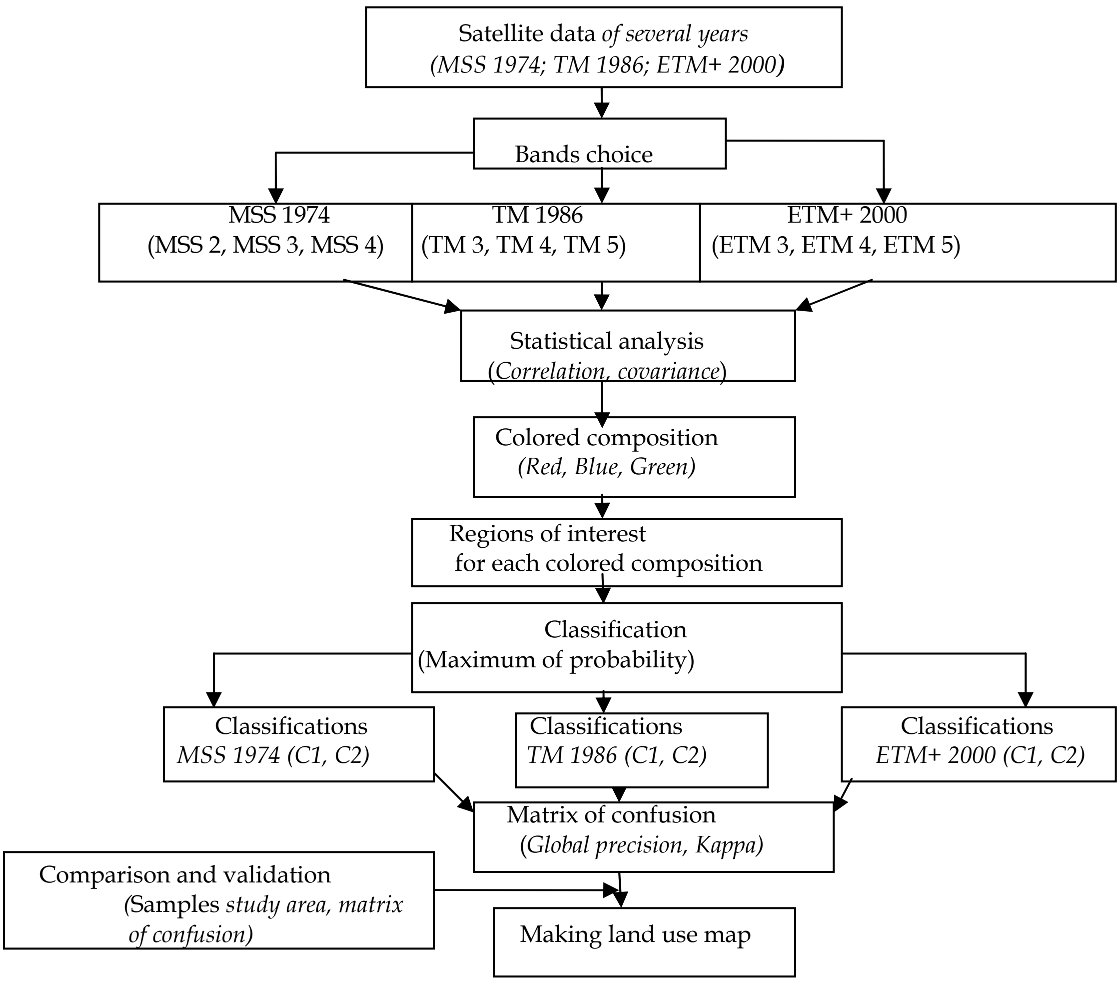


Figure4: General model of classification of the satellites images modified of Fosting model (1998)

Table 3 represents the evolutionary cartography of the landscape units in Katiola area (ha)

Land use	1974		1986		2000	
	Hectares (ha)	%	Hectares (ha)	%	Hectares (ha)	%
Deep Forest	37 524,44	3,97	10 019,12	1,06	23 630	2,5
Shrubby savannah tray or destroyed forest	178 264,72	18,86	89 123,36	9,43	145 918,28	16,39
Grassy or clear arboreous savannah	386 397,76	40,88	660 883,84	69,92	514 566,88	54,44
Water resources	287 624,36	30,43	5 765,72	0,61	19 754,68	2,09
Wetlands	4 253,4	0,45	14 461,56	1,53	23 346,44	2,47
Fields Areas	1 323,28	0,14	2 173,96	0,23	9 262,96	0,98
Bare soils or naked ground	49 610,23	5,24	243 010,92	25,71	1 995,24	21,10

The evolution of the landscape units from 1974 to 2000 in the Katiola area cannot be well-known if we consider the year 1974 as the starting point. So, it is an evaluation of dynamics of elements of the vegetable cover.

Opposing to the analysis of the spatial data which uses the data of the most recent year, the analysis of the evaluation is based on the eldest satellite image, particularly that of 1974. The painful drought which damaged West Africa and Central during the decades 70-80 and 80-90 has considerably affected in a negative way the hydrological cycle, the socio-economic activities and environment (Goula *et al*, 2006). These negative effects on the environment have led to modifications and transforming at the level of surface qualities in the Northern part of the Katiola area. The seasonal farmings were shifted; the agricultural productions and the fertility of the grounds knew an important decrease and led to a displacement of the populations towards the southern part of the Katiola area.

Katiola area covers 945 200 ha. The land use in 1974 was significant and abundant (figure 5). Grassy and clear arboreous savannah occupied 386 397,76 ha or 40,88% of the area. The destroyed forests or clear shrubby savannah represented 178 264,72 ha or 18,86%.The deep forests covered only that 37 524,44 ha or 3,97%. In short, surfaces of vegetable cover were significant and very large with 63,71%.

The water resources had set out through different way and unequal with 287 624,36 or 30,43% of the territory while the wetlands (easily flooded, marshy zones and mangroves) covered 4 253,4 ha.

The fields areas and the fallow were slightly represented and covered 1 323,28 ha or 0,18%. As for the naked ground, they were many and disseminated on the whole of the area and covered 49 610,23 ha or 5,24%.

In 1986, some surfaces of the vegetable cover decreased either by modifications or by transforming (figure 6).The deep forests are reduced and covered 10 019,12 ha or 1,06% of the area. The most significant reductions are noticed at the level of water resources with 5 765,72 ha and clear shrubby savannah with 89 123,36 ha or 9,43% of the territory.

However, the zones of grassy savannah and that of fallow knew an increase in their surface, they go to 660 883,84 ha or 69,92% of the whole surface of the territory. The naked zones and the fields areas ones became numerous and respectively covered 2 173,96 ha and 243 010,92 ha.

In 2000, the fields areas are increasingly numerous going from 2 173,96 ha in 1986 to 9 262,96 ha in 2000 (figure7).The water resources and the wetlands increased and covered respectively 19 745,68 ha and 23 346,44 ha. While surfaces of the deep forest formations decreased with 23 630 ha, clear shrubby savannah with 14 918,28 ha and grassy or arboreous savannah clear covering 514 566,88 ha. The fields areas are decreasing moving from 243 010,92 ha in 1986 to 1 995,24 ha in 2000.

8.1 Evolution of the land use between 1974 and 2000 in Katiola area

Taking into consideration this analysis, the vegetable cover has known significant modifications between 1974 and 2000. From 1974 to 1986, the phenomenon of armouring firstly in the Northern part of Tafiré area increased and reached the district of Niakara located in the center and Tortya in the West. In 1986, armoured surfaces and the naked grounds have increased by 20, 47% from 1974.The naked grounds increased in a considerable way reaching 243 010,92 ha in 1986s.This situation led to the loss of several fields' areas and an important displacement of populations from Tafiré in the North towards Katiola in the South. The increase in surfaces of the naked zones and the fields of crops are in fact a combined effect of the anthropic activities, higher demography and with migrations of the populations of the close countries in quest for fertile areas. These anthropic activities are mainly the agricultural and agropastorals activities, the bush fires, the deforestation, the overexploitation of the grounds.

In fact, until 1986, the techniques of conservation and protection of the resources were limited till the protection of the protected surfaces (classified forests, reserves) and the animal species, there was no strategy of conservations and restoration of the arable lands. This great lack of conservation of the grounds and water has obliged the populations to exploit classified forests. These ones disappeared and are transformed into grassy or shrubby savannah. From 1974 to 2000, the forests moved from 37 524, 44 ha in 1974 to 23 630 ha in 2000 that represents 13 894, 44 ha destroyed with the profit of savannah. The wetlands knew a permanent rise with 4 253,4 ha in 1974 and 23 346,44 ha in 2000 that is an increase of 2,02%. As for the water resources, they knew strong influences due to the drought of 1970s. It drained by 30% of water resources between 1974 and 1986.The building of agricultural dams, agro-pastorals, AEP in the 1980s has increased the water resources by 2% till 2000.

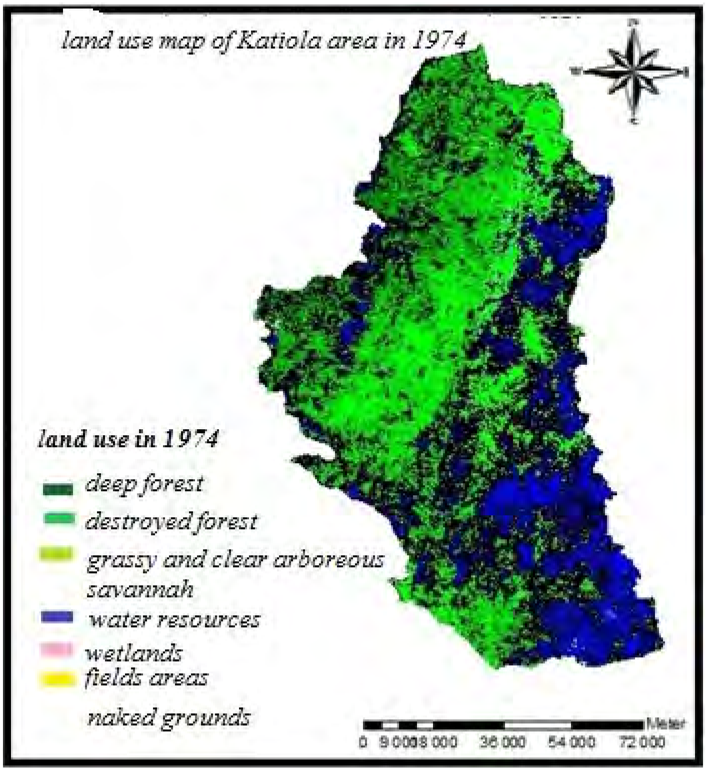


Figure 5 : carte d'occupation du sol du département de Katiola en 1974.Land use map of Katiola area in 1974

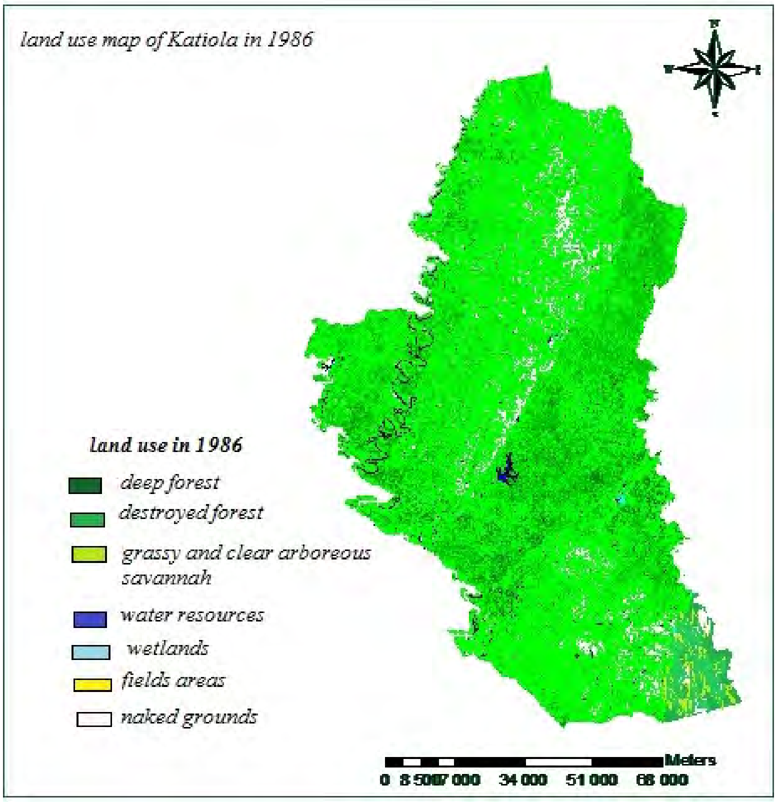


Figure 6 : carte d’occupation du sol du département de Katiola en 1986.Land use map of Katiola area in 1986

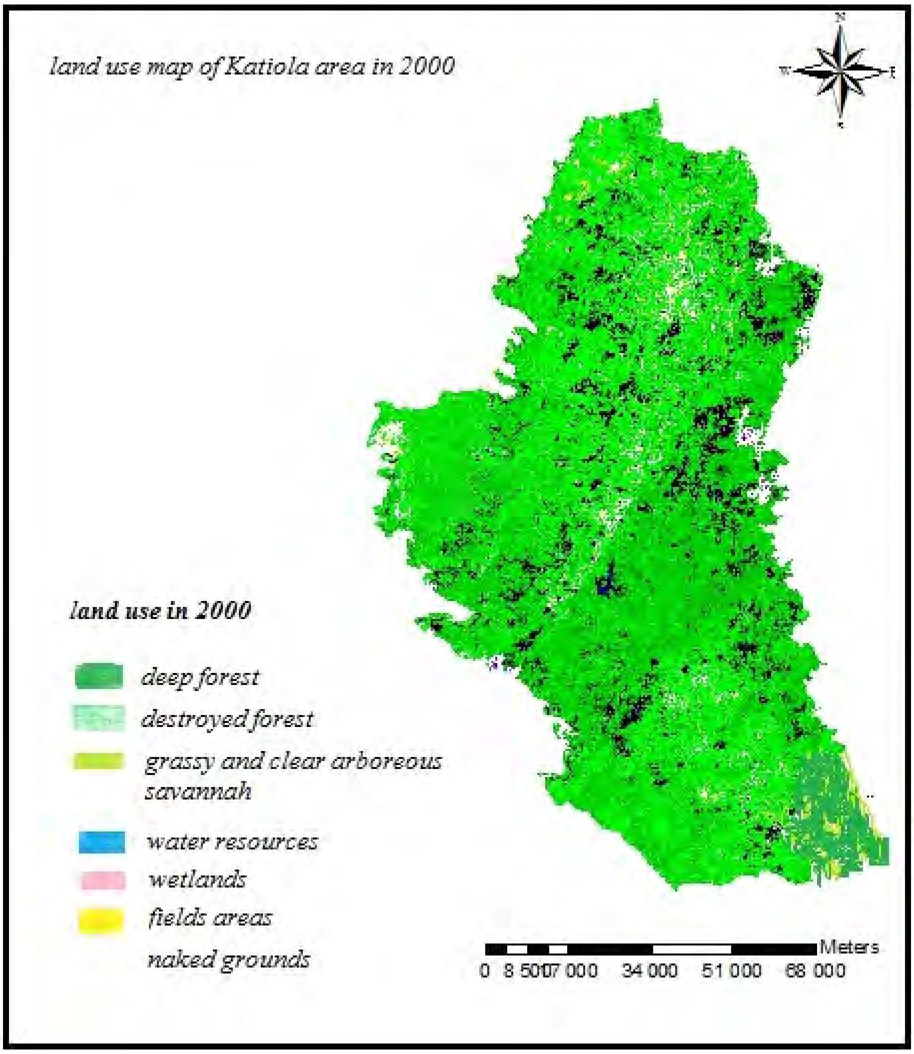


Figure 7 : carte d'occupation du sol du département de Katiola en 2000.Land use map of Katiola area in 2000

8.2 Discussion

The dynamics of the ecosystems is in relation with the climatic disturbances and the anthropic causes (Mainguet, 2003). Indeed, the successive droughts had some consequences on the woody vegetation, in particular on the species which do not support a lack of water prolonged, leading to their disappearing (Marchal, 1983). The decrease of the vegetation has prevented the grounds from a protective cover and exposes them to the agents of erosion which are the streaming and the winds. The anthropic causes are related to the agro-pastorals activities that are the growing up of weakened areas and the reduction of the practice of the fallow, which prevents grounds to reconstitute themselves (Totté, 1996).The overgrazing and the trampling of the animals take part in the impoverishment of the soil destroying the herbaceous woody cover, thus exposing the grounds to the effects of erosion. It follows from there the appearance of plateau of stripped grounds.

In 1980s, the rainfall conditions were degraded in Katiola area. The great droughts of years 1973, 1983 and 1984 left damages traces in the population's memory. The naked grounds became unproductive because of erosion and the reduction in the fertility of the grounds exploited abandoned without measurement neither of conservation nor of protection. The processes of appearance of the naked grounds generate the loss of the cultivable grounds (Zombré, 2003).

Between 1980 and 2000, several hollows and wetlands were transformed into favorable farming spaces for agricultural use. They are troughs of low pressure which have ochres grounds, argilo-sandy, argillaceous and ferralitic which is regularly enriched by the alluvial deposits and colluviums. The risks of permanent floods and the overflows of the rivers in rainy season knew an important fall conditioned by the fall of precipitations and the appearance of the drought in the decade 70-80.The high reliefs (hills, the mountains) had known a destroyed vegetable cover. Each geographical entity (piece of culture, forest, city, sand) evolves at its rhythm in time (Robin, 2002).These units know a continuous destroying in their vegetable and pedological cover (Boulet, 1973).The streaming becomes very important and these areas remain unsuitable for agriculture.

The overgrazing occurred in 1980s contributed to the strong aggression of the vegetable cover, because the repeated passage on the naked grounds and the grassy savannah of the ox herds and the livestock lead to the accumulation and the encrusting of the grounds. In 1986, we note a rate of the stripped areas of 25% against 5 % in 1974.

The earth planet knows since the 15th century till our days a persistence of the climate change phenomenon which corresponds to a modification in the time of the various regional climates (FFEM, 2004). Côte d'Ivoire is touched much by these climate disturbances, which involve an increasing of the temperatures (PANA, 2006).This consequence leads to September, December, January and February increasingly hot that before in Katiola area with a recorded average temperature of 33 °C. The decrease of the rainfall is important and continues till our days. These consequences are perceptible and lower the agricultural productions enormously.

For that situation, the introduction of the perennial cultures such as the cashew tree, the cotton plant, the mango tree was necessary in 1980s which answer to the adaptation measurements of climate change.

Several studies using the satellite images showed that vegetable cover knew a true aggression in years 1980 due to the drought occurred during 1970.They have mentioned that the lack of strategy of conservation of water resources and grounds are strongly contributed to the destroyed of the vegetable cover (Sawadogo *et al.*, 2008). According to Totté (1998), the vegetable cover in the North of Yatenga between 1987 and 1993 improved on practically all the morpho-pedological supports thanks to the method of water resources and grounds conservation (called stony cords or anti-corrosives sites) set up in 1980s. In the prospect (Belemviré, 2003;Sanou *et al.*. 2003;Reij & Thombiano, 2003) showed in their studies that there was a significant resumption of the vegetation in the soils of Ziga.

In Katiola area we can observes a light resumption of the vegetation in 2000 thanks to the policy of reafforestation set up in 1980 by the SODEFOR and the Côte d’Ivoire government.

Several teak plantations were born in particular in the areas such as Kpéfélé in 1970, Kowara in 1995, Katiola and Kationon in1980 and Fronan in1987.

This strategy of reforestation aiming at the conservation of the natural resources was a success in some areas, it remained however very limited in time and space. The reforestation spaces were only fields of experiment and covered small surfaces from 10 to 20 ha. The strategy could not integrate large population. The consciousness-raising campaigns were not intensified and remained very deficient what is involved an end of the project in 1997.The regeneration of the vegetation observed in 2000 is a natural regeneration (NRA). It is so important to set up a good strategy of conservation of the grounds in order to reduce to the maximum the naked grounds which support the streaming and disturbs the infiltrations intended for the refill of the sheet.

9. Conclusions

This study shows the importance and interest of the satellite images and the photo-interpretation in the analysis of the dynamics of the landscape units. Between 1974 and 2000, vegetable cover was modified considerably by transforming. The naked grounds, the fields’ areas and savannah evolved and increased between 1986 and 2000.The field’s areas were transformed into naked grounds. The areas of Niakara and Tafiré knew the strongest rates of damage of the vegetable cover. The grassy savannah made up with the plants such as andropogonnees long-lived of savannah (andropogon, hyparrhenia, sehigachyrium) very abundant and constituting an advantage for the breeding in 1986, has lost nearly 10 % of its resource in 2000.The situation observed on the image of 2000 catch as recent for the study shows that the evolution of vegetable cover is much accentuated giving way to armourings, strong erosion and a massive destruction of the forests transforming itself into grassy savannah. The matrix of the changes generated by the crossing study of the charts of land use of 1974 and that of 2000 shows an evolution on the level of the various units of land use.

As a rule, the matrix of confusion got by the crossing study of the land use map shows an acceptable coefficient of about 88%.That showed a good conformity or representativeness between the data processed on the satellite images and the reality-land.

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