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Vegetable Cover of Soils in the Kwilu Valley in Bulungu Territory/ Rd. Congo

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Abstract: Through spatio-temporal analyses, the present study focused on the evolution of the vegetation cover of soils between 2001 and 2018. The Mikwi, Kwilu-Kimbata and Kilunda Sectors in the Bulungu Territory, Kwilu Province in the Democratic Republic of Congo constitute our dition. The area thus defined fits well into the Kasai Sector, the Regional Center of Guinean-Congolese Endemism. The estimated area is equivalent to 385101.8 ha. The main objective of the study consisted in discovering the direction of the evolution of the plant cover by quantifying the reduction of the area between 2001 and 2018, in order to foresee actions that could mitigate the effects of the original causes. The material used for this research consisted mainly of botanical samples for scientific identification and characterization, vegetation maps of the Kwilu Province, satellite images covering the study area. Surveys of the sites were carried out based on the observations of the constituent elements of the environmental factors. The results obtained show that the base and terminal years are marked by the predominance of the light green color which corresponds to herbaceous formations. Despite this prevalence of the light green color between the two years, the difference in contrast is very significant, reflecting a regressive evolution of the forests marked by a decrease in the bright green and light green colouring (secondary forests). Statistical analyses indicate that the rate of deforestation between the two reference years is 23.90% with an average annual rate of deforestation per hectare of 1.32%. Applied analysis of variance shows a significant difference between the two years, with ANOVA (f=1.865; df=6.392; p value=0.9997). The expansion of agricultural areas, the exploitation of timber and fuelwood, and the manufacture of charcoal are indicators of the degradation of these forests that induce regressive forest dynamics. These disturbances have effects on biological resources, agricultural production, climate and water.
Keywords: Kwilu Valley, Ecosystem, Vegetation cover, Land cover, Deforestation, Degradation.

Resume : Par des analyses spatio-temporelles, la présente étude a porté sur l'évolution de la couverture végétale des sols entre 2001 et 2018. Les Secteurs Mikwi, Kwilu-Kimbata et Kilunda dans le Territoire de Bulungu, Province du Kwilu en République Démographique du Congo constituent notre dition. L'aire ainsi définie s'intègre bien dans le Secteur du Kasaï, Centre régional d'endémisme guinéo-congolais. La superficie estimée équivaut à 385101,8 ha. L'objectif principal de l'étude a consisté à découvrir le sens de l'évolution du couvert végétal en quantifiant la réduction de la superficie entre 2001 et 2018, en vue d'entrevoir des actions pouvant atténuer des effets des causes à l'origine. Le matériel utilisé pour cette recherche est constitué essentiellement des échantillons botaniques en vue de leurs identifications scientifiques et leur caractérisation, les cartes de la végétation de la Province du Kwilu, les images de satellite couvrant l'aire d'étude. Des prospections des sitesont été menées en nous basant sur les observations des éléments constitutifs des facteurs environnementaux. Les résultats obtenus montrent que l'année de référence et terminale sont marquées par la predominance de la coloration vert-pâle qui correspond à des formations herbacées. Malgré cette prevalence de la coloration vert-pâle entre les deux années, la différence de contraste est très significative, ce qui traduit une évolution régressive des forêts marquée par la diminution de la coloration vert-vif et vert-claire (forêts secondaires). Les analyses statistiquesindiquent que le taux de déforestation entre les deux années de référence s'élève à 23,90 % avec un taux moyen annuel de déforestation par hectare de 1,32 %. L'analyse de la variance appliquée met en évidence une difference significative entre les deux années, avec ANOVA (f=1,865; df=6,392; p value=0,9997). L'expansion de zones agricoles, l'exploitation du bois d'œuvre et de chauffe, la fabrication du charbon de bois sont des indicateurs de dégradation de ces forêts inducteurs de la dynamique régressive forestière. Ces perturbations ont des effets sur les ressources biologiques, la production agricole, le climat et l'eau.
Mots clés: vallée du Kwilu, écosystème, Couverture végétale, Couverture du sol, déforestation, Dégradation.

1. Introduction

Current trends in the decline of tropical woodland quality and quantity are reflected in eloquent numbers (Anonymous, 1983). In response to deforestation caused by shifting agriculture and other activities, forest services have taken the initiative to quantify, and possibly map, the decline in forest cover, without generally attempting, through a continuous ground-based inventory, to assess changes in standing potentials (FAO, 1972).

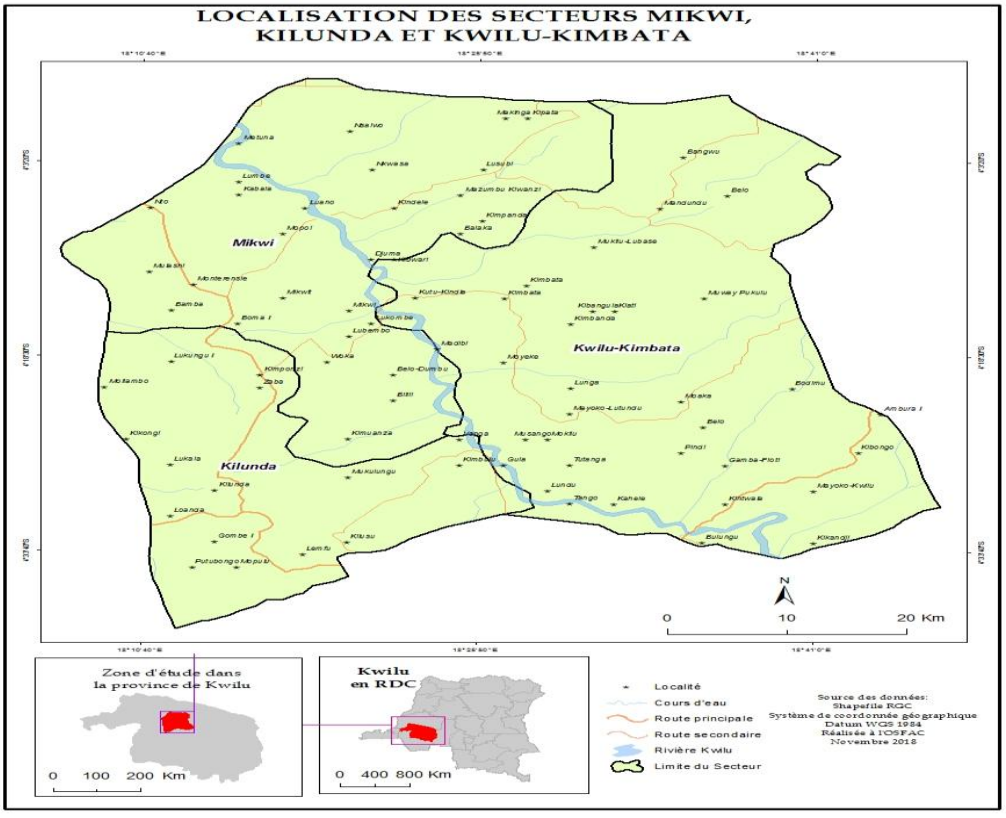
The forests of the Kwilu Valley in Bulungu Territory are relatively unknown, yet they are seats of rapid change. The total dependence on the forest, coupled with the region's population growth, means that the balance of nature is being profoundly altered and the rate of deforestation is locally much higher than average. The study on the evolution of vegetation cover in the Bulungu area in the Kwilu valley in the Democratic Republic of Congo makes it possible to measure the impact of human activities on the structure and functioning of forest ecosystems and to study the various phases of regression or biological recovery.

This forest monitoring initiative is designed within the framework of the global environmental monitoring system and the REDD+ process advocating the conservation and reforestation of natural sites and degraded forest lands (Azangidi *et al*, 2019).

1.2 Study environment

The Mikwi, Kwilu-Kimbata and Kilunda Sectors in the Bulungu Territory, Kwilu Province in the Democratic Republic of Congo constitute the study area. The area thus defined fits well into the Kasai Sector, Regional Center of Guinean-Congolese Endemism. The studied area is equivalent to 385101.8 ha. The geographical coordinates are as follows: S=04°089' 99"; E= 018°429' 25" and 436 m altitude. Map 1 locates the studied sectors.

Map 1: Geographic location of 3 Study Areas (Original Azangidi Map, 2018)



2. Hardware

The material used includes botanical samples for their scientific identification and characterization, vegetation maps of the Kwilu Province, satellite images covering the area of our study. The herbarium specimens collected during the field surveys underwent the usual treatment: placing in wooden presses, drying in the sun, establishment of harvest sheets. All of this material constitutes our reference herbarium, the foundation of the study area's florula study.

2.1 Methods

The method used here consists of surveys of the study area by observing the constituent elements of the environmental factors. These aspects concern: the state of the vegetation cover in the study area (continuity, discontinuity); the nature of the discontinuity in the vegetation cover (cutting, ploughing, fire or bush fires, creation of fields, new villages or roads, etc.); the nature of the vegetation cover (vegetation cover, vegetation cover, etc.); the nature of the discontinuity in the vegetation cover (vegetation cover, vegetation cover, etc.); the nature of the vegetation cover (vegetation cover, vegetation cover, etc.); the nature of the discontinuity in the vegetation cover (vegetation cover, vegetation cover, etc.). effects of activities on vegetation, flora and fauna; trend towards regeneration or regression of vegetation; local disappearance or rarefaction of certain species or types of vegetation; soil conditions (erosion, landslide, flooding, etc.).

The set of steps taken can be summarized in three complementary phases, namely:

- the search for Landsat 8 images (2001 and 2018) for spatio-temporal analyses during the two reference years;
- Fieldwork involving observations (description) of ecosystems and surveys through interviews and semi-structured interviews;
- laboratory activities related to the diachronic analysis and processing of satellite images and geo-spatial data for change detection.

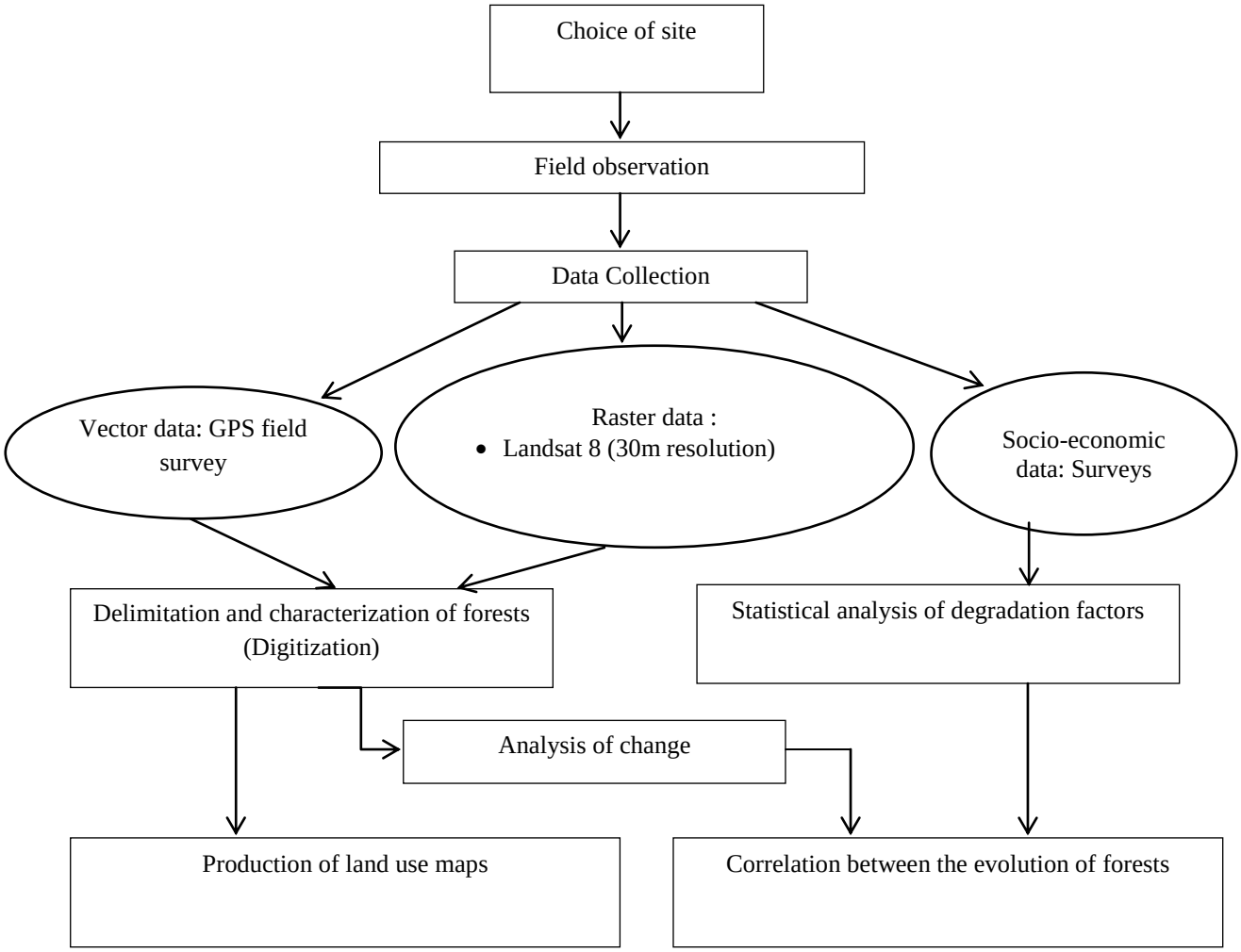


Figure 1: Diagram summarizing methodological steps

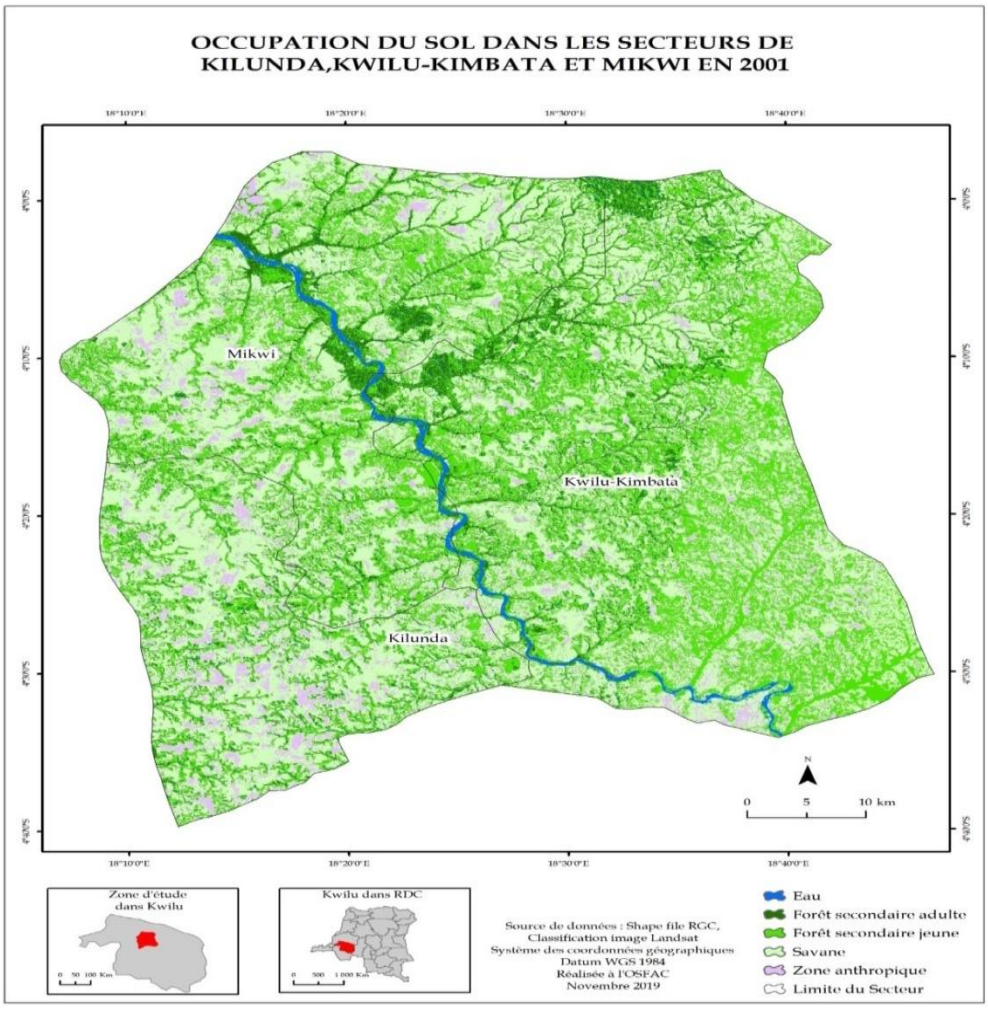
3. Results

3.1 Ground vegetation cover in 2001

The reading of Map 2 on land cover in 2001 shows effects of an accidental nature under the greyish color which represents anthropogenic sites or degraded areas; the bright green color which represents the adult

secondary forest, the light green color which represents the young secondary forest, the light green color which represents the cover in herbaceous formations and the bluish color which represents water.

Map 2: Land Cover of Areas Surveyed in 2001

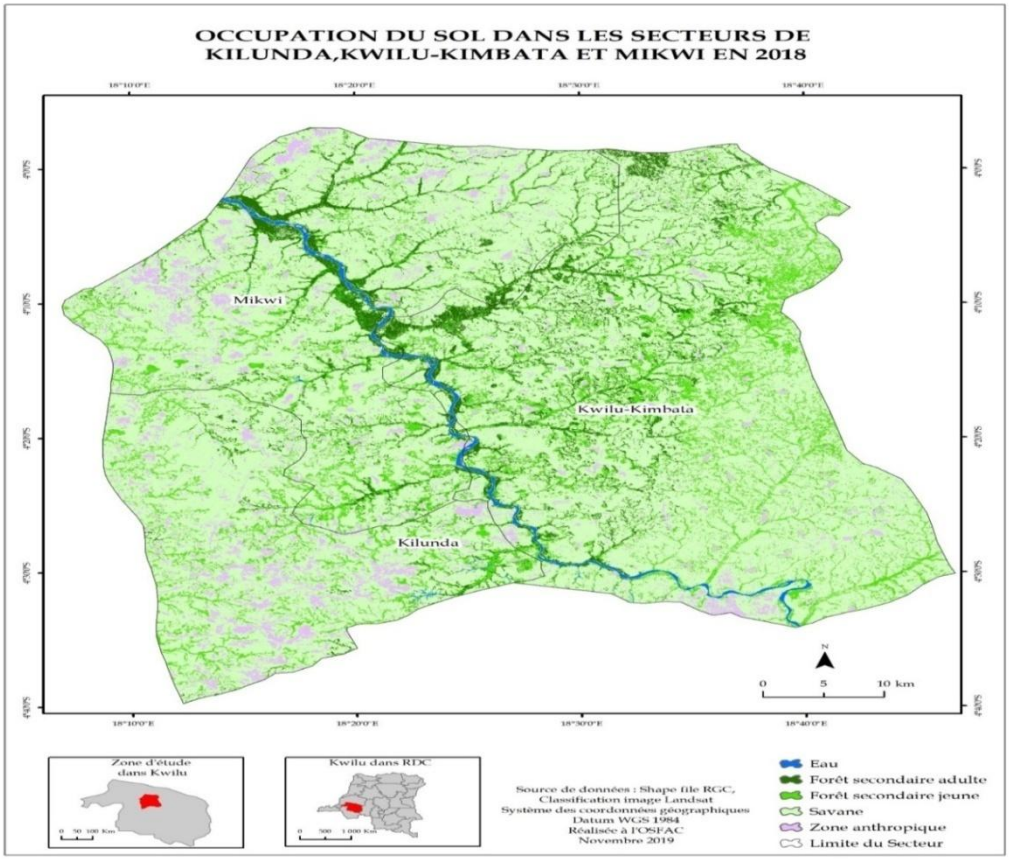


The physiognomical characteristics of the land cover in 2001 are marked by a high cover of herbaceous formations (41.3%), an area of 34.8% of young secondary forest. After observation and analysis of the results, herbaceous formations predominate. The result obtained after analysis shows that the herbaceous formation class dominates

3.2 Ground vegetation cover in 2018

Compared to the 2001 map restitution, the cover in herbaceous formation, which was replaced by the light green color, increased throughout the study area (72.7%). Cover in young secondary forest decreased significantly (11.7 %) in favour of herbaceous formation. For the adult secondary forest, the reduction is visible in the field. A few sites observed in 2001 have disappeared.

Map 3: Soil vegetation cover of the Sectors under study in 2018



Statistical analyses of the data in 2018 show that, the vegetation cover of soils is characterized by quantitative and qualitative changes. The following was observed: herbaceous formations cover an area of 72.7 %; the young secondary forest occupies an area of about 34.8 %; the anthropogenic class covers 7.6 %; the adult secondary forest has lost a few hectares and covers 6.1 % of the area; and finally the water class which loses 0.1 % of its area between 2001 and 2018.The results obtained for the year 2018 show that the herbaceous formations class has increased while the young secondary forest class has decreased significantly.

3.3 Land Cover Dynamics in 2001 and 2018

The aim is to analyse and explain the changing dynamics of land cover use between the two reference years (2001 and 2018). The objective is to assess the trends of change over time. The following maps unseal the changes over time.

Map 4. Dynamics of land cover occupation of the Sectors under study (2001 and 2018)

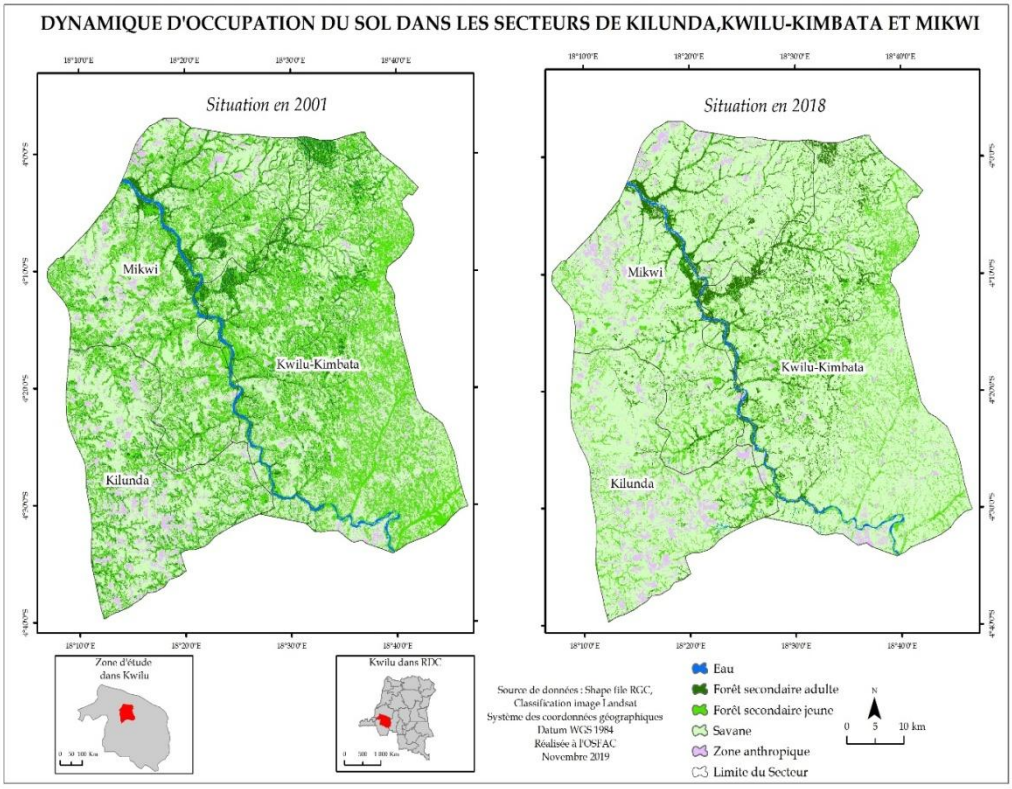


Figure 5 presents the curves of the evolution of the land cover between the two reference years. These curves make it possible to follow the old and recent evolution of the land cover of the Sectors studied. This analysis shows a progression of the cover in herbaceous formation to the detriment of the cover in young and adult secondary forest. The calculated analysis of variance shows a significant difference between the land cover classes, with F = 1.865; df = 6.392; p-value 0.9997.

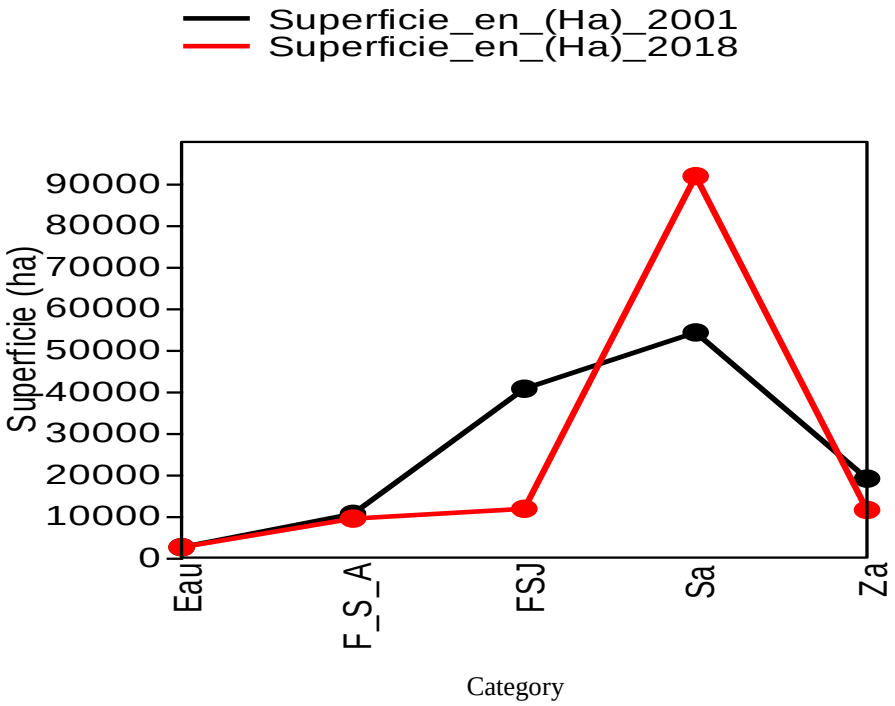


Figure 5.a. Overall change in soil vegetation cover in the study area (2001-2018)
Legend: S.A = anthropogenic sites; FSA= adult secondary forest; FSJ= young secondary forest; Sav= savannah

3.4 Analysis of land cover correlation between 2001-2018

Figure 6 shows a simple regression on the differences between the areas of the different land cover classes in 2001 and 2018. The Pearson test applied shows a significant correlation between these differences between 2001 and 2018; with r = 0.79 at p-value 0.0087 (Figure 6).

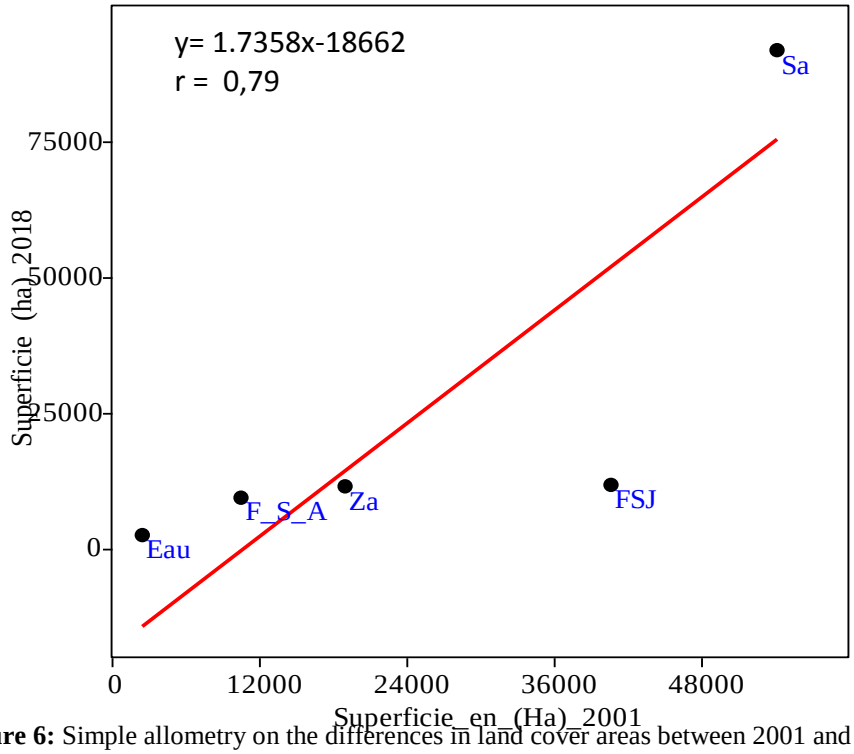


Figure 6: Simple allometry on the differences in land cover areas between 2001 and 2018.

Analysis of this figure indicates that the value of r2 is greater than 60%, in other words the values of the land cover classes are different for the two time series (2001 and 2018), i.e. r = 0.90, which reflects a regressive evolution from secondary forest to the herbaceous formation class.

3.5 Deforestation rates in 2001 and 2018

Over the 2001 period, the rate of forest cover was estimated at 41.70% while in 2018, this figure decreased significantly to 17.80%. The rate of deforestation between the two reference years, i.e. after 17 years, is 23.90%, i.e. an average annual rate of deforestation per hectare of 1.32%. Table 4 presents the overall deforestation rate of the Kilunda, Mikwi and Kwilu-Kimbata sectors**.**

Table 4. Deforestation rate (%)

Sectors	**Designation**	**2001**	**2018**
Study sites	Total area of land cover in (ha)	385101,7	385101,7
	Forest area in (ha)	160948,2	68924,6
	Forest rate (%)	**41,70**	**17,80**
	Deforestation rate (%)	**23,90**	
	Deforestation rate (ha/year)	**1,32**	

3.6 Nature and Extent of Activities Leading to Decline in Vegetation Cover and Biodiversity in the Study Area

Based on our own observations and field surveys, agriculture is the main activity in the regression of vegetation cover and biodiversity (Figure 3).

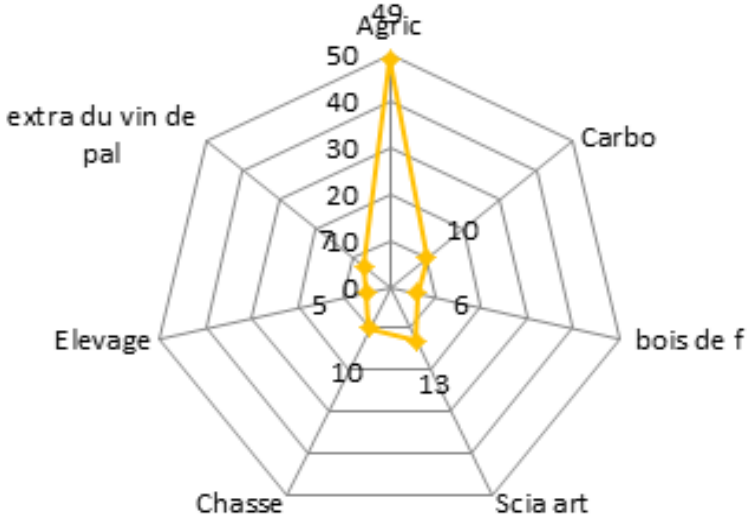


Figure 12: Details of the different ecosystem activities in the study area

Legend: Agri= Agriculture; Sawing art= Handcrafted sawing; carb. = Carbonization

4. Discussion

Our dissertation focused on the evolution of soil vegetation cover in the Bulungu Territory in the Kwilu Valley. The area considered is equivalent to 385101.8 ha. The objective was to determine the direction of the evolution of the vegetation cover by quantifying the reduction in area between 2001 and 2018, in order to recommend actions that could mitigate the effects of the original causes.

The land cover maps of the study area developed for the two reference years (2001 and 2018) are characterized by the dominance of the light green color corresponding to the herbaceous formation class. Despite this dominance, the difference in contrast remains very significant, reflecting a regressive evolution of the forests marked by a decrease in bright green and light green colouring (adult and young secondary forest). According to Beerling and Osborne (2006), herbaceous formations very often appear as a result of co-evolution between vegetation and the action of bush fires.

The results of the statistical analyses show that the regressive dynamics affect secondary forests (young and adult) much more in favour of herbaceous formations. In 2001, the rate of forests was estimated at 41.70 %, whereas this rate decreased significantly to reach 17.80 % in 2018. The rate of deforestation between the two reference years was 23.90 %, with an average annual rate of deforestation per hectare of 1.32 %.

Our results are higher than those published by Defourny *et al*, (2012) who estimated the rates of deforestation and forest degradation at 0.22% and 0.12% respectively at the national level, which is understandable since, although several sectors taken in isolation give different results, we can therefore observe rates that are both higher and lower than the national average.

However, the results are also close to those of Likunde (2012), who estimated average annual deforestation at 1.15% for the whole of the former Bandundu province.

Previous work by Leguet (2008) and Pascal (2003) has described tropical forests as very fragile ecosystems which, after disturbance, give way to herbaceous formation. This state of affairs can be observed in the Sectors under study where forests give way to herbaceous formations following very advanced anthropogenic disturbance.

The observations made by Belesi (2018) are also equivocal; the author confirms that the regressive evolution of the rainforest gradually leads to herbaceous formations. This is the result of frequent repetitions of the same point of cultivation, leading to the disappearance of forests and the appearance of herbaceous formations.

Field investigations have unsealed the causes of forest decline in the study area. Among the causes identified were slash-and-burn agriculture, charring and tree felling. However, slash-and-burn agriculture is seen as the main driver of change.

It is necessary to understand that the practice of slash-and-burn agriculture can have both positive and negative impacts on the evolution of forests. Negatively, the population growth noted in the study area increases the need for agricultural land; this contributes to the over-exploitation of forests with reduced fallow periods and consequently compromises forest regeneration and leads to the regressive series. When clearings are repeated

with too short a fallow period or when food crops follow one another on a clearing until the soil is exhausted, the very existence of the forest is called into question.

However, agricultural land clearing in forests can have a beneficial influence if it is carried out in a reasonable manner, as it can favour the installation of secondary species of high economic and environmental value such as *Terminalia superba, Millicia excelsa,* etc. For this influence to be exercised, population pressure must be low and fallow time between clearings must be sufficiently long.

With regard to the practice of Slash-and-Burn agriculture in herbaceous formation, it should be noted that some species in herbaceous formation are resistant to bush fire (a form of degradation). These therophyte or pyrophyte species are heat resistant and may reappear after bushfire (Anonymous, 1981), and this may be the basis for the increase in cover in herbaceous formation in the Sectors under study. Apart from slash-and-burn agriculture, other causes also influence forest degradation in the study area; these are logging.

Lebrun and Gilbert (1954) and Baur (1962) confirm that disturbances, when not caused by fire, may be due to the fall of large trees, creating clearings in the upper canopy that favour the penetration of light harmful to sciaphilous species.

The work carried out by the FAO (2001a) on the assessment of world resources shows that several phenomena are observed in the forest landscape and lead to the progressive deforestation of land which is manifested by a decrease in the duration of fallow periods; an increase in the area of fields and an imbalance in agricultural yields, which pushes the population to deforest forests and forest galleries notably for their unlimited needs.

With regard to natural biological resources in the plant formations of the study area, the results obtained indicate that several genetic resources (caterpillars, fungi, wild animals) are locally endangered; some have already disappeared and others have become rare. According to Barima (2010), the modification of the spatial structure of the landscape leads to the destruction of ecological habitats, the dysfunction of biological balances, the loss of specific and genetic diversity, the decrease of biological resources, etc.

The same observation has been reported by Raven (2009), who states that when natural habitats are degraded by human actions such as the construction of roads, bridges, deforestation for slash-and-burn agriculture, felling of trees for sawing etc., genetic resources disappear as the situation evolves.

Conclusion

This study investigated the changes in vegetation cover in the Mikwi, Kwilu-Kimbata and Kilunda Sectors of the Bulungu Territory in the Kwilu Valley between 2001 and 2018. The study area thus defined fits well within the Kassaï Sector, the Regional Centre of Guinean-Congolese Endemism. The study area is equivalent to 385101.8 ha. The objective of this study consisted in discovering the direction of the evolution of the plant cover of the years concerned, in order to recommend actions that could mitigate the effects of the causes at the origin. The material used included botanical samples for their scientific identification and characterization, vegetation maps of the Kwilu Province, satellite images covering the study area.

The method used consisted of surveys of the study area based on the constituent elements of environmental factors. The geophysical and landscape light green color (herbaceous formation). Despite this prevalence, the difference in contrast is very significant, reflecting a regressive evolution of the forests marked by a decrease in the bright green and light green color (adult and young secondary forest). Statistical analyses indicate that the rate of deforestation between the two reference years, i.e. after 17 years, is 23.90 % with an average annual rate of deforestation per hectare of 1.32 %.

Generally speaking, the results obtained reveal that, indeed, there is forest degradation and decline. The expansion of agricultural areas, the exploitation of timber and fuelwood, and the manufacture of charcoal are criteria for the degradation of these ecosystems which induce forest dynamics.

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