Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 15, Issue, 07, pp.25378-25382, July, 2023
DOI: https://doi.org/10.24941/ijcr.45274.07.2023

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

MONITORING OF THE SPATIO-TEMPORAL DYNAMICS OF THE KUINIMA CLASSIFIED FOREST : CONTRIBUTION OF REMOTE SENSING

Tankoano Boalidioa[1,*], Ouédraogo Dramane[1], Sanon Zézouma[2], Yao Abdoulaye[1,3], Sehoubo Yawo Joseph[1,3], Séremé Hamadou[1,3] and Hien Mipro[1]

[1]Institut du Développement Rural (IDR) / Université Nazi Boni, BP 1091 Bobo-Dioulasso
[2]Agence Nationale de Biosécurité (ANB) / Institut de l'Environnement et de Recherches Agricoles (INERA) / Centre National de la Recherche Scientifique et Technologique (CNRST), Ouagadougou, BP 10798, Ouagadougou
[3]Ministère de l'Environnement, de l'Eau et de l'Assainissement

ARTICLE INFO

Article History:
Received 10th April, 2023
Received in revised form
08th May, 2023
Accepted 20th June, 2023
Published online 26th July, 2023

Key words:

Forêt Classée de Kuinima, Télédétection, Anthropisation, Dynamique du couvert végétal, Burkina Faso.

Corresponding Author:
Tankoano Boalidioa

ABSTRACT

Les actions anthropiques et la péjoration climatique sont les causes majeures de la dégradation des espaces de conservation au Burkina Faso. Pour mieux cerner l'impact de ces facteurs sur le couvert végétal, une étude a été menée dans la Forêt Classée de Kuinima. L'objectif général de l'étude était d'améliorer les connaissances sur la dynamique des superficies forestières de la Forêt Classée de Kuinima de 1990 à 2018 pour une politique de gestion durable. Pour ce faire, une cartographie de la Forêt Classée de Kuinima à l'aide des images satellitaires Landsat de 1990, 2002, 2014 et 2018 a été réalisée. La classification supervisée par l'algorithme du Maximum de vraisemblance en utilisant l'extension SCP de QGIS a été utilisée. L'analyse des résultats cartographiques obtenus a montré que de 1990 à 2018 la Forêt Classée de Kuinima a perdu une grande partie de sa végétation naturelle au profit des parcs agroforestiers qui occupent de nos jours plus de 77,04% de la superficie totale de cette forêt. Les activités agricoles et le manque de surveillance sont autant de facteurs explicatifs de la dégradation de cette Forêt Classée de Kuinima. Cette situation aura pour conséquence immédiate la perte de la biodiversité de ladite Fo en absence de toute action de renforcement de sa protection contre les pratiques agricoles inappropriées. Il est plus que nécessaire de former les producteurs aux pratiques de l'agroforesterie afin de réduire leurs impacts sur les services et les biens offerts par la forêt.

Citation: ***Tankoano Boalidioa, Ouédraogo Dramane, Sanon Zézouma, Yao Abdoulaye, Sehoubo Yawo Joseph, Séremé Hamadou, Hien Mipro.*** **2023.** "Monitoring of the spatio-temporal dynamics of the Kuinima Classified Forest: contribution of Remote Sensing". *International Journal of Current Research*, 15, (07), 25378-25382.

INTRODUCTION

Forests feed more than one billion people (FAO, 2016) and are an important reservoir of biodiversity according to Tankoano *et al.* (2016). Despite their vital role, the world's forest have been in a without precedent state of degradation (Tankoano *et al.* 2016 ; Hodabalo *et al.*, 2021). Forest resources are thus evolving in an environment that is increasingly undergoing rapid and worrying change (Mamane *et al.*, 2018). This modification is reflected in the degradation of vegetation cover caused on the one hand by the intensification of human activities (Tankoano *et al.*, 2016; Koffi *et al.*, 2016) and the other hand by the effect of climate change (Tankoano *et al.*, 2015). Indeed, between 1990 and 2015, the global forest area decreased from 31.6% to 30.6% (FAO, 2015). In sub-Saharan Africa, it decreased from 30.6% to 27.1% during the same period (FAO, 2018). In Burkina Faso, between 1992 and 2002, forest cover suffered an average annual decrease of 110,500 ha, or 4.04% of its total vegetation cover according to the REDD+ readiness plan report (R-PP, 2012).

Unfortunately, protected areas are also impacted.Indeed, nearly 60% of Burkina Faso's protected areas are now under the control of farms and crop hamlets (DIFOR, 2007). The Kuinima Classified Forest is not exempt from this anthropisation phenomenon. Faced with the growing demand for agricultural land and the phenomenon of agglomeration, the Burkinabè government has proceeded to declassify an area of 2,600 ha of this classified forest (Robinneau, 2012). For example, the annual wood requirement of the city of Bobo-Dioulasso has been estimated at 470,504 steres (Dilema, 1998). This need describes on the one hand the level of degradation of the Kuinima Classified Forest (KCF) because certain activities such as firewood cutting and carbonisation are carried out there illegally..According to Nikiema *et al.* (2001), this is responsible for the degradation of nearly 90.1% of the forest. In view of the level of degradation, it is more than urgent to put in place strategies for the conservation of biodiversity and the sustainable management of the KCF To do this, it is imperative to have precise and reliable data on its spatio-temporal dynamics. However, these data are lacking because no study has been conducted in this area, hence this study.

The main objective of this study was to improve knowledge on the state of the forest resources of the KCF in order to facilitate the implementation of a sustainable management policy.

Specifically, the aim was to

- map the KCF in 1990, 2002, 2014 and 2018 ;
- assess the dynamics of vegetation cover between 1990, 2002, 2014 and 2018.

METHODOLOGY

Presentation of the study area: The Kuinima Classified Forest is located south of the city of Bobo-Dioulasso between latitudes 11°03 and 11°7 North and longitudes 04°19 and 04°36 West (Figure 1). The localities bordering the FCK are Kouakoualé, Dingasso, Farakoba and sector 18 of the city of Bobo-Dioulasso. Its surface area is 4,000 ha according to the classification order of 20 November 1935, but nowadays this forest covers only 2,150 ha after the declassification of a part on 31 May 1947 (Robinneau, 2012). Since its classification, the Kuinima Classified Forest was characterised by a wooded savannah evolving on raw mineral soils, ferralitic soils, soils with little evolution, soils with iron and manganese sesquioxides (Fontès and Guinko, 1995).

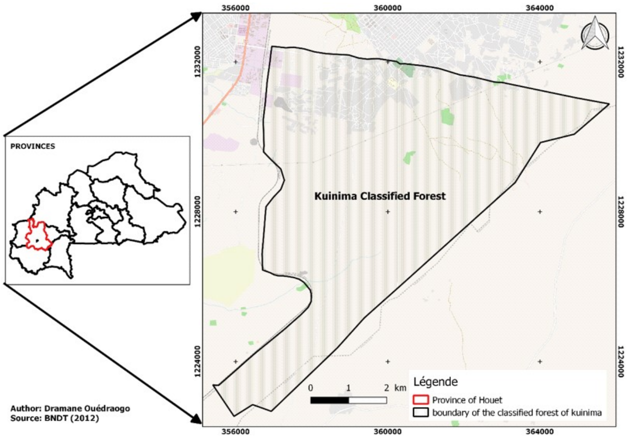


Figure 1. Study area map

Image acquisition and pre-processing: Four Landsat images from 1990, 2002, 2014 and 2018 were downloaded free of charge from the United State Geogical Survey database (https://earthexplorer.usgs.gov/). Atmospheric and radiometric geometric corrections were made for each of the images. Extraction of the study area was done using the KCF contour file to clip it from the entire scene. The « Clip multirasters » command in QGIS software was used to perform this step of the process.

Image processing

Color compositions and NDVI: The colour compositions were carried out with the 5-4-3 bands for the OLI images and the 4-3-2 bands for the other images (TM and ETM+). These colour compositions facilitated the visual interpretation of the images. The normalized difference vegetation index (NDVI) was calculated in addition to the colour compositions. This index allows a better discrimination of land cover classes (Hussain et al., 2013). Its formula is as follows :

Where PIR=Near Infrared band, and RED=Red band

Selection of training and control Regions of interest (ROI): The visual interpretation of the colour compositions in combination with the NDVI was used to select the plots. In total, for each image, 120 Regions of Interest (ROIs) or training and control plots were selected based on field knowledge. The 2018 image was used as the basis for creating the training and control plots for the old images and these plots were taken in areas that remained stable.

Classification of satellite images: Maximum likelihood classification was applied to each of the Landsat images and allowed the identification of the different land cover classes. This algorithm has the ability to determine the probability of a pixel belonging to a given class rather than another and the pixels are assigned to the class for which the probability is highest (Kpedenou et al., 2016). This feature makes this algorithm the most efficient in the production of thematic maps in the land cover domain (Kouassi, 2007). To better classify our images, we performed a field trip based on a colour composition of the most recent Landsat image of 2018. This field trip allowed us to make a visual interpretation and to identify the different land use types in the KCF. Thus, half of the 120 ground truth plots were used as a basis for the classification. For the classification of older satellite images, the areas that were stable during the study period were used.

Post-classification processing: The post-processing operations consisted in cleaning the classified image. Thus, a majority convolutional filter using a 3*3 pixel scanning window was applied to all the classified images in order to make them sharper by eliminating isolated pixels or by cleaning up the noise or "salt and pepper" effect. Finally, in order to facilitate the editing of the land use maps, we proceeded to the vectorisation of the classified images. The vector files of each of the processed images were used to generate land cover maps of the KCF in 1990, 2002, 2014, 2018.

Validation of the classification

The validation phase of the classification was carried out in two stages:

- a first statistical validation was carried out. For this, the ROIs of the control plots and the classified image were used as a basis for generating the confusion matrix;
- and a second validation was carried out in the field. This part consisted of verifying the accuracy of the cartographic rendering in the field.

Assessment of land cover dynamics

A quantitative analysis was carried out in order to evaluate the dynamics of the land cover. To do this, we calculated the rate of change (Tc) which is a good indicator commonly used (FAO, 1996) from the following formula:

Where Tc = rate of change (%); S1= area of the class at date t1; S2= area of the class at date t2 and t = number of years between the dates)

RESULTS AND DISCUSSION

RESULTS

Validation of classifications: The processing and analysis of the different images made it possible to distinguish six land cover classes for the 1990 and 2002 images and seven classes for the 2014 and 2018 images. In general, the discrimination of the different land use classes was very satisfactory, even if there were a few cases of confusion between certain classes. We obtained overall accuracies of 98.40%; 91.97%; 95.35%; 97.25% and Kappa indices of 97.20%; 89.48%, 90.49% and 90.09% respectively for the years 1990, 2002, 2014 and 2018 (Tables 1,2,3,4). However, the 1990 confusion matrix (Table 1) revealed confusions between forestry plantations and open tree savannah of almost 6.59%. We also noted confusions of almost 4.61% between dense tree savannah and open tree savannah. The classification of the 2002 image (Table 2) revealed a confusion of around 20% between open tree savannah and shrub savannah.

Table I. 1990 confusion matrix

Classes	AP	FP	DTS	SS	OTS	BS
AP	**100**	0	0	0,82	0	2
FP	0	**93,41**	0	0	1,54	0
DTS	0	0	**97,66**	0,08	4,61	0
SS	0	0	0	**98,77**	0	0
OTS	0	6,59	2,3	0,33	**93,85**	0
BS	0	0	0	0	0	**94**

Overall accuracy: 98,4%, Kappa coefficient : 97,2% Legend : RS : Residential areas ; BS : Bare soil ; FP : Forestry plantation ; DTS : Dense tree savannah OTS : Open tree savannah ; SS : Shrub savannah ; AP : Agroforestry parks

Table II. 2002 confusion matrix

Classes	FP	BS	AP	SS	DTS	OTS
FP	**98,2**	0	0	0	0,99	0
BS	0	**100**	0	0	0	0
AP	0	0	**99,6**	0	0	0,59
SS	0	0	0,18	**76,1**	2,97	17,65
DTS	1,8	0	0	3,82	**96,04**	0,59
OTS	0	0	0,18	20,1	0	**81,18**

Overall accuracy : 91,97%, Kappa coefficient : 89,48%

Table III. 2014 confusion matrix

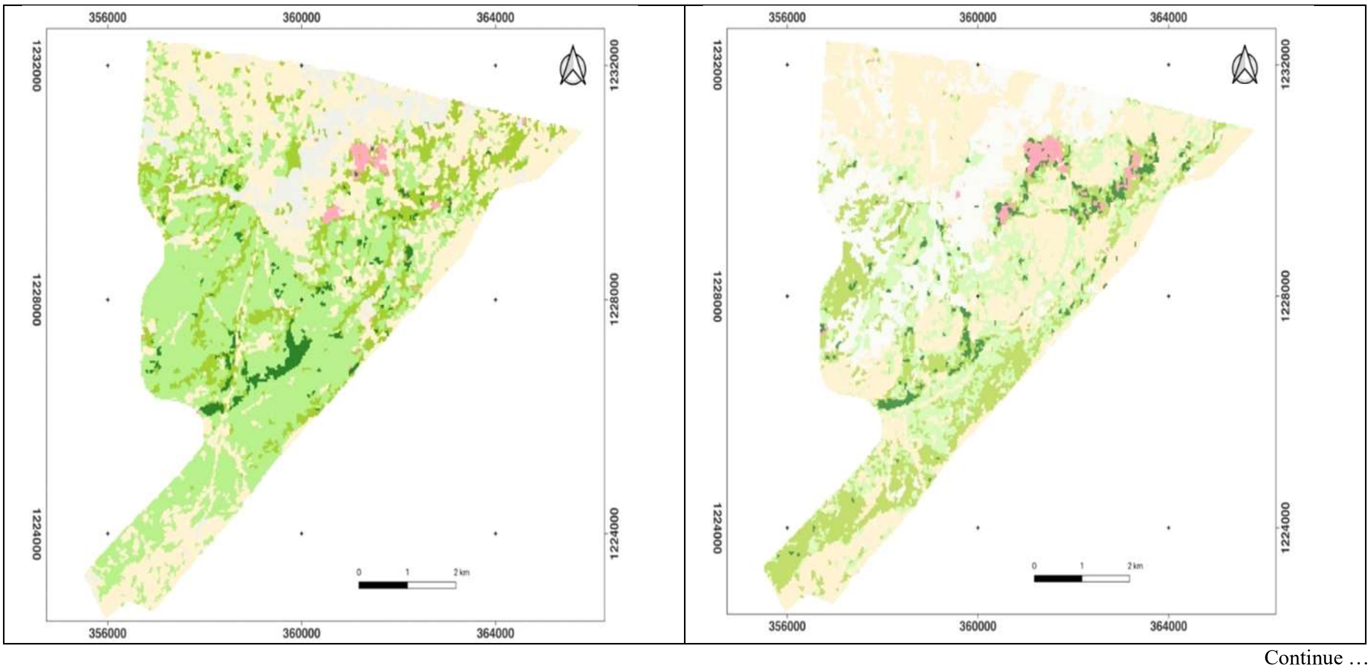
Classes	RA	BS	FP	DTS	OTS	SS	AP
RA	**97,41**	7	0	0	0	0	0,3
BS	2,59	**92,6**	0	0	0	0	1.90
FP	0	0	**91,5**	0	0	0	0.20
DTS	0	0	6,03	**100**	0	0	0
OTS	0	0	2,01	0	**100**	0	0
SS	0	0	0,5	0	0	**98,3**	1,97
AP	0	0,42	0	0	0	1,7	**95,62**

Overall accuracy: 95,35%, Kappa coefficient: 90,49% Legend : RS: Residential areas; BS : Bare soil; FP: Forestry plantation; DTS: Dense tree savannah OTS: Open tree savannah; SS : Shrub savannah; AP: Agroforestry parks

Table IV. 2018 confusion matrix

Classes	RA	BS	FP	DTS	OTS	SS	AP
AP	**99,19**	0,84	0	0	0	0	1,14
FP	0	**98,53**	0	0	0	0	0,02
DTS	0	0	**98,8**	0	0	0	0,53
SS	0	0	0	**100**	0	0	0
OTS	0	0	0	0	**100**	0	0
BS	0	0	0	0	0	**100**	1,39
AP	0,81	0,63	1,2	0	0	0	**96,92**

Overall accuracy: 97,19%, Kappa coefficient : 90,09%



Continue …

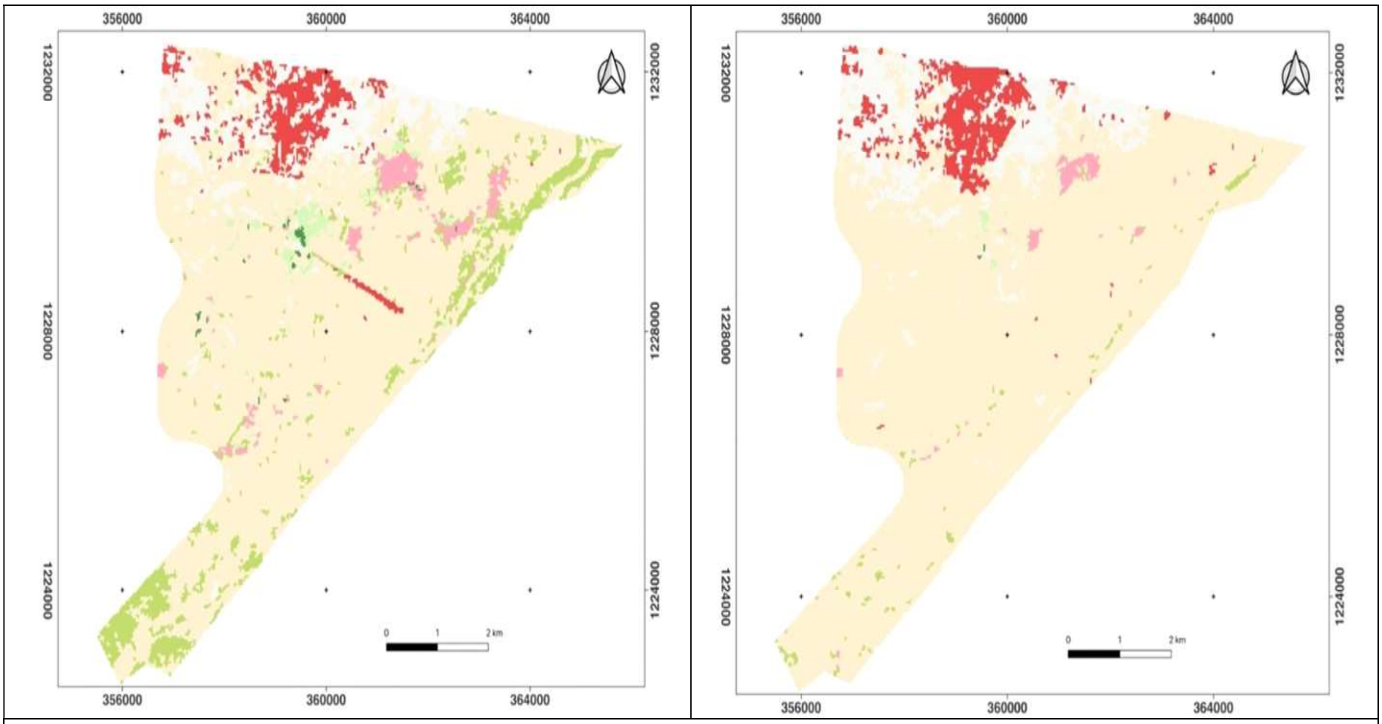


Figure 2. Land use maps of the KCF in 1990, 2002, 2014 and 2018

The 2014 image classification (Table 3) showed 6.03% and 2% confusion between forestry plantations and tree savannah and between clear tree savannah and forest plantations respectively. The classification of the 2018 image (Table 4) was more accurate with very low confusions between the different land cover classes.

Status of the KCF from 1990 to 2018: The different land use maps of the KCF show a progressive loss of natural formations to anthropised areas. In 1990, the agricultural front was observed in the northern part and to a lesser extent in the southern part (Figure 2). The area of natural formations in the Classified forest represented 55.23% of its total area. The degradation continued and in 2002, natural formations occupied only 39.78% of the total area. These natural formations are more scattered and more or less isolated from each other. The degradation of natural formations has increased between 2014 and 2018 from 11.79% to 1.79% respectively. In addition, the last two images show an exacerbation of anthropisation with the appearance of human settlements in the Kuinima Classified Forest.

Land use dynamics of the KCF from 1990 to 2018: The cartographic results show the different changes that took place within each land cover class in the KCF in 1990, 2002, 2014 and 2018 (Figure 3). From 1990 to 2002, all classes increased in area except shrub savannah, which decreased in area from 1699.02 ha to 749.16 ha. Agro forestry parks are the class with the largest increase in area. The area of agro forestry parks thus increased from 1550.52 ha in 1990 to 1686.6 ha in 2002. The area of dense tree savannah increased by 28.98 ha between 1990 and 2002. The areas of open tree savannah and forestry plantations each increased by 256.41 ha and 2.1 ha respectively between 1990 and 2002. Finally, the area of bare soil increased by 52.65 ha between 1990 and 2002.From 2002 to 2014, the areas of agroforestry parks and forestry plantations increased by 1317.96 ha and 63.72 ha respectively. During this time, the dense tree savannah recorded the largest decrease of about 130.23 ha in area. It is followed by the shrub savannah whose area decreased from 749.16 ha in 2002 to 435.15 ha in 2014. The open tree savannah and bare soil lost 760 ha and 38.27 ha respectively. Finally, from 2014 to 2018, only agroforestry parks and bare soil increased in area, from 3004.56 ha and 50.17 ha in 2014 to 3440.34 ha and 552.6 ha in 2018 respectively. However, the other classes have decreased in area between 2014 and 2018. Shrub savannah is the class with the largest decrease in area. Indeed, with an area of 435.15 ha in 2014, it was only 63.81 ha in 2018, a loss of 371.34 ha. The areas of forestry plantations and dense tree savannah have decreased by 47.71 ha and 18.3 ha respectively. The area of open tree savannah decreased from 81.99 ha to 15.39 ha, i.e. a loss of 81.23% of its area.

DISCUSSION

Analysis of the mapping data revealed a domination of agroforestry parks over other land use types. The proximity of the KCF to the city of Bobo-Dioulasso is the main factor favouring pressure on forest resources (Forman, 2009). Several authors (N'Da *et al.*, 2008, Tankoano *et al.*, 2015) have found that the expansion of cities is the primary factor responsible for deforestation with 98.25% correlation. This loss of natural vegetation is mainly attributable to agriculture, on which people are heavily dependent (Sodieu, 1993; Balac, 2000). For Barmo *et al.* (2021), the presence of farms within KCF can be explained by the strong land pressure but also by the effects of climate change. This study showed that 77.04% of the KCF is occupied by agroforestry parks. Noula (2006) estimated the area occupied by agroforestry parks within the KCF at 72.5%. This difference could be explained by the increase over time of agricultural land in the KCF. Urban forests have always been a major management concern for political and administrative authorities. In addition to being more exposed to all kinds of intrusions, they are also threatened by the phenomenon of agglomeration. Indeed, following strong demographic pressure, the KCF was the object of a declassification of nearly 2650ha in 1947 (Robinneau, 2012). Nowadays, more than 250 hectares formerly occupied by the forest are occupied by housing. The expansion of the city of Bobo-Dioulasso has led to the expropriation of agricultural land from the people living along the KCF. This has led to a rapid occupation of the KCF to the detriment of biodiversity conservation. Thus, faced with this anarchic occupation of the FCK, in 1990 the Water and Forestry Service set up agroforestry contracts with farmers by allocating one (01) hectare of agricultural land to each head of family in Kuinima (Robineau, 2012). A density of tracks has been noted in the KCF, which facilitates its accessibility by the riparian population. Numerous studies have revealed the role of tracks in the expansion of areas under conversion (Vallat, 1979 ; Koli Bi, 1990). The road network is said to serve as a vector for clearing by facilitating access to certain forest plots (Mertens *et al.*, 1997; Lambin, 2000; Mertens et al., 2001). Other studies conducted in various parts of the tropical world rely on road networks to explain the dynamics of land clearing (Southworth *et al.*, 2004). Despite the efforts made by the State to monitor protected areas, there are still shortcomings due to the high cost of logistics and the insufficient number of forestry officers (MECCV, 2007). The free access to this forest combined with the absence of frequent surveillance by forestry officers leads people to develop activities in accordance with their objectives (Mihigo, 2010). This observation was also made by Tankoano *et al*. (2015). According to these authors, the poor protection or surveillance of the Classified Forest and the increase in agricultural areas constitute a quasi-permanent threat to natural formations and biodiversity.

CONCLUSION

The digital processing of satellite images allowed the identification of different land cover classes and the mapping of the KCF. The land cover classes identified were dense wooded savannah, open wooded savannah, shrub savannah, fields and bare soil, forest plantations and dwellings. Cultivated land expansion and housing are the main forms of pressure in Kuinima National Park. This has caused a loss of 2289.26 ha of natural vegetation cover to anthropised areas between 1990 and 2018. Overall, the vegetation regressed by 52.27% of its area between 1990 and 2018. In 2018, the Kuinima classified forest is occupied by 3440.6 ha of agroforestry parks to the detriment of the natural formation. This high deforestation is attributable to anthropic pressure. In addition, the extension of the area of agroforestry parks and fields within the classified forest is an indicator of its poor protection. In view of this advanced degradation of the FCK's vegetation cover, it would be interesting to:

- Evaluate the impact of these anthropic actions on the floristic diversity of this forest
- Study the spatio-temporal dynamics of the FCK using civilian drone images.

Conflict of interest: According to the authors, no conflicts of interest were reported

ACKNOWLEDGEMENTS

We would like to thank the entire management team of the Sy. N.A.I.E. laboratory, which has contributed enormously to improving the scientific value of the content of this document. Our thanks also go to all the students of Sy. N.A.I.E. who contributed greatly to the data collection.

REFERENCES

Balac, R. 2000. Les économies pionnières prédatrices du milieu forestier : le cas de l'économie de plantation en Côte d'Ivoire, Société d'écologie humaine. 429-438p.

Direction des Forêts (DIFOR) 2007. Situation des forêts classées du Burkina Faso et plan de réhabilitation. Ministère de l'Environnement et du Cadre de Vie (MECV), Burkina Faso, p. 46.

FAO 1996. Aménagement des forêts naturelles des zones tropicales sèches. No 32. Rome : FAO, 71 p.

FAO 2015. Situation des forêts du monde. 44 pp

FAO 2017. Situation des forêts du monde. 45 pp

Fontès J. et Guinko S. 1995. Carte de la végétation et de l'occupation sol du Burkina Faso : Notice explicative. Institut des sciences naturelles/Institut du développement rural, Université de Ouagadougou, Burkina Faso, 67 p.

Forman R. 2009. Arrangements of Nature and People: Using Landscape-Ecology, CoastalRegion, and Urban-Region Lenses, Irish National Lands cape Conference 2009, 28-38.

Hussain M., Chen D., Cheng A., Wei H. and Stanley D. 2013. Change detection from remotely sensed images: From pixel-based to object-based approaches. *Journal of Photogrammetry and Remote Sensing, 80: 91-106.*

Koffi D. K., Tchaa B. et Thiou T.K.T. 2016. Quantification des changements de l'occupation du sol dans la préfecture de Yoto (Sud –est Togo) à l'aide de l'imagerie satellitaire Landsat. Rev. Sc. Env. Lomé Togo., 13. DOI: https://hal.archives-ouvertes.fr/hal-01409418.

Kouassi A. M. 2007. Caractérisation d'une modification éventuelle de la relation pluie-débit et ses impacts sur les réssources en eau en Afrique de l'Ouest : cas du bassin versant du N'zi (Bandama) en Côte d'Ivoire. Thèse de Doctorat de l'Université de Cocody, République de la Côte d'Ivoire. 210 p.

Kpedenou D. K., Boukpessi T. et Tchamie K. T.T. 2016. Quantification des changements de l'occupation du sol dans la préfecture de Yoto (Sud-Est Togo) à l'aide de l'imagerie satellitaire Landsat, *Revue des Sciences de l'Environnement, archives-ouvertes.fr. (13).*

Mamane B., Amadou G., Barrage M., Comby J. et Ambouta J.M.K. 2018. Dynamique spatio-temporelle d'occupation du sol dans la Réserve Totale de Faune de Tamou dans un contexte de la variabilité climatique (Ouest du Niger), *Int. J. Biol. Chem. Sci. 12(4): 1667-1687.*

MECCV, 2007. Inventaire national des gaz à effet de serre. Disponible en ligne à l'adresse: http://www.ecologie.gouv.fr/ Inventairenational-2007.html

Mertens B. and Lambin, E.F. 1997. Spatial modelling of deforestation in southern Cameroon: spatial disaggregation of diverse deforestation processes. *Applied Geography, 17:1-20.*

Mertens B., Forni E. and Lambin E.F., 2001. Prediction of the impact of logging activities on forest cover: A case-study in the East province of Cameroon. *Journal of Environmental Management, 62(2) : 21-36.*

Mihigo J-P. N. 2010. Evaluation de la pression anthropique sur les forêts périurbaines de la ville de Kinshasa : cas du peuplement de millitia sp de la commune de Mont-Ngafula. Mémoire d'Ingénieur, Université des sciences agronomiques de Kinshasa, République Démocratique du Congo, 76p.

N'Da D. H., N'Guessan K. E., Wadja E.M. et Affian K. 2008. Apport de la télédétection au suivi de la déforestation dans le Parc National de la Marahoué (Côte d´Ivoire). *Archives-ouvert.fr. 8 (1) : 17-34.*

Nikiema A., Ouedraogo S. J. et Boussim J. 2001. Situation de ressources génétiques forestières au Burkina Faso. Note thématique sur les ressources génétiques forestières, in : Atelier sous-régional FAOI/PGIUI/CRAF sur la conservation, la gestion, l'utilisation durable et la mise en valeur des ressources génétiques forestières de la zone sahélienne (Ouagadougou, 22-24 sept. 1995).

Noula, K. 2006. Forêt classée de Kuinima, de Kua: analyse de l'état général, des fonctions, utilisations et tendances. Recommandation pour leur protection, restauration et valorisation. Version définitive, BKF/007.PAFDK, 41 p+ annexes.

Rapport du Plan de Préparation (R-PP) 2012. Plan de préparation de la REDD+, Burkina Faso, 166p.

Robineau O. 2012. Dynamique territoriale et jeux d'acteurs autour du foncier en frange urbaine, cas de Bobo-Dioulasso au Burkina Faso. Thèse de Doctorat en Géographie. Université de Montpellier, France, 72p

Sodieu O. 1993. L'impact de la production et de la transformation du café, du cacao et du riz sur l'environnement en Côte d'Ivoire, Abidjan, UNCTAD/COM/24, 83 p.

Tankoano B., Hien M., N'Da H. D., Sanon Z., Yaméogo J.T. et Somda I. 2015. Dynamique spatio-temporelle des savanes boisées de la forêt classée de Tiogo au Burkina Faso. *Int. J. Biol. Chem. Sci. 9(4): 1983-2000.*

Tankoano B., Hien M., N'Da D.H., Sanon Z., Yameogo J.T. et Somda I. 2016. Anthropogenic pressure and vegetation dynamics in the classified forest of Tiogo in Burkina Faso : Contribution of remote sensing. *Tropicutura 34, 193-207.*

****