

Research Application Summary

Effects of mono-cropping on land-cover transitions in the wet evergreen agro ecological zone of Ghana

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Abstract

There is notable vegetation changes taking place in the Wet evergreen forest zone of Ghana even though it appears “evergreen” in most map depictions. It has been observed that natural vegetation habitats have gradually been replaced by several hectares of plantation agriculture such as rubber, oil palm, and coconut over the years, and this threatens indigenous biodiversity. Currently, there are no records on the rates of habitats loss. This research applied remote sensing to assess the landcover changes taking place in the Ankobra River landscape which covered four districts of the western region of Ghana. Using landsat historical images, landcover maps were produced for 1991 and 2018, and the two maps were subsequently compared through a landcover change detection approach using Erdas software. Closed and opened forest dominated the 1991 landcover map, and tree crop plantation and farmland/grassland were of the same coverage. Tree crop plantation covers about 51%, more than opened and closed forests put together, in the 2018 classified map. The closed and opened forest were mainly converted to tree crop plantations.

Keywords: Ghana, landcover change, remote sensing, tree cover, wet evergreen zone

Résumé

Des changements notables de la végétation ont lieu dans la zone forestière humide sempervirente du Ghana, même si elle apparaît “ sempervirente “ dans la plupart des représentations cartographiques. Il a été observé que les habitats de végétation naturelle ont été progressivement remplacés par plusieurs hectares de plantations agricoles telles que l’hévéa, le palmier à huile et la noix de coco au fil des ans, ce qui menace la biodiversité indigène. Actuellement, il n’existe pas de données sur les taux de perte d’habitats. Cette recherche a appliqué la télédétection pour évaluer les changements de couverture des sols qui ont lieu dans le paysage de la rivière Ankobra qui couvre quatre districts de la région occidentale du Ghana. En utilisant des images historiques des terres, des cartes de couverture des sols ont été produites pour 1991 et 2018, et les deux cartes ont ensuite été comparées par une approche de détection des changements de couverture des sols à l’aide du logiciel Erdas. Les forêts fermées et ouvertes dominaient la carte de la couverture terrestre de 1991, et les plantations d’arbres et les terres agricoles/les pâturages avaient la même couverture. Les plantations d’arbres couvrent environ 51%, plus que les forêts ouvertes et fermées réunies, dans la carte classifiée de 2018. Les forêts fermées et ouvertes ont été principalement converties en plantations d’arbres.

Mots clés : Ghana, changement de couverture terrestre, télédétection, couverture arborée, zone humide à feuilles persistantes.

Introduction

The wet evergreen ecological zone of Ghana found mostly in the western region of Ghana has been reported to be undergoing environmental changes over many years. Most natural habitats are getting replaced by large hectares of mono-crops such as coconut, oil palm, and rubber plantations, thus threatening indigenous biodiversity (deGraft-Johnson *et al.*, 2010). The coastal zones are also faced with wetlands destruction to develop infrastructure for the increasing population and the fish and petroleum industry. Mangroves are also extracted for fuelwood and due to the increase demand the rate of the exploitation of these fragile ecosystem resources are becoming unsustainable. Mineral mining activities and beach sand and stone mining are some of the undertakings ongoing.

There are no records on the rates of habitat loss in the ecological zone although losses have occurred over the years. This research was therefore designed to determine the metrics on the exchanges taking place between the various land-cover types and also determine the potential impacts on biodiversity. The study aimed to identify and document areas of landcover change in the study area between 1991 to 2018, and suggest priority research activities for addressing emerging gaps.

Materials and Methods

Study Area. The study area partly covers Ellembelle, Nzema East, Nsuaem, and Ahanta West districts located in the Wet Evergreen Agro-Ecological zone as well as in the Western region of Ghana. This region has many wetland systems which are usually freshwater habitats unlike the eastern coastline of Ghana, which is brackish (deGraft-Johnson *et al.*, 2010). Wet evergreen forest is restricted to the highest rainfall (1500-2100 m) areas and has the highest concentration of rare and endemic species in the country (Hawthorne *et al.*, 1998). It is believed to be the least disturbed forest type in Ghana and is reasonably well represented by the Nini-Suhien National Park and Ankasa Resource Reserve where the only endemic forest genus, *Monocyclanthus* (Annonaceae), is found.

The area lies along the Gulf of Guinea (2°20'0"W and 2°0'0"W and 5° 10'0"N and 4°40'0"N) and has an area of about 1,000 km² and a 37 km coastline with some lagoons and associated wetlands (Figure 1). The area covers partly Ndumfri, Neung south, and Ebi river shelterbelt forest reserves. Many river channels are distributed in the area including the Ankobra River which ends at the coast as an estuary.

Data and data sources. To understand the historical dynamics in land cover/use under the combined influence of nature and anthropogenic activities in the Western region landscape, the study employed the Landsat satellite data series. The Landsat data series has widely been used in historical territorial studies for reasons of its freely available rich historical medium-resolution (30m) achieved data sets (Wulder *et al.*, 2012).

Surface reflectance images of Landsat-5 TM (1991), and Landsat-8 OLI/TIRS (2018) were downloaded from the USGS Earth Explorer online data clearing house (<http://earthexplorer.usgs.gov>). Although data sets were captured on different dates, they were all dry season data and hence comparable. The area lies in path 194 and row 057.

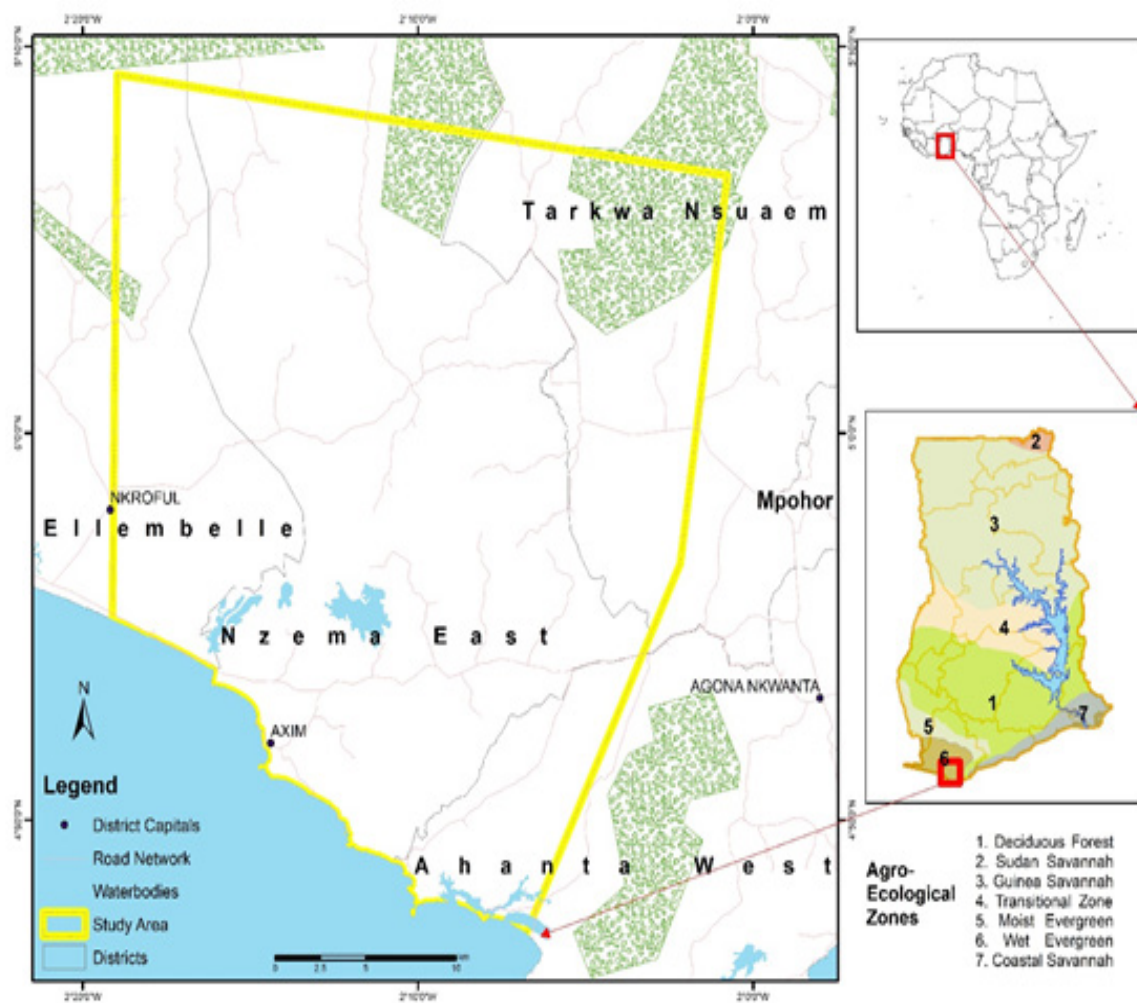


Figure 1. Wet Evergreen Agro-Ecological Zone of Ghana

Land cover classification. A well-defined classification scheme is fundamental to the success of any land cover identification categorization project. For this study the main land cover types within the landscape were identified and regrouped into mapping classes with their definitions. Based on the objectives of this study, and the spatial resolution of images (30m), regrouping yielded seven final mapping classes (Table 1).

Satellite image classification. Image classification constitute an important part of detecting changes in a landscape. It refers to an interlinked processes of clustering image pixels based on similarities into predetermined meaningful land cover classes. This was employed in the study to obtain the images.

Classification and change detection. The images were segmented spectrally into 50 classes each using the ISODATA unsupervised classification algorithm in Erdas software. Unsupervised classification algorithm statistically groups pixel of an image into a specified number of spectral classes based pixel values rather than comparing it to a reference data (Lu and Weng, 2007).

Results and discussion

Distribution of land cover classes. The land use /cover classes as shown on the 1991 classified

image has the closed forest dominating with about 55% (54,877 ha). These classes were found mostly in and around the three forest reserves and along the Ankobra River and the lagoons near the coast. Some contiguous forest were also observed at the mid-sections of the area, which is found around Eluku, Adelekezo, and Kokofre communities. Closely matching the closed forests were the opened forest distributed all over the area, and it occupied about 32% (3 1,928 ha) of the area. The opened forests are distributed mostly along the road network that runs across the map and were scattered in patches within the closed forest. They were found near townships, such as Simpa, Kekadwen, Essaman, Axim, Dadwen, and many others. Grassland and farmland landcover type was also found around townships as well as along the road networks (Figure 2).

Table 1. Land cover classification scheme

Land cover/ use classes	Map classes	Class description in the landscape
Continuous forest canopy	Forest	Woodland areas with dense tree canopy occupying more than 0.5 hectares with trees higher than 5 meters. This includes woodlands in and outside conservation areas but excludes tree crops meeting this criteria
	Open forest	Degraded woodland areas with dense tree canopy occupying more than 0.5 hectares with trees higher than 5 meters
Annual and Biennial crops Vegetables Fallow	Farmland and Grassland	Portions of the landscape is arable and planted with temporal annual or biannual crops and devoid of permanent commercial crops. This class includes fallow areas that are in series with cropping periods
Creepy bushes Grasses		A grassland may also contain low shrubs and other plants, but its predominant feature is that it is a place where plenty of grass grows.
Rivers & Streams Lagoons & Lakes Seas	Waterbodies	Refers to all forms of waterbodies in the study area. i.e. river networks, streams, lagoon , stagnant waterbodies that can be resolved at 900m ² on the image
Bushes and shrub Mangroves	Wetlands	Areas of land that are inundated with water during some periods of the year. i.e. marshy grasslands sometimes can have other bushes
Rubber Oil palm Coconut Cocoa	Tree crop Plantation	Refers to areas under the cultivation of tree like crops that produces outputs over many harvesting seasons and last longer on the land. Usually planted for commercial returns.
Built infrastructure Bare areas, Rocky outcrops, Sandy beach	Built-up/bare	Minimal isolated to non -vegetated parts of the landscape including built-up, bare, rocky, beach and mined out areas

Tree crop plantation formed 5% (4,928 ha) of the cover and this was found in the eastern portion of the study area. The tree plantations located close to townships such as Anyaano, Dadwen, Awukyire, Bamiankor, and Kekadwen. Built-up/bare land, Wetland, and Waterbody each constituted 1% of the landscape (Figure 3).

The 2018 classified image results of the same area showed tree crop plantations gaining more coverage in the landscape to the detriment of closed and opened forest and wetlands. Tree crop plantations show the highest area coverage (51,066 ha) which represented 51% of the landscape. This is followed

by opened forest (25,003 ha; 25%), closed forest (14,751 ha; 15%), grassland/ farmland (5,587 ha; 6%), and 1% for each of the remaining classes (figure 5 and table 2).

Tree crop plantations are contiguous at the south-eastern portion of the map, and also near the townships such as Axim, Dadwen, Ewuku, Bamankor, Akongo, and Simpa. It can be observed that the closed forest was limited to the reserves, portions along the Ankobra River course, and in between the shelterbelt and Nkroful in the north-west (Figure 4).

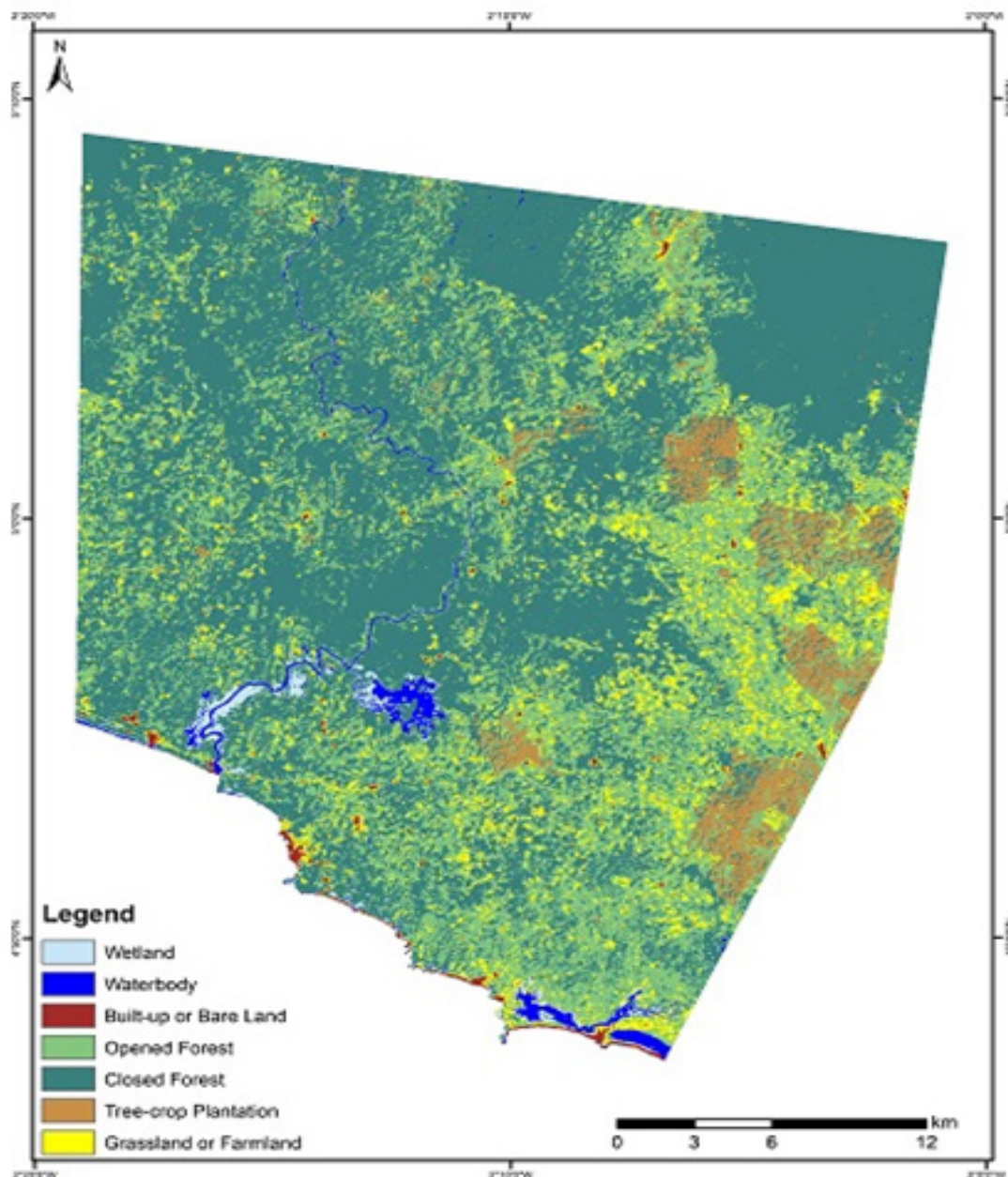


Figure 2. Land-cover map (1991) of Nzema East and adjoining districts

Numerically, wetlands had reduced by 21%, with an annual rate of 1% while waterbody had increased by 15% (1% annual rate), and bare/built-up had increased by 102% (and with an annual rate of 4%) (Table 2 and Figure 6).

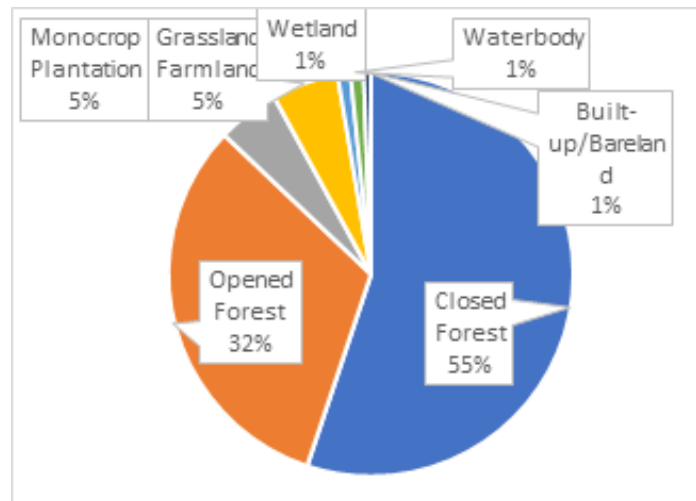


Figure 3. Percentage class distributions in 1991

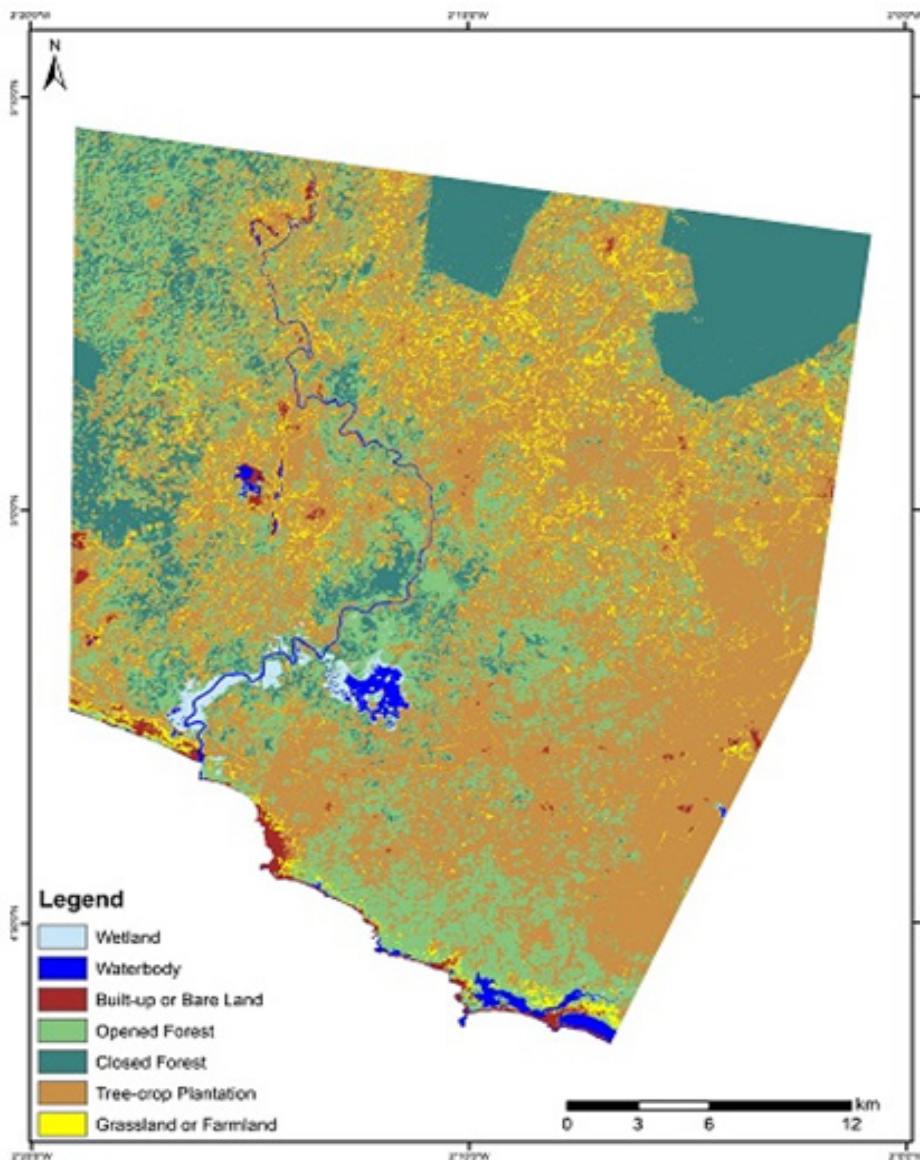


Figure 4. Land-cover map (2018) of Nzema East and adjoining districts

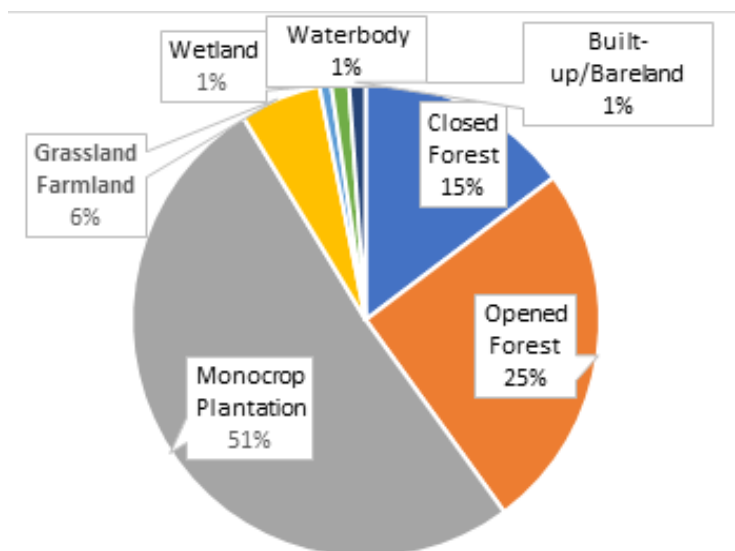


Figure 5. Percentage of land cover class distributions in 2018

Table 2 - Percentage area coverage and changes (negative percentages represent reduction)

Class Names	1991		2018		Changes	
	Area (ha)	% Area	Area (ha)	% Area	% Change	Annual
Closed Forest	54,877.3	55%	14,751.3	15%	-73%	-3%
Opened Forest	31,839.7	32%	25,003.2	25%	-21%	-1%
Tree crop Plantation	4,928.3	5%	51,066.6	51%	936%	35%
Grassland Farmland	5,285.2	5%	5,587.0	6%	6%	0%
Wetland	1,014.4	1%	802.3	1%	-21%	-1%
Waterbody	1,049.3	1%	1,204.7	1%	15%	1%
Built-up/Bare-land	567.7	1%	1,146.9	1%	102%	4%

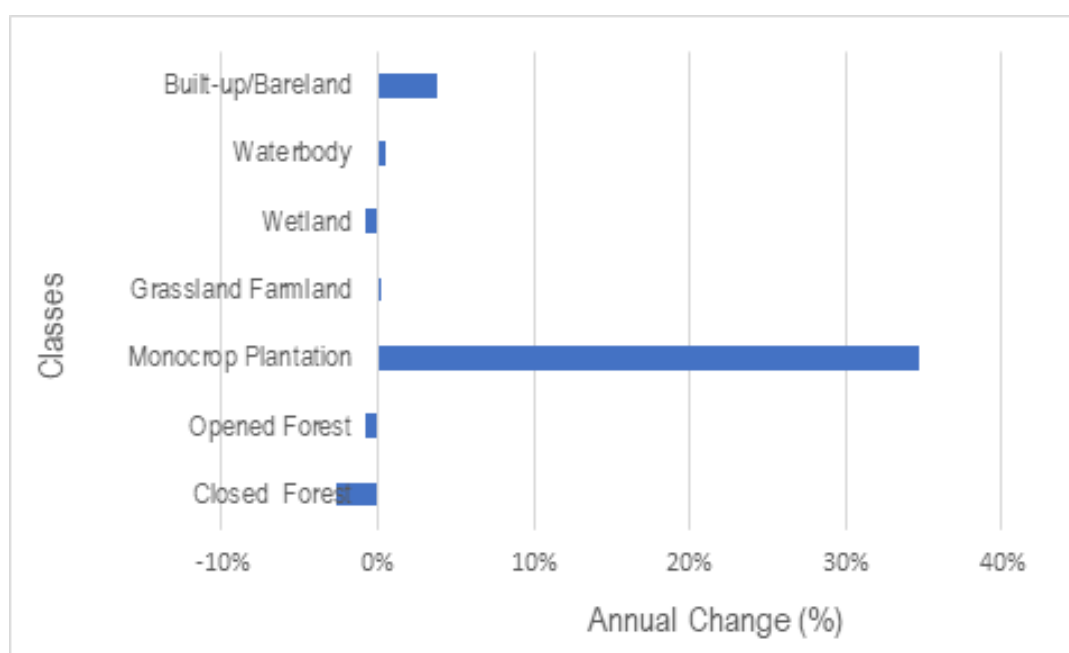


Figure 6. Percentage Annual Class Area changes from 1991 to 2018

Tree crop showed the highest annual rate of increase (35%), while grassland/farmland showed the least rate of increase (almost 0%). Also, closed forest has the highest annual rate of decrease (3%), followed by opened forest and wetland (1%) (figure 6).

The highest conversions into tree crop plantation were for farmland/grassland, opened forest and closed forest with 680 0, 63%, and 42%, respectively (Table 3). Notable was that, some portions of the wetland (5.8%) had changed into built-up/ bareland. According to deGraft-Johnson *et al.* (2010), wetland reclamation for development and waste disposal is the reason for the loss of many lagoons and wetlands in the region. Extreme extraction of mangrove as fuel wood was about 290,705 MT in 2007 and this greatly affected the mangrove ecosystem along the River Ankobra estuary.

Conclusion

This study set out to identify land cover types and transitions in the Ankobra River Landscape of Western region of Ghana. Remote sensing technology was used for this purpose. Tree crop plantation covers about 51%, more than opened and closed forests put together, of the study area in 2018 classified map. The closed and opened forest were mainly converted to tree crop plantations.

Acknowledgement

This paper is a contribution to the Fifteenth RUFORUM Annual General Meeting held 2-6 December 2019 in Cape Coast, Ghana.

References

- DeGraft-Johnson, K. A. A., Blay, J. , Nunoo, F. K. E. and Amankwah, C. C. 2010. Biodiversity threats assessment of the Western Region of Ghana. The Integrated Coastal and Fisheries Governance (ICFG) Initiative, Ghana.
- Hawthorne, W. D. , Abu Juam, M., Gyakari, N. and Ekpe, P. 1998. Plants in Ankasa, Nini-Suhien, and Bia. Review of existing knowledge, results from a new survey and recommendations for management plans. Western Region, Ghana: Protected Areas Development Programme.
- Lu, D. and Weng, Q. 2007. A survey of image classification methods and techniques for improving classification performance. *International Journal of Remote Sensing* 28 (5): 823-70. doi: 10.1080/0143 1160600746456.
- Wulder, M. A. , Masek, J. G. , Cohen, W. B. , Loveland, T. R. and Woodcock, C. E. 2012. Opening the archive: How free data has enabled the science and monitoring promise of Landsat. *Remote Sensing of Environment* 122: 2-10.