Analysing land use/land cover change and prediction in a cloudy urban area using SAR: the case of Douala, Cameroon

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Keywords: Land use/land cover change, prediction, cloudy urban area, SAR, Douala.

Abstract

Land use/land cover change analyses and prediction remains a fundamental tool in shaping urban decision making. This is because it keeps a spatial track record of the past, present and predict the future. The city of Douala is one of those coastal cities that is under permanent cloud cover which makes it difficult to use optical sensors, therefore existing works within this area remain inadequate. The Synthetic Aperture Radar images were processed using deep machine algorithms in Google Earth Engine Platform using multiple polarisations. Moreso, Random Forest Classifier was used to classify both images. Results show that the built-up area has increased from 26 to 34% from 2016 - 2024, vegetation has drastically reduced from 38 to 30% while the areas occupied by bare land and water show a slide increase 0.08 and 0.15% respectively. In addition, land use/land cover prediction reveals that the built-up area will occupy close to half of the total surface area in 2035 (49%) and vegetation will reduce drastically to less that halve of its present state. Meanwhile bare land and water remains more or less the same compare to their presence state. The overall accuracy ranges between 80-84% and kapa between 79-85%. Thus, this can be a strategic information to both public and private agencies involved in drafting, orienting and monitoring urban growth in a cloudy environment.

1. Introduction

Mapping land use /land cover changes have so far remained challenging within the tropics which is characterised with permanent cloud covers. Today, optical sensors remain the most widely used images in most tropical zones because it has a wider archive in terms of historical data, widely accessible, occupies less space and easy to process but poses sequential image series issues due cloud cover. Thus, result obtained through optical image processing are often inadequate in terms of sequence and cloud obstruction. Therefore, SAR which is an all-weather satellite provides appropriate solution for land use/land cover mapping in the tropics.

The use of SAR images in land use/land cover mapping across the world in general and urban areas in particular is not new in remote sensing (Abdikan et al., 2016; Guste et al., 2022; Heena et al., 2019; Prudente et al., 2020; Victor et al., 2020). However, the combination or fusion of optical and microware data has proven to be effective in most urban areas in general and areas with frequent cloud cover in particular (Esther & Edward, 1019; Njutapvoui et al., 2021; Shimelis et al., 2023; Victor et al., 2022). Nevertheless, investigating the contribution of optical and polarimetric SAR features for LULC classification improved its accuracy (Yunkun et al., 2021).

2. Material and method

2.1 Location of the study area

Administratively, Douala doubles as the economic capital of Cameroon and the chief town of the Littoral Region of Cameroon. Douala is one of the most popular cities in the Central African Sub-Region that is located in the Gulf of Guinea and a major outlet to must landlock countries in the Sub-Region (Figure 1).

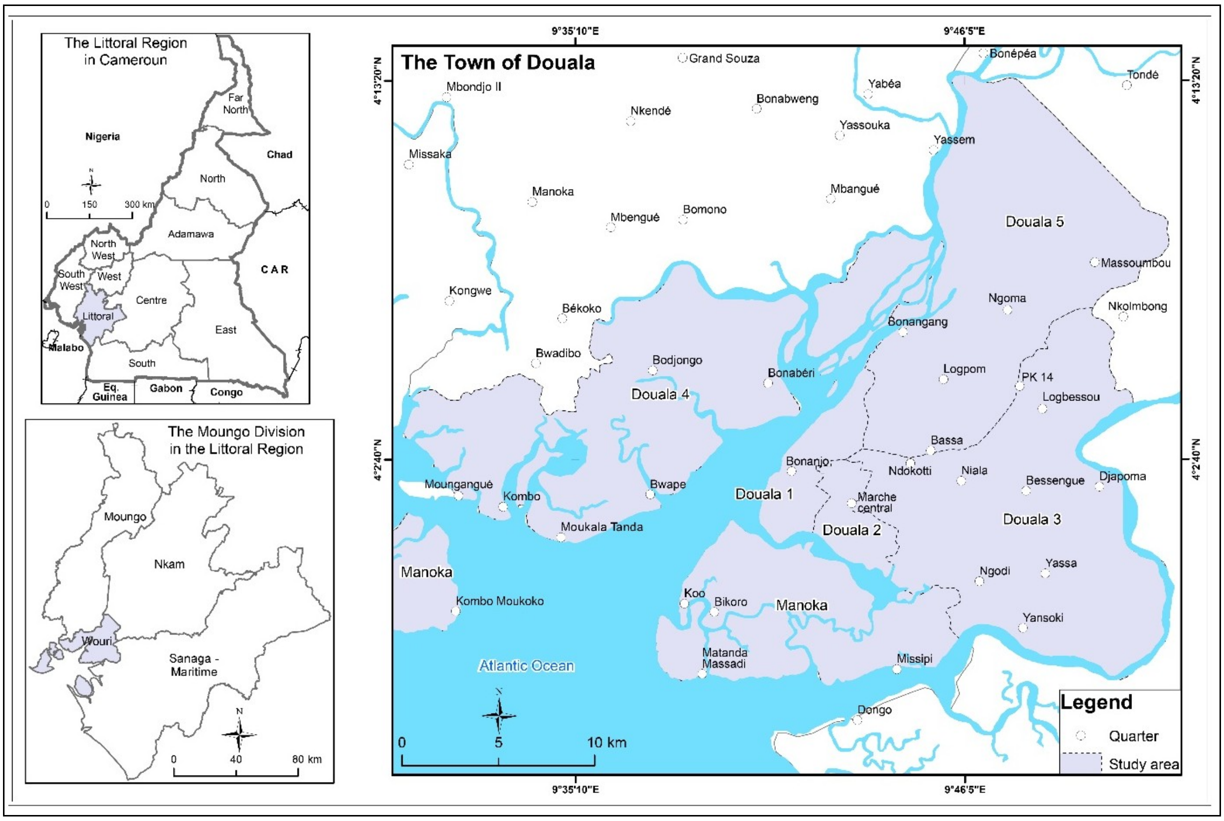

Figure 1: Location of study area
Source of data: Extract of the Administrative map of Cameroon produced by the National Institute of Cameroon, 2013

2.2 Description of dataset

The Synthetic Aperture Radar (SAR) images were assembled and processed using deep machine algorithms in Google Earth Engine Platform using multiple polarisations. This work made use of SAR images of 2016 and 2024 gotten from Copernicus Open Access Hubi1. The Ground Range Detected (GRD) with VH and VV polarisations was used. Both ascending and descending orbit were used in this work and a vector layer was used to clip our study area.

2.3 Data processing and analysis

Different band combinations were applied to facilitate the identification of the different land use/Land cover classes and over 150 training sites were created to train the SAR images. In addition, Random Forest Classifier was used to classify the past, presence and predict future land use/Land cover classes. Both confusion matric and accuracy were produced to measure the quality of the land use/Land cover classes classification in question. These classified images were converted into vector layers and open in excel sheets for further analyses using the pivot table. The results were presented in histograms and maps to facilitate comprehension.

3. Result and discussion

The major results obtained shows that SAR has proven to be effective in Analysing land use/land cover change within the cloudy study area and future land use/land cover prediction. In less than 10 years, there have been an outstanding increase of the four major land use/land cover classes identified within the study area. For instance, build-up have increased from 26 to 34% from 2016-2024 while vegetation has drastically reduced from 38 to 30%. Moreso, the areas occupied by bare land and water shows a slide increase of 0.08 and 0.15% respectively (Figure 2 and Figure 3).

[1]https://developers.google.com/earth-engine/datasets/catalog/COPERNICUS_S1_GRD#bands

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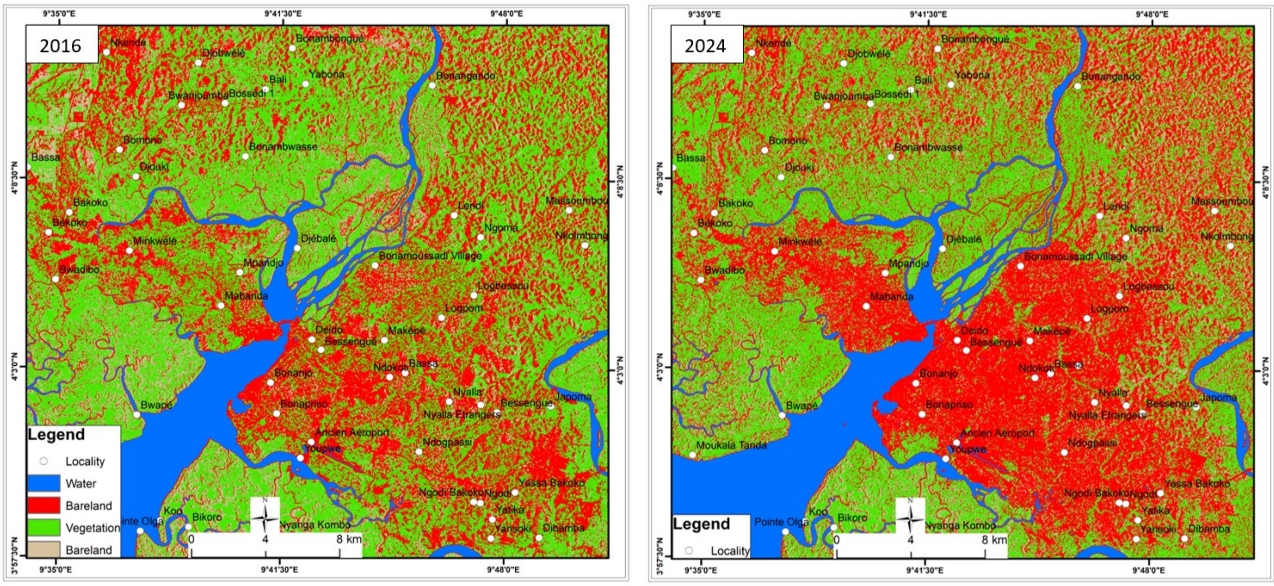

Figure 2: Land use/Land cover change in 2016 and 2024 of Douala and its surroundings
Source: SAR 2016-2024 and National Institute of Cartography, 2022

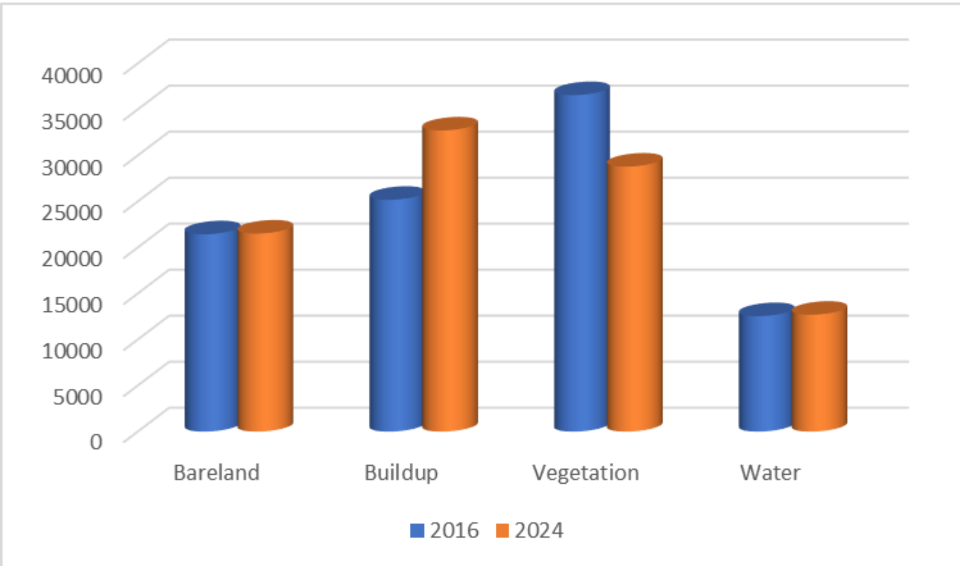

Figure 3: Land use/Land cover change in 2016 and 2024
Source: SAR 2016-2024

Projected information on Land use/land cover transition in 2035 put vegetation – build-up at the top with closed to 12% of the entire transition while build-up and vegetation will occupy less than 5% of the total surface area. In addition, bare land to build-up will occupy up to 8% and the reverse will occupy about 4%. However, transition within the same class will occupy close to 35% with vegetation at the top with 16% and water at the bottom with less than 2% (Figure 4).

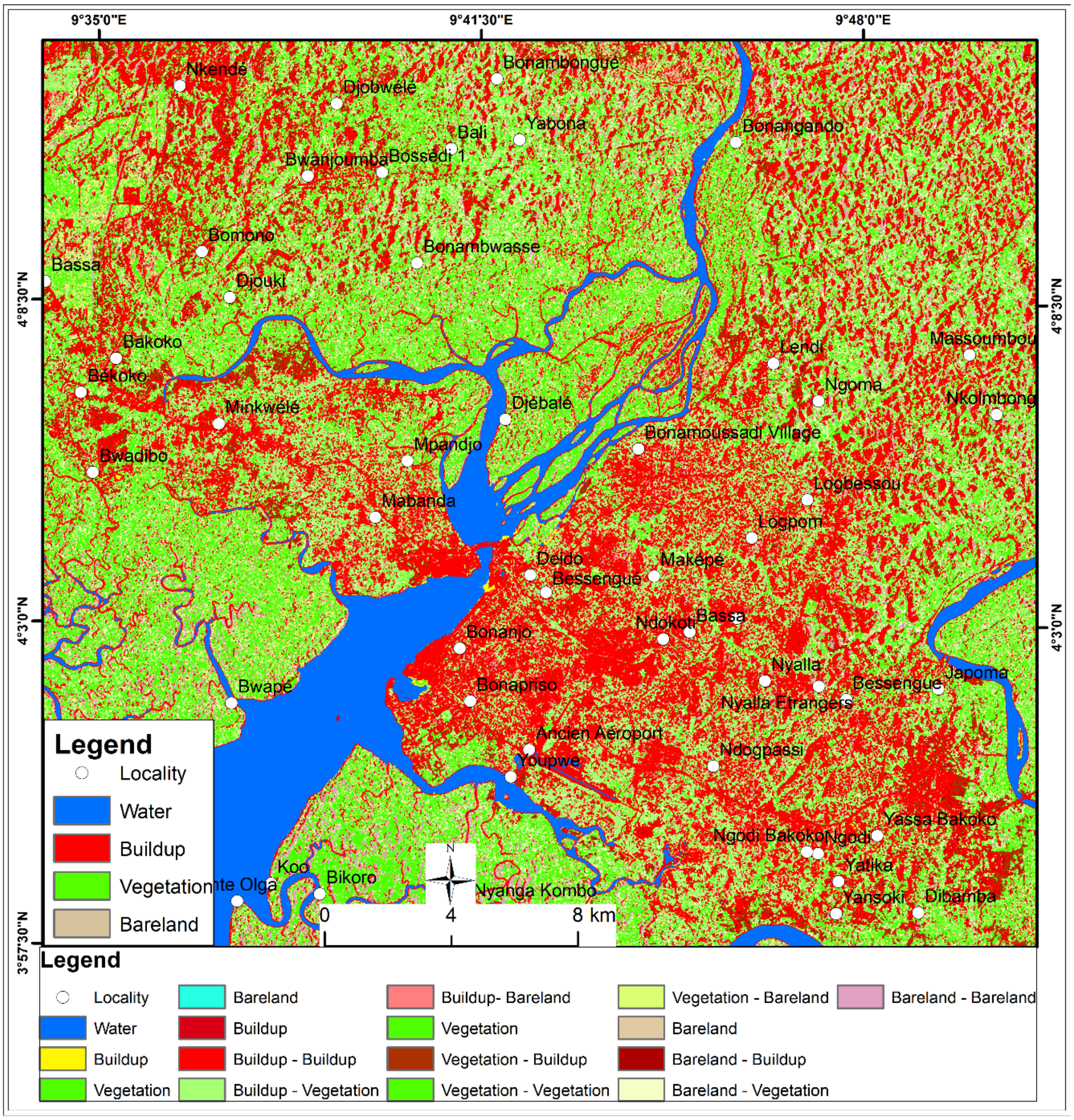

Figure 4: Land use/land cover transition map
Source: SAR 2016-2024 and National Institute of Cartography, 2022

Predicting land use/land cover in 2035 shows that the build-up area will occupy close to half (49%) of the total surface area while vegetation cover will reduce by half (30-15%) of its present state. Nonetheless, bare land will slightly increase by 0.35% while water bodies will reduce by -0.24 of its presence state (Figure 5).

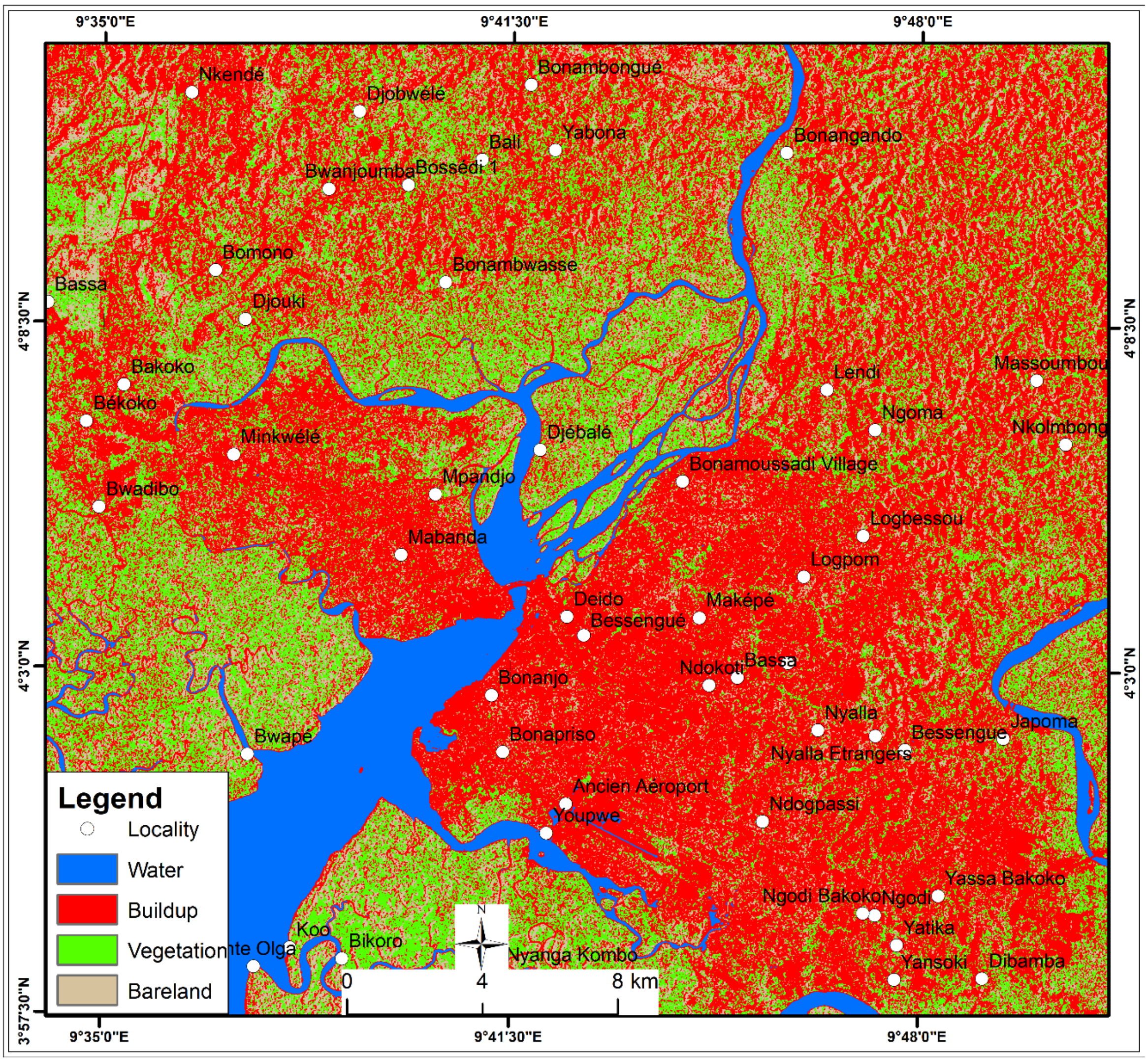

Figure 5: Land use/land cover prediction in 2035
Source: SAR 2016-2024 and National Institute of Cartography, 2022

The findings obtained from this work using Random Forest Classifier which ranges between 80-84% guarantee its credibility within this area and the possibility of reproducing it in area with similar characteristics. However, Random Forest Classifier remains one of the best images classification algorithms as proven by (Mishra et al., 2017). Even though, the findings seem to be accurate and might be very useful for present and future urban planning, the shortcoming are almost similar to those raised by (Victor et al., 2020).

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Conclusion

Successfully urban planning and development lies on keeping track of the past, mastering the presence and projecting the future. The case in question just like most developing cities is characterised by limited resources, irregular updates of town planning documents and a permanent cloud cover that limit the use of optical satellite images thus bringing SAR images in particular and radar in general at the forefront of urban planning and follow-up. The objective of this work was to use SAR images to analyse land use/land cover change and predict future land use within the city of Douala. This was attained through the aids of deep learning algorithm in Google Earth Engin platform. The results obtained remains applaudable given that is the first of its kind within this area. However, working with many land use/land cover classes might produce poor accuracy reason why we had just four major classes.

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