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Status-quo of selected nationally determined contributions in West African countries using spaceborne remote sensing – a data perspective

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Abstract

With the nationally determined contributions (NDCs), Parties of the Paris Agreement (PA) keep hold of the policy goals and measurements, which they consider crucial for their nations' climate action plans. Progress towards the NDCs must be communicated every five years, which is why monitoring their implementation and effectiveness is essential. Here, we take a step towards deriving information on the status-quo of selected NDCs of West African (WA) countries using open-access spaceborne remote sensing (RS) products, by comparing the Food and Agriculture Organization Corporate Statistical Database (FAOSTAT) land-use (LU) data and RS-derived annual land-cover (LC) maps produced by the European Space Agency Climate Change Initiative project and the Copernicus Global Land Monitoring Service, respectively, regarding set goals in the forest sector. Forests are a key policy sector for which mitigation and adaptation goals, such as reforestation/afforestation, are listed in WA countries' NDC documents from 2015. For the years 2015 to 2019, we compare the datasets regarding values in forest area (kha) at country-level and the NDC goal "increased annual reforestation/afforestation" using Ghana as case study. Log-linear regression modeling was used to assess the proportion of the variance between the datasets. The Kruskal-Wallis-Test was applied to test the annual difference of the datasets for each country. Our results show significant differences in estimated forest area values among datasets and countries, whereby the LC products estimate either higher or lower forest area than the LU data. Although the LC products show similar directions of forest values, i.e., either higher or lower estimates for most countries, than the LU data, they depict different magnitudes in values and diverging directions in the change of forest area over time. Thus, we identified deviating outcomes regarding the progress towards the NDC goal "increased annual reforestation/afforestation" depending on the dataset used. Our results underline the importance of data source comparison and the prevailing issue that open-access data and products are often based on diverging methods, definitions, and different accuracies, which can have significant impact on the reporting of policy goals and agreements. This points towards the necessity to push further standardization ambitions to allow for comparable and robust evidence for monitoring progress to achieve the PA.

Keywords: Nationally determined contributions (NDCs), remote sensing, land-cover/land-use, West Africa, climate change, Paris Agreement

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Introduction

Compared with industrialised countries, West African (WA) countries have relatively low emission rates, such as for CO_2 [1]. Yet, these countries will suffer severely from climate change (CC), for instance through increased food insecurity, degradation, and exposure to disasters [1]. To tackle CC worldwide, the Paris Agreement (PA) from 2015 aims at keeping the global raise in temperature below 1.5°C [2]. With the nationally determined contributions (NDCs), Parties of the PA keep hold of the goals and measurements, which they consider essential for their nations' action plan to reduce emissions and build climate resilience. To track compliance towards the PA, the NDCs must be communicated in a five-year cycle and made available in a public registry[1]. Monitoring their implementation and effectiveness is therefore essential. A critical barrier is here a comprehensive, spatially explicit, neutral policy monitoring and evaluation – a process that often involves financial and personal resources and can constitute a non-negligible hurdle for developing countries, such as in WA [3, 4]. Often, open-access data are used to monitor progress on international agreements, such as the NDCs. One such source is land-use (LU) data from the Food and Agriculture Organization (FAO). These data originate from a combination of data sources, including national inventory, remote sensing (RS), and estimated data, with the quality of the data varying across countries [5]. Spaceborne RS data, instead, provides objective information about the physical earth's surface at various spatial-temporal scales and in an area-wide, systematic, and consistent manner [6, 7]. Further, pre-processed RS products and information exist that can support decision-making, e.g., in land management [8]. Thus, it can be a valuable tool to complement monitoring systems for NDCs. Here, we compare annual FAO LU data with land-cover (LC) data from two spaceborne RS-derived LC maps produced by the European Space Agency Climate Change Initiative (ESA-CCI) project and the Copernicus Global Land Monitoring Service (CGLS), respectively, regarding values in forest area (kha) and annual forest area change (kha a^{-1}) at country-level for the years 2015 to 2019. Using Ghana as a case study, we explore whether the country is meeting its target for the NDC "increased annual reforestation/afforestation (kha a^{-1})". This work is a first step in our endeavor to monitor the status-quo of selected NDCs of WA countries using open-access RS products.

Material and Methods

Data on forest area were derived from FAOSTAT[2]. We downloaded annual forest area from the LU database and ESA-CCI and CGLS LC data (all provided in kha a^{-1}) from the LC database for 16 countries in WA for the years 2015 to 2019. Originally, both RS-products have different spatial resolutions (ESA-CCI: 300 m; CGLS: 100 m) and use their own definitions for the LC classes. To align the LC data, the FAO converts the data following the LC classification of the United Nations System of Environmental-Economic Accounting Central Framework [9, 10]. For comparability, we further aggregated specific LC classes to match the LU class "forest land". Log-linear regression models were used to derive information on the proportion of the variance. The Kruskal-Wallis Test was applied to test whether the fundamental tendencies of the datasets differ significantly from each other [11, 12]. Thereafter, we calculated forest area change for every country from 2015 to 2019 and used Ghana as case study to compare the progress of the country towards reaching its set NDC goal of 20 kha a^{-1} [13] of reforested land based on the three different datasets.

Results and Discussion

Variation in forest area values between land-use and land-cover data

The log-linear regression models (Fig 1) show that for nearly all countries the RS-based LC data estimated either higher or lower forest land values in comparison to the LU data, with the model for the ESA-CCI data showing a slightly better fit than the model using the CGSL data (R^2=0.82 and R^2=0.76, respectively). Further, the ESA-CCI and CGLS data show, except for Liberia and Sierra Leone, similar directions of forest values, i.e., either higher or lower estimates, than the LU data. However, they both reveal different magnitudes in the relationship between the country-wide forest area values. Forest area from the three datasets is significantly different (Kruskal-Wallis Test, $p < 0.05$).

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[1] https://unfccc.int/NDCREG
[2] https://www.fao.org/faostat/en/#data

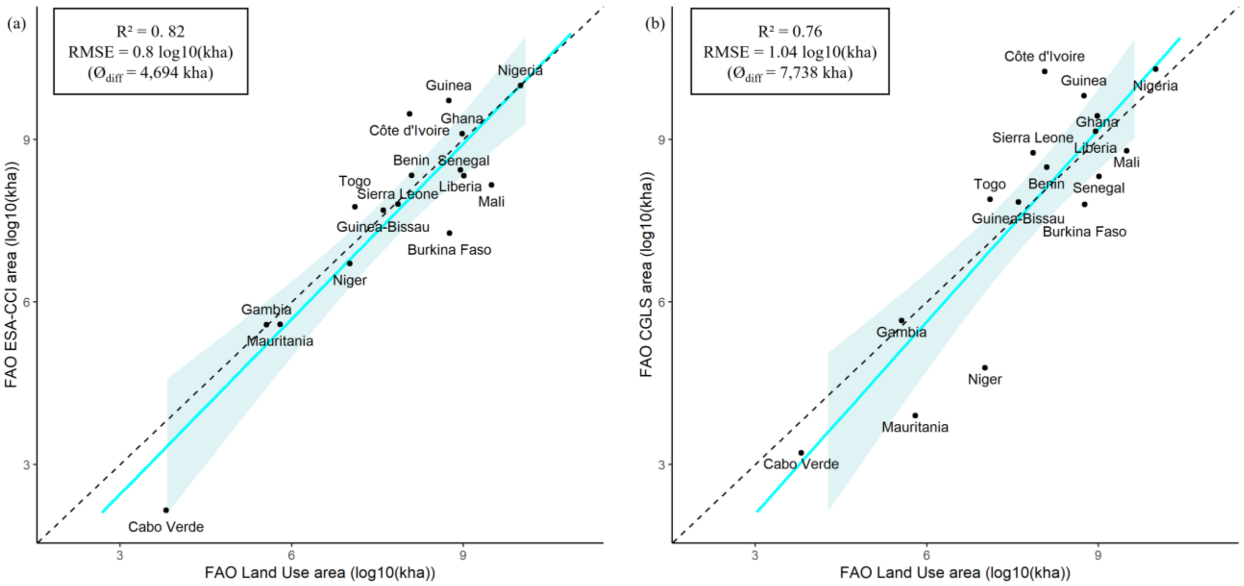

Figure 1 Relationship between the two spaceborne remote sensing-based land-cover and FAO land-use data plotted in a logarithmic scale (kha a^{-1}). The black dashed line indicates the 1:1 ratio line. The regression line is displayed in cyan. (a) shows the relationship for the relationship for the ESA-CCI and (b) for the CGLS data, both in comparison to the land-use data.

Forest area change from 2015 to 2019

Calculations revealed that the LC data show, except for Guinea-Bissau, diverging results for change in forest area. In almost all countries (exceptions are Ghana and Mali for the LU data), forest area is decreasing according to CGLS LC and FAO LU data, though to varying magnitudes. In contrast, the ESA-CCI LC data indicate, except for Guinea-Bissau, an increase in forest area (Figure 1).

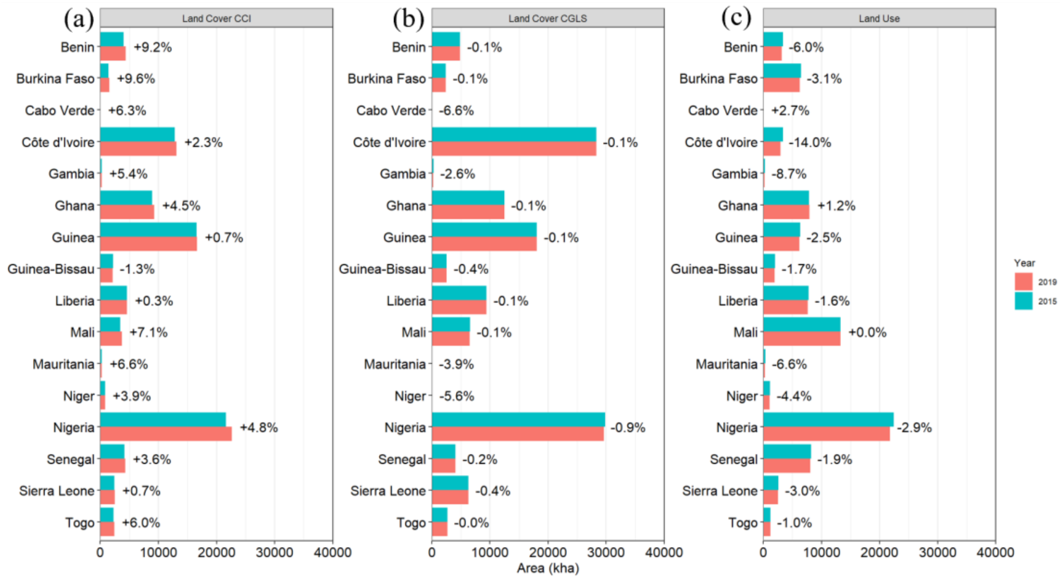

Figure 1 Change in country-wide forest area from 2015 (blue) to 2019 (red) for the three datasets ((a) LC CCI, (b) LC CGLS, (c) LU data). Displayed is the area of forest (kha) and the percentage of change (%).

Case study of Ghana: NDC goal "increase in reforestation/afforestation"

Ghana targets to reforest 20 kha per year nationally in their NDC document from 2015. Based on the change in forest area from 2015 to 2019, we derived the mean change in forest area per year (kha a^{-1}) as an indication of Ghana's progress towards meeting this target. We found that if we were to use the ESA-CCI LC or FAO LU data, Ghana would have either hugely exceeded or exactly met its NDC goal (increase by 102 kha a^{-1} and 24 kha a^{-1}, respectively). However, using the CGLS data, the country would be showing an opposing development (decrease by -4.5 kha a^{-1}).

Getting to the heart of the matter: The origin of data

Important sources of these diverging results are the origin of the data, methods and ground-truthing data applied, and the resulting accuracies of the products. The LU data for WA countries comes from a combination of sources, including inventory and RS data and estimates, with the origin, availability, and quality of data remaining an issue [5, 14]. Further, national inventory data depend on the country's methods of surveying, definition of "forest", and statistical methods used to derive the data, all of which vary across countries. These uncertainties challenge the comparison between countries and the reliability of the data for reporting on international goals. Yet, using the LC data also comes with flaws. Both RS-products have different spatial resolution and definitions for their LC classes (c.f., section "Materials"), and apply different ground-truthing data. This leads to varying accuracies (ESA-CCI: 71.1%; CGLS: 80.6+/-0.4%), also for the different LC classes. The aforesaid calls for a closer evaluation of the approaches used for data generation when used for the NDCs [15, 16].

Conclusions and Outlook

Our work shows that open-access data from RS-derived products on LC can be used to monitor relevant NDCs in the forest sector. It provides an objective, systematic approach that may be utilized across countries. Yet, although the LC data showed for forest area values a similar relationship to the LU data, they revealed contrasting results for change in forest area. Congruently, the LC products suggested diverging results as to Ghana's success in achieving the NDC goal "increased reforestation/afforestation". This underlines the importance of data source comparison and selection along with data standardization, such as through standardized methods and definitions, for comparable and robust evidence. It also indicates the need of the political field to consider monitoring tools when defining goals for international agreements. Further research aims at defining the optimum possible way in using one or combining both RS-derived products to derive concrete information on the progress of selected NDCs in the forest and agricultural sector.

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