Environmental sustainability asmara

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Ecosystem services (ES) hotspot/cold spot analysis aids sustainable planning in rapidly urbanizing African cities.

We mapped ES hotspot/cold spot dynamics in Greater Asmara Area, Eritrea, from 2009 to 2020.

GAA"s ES potential is low but stable, showing some improvements over time.

It is crucial to interpret observed ES cold/hotspot dynamics in GAA with caution.

Our approach is replicable in other resource-scarce, rapidly urbanizing African cities.

In this study, we propose a MAES pilot to support sustainable planning in the rapidly urbanizing Greater Asmara Area (GAA) in Eritrea. This study aims at mapping and analyzing ES hotspots and coldspots dynamics in the GAA to identify recent trends and opportunities for enhancing ES potential. The GAA, the largest urban area in Eritrea and including a UNESCO World Heritage Site, houses 50-60% of the country"s population (Ministry of Public Works and BCEOM 2006; Ghebru et al. 2011). It faces risks from local urbanization, regional rural resource degradation, and global climate change impacts (MoLWE 2012a). This pilot study in the GAA seeks to raise awareness of these challenges and their effects on ecosystems and their services.

We map and assess six illustrative ES using land cover data from 2009 and 2020, obtained via remote sensing. To evaluate changes in ES supply potential, we employ the ES matrix approach by (Burkhard et al. 2010), a tier 1 MAES method suitable for data-scarce regions, as demonstrated in Eritrea and Kenya (Wangai et al. 2019; Adem Esmail et al. 2023). This analysis identifies recent trends and future land use opportunities by considering changes in ES hotspots and cold stops distribution across the GAA.

Like many African countries, Eritrea relies heavily on natural capital, making it vulnerable to environmental challenges, such as droughts, which are exacerbated by climate change (MoLWE 2012a; Wangai et al. 2016; IPBES 2018). The country faces a variety of challenges, including low availability of arable land and water scarcity, which can significantly impact food security and overall human well-being. Studies suggest that the average temperatures in Eritrea could increase by up to 3.39?C by 2080 (Hunt et al. 2019). These environmental stressors underscore the urgent need for effective governance and planning strategies informed by ES knowledge, particularly in urban contexts.

Study area location in Eritrea, in the Horn of Africa [A] and in the Maekel or Central region, one of the six administrative regions in the country [B]. The Greater Asmara Area (GAA) divided into six subzones for analysis based on the sub-regional boundaries in the Zoba Maekel [C]. NB. The subzones in the GAA are not

official administrative areas; rather, they are analytical units for the present study only. (Sources: Google Earth, FAO, digitization of the SUDP)

The research design comprises three main steps (Fig. 2). Firstly, we analyze land cover changes between 2009 and 2020 using remote sensing data. Secondly, we map and assess the potential supply of ES and calculate changes between 2009 and 2020. Finally, we produce hotspots and coldspots maps to analyze the changes between 2009 and 2020 and draw conclusions for the further spatial development of the GAA.

Global datasets on land use and cover, such as those released by ESRI (Karra et al. 2021) and (Zhang et al. 2024), provide a comprehensive overview of land cover patterns across the world. However, upon a detailed examination of the land cover data in the GAA, noticeable uncertainties emerge, particularly in the classification and mixture of built-up areas and bare ground. Therefore, we produced our own land cover dataset for the GAA, following four key phases: dataset selection and pre-processing, land cover and use classification, accuracy assessment and land cover changes analysis.

Furthermore, to remove the "salt-and-pepper" noise that persists after classification, post-processing techniques were applied (Wang et al. 2019), such as post-classification smoothing filter with a kernel size of 2.5. The results were subject to manual review for both study periods to ensure the reflection of changes in land cover, such as the disappearance of water bodies.

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