AN ASSESSMENT OF SPATIO-TEMPORAL DYNAMICS OF FRACTIONAL AND FUTURE LAND COVER SCENARIOS IN SUDAN SAVANNA ECOLOGICAL ZONE IN GHANA

ABSTRACT

Land Use Land Cover (LULC) dynamic is vital in land and land use sustainability. It also helps in understanding the impact of anthropogenic activities and forging sustainable ways to manage the land cover. This study harmonized the existing 2006 and 2015 LULC maps of the Sudan and Guinea savanna ecological zones of Ghana and used this process to develop a standardized LULC classification procedure for consistent mapping and long-term land management. The same procedure was applied to produce a 2023 LULC map of the study area using composite imagery from Landsat 8, Sentinel-1, and Sentinel-2, classified with the Random Forest algorithm in Google Earth Engine. In addition, Fractional Cropland Cover (FCC) for the entire Sudan and Guinea savanna ecological zones was estimated using MODIS satellite imagery and a Random Forest Regression model. Future LULC scenarios for 2050 were projected based on historical and current LULC maps using the Markov Chain and Multi-Layer Perceptron (MLP) neural network within the Land Change Modeler framework. Furthermore, both statistical and spatial autocorrelation analyses were conducted on vegetation change data derived from interviews with local residents to assess vegetation dynamics associated with anthropogenic activities. The results show that the Random Forest classification achieved an overall accuracy of 80.21% and a Kappa coefficient of 0.7225, indicating substantial agreement. The Fractional Cropland Cover estimation produced robust performance metrics with RMSE: 014.8545; R^2: 0.771; MAE: 10.1582 and MA: −0.0568. The projected 2050 LULC scenario indicates that several land cover classes are likely to experience significant changes. Moreover, the statistical and spatial autocorrelation analyses reveal clear evidence of anthropogenic footprints influencing ecological conditions within the study area. Overall, the adopted methodology achieved accuracy levels within established acceptable standards, demonstrating robustness and providing strong confidence in the reliability, replicability, and socio-ecological relevance of the results. The findings ensured that the current LULC map is consistent with previously produced LULC maps, thereby enhancing the understanding of historical land cover changes and long-term landscape dynamics. For regional planning, the fractional cropland cover estimates provide critical information on the extent of actively cultivated areas, enabling stakeholders to better assess agricultural productivity and strengthen food security strategies. The results also offer valuable insights into present and projected LULC dynamics, supporting policymakers and other stakeholders in identifying land use practices influenced by government policies and population growth within the region. By explicitly linking intensified human activities to observable ecological and land cover changes, the study provides an evidence-based foundation for policymakers and stakeholders to design informed interventions aimed at mitigating environmental degradation.