

Time Series Land Cover Mapping and Change Detection Analysis Using Geographic Information System and Remote Sensing, North and West of Africa †

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Abstract: Land use planners require a time series land resources information and changing pattern for future management. Therefore, it is essential to assess changes in land cover. This study was to quantify the spatio-temporal dynamics of land use change over North and West Africa between 1985 and 2015 using the Normalized Difference Vegetation Index (NDVI) from the Very High Resolution Radiometer (AVHRR). The total investigated area was determined by 17,328,557.16 km². The class of Urban and Built-up, Barren or sparsely vegetated, Savannas and Deciduous Broadleaf Forests increases considerably during the last three decades. In contrast, the class of Open Shrublands, Woody Savannas and water decrease notably during the three decades. The class of croplands decreases from 1985 to 1995 and increased from 1995 to 2015. The class of grasslands recorded a first increase from 1985 to 1995, and then decreased from 1995 to 2015. The class of permanent wetlands first decrease from 1985 to 1995, then increase from 1995 to 2005, followed by a decreasing trend during the last decade. The class of evergreen broadleaf forests decreased in the first two decades, from 1985 to 2005, and increased over the last decade.

Keywords: land cover; random forest classification; change detection; North and West Africa

1. Introduction

Africa has encountered the fastest rate of change in the land cover; portions as of now are influenced by a variety of environmental problems [1–5]. Taking into account that LCLU remains a significant factor in overall habitat degradation and suppression, as well as losses related to bio-diversity and plant resources [6]. Remote-sensing dataset could potentially give a particular and reproducible data on LULC for monitoring the changes [7].

The current study aims to generate annual LULC maps during the last three decades from 1982 to 2015 over North and West Africa. The maps are generated based on a random forest classification using the NDVI AVHRR GIMMS data and training using MCD12Q1 dataset from the MODIS sensor, and discerning the magnitude of the changes occurred in the study area to determine the LULC category through spatial comparison of the LULC maps produced.

2. Methods

- This study will be applied to the North and West of Africa. It lies between latitudes 4° and 38° N, and longitudes 18° W and 40° E.
- The dataset used in this study have the same resolution of pixels 1/12°. The first dataset utilized is the AVHRR GIMMS NDVI3g from 1982 to 2015, and the second dataset used in this study is MODIS MCD12Q1 from 2002 to 2015. These were used as reference data for the AVHRR classification to identify areas of training and contained a set of annual LULC maps from 2002 to 2015, corresponding to the classification system of International Geosphere-Biosphere Program (IGBP).
- We use the random forest classification to classify the AVHRR data from 1982 to 2015.
- Detect the change in the land cover from 1985 to 1995, from 1995 to 2005, and from 2005 to 2015.

3. Results and Discussion

The LULC map classified for 1985, 1995, 2005 and 2015 are shown in Figure 1. The classification results for 1985, 1995, 2005, and 2015 are summarized in Table 1. The results acquired demonstrated that the total investigated area was determined by 17,328,557.16 km². This area divided into 11 land cover classes.

Figure 2 illustrates the overall trends and the time series of the 11 LULC classes from 1982 to 2015 over the study area. To deepen the analysis, we choose to study the evolution of land cover change with a time interval of 10 years, likewise; 1985/1995, 1995/2005 and 2005/2015 (Table 1).

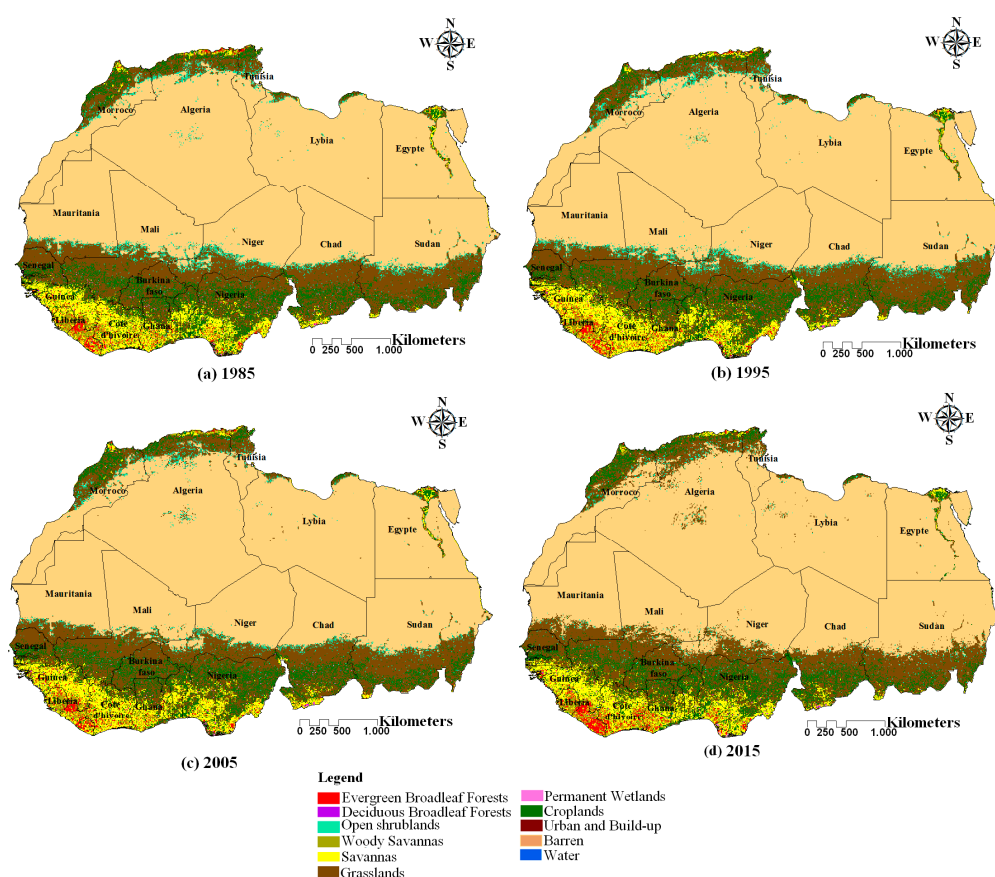


Figure 1. Annual LULC maps of the study area, produced by random forest classification. (a) 1985, (b) 1995, (c) 2005, and (d) 2015.

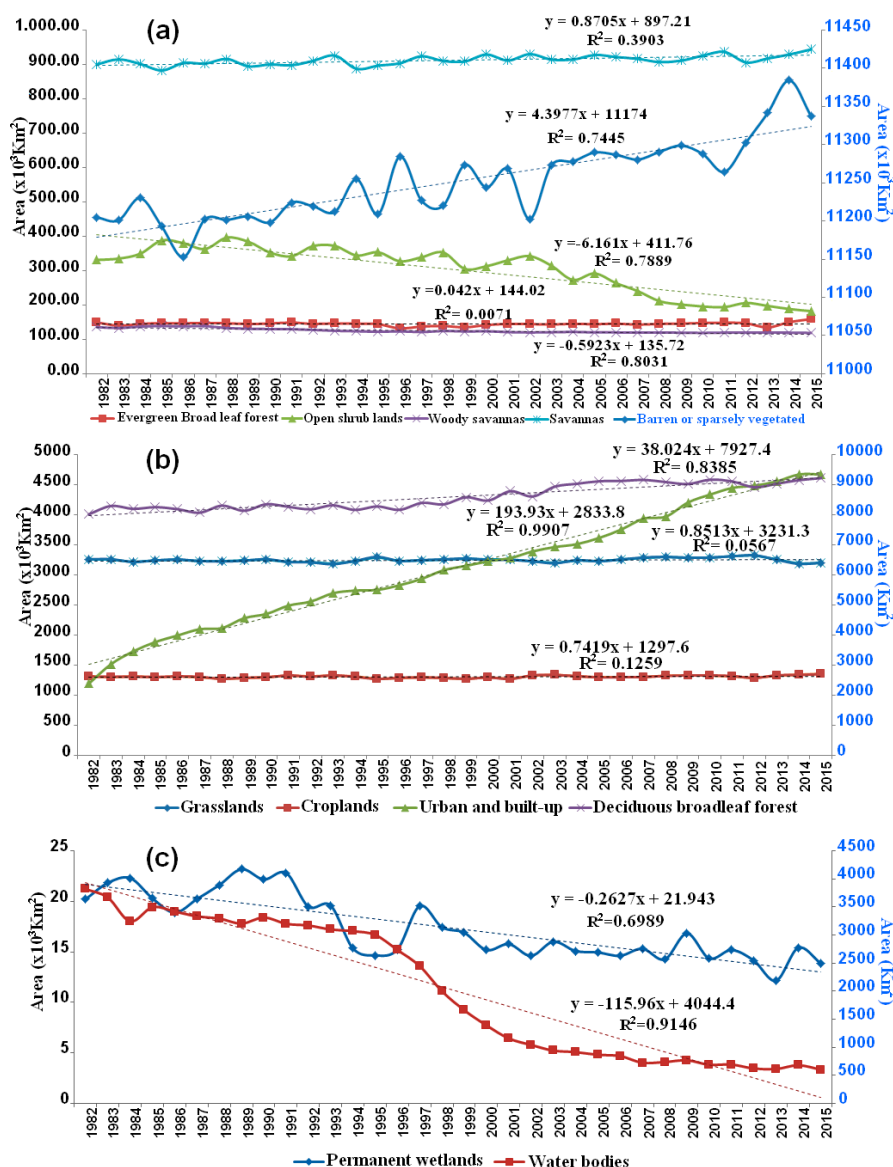


Figure 2. Temporal changes in area of LULC from 1982 to 2015.

Table 1. Land cover/land use classes and areas in km².

Map Unit	Area 1985	Area 1995	Area 2005	Area 2015	Change Area km ²		
	km ²	km ²	km ²	km ²	1985/1995	1995/2005	2005/2015
Evergreen Broadleaf Forests	147,408.7	144,269.68	144,117.4	159,132.1	-3138.98	-152.25	15,014.69
Deciduous Broadleaf Forests	8246.75	8270.13	9105.37	9208.81	23.38	835.24	103.44
Open Shrublands	387,886.6	353,501.68	291,959	182,273.2	-34,385	-61,542.7	-109,686
Woody Savannas	138,728.8	122,261.54	120,304.1	118,926.6	-16,467.3	-1957.41	-1377.53
Savannas	882,638.4	896,636.02	927,632.6	943,824.9	13,997.58	30,996.58	16,192.28
Grasslands	3,239,830	3,298,144	3,224,773	3,201,880	58,314.01	-73,370.8	-22,892.8
permanent Wetlands	20,302.31	14,665.85	14,955.08	13,888.51	-5636.46	289.23	-1066.57
Croplands	1,303,639	1,273,444.02	1,298,141	1,351,932	-30,194.9	24,696.49	53,791.36
Urban and Built-up	3463.03	5479.32	7020.12	9331.29	2016.28	1540.8	2311.17
Barren or sparsely vegetated	11,192,916	11,208,880.48	11,289,682	11,337,555	15,964.3	80,801.46	47,873.03
Water	3497.5	3004.44	867.78	604.58	-493.06	-2136.66	-263.19
Total area	17,328,557	17,328,557	17,328,557	17,328,557			

4. Conclusions

Africa has had the fastest rate of change in LULC and most of its sectors have already been affected and are facing various environmental problems. Although, given the limited time period in which the LULC annual map time series are available, LULCC dataset in North and West Africa is generally employed in the climate modeling. To address this necessity for a long time series of LULC

dataset, we have created a continuous LULC time series of the last three decades over North and West Africa between 1982 and 2015 using data from AVHRR GIMMS NDVI3g.

The availability of LULC generated over a period of 33 years has been an important dataset to characterize the LULC dynamics of large areas. The detection of change over the last three decades shows that the class of urban and built-up, barren or sparsely vegetated, savannas and deciduous broadleaf forests has declined considerably. Open shrublands, woody savannas and water decrease considerably over the three decades. Croplands decrease in the first decade and increased over the last two decades. Grasslands recorded a first decade increase, and then decreased from 1995 to 2015. Permanent wetlands first decade decrease, and then increase a second decade, followed by a decreasing trend during the last decade. Evergreen broadleaf forests decreased in the first two decades and increased over the last decade. The 33 years of annual land cover maps with the detection of changes over the last three decades, will form an important dataset to identify recent LULCC associations with climate changes over North and West Africa. If we don't have a continuous LULC map in other geographic areas, we can use the pre-processing, the classification and the validation methods applied in this study.

Author Contributions: M.H., J.Z. and W.K. conceived and designed the experiments. M.H. performed the experiments. M.H. analyzed the data. M.H. wrote the paper. J.Z. and Z.S. reviewed and revised the paper. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare that they have no conflict of interest.

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