Drought Dynamics in the Mediterranean GIAHS: Insights from the Arganeraie Biosphere Reserve, Morocco

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Abstract

Recently, the agroforestry systems in rural areas have received increasing attention for environmental sustainability and food security. Climate stressors, especially drought, have become one of the most devastating natural risks to the environment. Thus, understanding land use/land cover change (LULCC) and the spatiotemporal characteristics of drought and its associated impacts is crucial in drought early warning management and adaptation for agroforestry systems sustainability. Therefore, this study aims to assess the impact of drought in the ecosystem of the Globally Important Agricultural Heritage Systems (GIAHS) site of Ait Saoub ait - Mansour in, Morocco, from 1995 to 2021. For this purpose, the Landsat satellite images data (Thematic Mapper, Enhanced Thematic Mapper Plus, and Operational Land Imager) were used to map the LULC, and the Mann Kendell test has been used to identify the trend variability for the Standardized precipitation index (SPI) and Normalized difference vegetation index (NDVI). The results showed that the surface of woodland agriculture decreased in the same period. While both NDVI and SPI showed an annual and seasonal negative trend. These results provide evidence of the ongoing degradation of this ecosystem. Therefore, an integrated approach is necessary to improve environmental and social resilience.

Introduction

In the north Africa (NA) and Mediterranean, climatic projections indicate more severe and intense drought events. In Morocco, drought and its effects are documented in the past millennia as well as in contemporary time). For instance, one drought event can cost the agriculture sector up to $500 million. Furthermore, the climate change effects, characterised by high spatiotemporal variability of precipitation, and long-term meteorological drought, also has significant environmental impact. The risk of long drought events include biodiversity losses, increases of wildfire, decreases in water storage, groundwater depletion, and growing animal and plant diseases. In addition, agricultural practices in the region are highly vulnerable to drought. The GIAHS site Agro-silvo-pastoral system of the Argan tree in the Ait Souab - Ait Mansour region is in the Southeast of Agadir in the Souss Massa region. The income of the rural population in the area is mainly dependent on biodiversity related sources such as agriculture and tourism

The Argan tree serves multiple purposes as a forest, fruit, and forage tree. It stands as a cornerstone of the region's traditional agricultural framework, exerting an indispensable influence on the region's ecological stability. In this context, this study aims to evaluate the climate changes impacts on the agro-sylvo-pastoral ecosystems in the region via remote sensed data. First, the annual and seasonal variabilities of NDVI and SPI time series have been analysed as an indicator for crops and precipitations respectively. Then the LULCC map have been created using the random forest (RF). Then, the impacts on the local ecosystem have been identified.

Methodology

The figure and photos below show the methodology used in this work, as well as the field missions carried out to map the control and validation points.

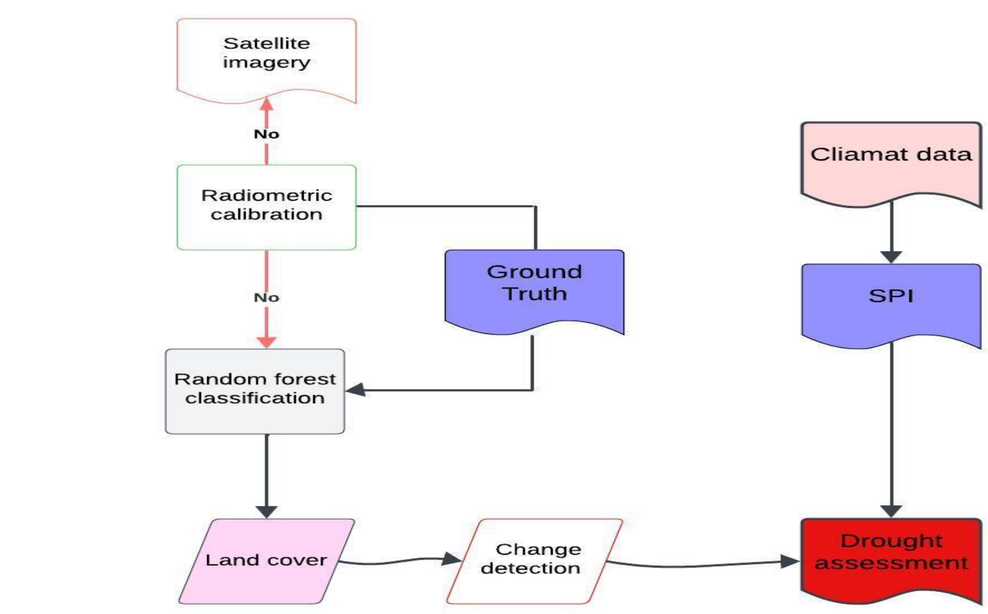

Figure 2: Flowchart of the methodology employed

Results

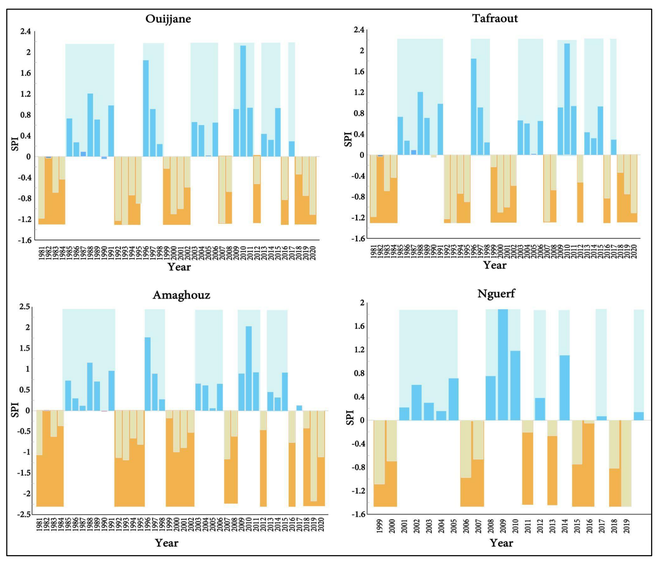

Figure 3: Time series of changes in SPI

SPI Index:

One of the SPI advantages that give information about the drought condition and highlight the characteristics for a given period. In the figure 9 the values SPI-12 were calculated in four stations in the study area. The stations of Ouijjane, Tafraout, Amaghouz for the period of 1981-2020, and the station of Nguerf for the period of 1999-2020. The annuals values of SPI-12 show an alternation of dry and humid periods, with a domination of the dry one especially the periods 1981-1984, 1992-1996, 1998-2003, and after 2016.

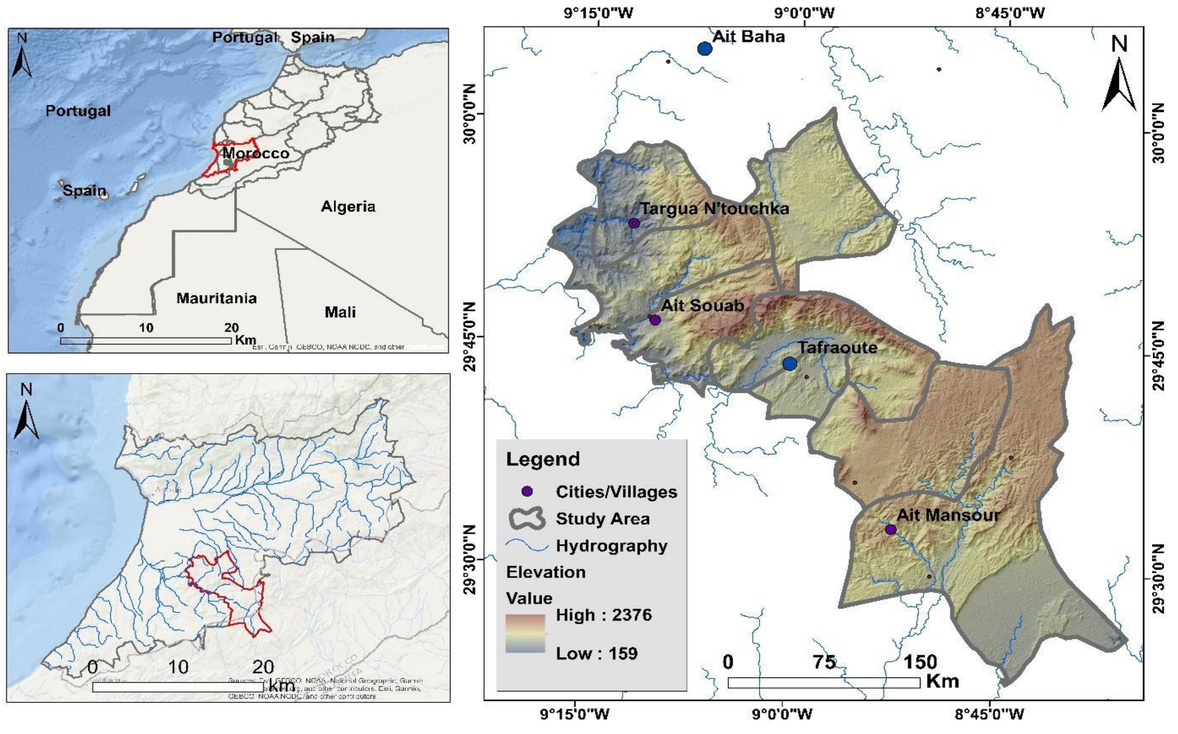

Figure 1: Study Area

3.4. Change detection of LULC

LULC change detection between 1995 and 2000 revealed a modest increase of 0.86% in desert bareland, alongside a decrease of 0.76% in agricultural land, a slight gain of 0.02% in built-up areas, and a reduction of 0.11% in woodland cover. Moving to the subsequent period from 2000 to 2005, there was a modest decrease of 1.56% in bareland, juxtaposed with a 1.29% increase in forest cover, a 0.28% growth in agricultural land, and a marginal 0.01% decline in built-up areas. Transitioning to the timeframe spanning 2010 to 2015, the analysis revealed a 1.09% decline in bareland, a 1.15% rise in forest cover, a slight 0.02% increase in built-up areas, and a 0.09% reduction in agricultural land. Notably, the most significant changes in land cover and land use at the GIAHS site occurred between 2015 and 2020, characterized by a notable 1.65% increase in bareland, a 2.07% decline in forest cover primarily attributed to conversion to range land, a 0.1% growth in built-up areas, and a 0.41% expansion in agricultural land (**Figure 4**).

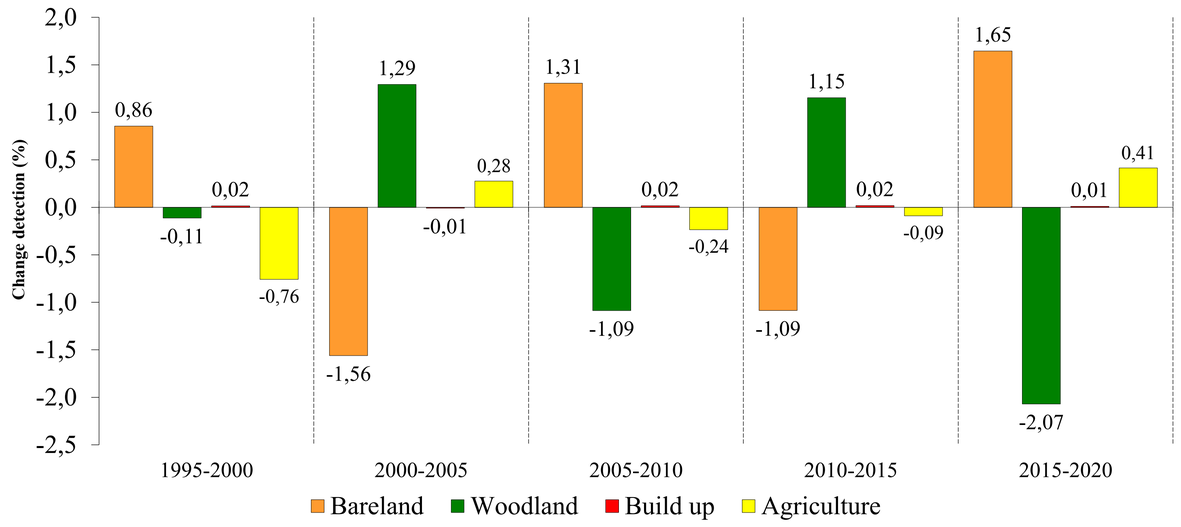

Figure 4. Area based change detection of LCLU in respective time periods.

The accuracy assessment of the classification showed a good performance of remote sensed data in the evaluation of the LULC changes. Results indicate that in the last three decades, the region experienced a very large period of drought which had a negative impact on the surface water and groundwater.

This study represents a preliminary step to investigate the drought and land degradation in the GIAHS site. However, the assessment using the drought and vegetation indices is difficult to interpret without deep local knowledge. Thus, farmers' surveys and interviews are recommended to complete the analysis and validate the findings.

Conclusion

Understanding drought characteristics, land degradation and their impacts on vegetation plays a key role in water resources, Biodiversity planning and ecosystem preservation. The objective of our study was to determine the LULC status over the entire period from 1995 to 2020, to characterize the vegetation cover and their degradation, then to characterize the SPI index and spatiotemporal analysis of NDVI based on time series changes in vegetation conditions and drought severity during the growing seasons from 2000 to 2020. Since climate change in recent years, with humains pressure and social problem, the drought degree of the the traditional agriculture and food security in the region becomes weakened,