

Summary of doctoral thesis

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Assessment and Monitoring of Water Resources and Ecosystems for Sustainable Development in Mauritanian Arid and Semi-Arid Regions

モーリタニアにおける乾燥、半乾燥地域の持続的発展のための水資源と生態系の評価及び計測

The aridity and its consequences are the main environmental problems in Mauritania in general and in the northern region particularly. The cultivations of palm trees and associated gardening are the main economical activities in Adrar province. Farmers in this area depend directly on the water points at the alluviums of Wadis for irrigation and water supply. However, this sensitive resources are under the threat of sever natural conditions and increasing demand. Therefore, we attempted first to analyze the characteristics of rainfall time series and their links with sea surface temperature (SST) in this region.

Trends for meteorological stations time series (Atar, Akjoujt and Chenguetti) were evaluated using the non-parametric test of Mann-Kendall (MK) and Spearman, regression analysis, and autocorrelation for persistence analysis. In addition, power spectrum of Maximum Entropy Method (MEM) and Fourier fit analysis were deployed for frequency and periodicity analysis. Then, cross correlations were computed between August and September average rainfall, as they constitute the most important rainy months for northern Mauritania, and SST to check the areas that have significant correlations. Furthermore, relationship of El Niño Southern Oscillation (ENSO) and sunspot number with rainfall was investigated.

The MK test showed a significant decreasing trend for Akjoujt and an insignificant trend for the rainfall time series of other stations. However, the decreasing linear trends shown by regression were highly significant for the different time series. On the other hand, persistence analysis indicated the presence of a linear Markov type. We speculated the possibility of a teleconnection between precipitation in this region and sunspot numbers. SSTs of the Atlantic Ocean, Indian Ocean, and Mediterranean Sea showed significant cross-correlations with precipitation in the study area. The ENSO effect can be considered as marginal. On the other hand, the tendency of Atar rainfall (1923-2004) showed rainy periods in 1920's and 1950's and decreased rainfall since the late of 1950s. On the other hand, the prolonged drought periods appeared during 1970's in contemporaneous with the Sahelian drought. The persistency analysis indicated the presence of biennial components during last three decades. SSTs of Atlantic, Indian and Pacific Oceans modulated Atar rainfall during 1923-1992 period.

Taking into consideration the previous finding about rainfall conditions in northern Mauritania and particularly in Atar city, the identification of groundwater potential zones and water harvesting suitable sites are important steps for water development. Therefore, we aimed to develop a methodology for water resources development in the arid environment for identifying suitable sites for water harvesting (WH) and groundwater potential areas using Landsat imagery and GIS technology. In addition, we deployed the Analytical Hierarchical Process (AHP) to permit an effective combination of different thematic maps such as land cover, geology, slope, drainage, geomorphology and lineament.

The Landsat images of Earth Observation System (EOS) at different periods and SRTM were used in this research and downloaded from the GLCF. Other ancillary data such as topographic, hydrogeologic maps and several reports related water resources of the study area were collected from different sources in Mauritania. The methodology of the present study consists of the four steps starting by data collections and preparations. The second step is the preprocessing of

digital data and maps, those are, the geometric correction, mosaic of scenes, enhancement of the images and demarcation of the study area subset.

The results of suitability analysis reflected the limitations of suitable sites for WH, which are concentrated at the Wadis beds along the valley zone with 1.4 % of excellent to high suitability. Furthermore, the results showed that potential groundwater areas are located in the valleys of main Wadis with 2% of high to excellent potentiality zones, 24% of very poor potentiality and 64% of unsuitable zone (this zone extends from the North-East to the South-East). These numbers portray the serious water shortage in this region and the effectiveness of the presented method for arid land water resources planning.

As part of West African Sahel, Mauritania has been experiencing frequent droughts since late 1960s, which were more severe than in the neighboring countries due to its position at the immediate southern fringe of Sahara desert. Here, we aimed to analyze dynamic of Mauritanian arid and semi-arid ecosystems during 1983-2003 and its response to rainfall in different ecological zones using NOAA NDVI and rainfall time series. Moreover, we analyzed the dynamic of vegetations in the agro-ecological zones of Guidimakha (southern Mauritania) and their links to rainfall using the NOAA NDVI and MODIS.

Rainfall time series and GIMMS NDVI data set were used for the analysis of trends and the relationship between rainfall and NDVI in different ecological zones. In addition, the coefficient of variation (CoV) was used to demarcate the actual borders of Mauritanian Sahel and used as index for land degradation. For this analysis, the maximum composite value of the growing season, June to October (JO), the NDVI at 8 Km resolution was generated from 15-day NDVI composites to minimize the effects of cloud, solar zenith angles and surface topography. The annual rainfall records at eleven stations from 1983 to 2003, supplied by ASECNA, were used to analyze the rainfall trends and its relationship with NDVI. Also, NDVI 32-day composite derived from MOD09A1 of MODIS 500 m pixel resolution obtained from the Global Land Cover Facility was used to analyze the seasonal patterns of vegetations in different agro-ecological zones. Rainfall data were found for three meteorological stations (i.e. Gouray, Selibaby and Ould Yenge) from the Regional AGRIMET and have been used to analyze the links between vegetations dynamics and rainfall trends in this area. Soil adjusted vegetation indices (SAVI) and Modified SAVI (MSAVI) were also used to analyze their potentiality for estimating the vegetations fractions in southern Mauritanian's Savanna.

The least square method (LSM) and the non-parametric test of MK were applied for detecting the NDVI and rainfall trends. The results of both methods, parametric and non-parametric, confirmed the presence of increasing rainfall trends at different ecological zones except at the Sahara and coastal zones. On the other hand, NDVI time series were positive at east Sahel and east of Senegal River zones. It is concluded from trends of rainfall, NDVI and CoV, the west Mauritania Sahel and west of Senegal River zones were characterized by low performance and presence of degradation, while the East Sahelian and southern part of Senegal River zones exhibited very good performance and greenness during 1983-2003 period. The actual borders of Mauritanian Sahel rangeland are approximately closer to 200 mm isohyet and 0.20 mean NDVI. The land degradation in the Mauritania Sahel could be attributed mainly to human activities while the recent greenness could be attributed the increasing trend of rainfall.

Finally, for Guidimakha, the results showed significant NDVI increasing during 1983-2003 in the areas between watershed of Garfa, Niordel and Ain ague zone, Low valley of Karakoro and Valley of Senegal River zones. The mean NDVI patterns in different zones showed the highest amplitude in the South at Senegal River valley zone and the lowest in the north at northwest Mountains zone. Therefore, the northern part of Guidimakha suffers more from degradation. Moreover, the analysis showed the strong links between vegetations and rainfall in different areas. In addition, the use of NDVI, SAVI and MSAVI is likely to be effective in estimating Savanna fractions in the semi arid regions.