Modelling water availability and climate change with satellite remote sensing data

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INTRODUCTION

Seasonal variation in water availability has tremendous societal and economic impacts on Ondo-State in southwestern Nigeria, because the economy is mainly agrarian and it basically depends on rain-fed agriculture. The agricultural sector in this part of the world has been witnessing a shift in agricultural calendar and decline in productivity as has been observed in other parts of the world (Dow *et al.*, 2009). The possible explanation for this seasonal variation in water availability is the change in climate. Using an alternative source of water supply as an adaptive mechanism has been a problem due to low levels of technology and prohibitive costs. A potential way of overcoming the impact of climate change on water availability is to look for alternative or additional data sources to compliment the existing data from ground-based hydro-meteorological stations for effective forecasting and monitoring of extreme events that may result from climate change. This may be provided by the adoption of data derived by satellite remote sensing techniques.

Satellite remote sensing is a technique of collecting information about an object/environment, without physical contact with the object/environment, through the electromagnetic spectrum using a space platform (Schaepman-Strub *et al.*, 2006). Vegetation is a good indicator of water availability and climate change. Vegetation greenness information derived from vegetation indices has been used in many hydrological and climate change models (Donohue *et al.*, 2007). The retrieval of vegetation biophysical parameters from satellite measurements has led to the development of many vegetation indices. Normalized Difference Vegetation Index (NDVI) is the most commonly used vegetation index due to its simplicity; it can give a quick qualitative and quantitative estimate of vegetation cover in a satellite image. It is expressed mathematically as:

$$\text{NDVI= NDVI=}\frac{\text{NIR} - \text{red}}{\text{NIR} + \text{red}} \qquad (1)$$

The range is between –1 and 1 where –1 represents water/bare surface and 1 green and dense vegetation.

OBJECTIVE

The objective of this work is to test the suitability of NDVI time-series data sets obtained from satellite sensors and ground-based hydro-meteorological stations for the development of a climate change predictive model for water resources management.

METHODOLOGY

The MODIS-NDVI product obtained from the National Aeronautics and Space Administration (NASA), USA and rainfall data collected from five hydro-meteorological stations (Akure, Igbokoda, Ikare, Ore and Owo) in Ondo-State, southwestern Nigeria were used for this study. NDVI and rainfall data for the year 2006 were analysed and correlated to develop linear regression equations for a predictive model.

RESULTS AND DISCUSSIONS

Linear regression equation of NDVI and rainfall data shows a stronger relationship with R^2 ranging from 0.74 to 0.94 (Table 1):
- Increase in rainfall coincides with an increase in NDVI.
- Prediction of rainfall from NDVI is possible.
- NDVI data sets can be used for famine early warning.

Table 1 Linear regression of rainfall and Normalized Difference Vegetation Index (NDVI), Ondo-State, Nigeria, 2006.

Study site	R^2
Akure	0.86
Igbokoda	0.94
Ikare	0.78
Owo	0.91
Ore	0.74

The high value of R^2 is promising, indicating that the time series NDVI data sets derived from remote sensing can be an improvement on data accessibility. Even though a one year time series data set was used for this study, seasonal fluctuations of both rainfall and NDVI correlate well. This study marks the beginning of further investigation and longer term studies; however, the results obtained can still be utilised to develop adaptation strategies for the future occurrence of extreme events on water resources, even though the study area lacks sufficient hydrological data.

CONCLUSION AND FURTHER RESEARCH

- Using additional data sets from satellite sensors as a new tool will increase the possibility of obtaining better information on climate change in relation to water resources management at both spatial and temporal scales.
- There are challenges of availability of long time series data sets, sparse network of hydro-meteorological stations, and scaling issues.
- Future work will aim at analysing archived NDVI data sets of finer resolution, rainfall, and temperature data over a period of 10–20 years in order to get a clearer picture of how vegetation could be used as an indicator of climate change and to suggest possible adaptation strategies.

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