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DISSERTATION ON

PRECIPITATION-VEGETATION DYNAMICS OVER ZIMBABWE AND THEIR RELATIONSHIP TO THE EL NIÑO SOUTHERN OSCILLATION

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Abstract

The El Niño Southern Oscillation (ENSO) is the engine that drives weather extremes in various parts of the globe. Although the impacts of ENSO are global, most attention has been given to the regional impacts of the phenomenon which are often cause death, insecure livelihoods, and loss. Because of the strong teleconnection between Pacific Ocean sea surface temperatures (SSTs), large scale near surface pressure systems, and rainfall around the globe, scientists have been interested in modeling and predicting its regional impacts. Southern Africa is one of the regions whose climate experiences high variability related to the ENSO phenomena. A concerted effort to produce and disseminate consensus seasonal climate forecasts in Southern Africa, known as the Southern African Regional Climate Outlook Forum (SARCOF), to mitigate the negative consequences of ENSO especially in the agricultural sector. The assumption is that once a drought is forecast, agriculturalists can make anticipated adaptation and mitigation decisions. Unfortunately recent research indicates that climate forecasts are not realizing their potential value in the Southern Africa. There has been a gap between the information provided by forecasters and that which is useful to smallholder farmers. The present forecasts are given at large spatial resolutions, and their provided in the language of probability terciles, which is very difficult for end users to interpret. There is a need for higher spatial and temporal resolution climatic information that is simple for agriculturalists to understand.

Remote sensing technology permits evaluation with high resolution, the inter-annual and intra-seasonal oscillations of rainfall and its predictability (Matariara and Jury, 1991; Makaudze, 2005). The advantage with remote sensing technology is that it provides repeated measurements at a particular spatial scale that allows dynamic environmental monitored with considerable

accuracy (Makaudze, 2005). Therefore this study investigates, using higher resolution datasets, climatic variability over Zimbabwe and its predictability using the El Niño Southern Oscillation. A preliminary study is also carried out to assess the state of climatic information at the local level because locally captured climatic information can be used to complement seasonal forecasts and scenario maps that can be given at the country level.

At the local level, this study has shown that though abundant climatic information is being captured locally, this information is not effectively accessible to local farmers. Local agricultural extension personnel are also limited in their ability to derive the benefits of the available data and they rely mainly on sensory perceptions. Precipitation analysis results showing inter-annual variability and correlations with the Southern Oscillation Index (SOI) highlight the potential of response farming in this region. A participatory approach is recommended involving university scientists practicing agro-meteorology, farmers, and agricultural extension. Training extension personnel in agro-meteorology is recommended. Locally captured climatic data has the potential to complement regional seasonal forecasts or country level scenario maps.

At the country level, the dominant modes of vegetation variability over Zimbabwe are investigated using principal components analysis (PCA) on NOAA-AVHRR NDVI monthly imagery from 1982 to 2006. Spectral analysis is also used to determine the periodicities of the component loadings. NDVI PCA-1 corresponds to the major vegetation types of Zimbabwe, and we demonstrated that grasslands and dry Savannah have the strongest relationship with mean annual precipitation. Furthermore the March-April loadings showed the highest correlation ($r = 0.73$) to mean annual precipitation. NDVI PCA-1 sheds some light on the land reform challenge in Zimbabwe. NDVI PCA-2 is highly correlated ($r = 0.87$) to the mean annual relative variability

of rainfall map indicating a south-east/north mode of anomalies associated with the convectional rainfall bearing systems over Zimbabwe. NDVI PCA-2 is also highly correlated (r = 0.86) to precipitation PCA-2. NDVI PCA-3 shows a south-east/west mode and is highly correlated (r = 0.87) to precipitation PCA-3. A high correlation (r = 0.66) is also noted between NDVI PCA-4 and the elevation map. Spectral analysis of the PCA loadings revealed several periodicities corresponding to those found in tropical SSTs.

The spatio-temporal analysis of dry and wet years revealed new knowledge about the evolution of extreme precipitation seasons over Zimbabwe. Results show a significant ($p<0.01$) inverse relationship between early season and late season precipitation and NDVI for above normal wet seasons and major dry years (r = -0.49). The swing from normal to above normal wet seasons is shown to cause an alternating north-south mode of precipitation anomalies which is also resonated in vegetation. The greatest impacts of extreme precipitation seasons are noted from January to March, and lag 1-2 months later in vegetation. The length of rainfall seasons is shorter for dry years than for above normal wet years. Three distinct temporal patterns of dry years were also noted by considering maximum NDVI level, mid-post season NDVI condition, and nested dry spells. The intra-seasonal patterns observed in the study are shown to be occurring within a broader inter-annual pattern that is influenced by large scale climate forcing factors. The highest correlationship between Zimbabwe's NDVI and the four ENSO indices is obtained with the Southern Oscillation Index (SOI) at lag 6, though the earliest significant correlationship were at lag 4. Lag 4 correlations imply that as from approximately September-October, it may be possible to make forecasts about whether the forthcoming season will likely be a dry or wet. These results are encouraging because it may therefore be possible to make forecasts for farmers in Zimbabwe usually start planting crops in October. The findings of this

study can help to address the challenges of existing seasonal climate forecasts systems. Though this study was carried out using the case study of Zimbabwe, the methodology can be applied to other countries in Africa and the Asia Pacific that are often terrorized by the negative impacts of the El Nino Southern Oscillation.

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