Applications of NASA Earth Observations for Monitoring Surface Water Availability for Pastoralists in Remote Regions of Tahoua, Niger

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Overview

Small surface water bodies (< 10,000 m²) are an important source of water for pastoralists and small-scale agriculturalists in the Sahel region of Africa. Over the past 30 years, changing climatic conditions have altered the quantity, quality, and predictability of traditional sources of water normally relied on by these groups. As a scarce but essential resource, increased competition over access to water has contributed to conflict, and sometimes violence, between nomadic pastoralists searching for watering holes for their cattle and the sedentary smallholder farmers who own the small ponds and lakes to irrigate their crops. This project addresses the degree to which NASA Earth Observations can be used to monitor ephemeral water body dynamics and evaluates how changes in precipitation have impacted the availability of surface water for pastoralists and smallholder farmers in the Sahel. Thirty years of Landsat imagery were used to characterize inter- and intra-annual trends of surface water extent. Surface water surface area responsiveness to precipitation was also assessed. The results from this analysis will be used to inform water resource management in the region.

Objectives

• Create a 30-year time series of water body surface area using Landsat data from 1986 - 2016
• Calculate water occurrence (percent of time an area is covered with water) from 1986 - 2016
• Identify the seasonal character of water bodies
• Quantify the responsiveness of surface water extent to changes in precipitation from 1986 - 2016

Study Area

Figure 1 illustrates the surface water occurrence (% of time a pixel is covered in water) based on 30 years of Landsat data. Dark blue represents areas that are more permanent; light blue represents areas that are more ephemeral. Large lakes exhibit more permanent water availability, and smaller ponds exhibit a greater degree of ephemeralism.

Conclusions

• These results will contribute to natural resource planning and to the management of potential conflict associated with water body scarcity: e.g. years with less rain will have more scarce surface water.
• Future work will focus on using these results, along with additional variables, in the design of a water body forecasting system that will help pastoralists in locating water bodies, allocating water resources, and designing efficient transhumance corridors.

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Key Findings

Figure 2 illustrates the relationship between surface water area and basin-wide precipitation. Peak surface water area coincides with the rainy season (May – October), occurring between August and October. The dry season (November – April) is characterized by less surface water area, with the minimum surface water area occurring immediately before the start of the rainy season, in May or June.

Table 1. Results of Statistical Analysis

<table>
<thead>
<tr>
<th>Water Body Type</th>
<th>Precipitation Elasticity</th>
<th>October Surface Area and Precipitation Regression</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R</td>
<td>R²</td>
</tr>
<tr>
<td>Basin-wide</td>
<td>2.40</td>
<td>0.8154</td>
</tr>
<tr>
<td>Lakes</td>
<td>2.40</td>
<td>0.8081</td>
</tr>
<tr>
<td>Ponds</td>
<td>2.09</td>
<td>0.9034</td>
</tr>
</tbody>
</table>

Table 1 presents the results of the precipitation elasticity calculations and the linear regression between October surface area and the preceding year’s total precipitation. Precipitation elasticity for the entire basin was 2.4, this means that for every 1% increase in precipitation there was a 2.4% increase in surface water area. The results of the linear regression suggest that over half of the variation in October surface water area is explained by variation in Precipitation. Taken together, these results reiterate the importance of precipitation to the availability of surface water in the region.