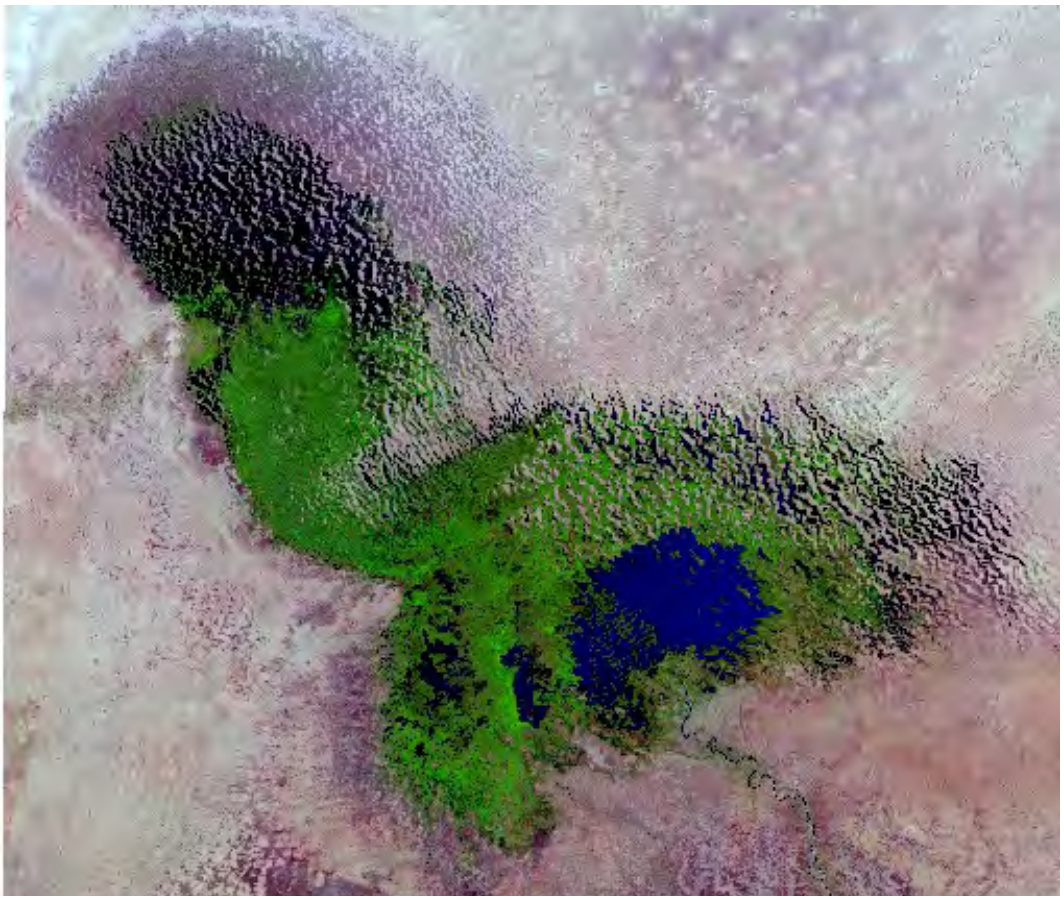
AFRICA'S GREAT OASIS: the Changing Environments of Lake Chad

Spanning the borders of Chad, Cameroon, Nigeria, and Niger, Lake Chad and its basin are an important economic and environmental area for all four countries, providing freshwater for irrigation, arable and grazing lands, and fish stocks. Since the late 1960s, however, the size of the lake has seen dramatic variations, including during the great Sahel droughts of the 1970s and 1980s. Many in political circles are pointing to climate change as the cause of the droughts and lake-level fluctuations, which have had dramatic impacts on the millions of people relying on the lake's waters for their livelihood, in this poorest of regions of the globe. Others blame overuse of water for agriculture within the basin, poor enforcement of environmental legislation, and difficulties with water resources management of this trans-national water system.

In an effort to better understand the changes, Professors Frederi Viens, *Statistics*, Otto Doering, *Agricultural Economics*, undergraduate student researchers Kexin Nie, Mikaela Meyer, and Brain Kidd, along with collaborators Jacques Lemoalle (IRD, Montpellier, France), C.J. Johnston (Marian University), and Molly Brown (University of Maryland) are gathering data and using Bayesian modeling to determine the key factors influencing the hydrology of Lake Chad.

Lake Chad is now understood to have entered a new regime described by hydrologist Lemoalle as "small lake Chad," in which its three sub-pools (North, South, and Archipelago) communicate yearly during the wet season only. The composite satellite photo below shows the maximal water extent for Lake Chad in 2013 and the three sub-pools (blue and black are open water, green is inundated vegetation, dark grey is former lake bed). The team's goal in this next year is to complete the work on what drives the lake's changes and quantify the value of ecosystem services provided by Lake Chad as a function of how much water is in the lake over a hydrological year.

The map on the facing page, reproduced from a 2014 publication by Lemoalle, shows the variety of activities around Lake Chad. One notes in particular that the north pool activities are described as "miscellaneous," because the environment changes so unpredictably. The team will build on Lemoalle's



groundbreaking hydrological study (Lemoalle, J.; Bader, J.-C.; and Leblanc, M. (2011) Modèle hydrologique du Lac Tchad, Hydrological Sciences Journal, 56:3, 411-425), providing validation of key parameters and an evaluation of uncertainty in their hydrologic model. The team has also recently partnered with Purdue anthropologist Professor Jennifer Johnson, an Africanist, to better explore the influence of the historical and current practices in the region.

Preliminary Bayesian analyses over a 40-year period show that the major external factor influencing lake volume is regional rainfall. The analysis also shows that most agricultural activities in the larger Lake Chad basin do not seem to have an adverse influence on the lake's volume, but those activities closest to the lake do, particularly those taking water away from the North pool (e.g. from irrigation projects along the Komadugu Yobe river system in Nigeria's Yobe state, and along the shores of the lake itself in Borno state). It has proven difficult to obtain reliable data on the various factors influencing Lake Chad over the entire Lake Chad Basin given its multi-national geography.

In the summer of 2015, Viens and Johnston, assisted by undergraduate Brian Kidd, traveled to colonial archives in Paris and London (the colonial powers before 1960) to find documentation that the lake level saw great variations in amplitude and number since the first Europeans visited the area in 1823, and to document colonial agricultural activity in the region before 1970. While the team has a good handle on historical documents describing the area's hydrology and agricultural activities qualitatively, they are still looking in France and the UK for production numbers for thirsty crops such as cotton, and for fisheries production, during the colonial period.

PHOTO: From left to right, undergraduate student researchers Brian Kidd, Mikaela Meyer, and Kexin Nie.

Working with geographer Molly Brown to estimate local rainfall values, the team is using the so-called Chirps database, which uses infrared satellite data designed for USAID's Famine Early Warning System, to estimate daily rainfall reliably since 1981. Converting the data into reliable rainfall values for entire states (e.g. Yobe and Borno states in Nigeria) is a non-trivial task, and undergraduate students Kexin Nie and and Mikaela Meyer are working with Purdue GIS specialist Dr. Nicole Kong to generate the data.

Ultimately, the team hopes to be able to understand drivers of changes in the lake and be able to estimate future states of the lake and its resources, based on various climate and agricultural scenarios to better inform policy decisions about Lake Chad.