Assessment, Monitoring, and Modeling of LCLUC and Its Impact on Groundwater Resources, Ecosystems, and Carbon Cycling in Saharan Africa: A Case Study, SW Egypt

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We propose to develop and apply an integrated systems approach (involving remote sensing, geochemical and ecological analyses, and hydrologic modeling) to assess, monitor, and model the recent and future impacts of changes in the landscape and land cover associated with major agricultural development projects in Saharan Africa. Southwest Egypt was chosen as a test site because Egypt's landscape and its climatic and hydrologic settings resemble those in neighboring Saharan countries, where aggressive land use development projects are also under way. Results from this research in Egypt are applicable throughout the arid regions of North Africa and the Middle East.

In Egypt fossil waters are currently being used for irrigation in the Dakhla, Kharga, and Farafra Oases in Egypt, and plans are under way to increase extraction to 2800 x 10^6 m^3/yr, about half of which will be extracted from East Uweinat area in SW Egypt. The construction of the Aswan High Dam in Egypt has resulted in the development of an extensive artificial lake (approximately 500 km long, with an average width of 12 km) behind the dam, as well as four large adjoining lakes that were recently developed in the Western Desert as lake levels peaked. Furthermore, recharge from the lake has raised groundwater tables of the Nubian aquifer in the vicinity of the lake by over 40 m. The Egyptian government has been constructing the Tushka Canal to divert approximately 9 x 10^9 m^3 of Nile River waters currently stored in Lake Nasser to the Western Desert to develop approximately 500,000 acres of new agricultural communities. The Tushka spillway, west of Lake Nasser in the southern Western Desert of Egypt, is currently being used as a natural flood diversion basin to reduce possible downstream damage to the Nile valley by exceptional flooding. Excess Nile River waters from flooding events, now residing in Lake Nasser, will be injected into the Nubian aquifer.

These development projects are affecting the water resources of the underlying groundwater aquifers and the existing freshwater ecosystems, as well as producing new carbon sinks. The availability of water governs not only growth, but also the activity of the microbial community; hence, in an extreme desert environment, water (in conjunction with temperature) is the limiting factor controlling the accumulation and cycling of carbon. The following are the objectives of the proposed work:

- Monitor the changes of land use and land cover in SW Egypt since the erection of the Aswan High Dam.
- Assess the hydrologic effects of the LCLUC in SW Egypt on the Nubian aquifer water level and water quality.
- Identify and quantify carbon sinks in arid lands, and develop methodologies to predict and quantify future carbon sinks in these areas as new agricultural lands are developed.
- Identify procedures by which carbon sequestration could be increased in desert areas being developed into agricultural communities.

We will apply an integrated systems approach to address these objectives. Temporal Landsat TM and MSS data, together with DTED, will be used to monitor the LCLUC. To estimate recharge

from Lake Nasser and from the recently developed adjoining lakes, changes in the area occupied by the lakes will be estimated by using the DTED data with TM-based areal distribution information. We will use SIR-C data to map faults at depth and to test the hypothesis that the faults that control the lake tributaries extend at depth under the sedimentary cover and act as channels along which groundwater flows from the lake. Isotopic data and solute chemistry will be measured for groundwater in the area to constrain its origin and evolution (e.g., evaporative losses, mixing proportions). To estimate the amounts of carbon being sequestered in the newly developed lands in SW Egypt, we will measure the expansion of agricultural lands with time. This information, together with the amounts of carbon sequestered in surface and subsurface sources, will be used to constrain the amounts of carbon being sequestered in the new agricultural communities as they develop. Inferences made from field, remote sensing, geochemical, isotopic, and soil investigations will be used as inputs to groundwater flow models and carbon cycle models.