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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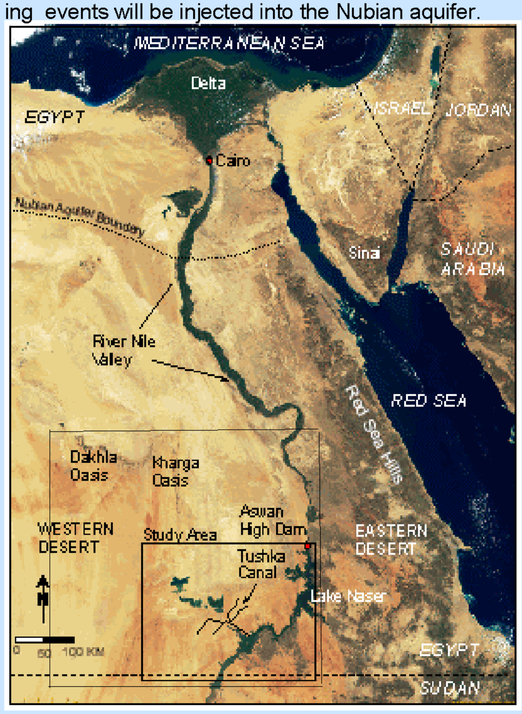
BACKGROUND

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 106 m^3/yr, about half of which will be extracted from East Uweinat area. The construction of Aswan High Dam led to 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, as lake levels peaked. Recharge from the lake raised groundwater tables of the Nubian aquifer in the vicinity of the lake by over 40 m. The Tushka Canal currently under construction will divert approximately 9 x 109 m^3 of Nile River waters to develop approximately 500,000 acres of new agricultural communities. The Tushka spillway is currently being used as a natural flood diversion basin. Excess Nile River waters from flooding events will be injected into the Nubian aquifer.



Moderate resolution imaging spectroradiometer (MODIS) satellite image acquired on February 19, 2000, showing the general physiographic features of Egypt.

OBJECTIVES

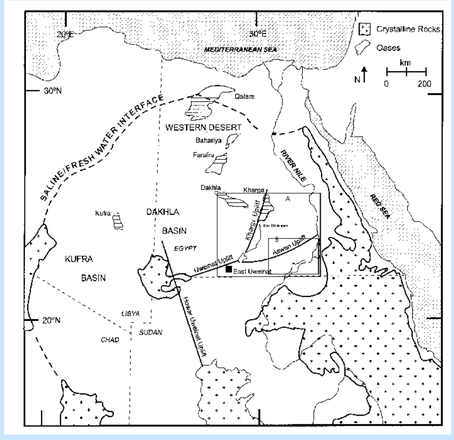
We will develop and apply an integrated system approach (remote sensing, geochemical and ecological analyses, and hydrologic modeling) to assess, monitor, and model the recent and future impacts of changes in the landscape and land cover associated with major agricultural development projects in Saharan Africa. SW 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. We will accomplish the following:

· Monitor the changes of land use and land cover in SW Egypt since the erection of the Aswan High Dam.

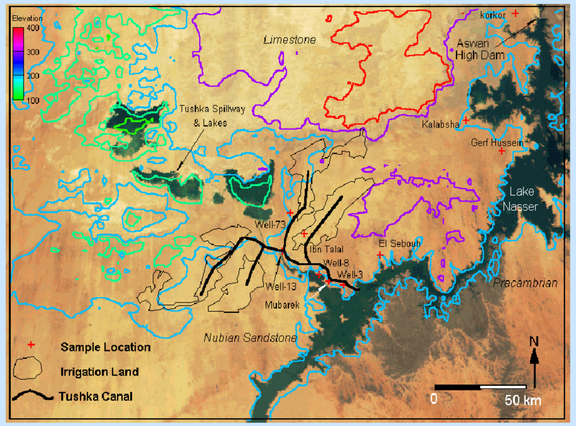
· Assess the hydrologic effects of the LCLUC in SW Egypt on the Nubian aquifer water level and water quality.

· 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.

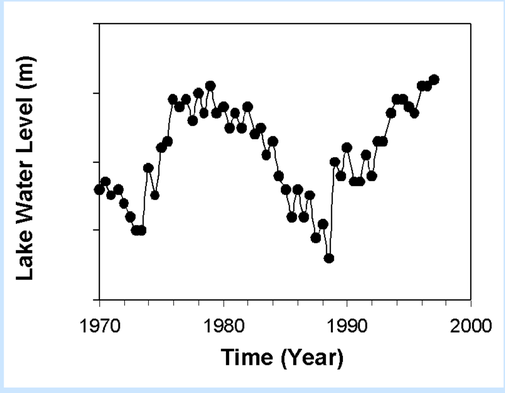
· Identify procedures by which carbon sequestration could be increased in desert areas being developed into agricultural communities.



Distribution of the Nubian Aquifer in Egypt, Sudan, Libya, and Chad.



MODIS satellite image showing the Tushka Canal, the lakes to the west of Lake Nasser formed due to the current high lake level, and the areas that will be cultivated.



After construction of the Aswan High Dam (1964), surface water level rose from 121 m to 178 m in 1978. Subsequently, the lake level fluctuated (158 m - 182 m), reflecting the intensity of the Nile inflows. In the early 1980s, the lake declined, reaching its lowest level (158 m) in 1987, but the level started to rise again in the early 1990s, reaching 182 m by 1997. This caused the Lake waters to overflow the Tushka spillway and created four lakes.

Tushka Canal, under construction (summer 2001)

Irrigation using Nubian aquifer water

Lake Nasser

USE OF REMOTE SENSING DATA TO MONITOR LCLUC

(1) Mapping fluctuations in the areal extent of Lake Nasser
(2) Mapping fluctuations in the areal extent of the Tushka spillway and lakes
(3) Mapping the expansion of agricultural communities and areas of similar soil and vegetation communities
(4) Mapping faults at depth from SIR-C imagery

METHODOLOGY

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.