Annual Progress Report

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Project Title: Introducing Remotely Sensed Irrigation Information into the USDA FAS Decision Support System

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Abstract

This project aims to develop high-resolution, seasonal, and up-to-date information on irrigation extent and acreage from NASA Earth Science observations to enhance USDA Foreign Agriculture Service (FAS) Decision Support System. The primary goal of FAS is to improve foreign market access to U.S. agricultural products by providing accurate global crop production, supply, and demand estimates that are of primary national importance. To improve these estimates the Office of Global Analysis (OGA) unit of FAS now requires the capability to rapidly separate and delineate irrigated and dryland agriculture every crop season. The ability to accurately identify and estimate irrigated agriculture is especially important for countries where irrigated agriculture plays a dominant role because yields on irrigated lands can be nearly twice or more than those on dryland farmed areas. Moreover, a remote sensing based methodology that assesses irrigation capacity in a season for large regions of a country such as Iraq with a large US involvement is critical to assessing the success of development projects and the capacity of Iraq to support itself. However, national- (and occasionally) subnational-level information on irrigated acreage is not routinely available and even if available, this information often tends to be flawed, outdated or simply not useful in seasonal crop production estimates. The primary objective of this project is to fill this gap in Iraq, identified by FAS as an important priority area, using NASA Earth Science measurements and research results.

FAS has identified Iraq as a priority location where irrigation information from remotely sensed data sources would be immediately and most beneficial. Iraq has a rich farming heritage and agriculture is the second largest contributor to the country's GDP. Approximately, seventy percent of the country's cultivated area is irrigated and predominantly located in the central and southern regions. The remaining cultivated area in the northern region of the "fertile crescent" is mostly rainfed with crop yield being highly dependent upon the timing and amount of seasonal precipitation and temperature. During times of drought, the country relies on irrigation to supplement the reduced crop production expected in rainfed areas. In addition, a large part of the population depends on the irrigation for watering livestock and for domestic use.

During the former regime, Iraq's irrigation infrastructure had fallen into disrepair due to a lack of canal maintenance, intermittent power supply for pumping stations, and soil salinity problems. Several development agencies have implemented irrigation projects such as the USAID funded Agricultural Reconstruction and Development Program for Iraq (ARDI) to repair, improve, and extend the current infrastructure. Development projects such as ARDI highly affect crop production and; therefore, the food supply and economic vitality of the nation.

keywords: irrigation, water management, Middle East, MODIS, Google Earth

Scientific and Application Questions

The core of this research addresses several key NASA Applied Sciences Program questions. In particular, the proposed research:

- seeks to directly integrate NASA Earth science research results into USDA-FAS decision support system for applications of national priority by providing accurate and timely information on the location and extent of irrigated croplands in each of the nine mandate areas;
- aims to improve a DSS specifically developed to disseminate global crop production related information broadly across the nation for a large national benefit;
- contributes directly to NASA's Agricultural Efficiency applications area;
- addresses methods to estimate global extent and acreage of irrigation through remotely sensed observations that are also applicable to future NASA and/or commercial missions/sensors;
- uses tested and proven methods to identify irrigated croplands;
- specifically integrates commercial remote sensing and geospatial information with NASA Earth Science measurements to improve a DSS; and
- builds on NASA's investments in remote sensing, and is designed to further understanding of the global crop production and food security.

Goals

The main goal of this study is to create an accurate map of current irrigated areas in Iraq at multiple spatial resolutions (AWiFS & MODIS-250m scale). Once the current extent of irrigation in Iraq is established using remotely sensed data and checked against ancillary sources, steps will then be taken to:

- distinguish how and where the extent of irrigated agriculture is differentiated from the extent of all agriculture in Iraq.
- locate areas of significantly *in*creased irrigated agriculture during the study period (2003 through present).
- locate areas of significantly *de*creased irrigated agriculture during the study period (2003 through present).
- produce not just a map of current irrigated areas in Iraq, but also a map of irrigation change in Iraq over the last decade or so.

Narrative on Project Progress

Multiple approaches to classifying irrigated areas in Iraq have been tested and compared. Supervised and unsupervised classifications have been tested as well as hybrid versions thereof. Input data has been finely tuned to include the most relevant spectral and temporal information for the classifier. Different selection methods for training data have also been tested for best results. We have determined that for the purposes of this project, with this type of land-cover (irrigation), the following methods work best:

- Ancillary Masking
    - Due to ephemeral/seasonal water bodies in the region, a water mask was employed.
    - FOA and USDA Irrigation data was used to guide us to areas highly likely to be irrigated.

        - For example, according to FAO data, Babil province should have the highest percentage of land cover constituted with irrigated lands (40.12%).
    - Mountainous regions which receive more precipitation and therefore more natural vegetation can confuse the classifier. In this case, DEM data is used to mask out areas with high slope.
- Input bands for Classifier
    - Suitable Vegetation Index
        - Green index (NIR/Green), when available, is used because it provides the largest differential in reflectance between irrigated lands and non-irrigated vegetated lands.
        - NDVI ((NIR — VIS)/(NIR + VIS)) is used when NIR is not possible due to missing bands on a particular sensor.
    - Temporal Bands
        - Because irrigation is often a temporal phenomenon (irrigated lands are green when being irrigated, whereas non-irrigated lands are not), as
        - many relevant, value-adding temporal bands as possible are used.

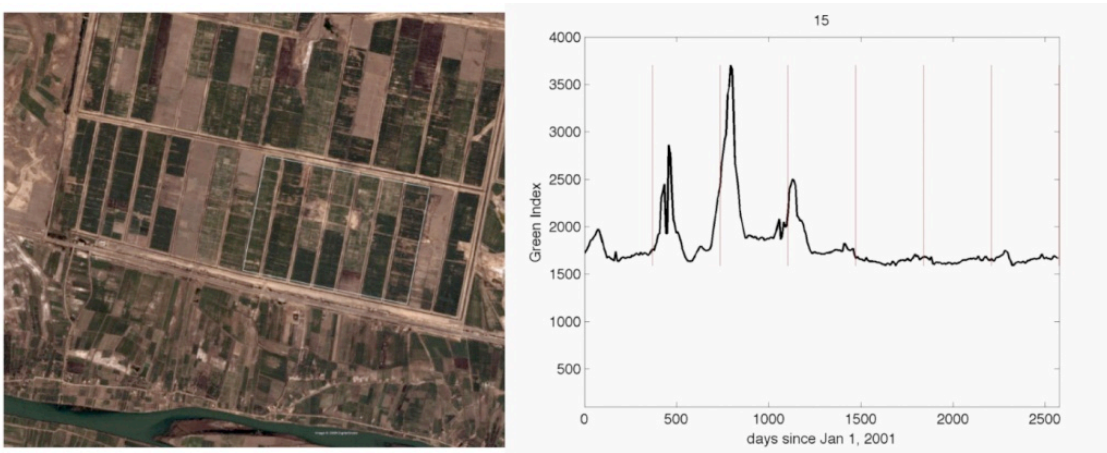

Figure 1. The procedure for selection of training data using IKONOS imagery in Google Earth (left) and refinement of training data using 250-meter MODIS NDVI temporal profiles (right). In this particlar case these fields have declined productivity following the invasion as revealed by reduced (or complete disappearance of) seasonality after 2004 in the form of changes in remotely sensed greenness.

- Identification of training data (polygons)
    - IKONOS imagery through Google Earth Pro was used to identify prime training data examples.
    - Training data location temporal profiles were checked to bolster the assumption being made based on the single-date IKONOS image.
- Further Refinement of training data (4-cell points)
    - Due to bias of availability of IKONOS imagery, the original polygons were complimented with hundreds of randomly generated training points
- Classification

- Classification trees
  - The original training data set was used for a decision tree classification.
- Unsupervised Classification for Refinement of Training Data
  - A K-means classification was performed to determine what types of land cover could be confusing the classifier.
  - Once land cover types that were confusing the classifier were identified, a new set of land cover classes was generated.
  - Finally, a random sample of training data was labeled according to the new land cover class for input back into the classification tree.

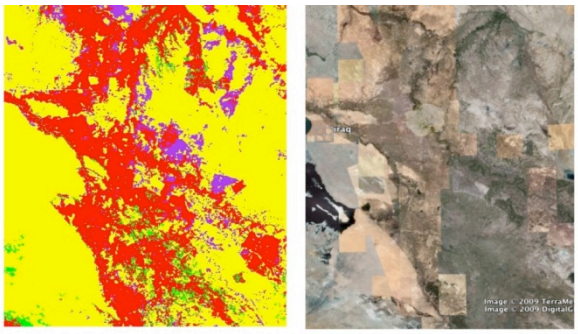

Figure 2. [left] Decision tree classification results of an area southwest of Baghdad. Red color depicts irrigated areas that have not been affected by the recent event while the purple color represents the agricultural areas with declined productivity. The yellow areas are not cultivated. The figure on the right shows the location of the area in Google Earth.

Next Steps

At this stage the input data for the classifier is still being fine-tuned. Different temporal slices have been tested for their effect on the accuracy of the classification. Soon a final list of inputs will be determined based on the value added by each band. Additionally, because the region has such incredible diversity in land cover (and therefore spectral signatures), additional and supplemental training data may be explored before the parameters for the final product are determined. Once the input data and training data samples have been fine-tuned and the parameters for the final product are determined, we will produce all products listed in the goals:

- Map of irrigated areas in Iraq at both MODIS 250-meter scale and AWiFS scale.
- Map of change in irrigated areas since 2003, including the following classes (and potentially others):
  - Non-irrigated agriculture
  - Unchanged irrigated agriculture
  - Abandoned irrigated agriculture
  - Increased irrigated agriculture
  - All other land cover
- Area estimates for all land cover classes will also be determined.

Conclusions

The Mapping Irrigation in Iraq project is proceeding on schedule. Through the use of high spatial resolution imagery and high temporal resolution imagery from MODIS, a new method for locating and mapping irrigated lands in Iraq has been developed. We found that a hybrid approach to both the selection of training data (using both targeted areas as well as a random sample) and the refinement of the classifier (using an unsupervised classification to locate land cover classes that could be confusing the decision tree) improves accuracy of the final product.