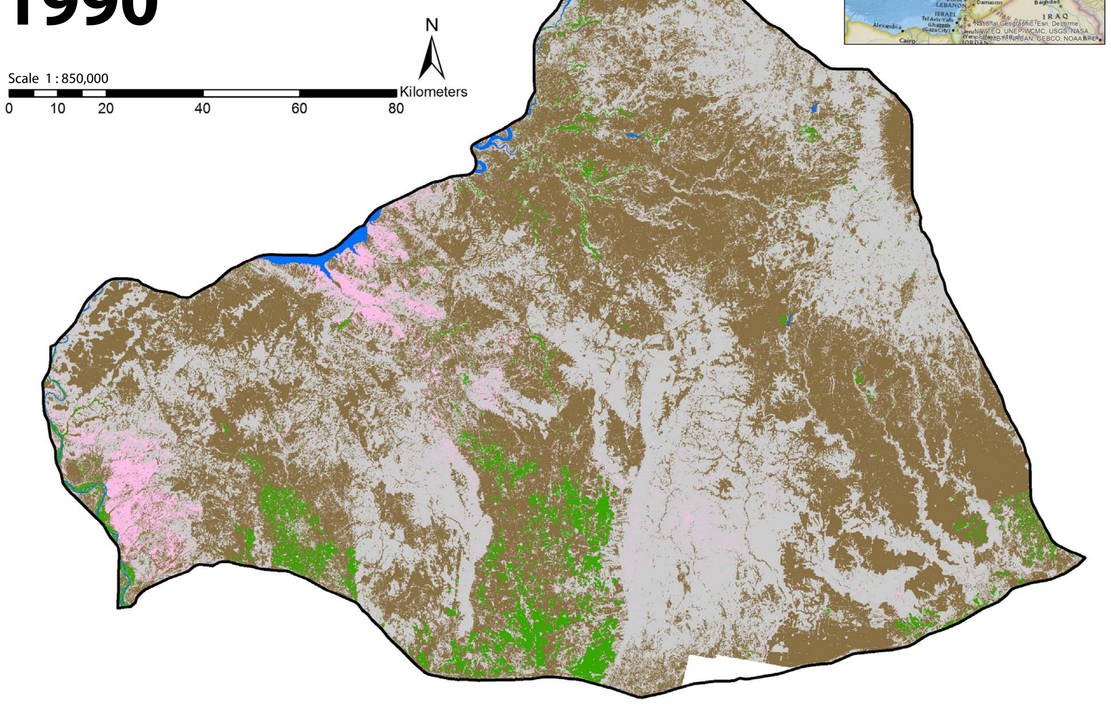
Changing Agriculture:

How the Ataturk Dam Impacted Sanliurfa's Agricultural Production

Ground Cover: Sanliurfa Province, Turkey

1990



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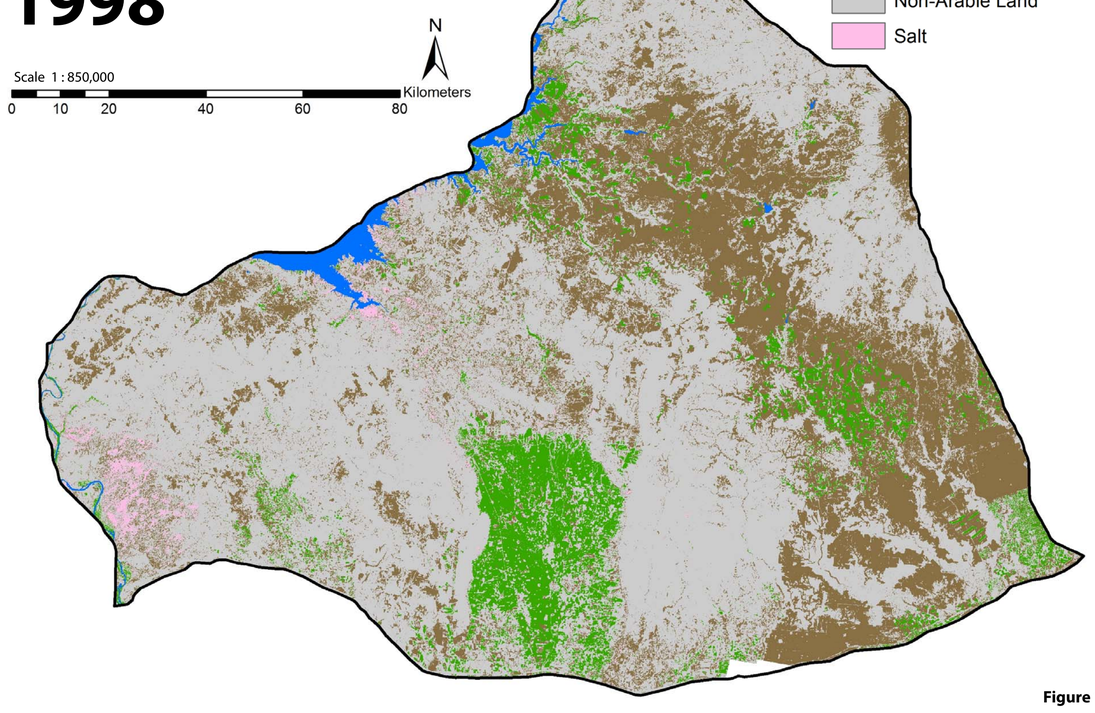

Figure 1.

Background

The Ataturk Dam is the centerpiece of the Southeastern Anatolia Project, a massive public works program that extends across 9 provinces and includes the construction of 22 dams and 19 hydro-electric stations on the Tigris and Euphrates Rivers.[1] The government of the Republic of Turkey has spent $32 billion on this project, which aims to increase domestic energy production, boost agricultural productivity, and resolve the economic imbalance in the southeastern provinces of Turkey.

Once the Ataturk Dam began operating in 1992, the man-made 48.7 km^3 reservoir provided a steady flow of water to irrigate hundreds of thousands of hectares of cropland in neighboring provinces, like Sanliurfa, via massive underground tunnels.

Typically, irrigated crops like cotton are more profitable for small farmers, many of whom began replacing their non-irrigated wheat fields with irrigated cash crops. As a result, the region faces an intensifying risk of food insecurity.[2]

This project uses satellite imagery and Turkish Agricultural Census data to measure the impact that the Ataturk Dam has had on agricultural production in southeastern Turkey. Using the province of Sanliurfa as an example, these maps demonstrate how rapidly the landscape has changed over a relatively short period of time.

Methods

These maps were constructed from high resolution imagery taken by the USGS Landsat 7 satellite. Images from comparable dates in September, when cotton is nearing harvest in Turkey, were selected with the Global Visualization Viewer. The years 1990 and 1998 represent a relatively short passage of time before and after the opening of the Ataturk Dam and the satellite captured high-quality photographs in September of these years.

Landsat 7 Thematic Mapper captures seven distinct wavelengths of visible and infrared light as they reflect off the earth's surface.[3] After compiling the different bands into a single raster image, two adjacent rasters from each time period were 'mosaicked' together.

After masking the assembled raster images to the border of the Sanliurfa province, it was apparent that several pixels were missing data. This slight deficiency was disregarded due to the limited scope of the project, and the excessive resources that would have been required to download and mosaic the missing segment of the Landsat imagery.

Next, each year's derived raster underwent several experimental IsoClusters and Maximum Likelihood Classifications. After much trial and error, the rasters were digitally organized into 25 classes according to similarities across the seven bandwidths. The classifications were manually compared with the false-color RGB composites for accuracy and then painstakingly reclassified into five general categories:

<u>Water</u>
The Euphrates River, irrigation channels, reservoirs, etc.
<u>Agricultural Vegetation</u>
Green cropland, ready to be harvested
<u>Non-Vegetative Cropland</u>
Inactive farmland or fields growing non-irrigated crops on a different cycle
<u>Non-Arable Land</u>
Rock, mountain, pavement, buildings, towns, etc.
<u>Salt</u>
Salt accumulates as a result of the river's natural flood/drought cycle.

The maps in Figure 1 represent a static picture of ground cover before and after the completion of the dam. To observe change over time, the 1998 map was reclassified again to a specific numerical system. The Raster Calculator multiplied the new map with the 1990 map and created 25 new classifications, shown in the table to the right.

The final map (Figure 2) required another reclassification, grouping together the pixels that didn't change between 1990 and 1998 and grouping the rest according to their 'changed' status in 1998. Because each pixel measures 30m x 30m, calculating the total area of each 'class' simply requires multiplying the quantity of pixels by 900 and then dividing by 1,000,000 to get a result in km^2.

Initial Observations

The significant change in ground cover over an eight-year span is immediately evident when comparing the maps in Figure 1. The eye instantly notices the loss of brown, non-vegetative cropland and the materialization of a distinct patch of green in the southern portion of the province. The almost rectangular green patch is the Harran Plain and it is the primary area irrigated by the twin Sanliurfa Tunnels that use gravity-flow to deliver water from Lake Ataturk.[4] Only one of the tunnels had opened by 1998, so it is possible to imagine that the area would contain even more agricultural vegetation today.

The expanding blue area in the north is also easily discernible. The Euphrates River flows southwest along the northern border of the province and the Ataturk Dam is located just below the point where the water begins to accumulate. Half of Lake Ataturk is situated in Sanliurfa while the rest of the 817km^2 reservoir extends northward into the province of Adiyaman.

The salt patches, visible in pink in Figure 1, are the result of the natural seasonal flood/drought cycle of the Euphrates.[5] Because the dam regulates the flow of the river, the banks no longer overflow and the salt patches have either been flooded (in the north) or replaced with agricultural land or impervious cover (in the southwest corner of the province) as indicated in the 1998 map and the chart below.

1990 Land Cover Status \ All measurements in km^2	1998 Land Cover Status: Water	Agricultural Vegetation	Non-Vegetative Cropland	Non-Arable Land	Salt	Total
Water	93	4	2	1	<1	100
Agricultural Vegetation	14	351	94	270	<1	729
Non-Vegetative Cropland	53	1,021	4,377	3,870	8	9,329
Non-Arable Land	57	189	1,001	7,579	16	8,842
Salt	51	1	57	287	124	520
Total	268	1566	5531	12007	148	19,520

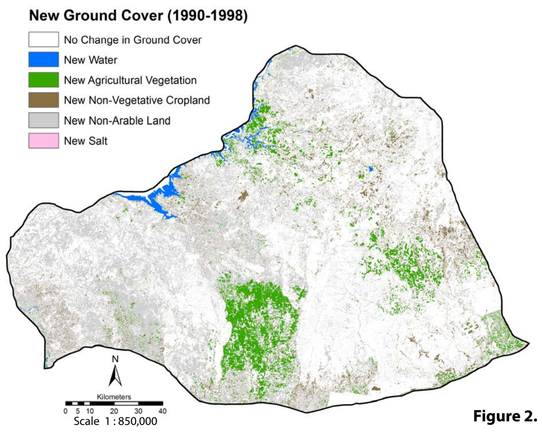

Figure 2.

Change in Crop Yield By Province

Cotton 1991-1998, Wheat 1991-1998

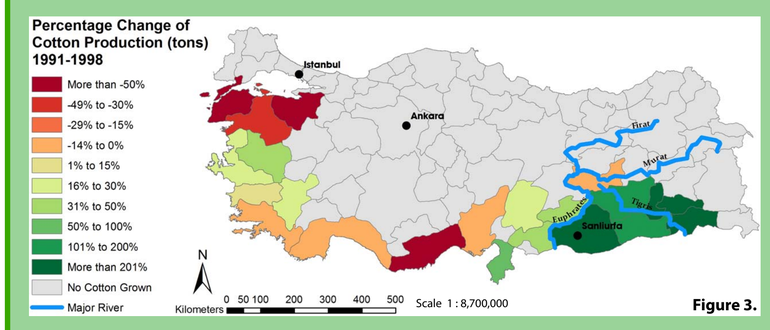

Figure 3.

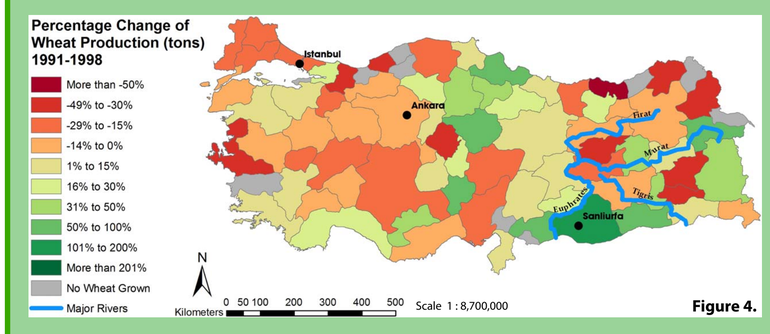

Figure 4.

It is difficult to use Landsat images to precisely differentiate between crops, but the Turkish Agricultural Census records annual crop production and organizes the data into different levels beginning in 1991. Figures 3 and 4 demonstrate the change over seven years in national crop production according to province where production is measured in tons.

Wheat and cotton were studied to observe if farmers were replacing staple foodcrops with cash-crops in response to the increasing availability of irrigation. Increasing cash-crop production changes the economic and social climate by encouraging larger monoculture operations and non-subsistence farming practices.

Data from the Agricultural Census was reformatted and joined to the geocoded vector shapefiles. Percentage change was calculated by the formula:

$$\frac{(\text{Production}_{1998} - \text{Production}_{1991})}{\text{Production}_{1991}} \times 100$$

Classes were then selected to best demonstrate changing trends and the color scheme imported from ColorBrewer was modified to emphasize the difference between positive and negative change. Provinces that did not grow the specified crop in both years were classified and coded separately as "no data." Major rivers and significant cities were selected from larger ESRI data sets to provide visual context.

Comparative Analysis & Conclusions

This project's objective was not simply to visualize the changing landscape, but also to quantify the impact. In the table above, the shaded boxes indicate land that was left unchanged by the construction of the dam. The remaining boxes, which total 6,996km^2, reveal how 36% of Sanliurfa's landscape changed in just eight years.

The total amount of agricultural land (vegetative and non-vegetative) declined by 2,961km^2, but the boxes highlighted in red show 1,210km^2 of agricultural vegetation was added. As a result, vegetative agricultural land makes up a much higher proportion of the total agricultural land in 1998.

In short, less total land is being cultivated, but in September—when irrigated crops like cotton are ready for harvest—more of it is vegetative.

This result is corroborated by the results of the crop yield analysis in Figures 3 and 4, on the left. Figure 3 indicates that a very clear increase in cotton production occurred in provinces where the Southeastern Anatolia Project improved irrigation from the Tigris and Euphrates Rivers.

Simultaneously, cotton production decreased in most other provinces, signifying a geographic shift in the country's cotton production.

The USDA Foreign Agricultural Service notes that the region experienced a 50% increase in land used for cotton production between 1994 and 2001. Over the same time period, the southeast region went from producing 25% of the country's cotton to producing half of the whole country's supply.[6]

With a large rural population that relies on subsistence farming, almost every Turkish province grows wheat. Again, the southeastern provinces outstripped the growth of the rest of the country's wheat production, but not to the same extent that it did with cotton.

Between 1991 and 1998, six provinces (all in the southeast) more than doubled their cotton production. Sirnak produced 18 times the amount of cotton it produced just seven years earlier! Meanwhile, Sanliurfa was the only province that saw more than a 100% increase in wheat production.

While this study cannot conclude that farmers replaced their wheat fields with cotton, the data shows that the increase in the production of cash-crops is outpacing the increase in the production of food-crops.

The map in Figure 2 accentuates the increasing concentration of agricultural land in Sanliurfa and supports the hypothesis that larger, commercial-scale agriculture is replacing a fragmented subsistence farming system.

Limitations

As explained previously, an area of ~83km^2 is missing from the final mosaicked rasters. As a result, the final data for Sanliurfa is partially incomplete.

The IsoCluster reclassification, though highly accurate for most of the province, misclassified a substantial number of pixels along the northeast border of the province. In 1990 and 1998 the non-vegetative cropland area appears to be mountainous and rocky in the false-color RGB photos. Because it repeated the error in both maps, this should not have greatly impacted the data in the comparative analysis.

The process of reclassifying into the five general categories was somewhat subjective because the reclassification the process was done manually. The classification system also failed to distinguish between man-made impervious cover (urbanization) and 'natural' non-arable land (rock). The IsoCluster would likely be unable to distinguish the difference if the man-made structures were made out of material cut from the 'natural' non-arable terrain.

A more detailed analysis and larger-scale project would benefit from a closer examination of other crops and an expansion of scale into neighboring provinces.

1. Republic of Turkey Ministry of Development Southeastern Anatolia Project Regional Development Administration. www.gap.gov.tr
2. Mustafa Yilmaz, "The Effects and Impacts of the Southeastern Anatolian Development Project." State University of New York at Binghamton, (2012).
3. For more information see "FAQ about Landsat Missions," www.landsat.usgs.gov/band_combination_browse_images.php
4. NASA Visible Earth: Ataturk Dam (2003). www.visibleearth.nasa.gov/view.php?id=3796
5. Dogan Altinbilek, "Development and Management of the Euphrates-Tigris Basin." *International Journal of Water Resources Development*. vol. 20, no. 1 (2004).
6. FAS online, "Southeastern Anatolia Becomes a Major Cotton Producing Region for Turkey," (2001). www.fas.usda.gov/pecad2/highlights/2001/08/turkey_gap/pictures/turkey_gap.htm

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Projection: WGS 1984 UTM Zone 37S

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