Remote Sensing and Spy Satellites:

An Analysis of Traditional Water Management Systems and Desertification in Southern Moroccan Oases

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Introduction

This project is an archaeological and historical analysis of desertification in Southern Morocco, using remote sensing to map the water management systems in the region. A comparison of the effect of diesel pumps, reservoirs, and khettaras (an ancient underground irrigation system) will be made.

Aims

Our research project had three clear aims:

- Digitise our area of interest so we can train the computer to differentiate urban areas, vegetation, water management systems, and desertification.
- Compare contemporary images with HEXAGON images and historic French maps to see how desertification has increased, and how landscapes have changed over the past 70 years.
- Read scholarship so we can theorise how we can combine traditional water management systems with modern technologies to create a sustainable solution.

How our project addresses the Sustainable Development Goals

Goal 6: Clean Water and Sanitation

This project aims to map and identify khettaras, which sustainably supply farmland in Southern Morocco. Data comparisons will be made with cropland unsustainably irrigated by diesel pumps and reservoirs to suggest a revitalisation of ancient water management systems with modern technology.

Goal 15: Life on Land

The findings of this project hopes to combat desertification in Southern Morocco by proposing alternate sustainable solutions (such as co-management, renewal of of generational interest, investment in modern conservational technologies, of khettara) that prevent cropland degradation.

Digitising Contemporary Southern Morocco

Manually digitising surface features using points, polygons, and lines on Google Earth Pro identifies areas with traditional water management systems (canals, khettaras) and contemporary land categories (cropland, tree cover, relict field systems, etc.) (see Figure 1).

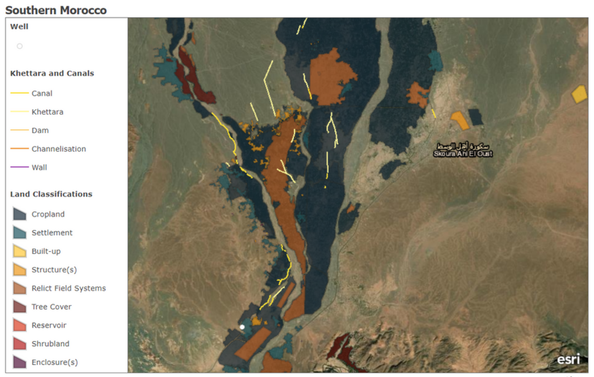


Figure 1

Training an Algorithim

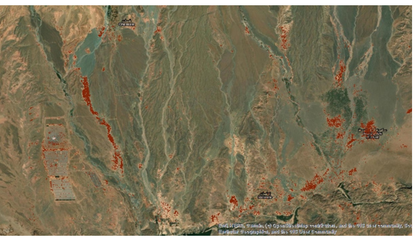


Figure 2

Figure 2 is the output of a machine learning algorithm designed to detect traces of former areas of cultivation in now-desertified land, based on trends in pixel values. The algorithm was trained on and applied to Sentinel-1 and -2 data and derived products from 2021.

Creating a Normalised Difference Vegetation Index (NDVI)

Creating an NDVI compares the values between the near-Infrared and the red bands in a satellite image; vegetation reflects more NIR and absorbs more red, so it is highlighted in an NDVI. Figure 3 shows all areas of vegetations in the Ouarzazate region from 2016-2022.

Figure 3

Figure 4 shows the NDVI overlaying the historic HEXAGON images in the lower Ghassate region. The cropland in the centre is productive, but on the peripheries, highlighted by the yellow polygons, we can see the remains of relict field systems on the 2018 satellite image.

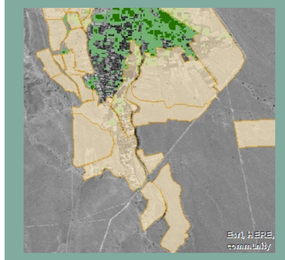


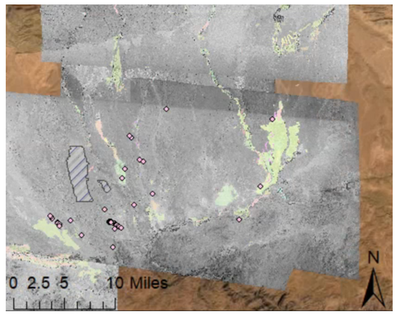
Figure 4

In the 1971 HEXAGON image, we see the land is bare soil, meaning that the field systems have been created, abandoned, and desertified in the last 50 years.

This is the case for much of Southern Morocco: overzealous farmers create new cropland, but with decreasing water availability due to droughts caused by climate change, and the use of private wells with diesel pumps, which rapidly decreases the groundwater table- the fields dry out within a few years.

Comparing and Analysing Historic Spy Satellite Imagery with Modern Maps

The black and white background images are from HEXAGON (1971-1982); the coloured polygons are representative of Google Earth 2022 satellite images (see Figure 5).



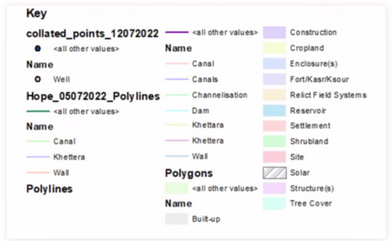
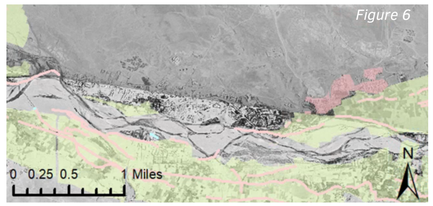


Figure 5

Settlement Retraction



It is possible that at the closing of the century, Saharan Africa's population will quadruple [1]. Estimates show that by 2050, there will have been a migration, partly induced by climate change, of 450 million people from rural to urban areas.

This may be a reason why this **settlement has retracted** since the 70's (see Figure 6).

Changing Cropland

The Medieval Climate Anomaly (MCA) may account for any desertification that was present in the 1971 HEXAGON imagery that modern climate change is not accountable for. Figure 7 shows that the **cropland has expanded into desertified areas**.

The MCA was hypothesised from studies that analysed surface moisture levels and dendrochronological data which suggested that North Western Africa was dry in the Medieval Period [2].

This may have caused higher rates of evaporation and evapotranspiration that will have dried up cropland for farming [3].

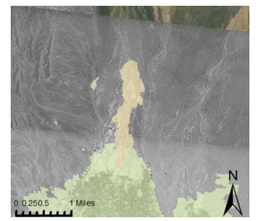
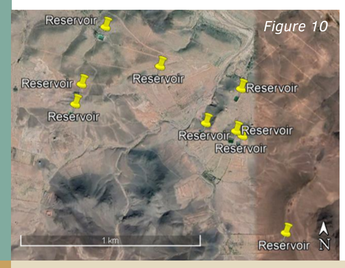


Figure 7



Figures 8 and 9 shows HEXAGON images where cropland is absent in the 1970s.

Since these cropland areas are new, they will not be fed by khettaras, they will be fed by diesel pumps and reservoirs. See Figure 10 to see the abundance of these reservoirs

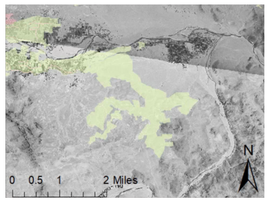


Figure 8

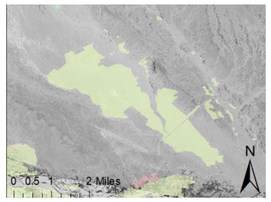


Figure 9

What does the Evidence Show?

This study has revealed that recent cropland expansion has been due to the increase of diesel pumps and reservoirs. This means that the farmland in Southern Morocco is unsustainably managed. This is because along with drought, the building of large dams and diesel pumps causes water tables to fall due to the over extraction of water [4].

Many farmers in this region are dissatisfied with leadership groups that run the water management systems and are suffering due to the underfunding of oases from the government [5]. This could be combatted by allowing for co-operative farmer-owned khettaras to ease over-exploitation of the water tables and result in the return to sustainable water management systems [6].

Scan QR Code for our StoryMap!

Scan QR Code for References

Acknowledgements

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