

Using Crop Phenology to Assess Changes in Cultivated Land after the Anfal Genocide in Iraqi Kurdistan

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Abstract

The Anfal genocide campaign, carried out by the Iraqi government against the Kurdish population in 1988, has been reported to have severe consequences for agriculture and food security by causing large scale land abandonment.

This study uses Landsat satellite data to detect agricultural changes that can be attributed to the Anfal genocide. Cultivated land were distinguished from other land cover types by focusing on crop phenology.

Initial results show a strong decrease in cultivated land in the years after the genocide, especially in the areas that were targeted by the genocide campaign.

Keywords: Agriculture, Crop phenology, Genocide, Iraqi Kurdistan, NDVI

1 Introduction

During the early 1980s, the northern Kurdish governorates accounted for between 25 and 30% of the total Iraqi food production [1]. The Anfal genocide campaign, carried out as a series of attacks on the Kurdish areas in 1988, included bombings of villages, destruction of agricultural land, and displacement from villages [2, 4]. This caused a drastic change from a mainly rural to an urban population.

Effects of conflicts on land have been studied satellite images and geographic analyses (cf. Kuemmerle *et. al* [5] and Gibson *et. al* [6]). Mubareka and Ehrlich [3] focused on land use changes in Anfal affected areas and found that agricultural land in the Sulaymaniah governorate had decreased, but not in the Duhok governorate. This, however, contradicts other reports of the Anfal effects on agriculture in Kurdistan [2-4], which motivates further analysis

This paper aims at quantifying the loss of agricultural land in connection to the Anfal genocide in the Duhok governorate, by using multi-temporal high resolution satellite imagery.

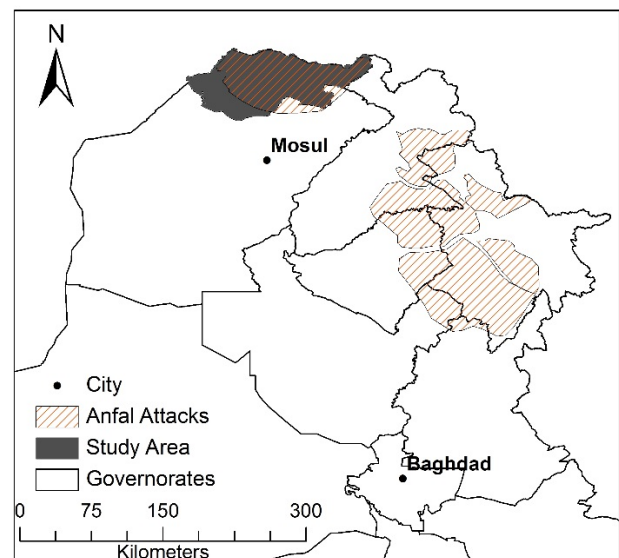
2 Data and Methods

Study Area

The Duhok governorate belongs to the Kurdistan Region, which is a semi-autonomous region situated in northern Iraq (figure 1).

In the plains, the main agriculture is cereal production, such as barley and wheat, which is harvested in June. In the mountain areas, orchards with fruit, nuts and almonds are common.

Figure 1: The study area location in northern Iraq and the Anfal genocide attack.



Data

This assessment uses data from two periods: pre-Anfal and post-Anfal (table 1). Seventeen surface reflectance images recorded by the Landsat 4 and 5 Thematic Mapper (TM) satellites were used. In addition to satellite data, digitized spatial data of the Anfal affected areas, and basic geographic data of administrative borders and cities were used for analysis and visualization.

Table 1: Julian dates for the land surface reflectance images.

PRE-ANFAL					
1984		1986		1987	
Spr.	Sum.	Spr.	Sum.	Spr.	Sum.
158		115		22	198
		163		150	246
POST-ANFAL					
1989		1990		1991	
Spr.	Sum.	Spr.	Sum.	Spr.	Sum.
35	195	86	190	129	
	211	134	238		
	243		254		

Methods

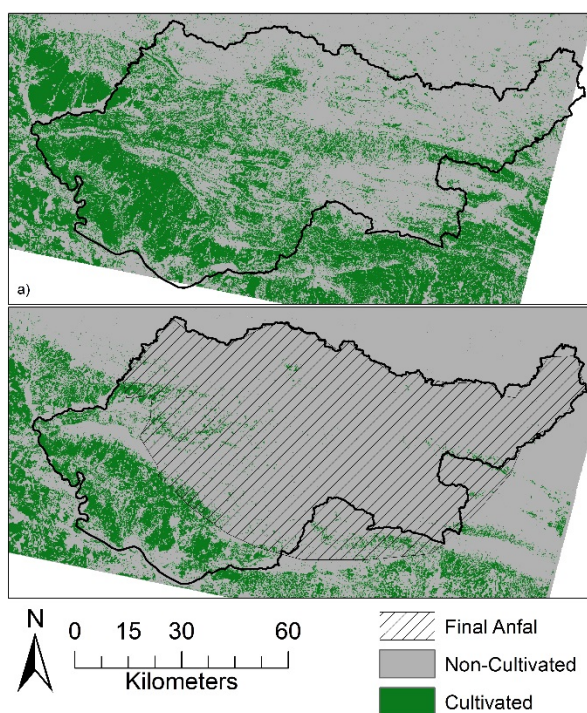
Crop Phenology is based on the different inter-annual variability in greenness of different land covers [6]. Agricultural cropland exhibit a large difference in NDVI between pre- and post-harvest months.

Normalized Difference Vegetation Index (NDVI) were calculated for all images and Maximum value composites (MVC) for pre-harvest and post-harvest periods were calculated for both periods. From the MVC images, ranges were calculated. Pixels with ranges larger than 0.3 indicated harvest and were classified as cultivated land.

3 Results

Much of the cultivated land had decreased in the post-Anfal period, especially in the areas that were targeted by the final Anfal attack (figure 3). Changes are, however, seen in the whole area, even in Turkey in the North West.

Figure 3: Areas in the Duhok governorate classified as cultivated land in the a) pre-Anfal period and b) post-Anfal period.



A decrease of 1438 km² in cultivated land were recorded in the whole governorate, representing 62% of the pre-Anfal cultivated area (table 2). In the Anfal area, cultivated land had decreased from 1283 km² to 150 km², representing a decrease of 88% of the original cultivated area.

Table 2: The change in cultivated land area within the Duhok governorate and the area targeted by Anfal

DUHOK GOVERNORATE				
	Pre Anfal (km ²)	Pre Anfal (%)	Post Anfal (km ²)	Post Anfal (%)
Cultiv.	2311	35	873	13
Other	4251	65	5706	87
Sum	6562	100	6579	100
ANFAL AREA				
	Pre Anfal (km ²)	Pre Anfal (%)	Post Anfal (km ²)	Post Anfal (%)
Cultiv.	1283	26	150	3
Other	3673	74	4815	97
Sum	4956	100	4964	100

4 Discussion

The results indicate a strong decline in cultivated land area after the Anfal attack in 1988, when many people were killed and forcibly moved, and about 4000 villages were destroyed [3]. Before Anfal, the Duhok governorate was a mainly rural area where livelihoods were largely based on agriculture [2]. The displacement of people during and after the Anfal attacks, together with the destruction of villages and lands, led to a decrease of more than 60% in cultivated areas. The change was especially severe in the mountain areas that were exposed to the attacks.

Several reports state that the Anfal genocide had negative consequences for agriculture in the Kurdistan Region, but until now it has not been proven quantitatively at province level. Using crop phenology of multi-temporal satellite images is a good alternative for areas and periods where agriculture is small scale and data is scarce.

5 References

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