



# **Verifying Crimes Against Humanity using Satellite Imagery & GIS**

# Online Projects

## **Eyes on Darfur / Eyes on Syria**

Amnesty International

## **Crisis in Darfur**

U.S. Holocaust Museum & Google Earth

## **Geospatial Technologies & Human Rights**

American Association for the  
Advancement of Science

## **Satellite Sentinel Project**

# Studies

## Zimbabwe | Porta Farm

June 2005

The Mugabe government's Operation "Drive Out Trash" demolished 850 buildings in Porta Farm, a poor slum outside of the capital of Harare, which housed political opposition members



June 2002





April 2006



# Studies

## Kyrgyzstan | Osh Region

June 2010

Thousands of people fled due to violent clashes between Kyrgyz and Uzbek rival gangs. Large scale arson and murders occurred in the mainly Uzbek-populated neighborhoods in Osh & Jalal-Abad. Over 1,600 buildings were destroyed.



March 15 2007



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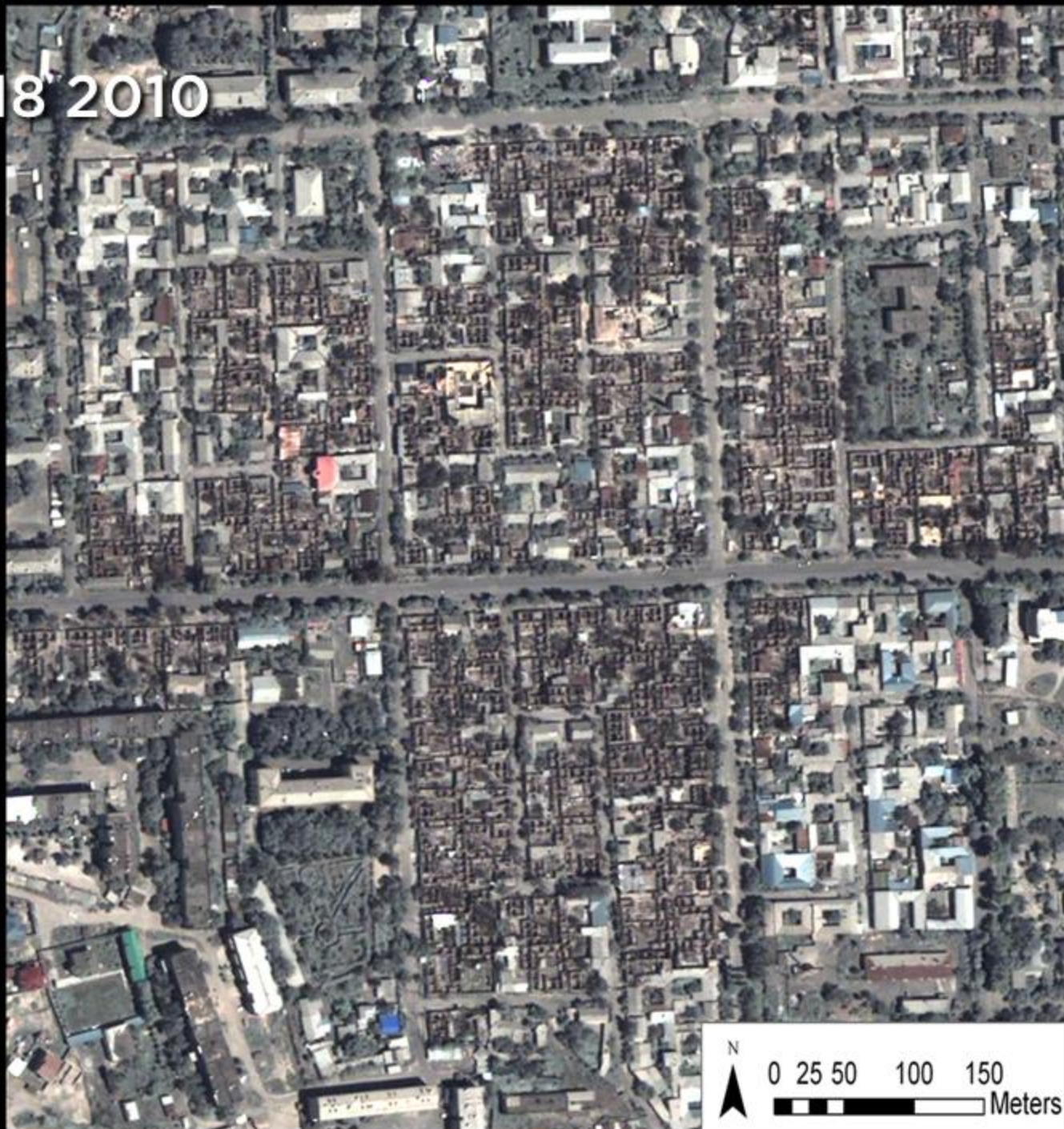
Imagery Date: Mar 15, 2007

lat 40.522250° lon 72.776307° elev 0 ft

Eye alt 2463 ft



June 18 2010





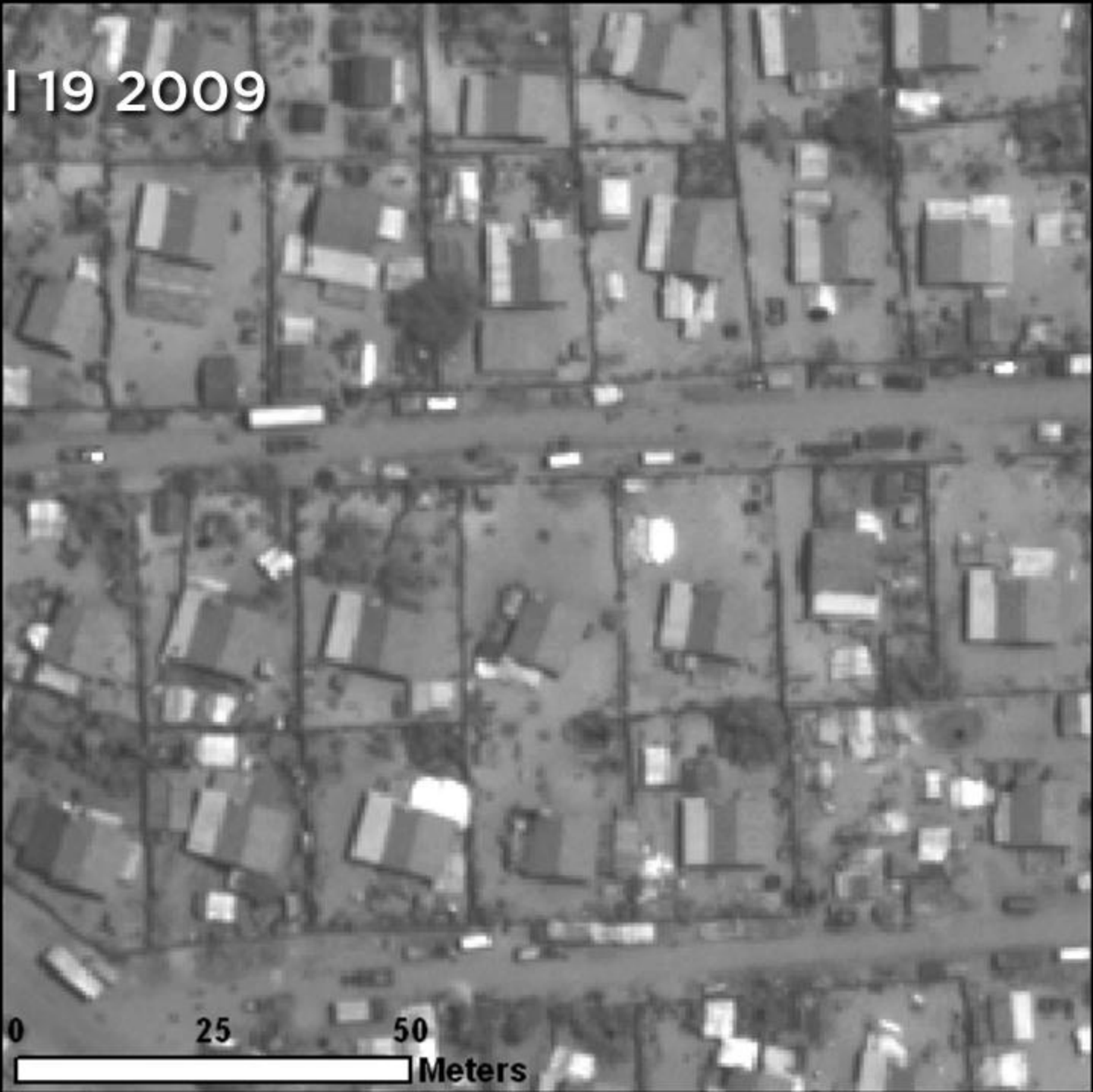
# Studies

## Sri Lanka | Civilian Safety Zone

May 2009

Government shelled a refugee camp in northeast Sri Lanka during an assault on the Tamil Tigers. The camp housed tens of thousands of IDP, and 1,346 graves were found through satellite analysis.

April 19 2009





May 6 2009







# Data

**GeoEye Foundation gives grants for high resolution imagery**

**Commercial satellite imagery is expensive, but getting cheaper**

Cost: \$700 - \$2000 per 100 km<sup>2</sup> in 2008

**Imagery is subject to U.S. restrictions**

The U.S. has exclusive rights to all high res imagery of Afghanistan since 2003, and as of 2008 it is impossible to obtain high res imagery of Israel or Israeli territories (Palestine, Gaza)

# Methodology

## **Sulik & Edwards 2010**

Performed feature extraction methods to identify huts in Sudanese villages. Method had a 67% accuracy rate.

Used a binary Boolean classification to determine huts from other features. An area threshold of 30 meters was used to eliminate features larger than huts, like trees, and then converted to shapefiles.



# Project

## **Gather High Resolution imagery from before and after an attack**

Use Sulik method to determine huts, and compare the before and after data in Arc

## **Verify the satellite data with data collected on the ground**

If the data compared is accurate and matches the eyewitness testimony, this method can be applied to future conflict verification

# Pilot Project

## **Google Earth Historical Imagery**

Obtaining high resolution imagery through GeoEye Foundation was not feasible due to time constraints

## **Identified four villages in Darfur through Amnesty International**

Used Google Earth to find the villages of Sanam el Naga, Donkey Dereis, Saraf Jidad, and Abu Suruj





# Darfur Genocide

The Masalit tribe is one of the three largest non-Arab tribes in Sudan, along with the Fur and Zaghawa. These three tribes formed the Sudan Liberation Army in the early 1990s, a Darfur rebel group which accused the Arab Sudanese government of oppressing the non-Arab tribes and of neglecting the Darfur region in the west. The Sudanese government retaliated with aerial bombing of rebel strongholds and using the Janjaweed, an Arab militia, to attack the tribes on the ground starting around 2003.

Five million Sudanese were affected.



# Pilot Project

## **Selected Donkey Dereis**

Donkey Dereis in South Darfur was the only village that Google Earth had high resolution imagery of from before and after an attack

## **Identified adjacent control village**

Donkey Dereis was completely destroyed, and luckily there was a village 8.25 km to the east that did not appear to be destroyed. This village's huts were used as a control for hut selection

# Pilot Project

## Timeline of Attacks

First attacks were in early 2004, and the final attack occurred in April 2006

## Satellite Data

Satellite imagery downloaded from  
Google Earth:  
December 2003  
October 2006

# Pilot Project

## Georeferenced imagery

### Identified Huts & Buildings

The huts were identified by hand using characteristics such as width (huts are approx. 6 meters in diameter), shape (huts are typically round), and material (huts typically have a thatched roof)

Traveled areas are visible by lighter soil color, so huts with dark soil were omitted



Donkey Dereis

Adjacent Village





# Before Donkey Dereis

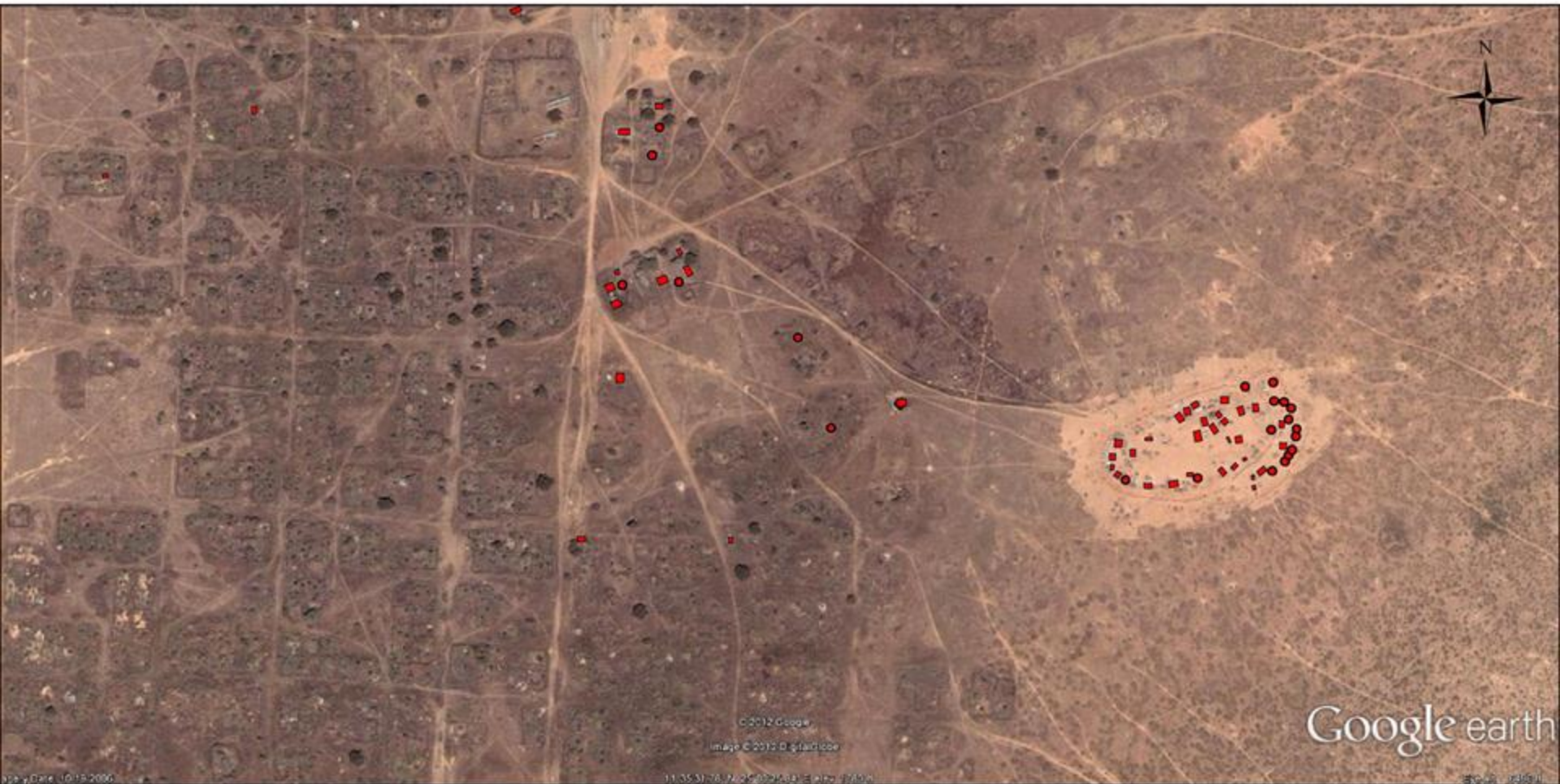


Satellite Source: Google Earth / DigitalGlobe (dated 12/31/2003)  
Hut & Building identification performed by author

0 50 100 200 300 Meters



# After Donkey Dereis



Satellite Source: Google Earth / DigitalGlobe (dated 10/19/2006)  
Hut & Building identification performed by author

0 50 100 200 300 Meters



# Before Adjacent Village



Satellite Source: Google Earth / DigitalGlobe (dated 12/31/2003)  
Hut & Building identification performed by author

0 50 100 200 300 Meters



# After Adjacent Village



Satellite Source: Google Earth / DigitalGlobe (dated 10/19/2006)  
Hut & Building identification performed by author

0 50 100 200 300 Meters





# Results

## **Donkey Dereis      Loss of 97%**

Dec. 2003	881 huts	105 buildings
Oct. 2006	21 huts	45 buildings

## **Adjacent Village      Increase of 9%**

Dec. 2003	250 huts
Oct. 2006	274 huts



# Conclusion

## **First Part of Methodology**

Not able to be determined if accurate due to inability to gather high resolution imagery

## **Second Part of Methodology**

Shown to be accurate and matches Amnesty International's report

# Interesting Discoveries

## **Google Earth imagery**

Could be useful in satellite analysis

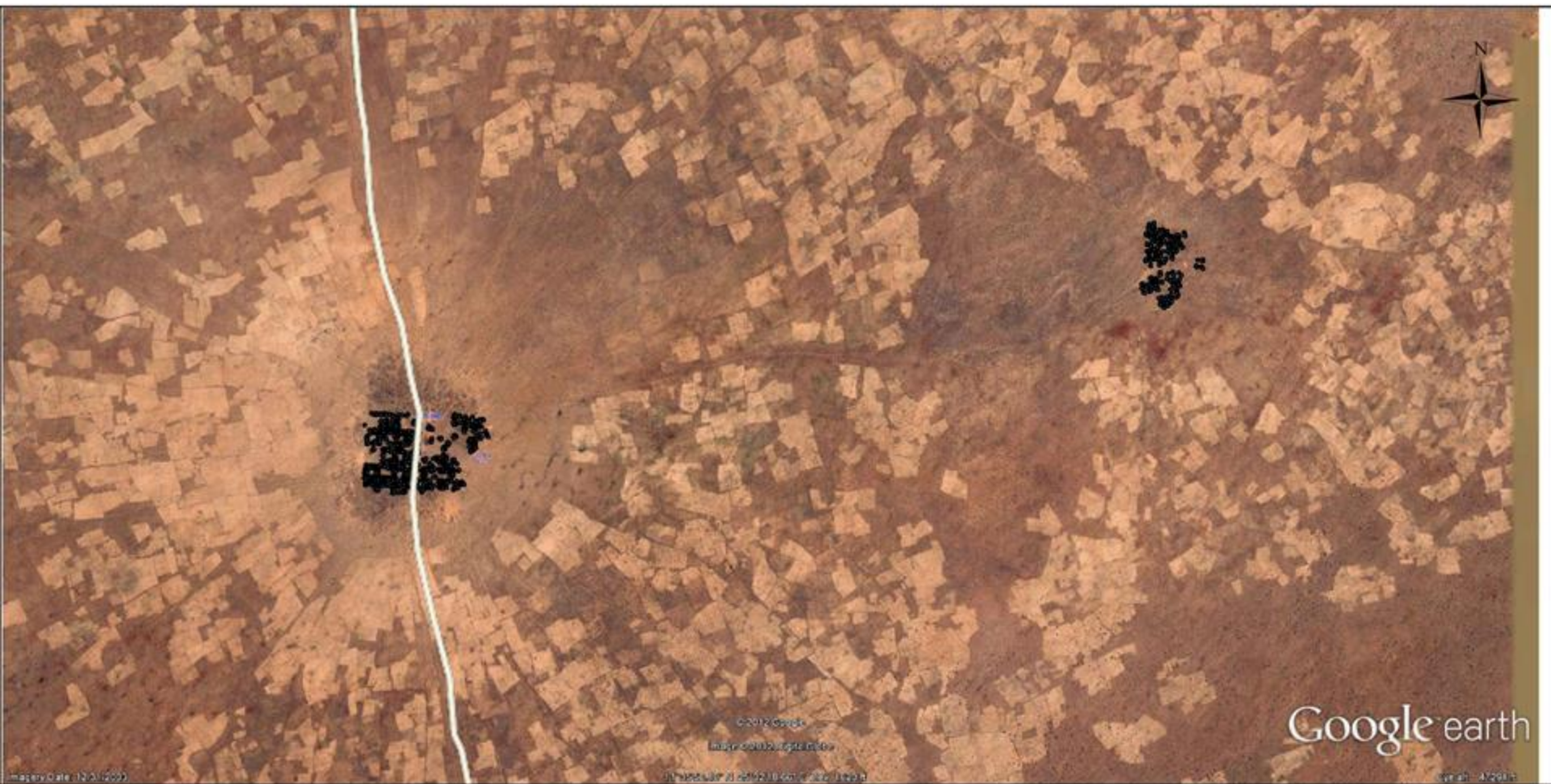
## **Relationship between accessibility and amount of destruction?**

Destruction occurred on main road

## **Agricultural patterns before and after attacks**

Possible use for future studies?

# Before



Satellite Source: Google Earth (dated 12/31/2003), Road Layer: ESRI, Delorme, NAVTEQ & TomTom, 2011  
Hut & Building identification performed by author

0 500 1,000 2,000 3,000 Meters



# After



Satellite Source: Google Earth (dated 10/19/2006), Road Layer: ESRI, Delorme, NAVTEQ & TomTom, 2011  
Hut & Building identification performed by author

0 500 1,000 2,000 3,000 Meters

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