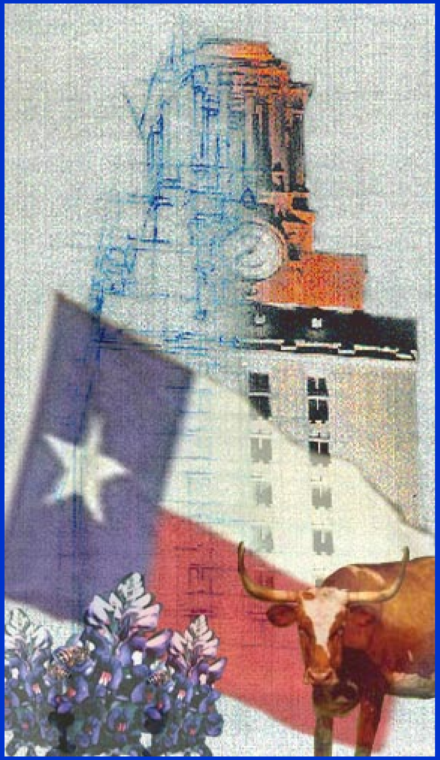
# Comparison of Earthquake Damage Evaluation using Change Detection and Thematic Classification

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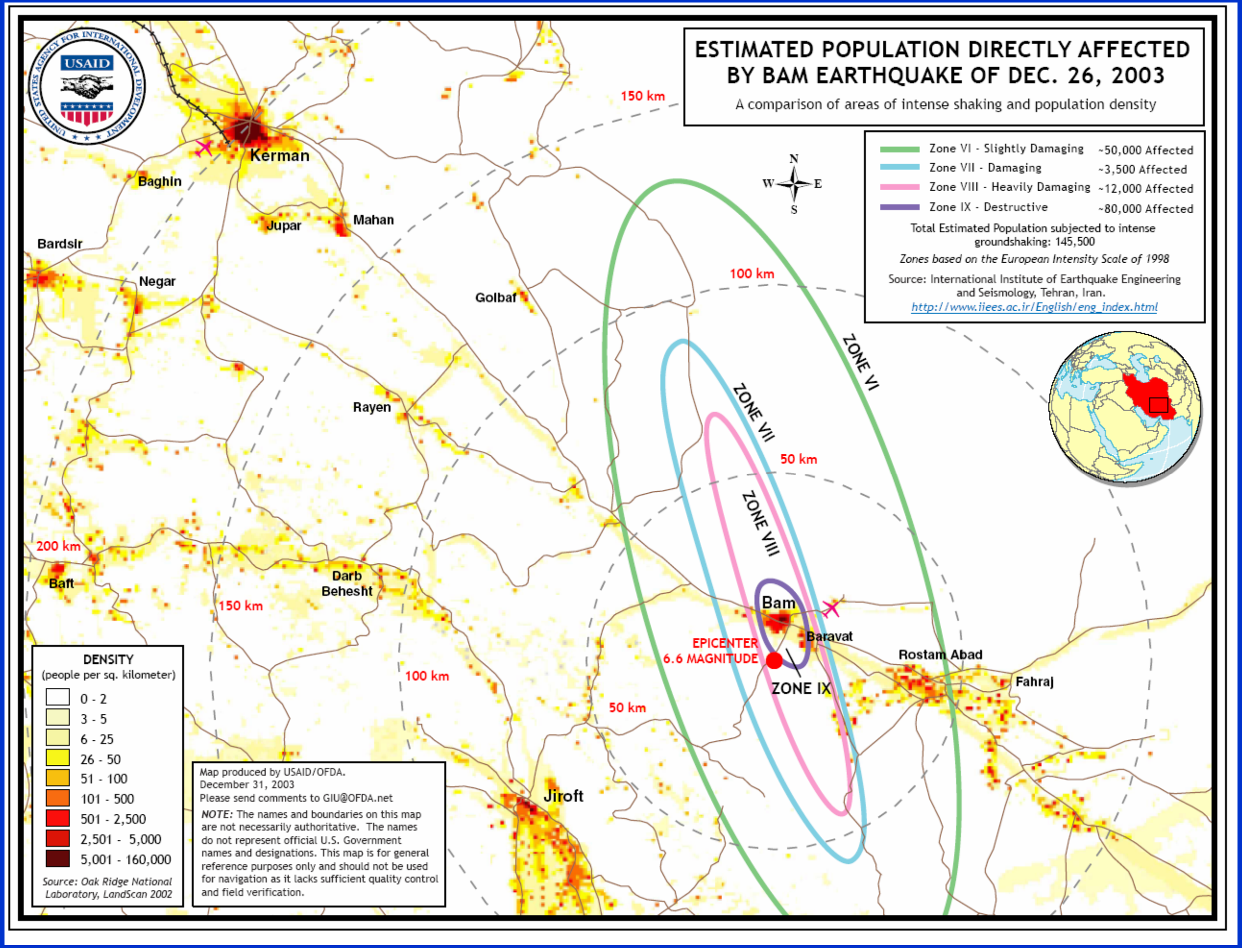
# Damage Detection Analysis

- Optical satellite images can provide critical information regarding earthquake damage
- Methods available to identify damage
  - Change detection (requires pre- and post-earthquake images)
  - Thematic classification (requires only post-earthquake image)
- Application of these methods to 2003 Bam, Iran earthquake
- Comparison of change detection and thematic classification results

# 2003 Bam, Iran Earthquake

## *2003 December 26 $M_w$ 6.6*




- Pre- and post-earthquake Quickbird images

30 Sept 2003

4 Jan 2004

# Change Detection

- Requires pre- and post-earthquake images
- Co-registered pre- and post- earthquake images
- Use image-to-image correlation

$$r = \frac{n\sum PV_a PV_b - \left(\sum PV_a\right)\left(\sum PV_b\right)}{\sqrt{n\sum PV_a{}^2 - \left(\sum PV_a\right)^2} \cdot \sqrt{n\sum PV_b{}^2 - \left(\sum PV_b\right)^2}}$$

$PV_a$ = pixel value in pre-earthquake image

$PV_b$ = pixel value in post-earthquake image

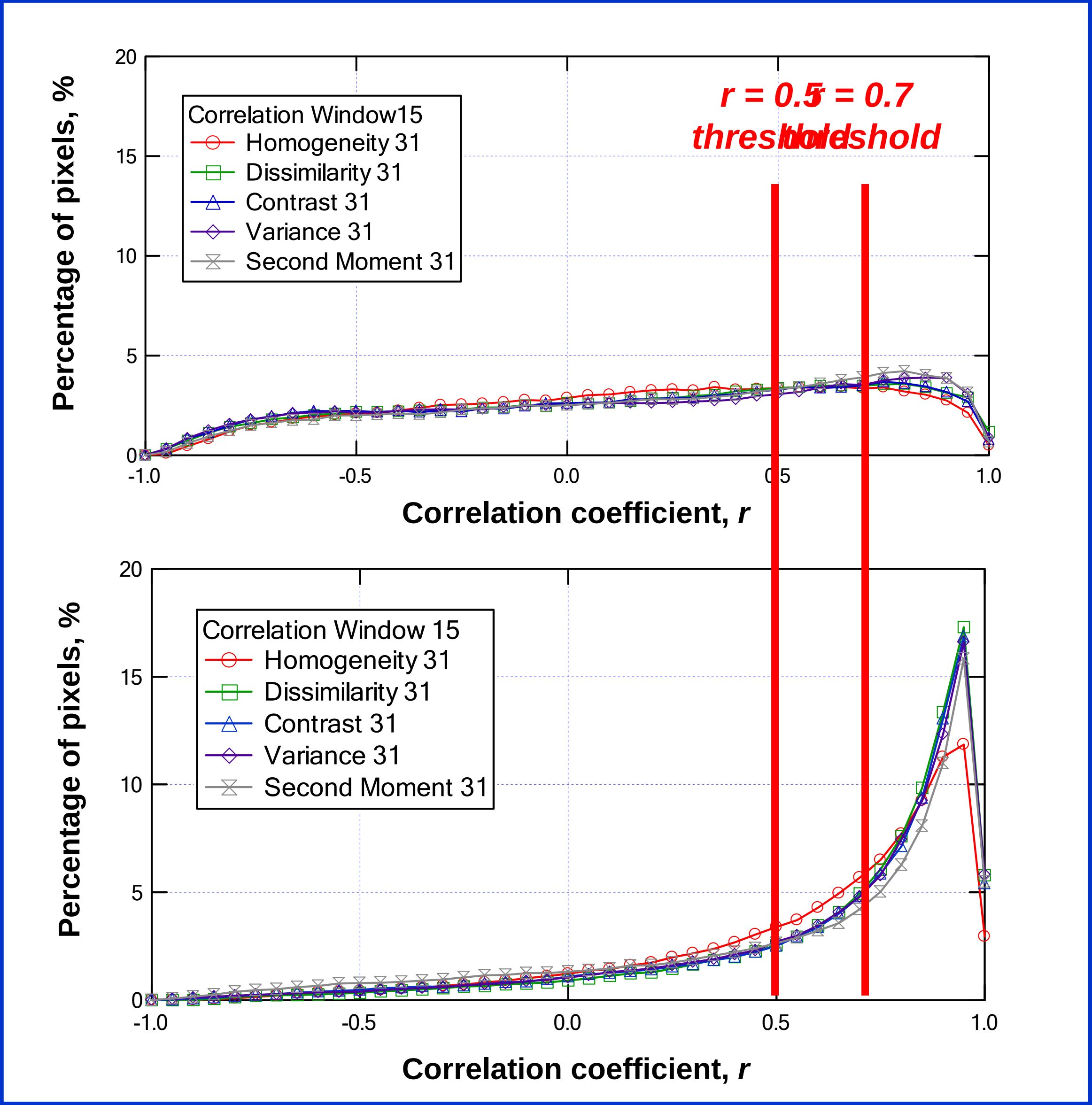
$n$ = number of pixels in correlation window

***15 by 15 pixel (9 m) window used***

# Texture

- Earthquake damage shows changes in texture
- Use texture measures based on the gray-level co-ocurrence matrix (CM)
  - Homogeneity, dissimilarity, contrast
  - Second moment, entropy
  - Mean, variance, correlation
- Considered texture over 31 by 31 pixel window, 15 pixel horizontal shift

# Change in Texture




***Heavily damaged area***

***Undamaged area***

# Results of Change Detection

Using correlation coefficient and VAR31 feature

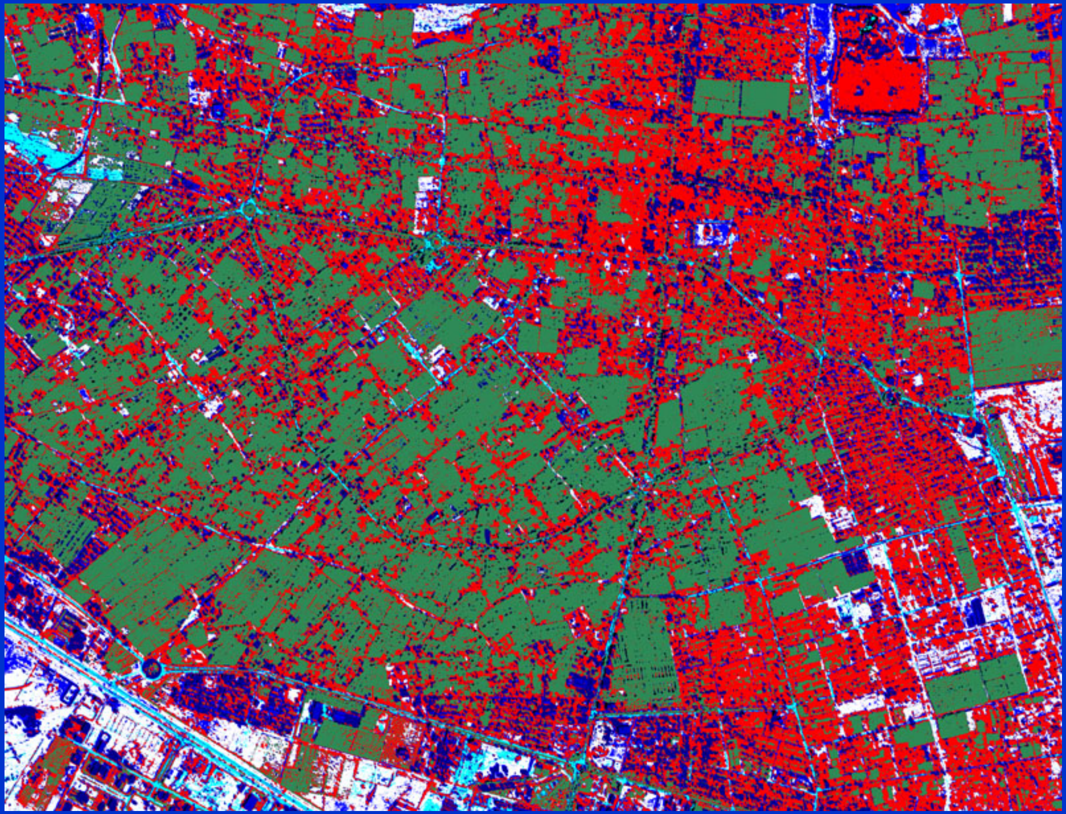
- Red – damage
- Threshold > 0.5
- Vegetation and shadow mask

# Thematic Classification

- Requires only post-earthquake image
- A subset of data associated with “damaged” and “undamaged” areas is identified for training the algorithm.
- Apply  Bayesian pair-wise feature selection algorithm in conjunction with a maximum likelihood classifier

# Results of Thematic Classification

Using maximum-likelihood classification and 14 spectral and textural features selected by feature selection

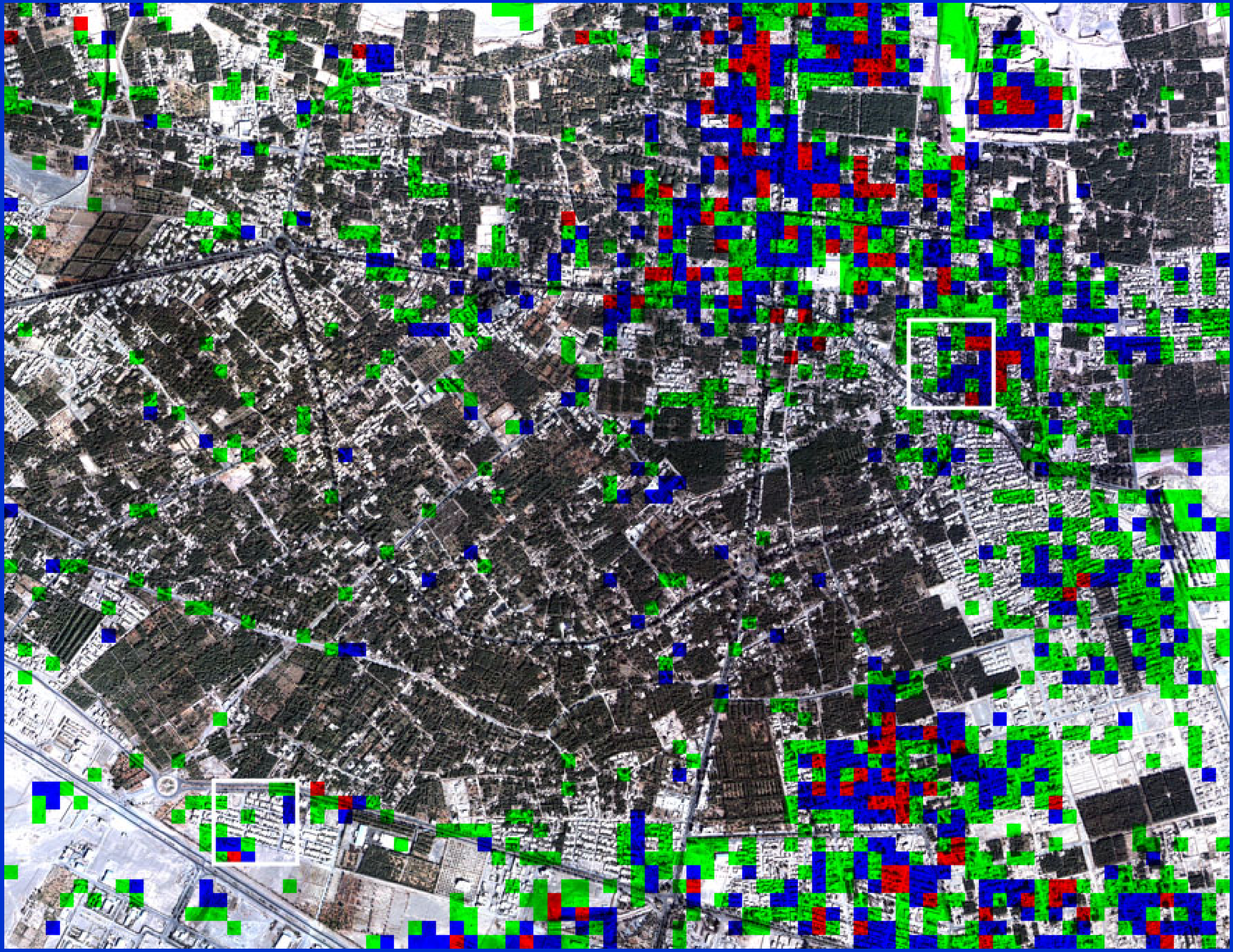


- Red – damage
- Green – vegetation
- Blue – buildings
- White – open areas
- Cyan – roads

# Damage Intensity (DI)

- Defined as percentage of damaged pixels within a 60 m by 60 m (100 pixels by 100 pixels) window
- Only consider pixels that are urban area
  - DIDN'T WE CHANGE THIS??
- Threshold for earthquake damage
  - DI > 40%

# Damage Intensity-CD



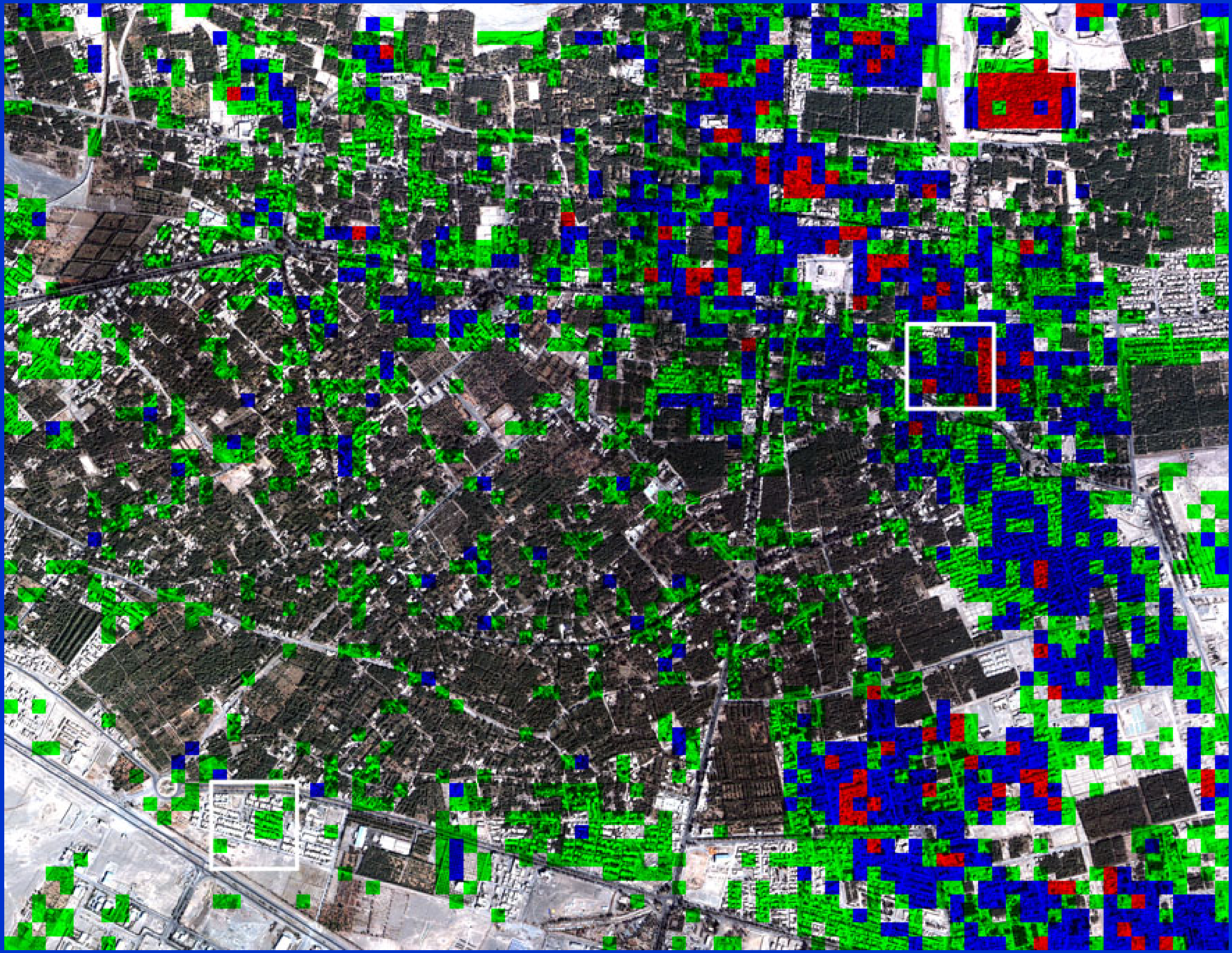
LEGEND

D3
DI = 40-60%

D4
DI = 60-80%

D5
DI = 80-100%

# Damage Intensity-ML



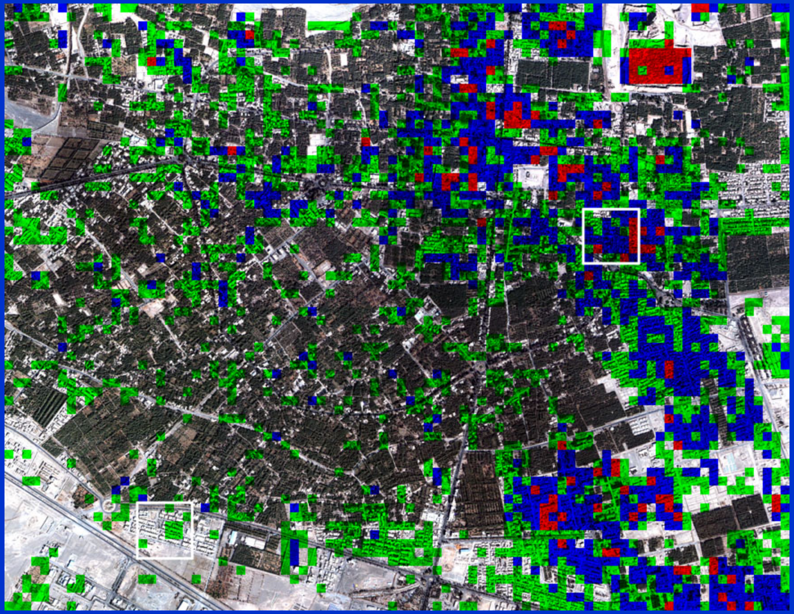
LEGEND

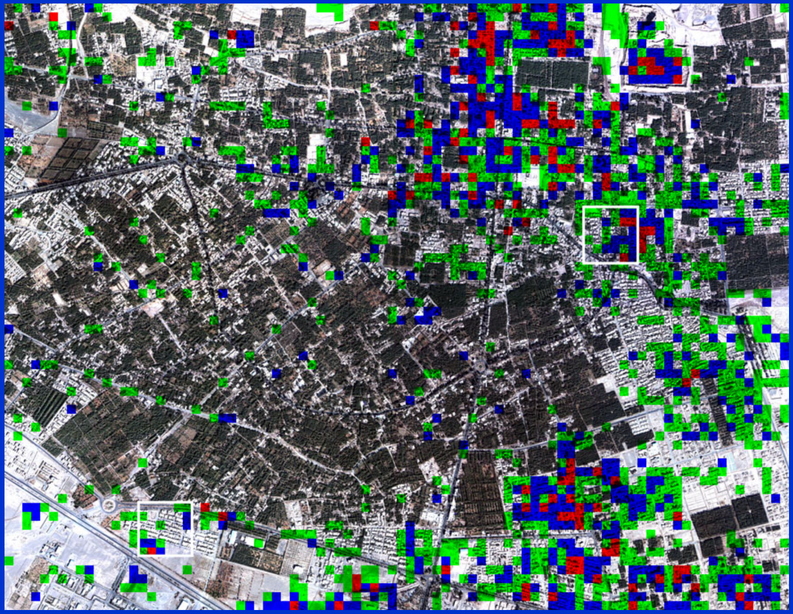
D3
DI = 40-60%

D4
DI = 60-80%

D5
DI = 80-100%

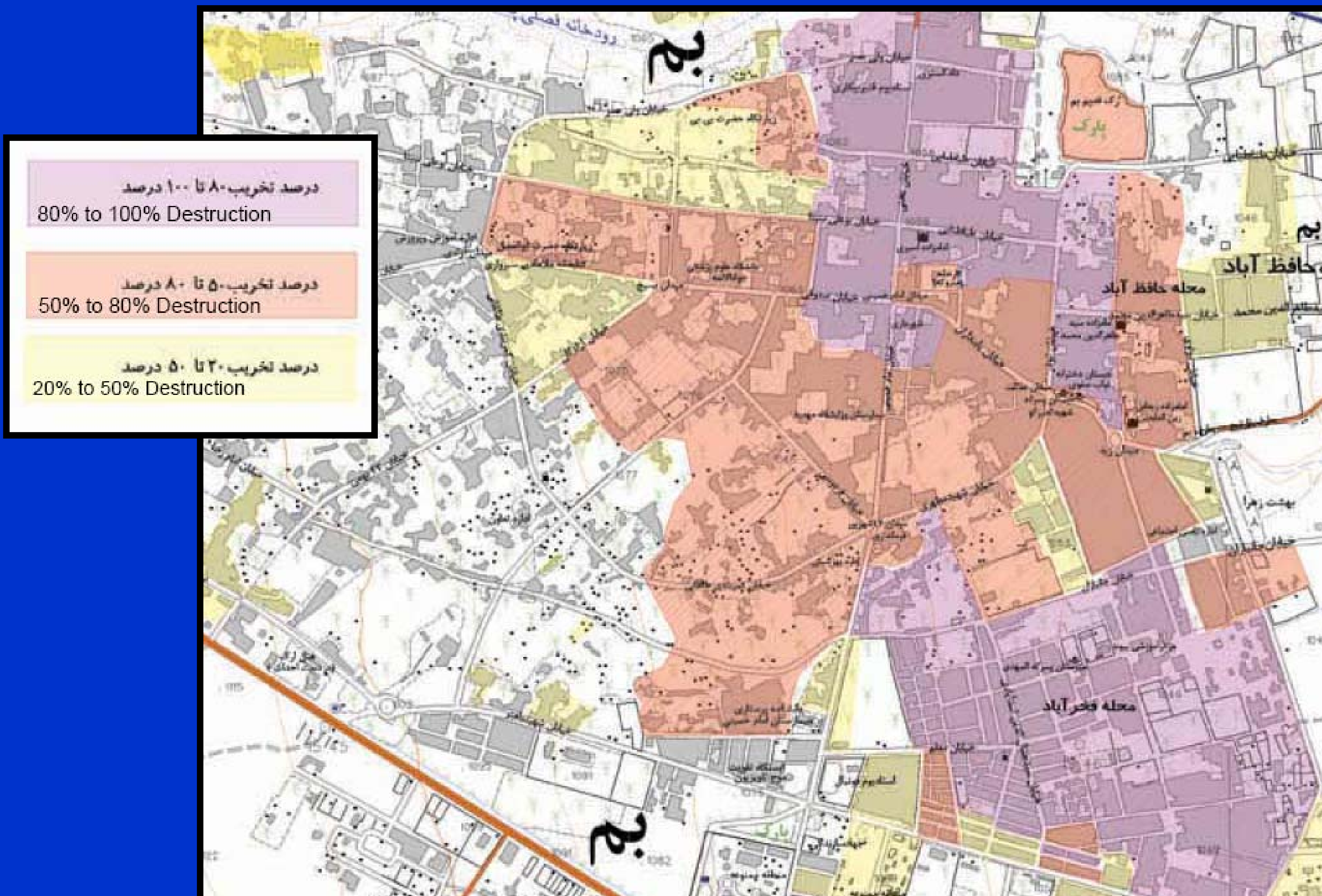
# Damage Intensity



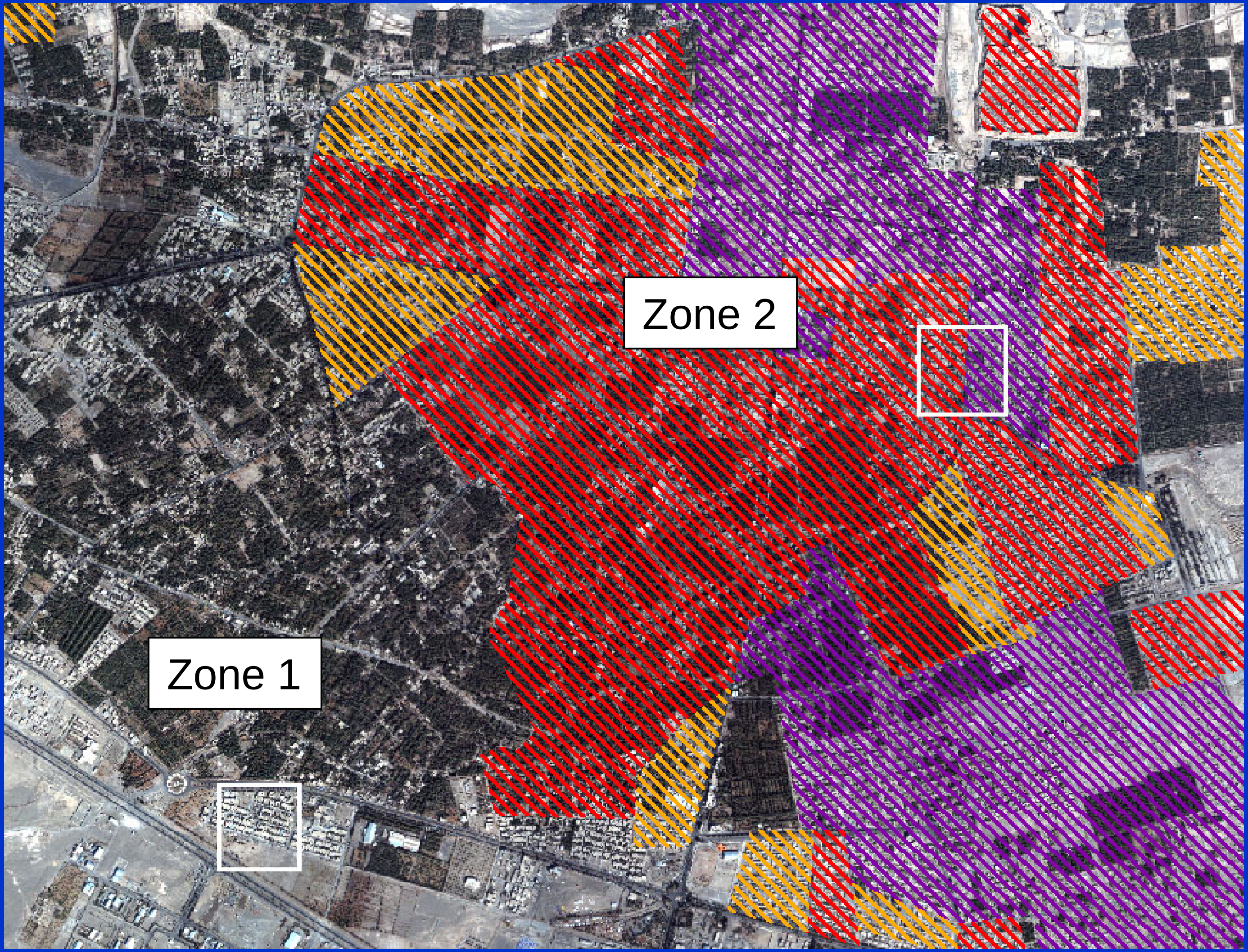


| ML | CD |
|---|---|
| 38% of image DI3-DI5 | 24% of image DI3-DI5 |
| DI3 – 5.16km$^2$ | DI3 – 2.98km$^2$ |
| DI4– 2.63km$^2$ | DI4 – 1.79km$^2$ |
| DI5– 0.44km$^2$ | DI5 – 0.48km$^2$ |

# Field Damage Survey



# Comparison with Field Survey



# Zone 1- Undamaged area

*Pre-earthquake*

*Post-earthquake*

# Comparison of Results

### *ML Classification*

### *Change Detection*

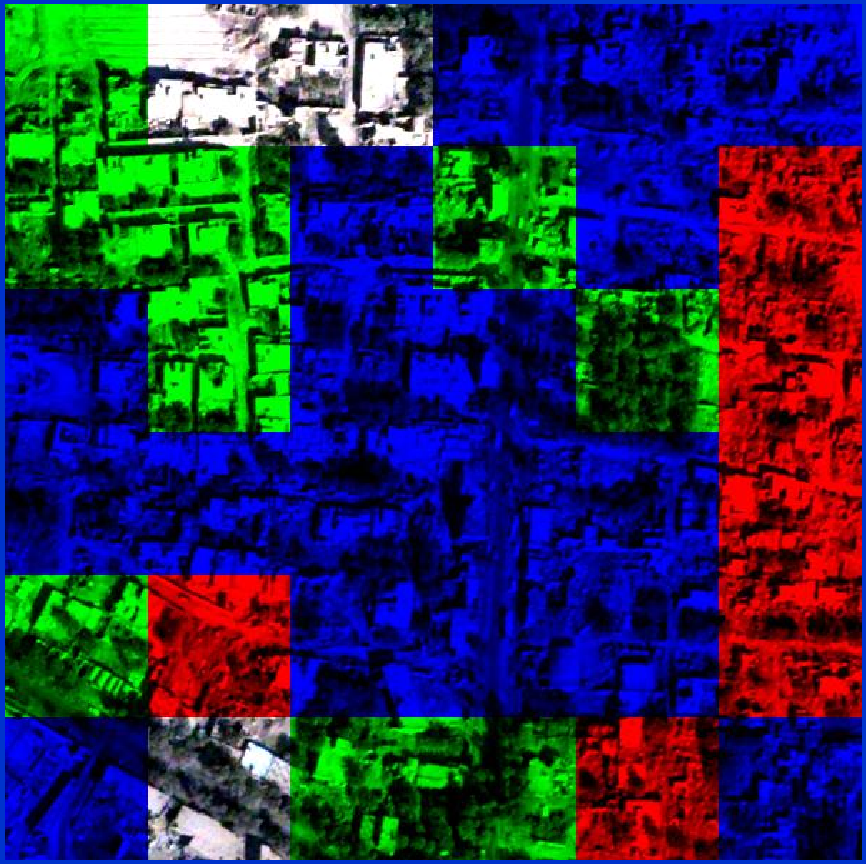
# Zone 2- Damaged area

*Pre-earthquake*

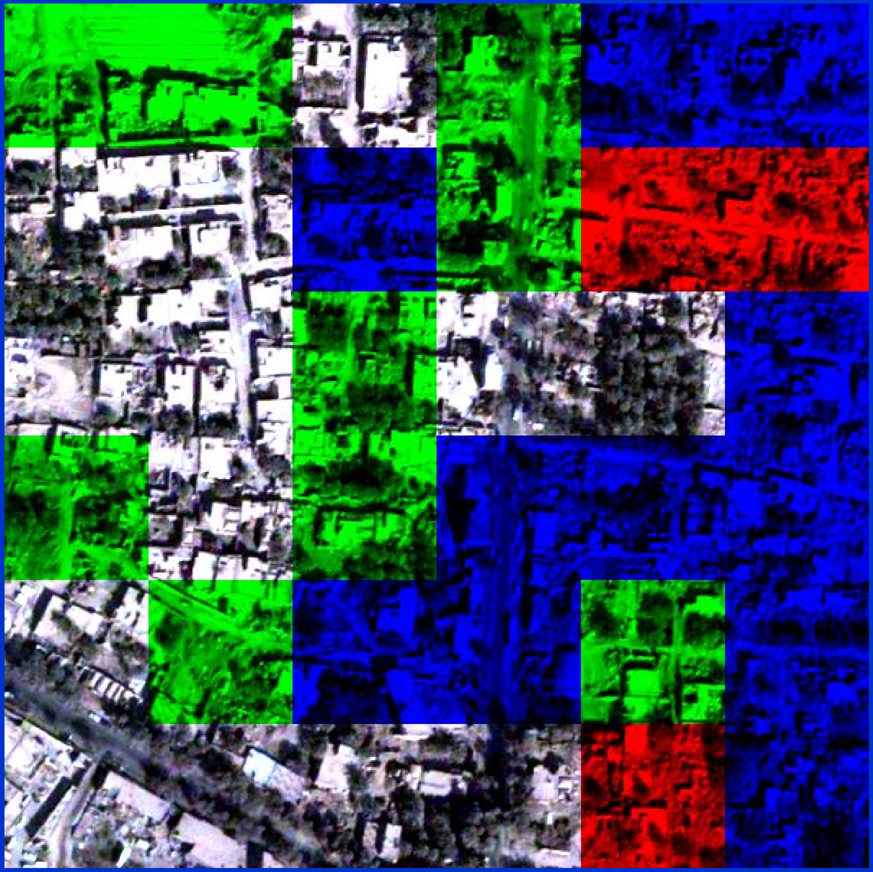
*Post-earthquake*

# Comparison of Results

*ML Classification*



*Change Detection*



# Conclusions

- Thematic classification identified more damage than change detection when considering the entire city
- Thematic classification is not always successful in distinguishing between different levels of severe damage

# Conclusions

- Change detection distinguished better different levels of severe damage
- Change detection identified some non-earthquake change that resulted in an overestimation of damage in isolated areas
- Future work
  - Developing multi-resolution techniques
  - Advanced textural features (e.g., wavelets)
  - Hierarchical classification