EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT

EO4SD-FCS Wrap-up Event with WB, 27/04/2022

USE CASE - Monitoring reconstruction efforts in Mosul, IRAQ

Sébastien DELBOUR, CLS
Context & objective

World Bank Unit: **Urban, Disaster Risk, Resilience, and Land Global Practice**
Regional Unit: **Middle East and North Africa**
Main WB team contacts
- Ellen Hamilton, *Lead Urban Specialist*
- Zheng Judy Jia, *Urban Development Specialist*
- Hogeun Park, *Urban Specialist*

Project supported by EO4SD: **Emergency Operation for Development for Iraq**
Region of interest: **Mosul, Ninawa Governorate**

**Objective:** In a context of strong limitations in terms of ground-based supervision, the World Bank looked for alternative methods and an assessment of the relevance of Earth Observation products in monitoring post-conflict reconstruction efforts undertaken.

Period of EO4SD service support: **Spring/Summer 2020**
Satellite-based service demonstration

Using very high resolution optical satellite images (pixel size better than 1m), the team analyzed the evolution of the urban fabric in Mosul through 3 different lines of service:

**Land Use Land Cover (LULC) mapping**
on key sectors of Mosul before (2013) and just after the conflict (2017), with the integration of the damage assessment made by UNOSAT in 2017 to lay the basis of the reconstruction analysis

**Inventory of the reconstruction efforts**
undertaken in the same area, that included building-level status assessment and yearly monitoring from 2017 to 2020

High importance infrastructure monitoring focusing on a small-scale water purification station at Al-Ghuwair (outside of Mosul) over 2013-2019

2 Areas of Interest in Mosul & surroundings
17,000 buildings analyzed
4 dates of analysis
Support from GISBOX
Land Use – Land Cover
Map describing physical coverage on the ground and its use
Methodology - overview

Input data

Optical satellite images with a resolution better than 1m

<table>
<thead>
<tr>
<th>Acquisition date</th>
<th>Acquisition time</th>
<th>Sensor</th>
<th>Cloud cover</th>
<th>Off-nadir angle</th>
<th>2D resolution</th>
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<tbody>
<tr>
<td>15/11/2013</td>
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</tbody>
</table>

Other data: Open Street Map dataset + Wikimapia + UNOSAT Mosul damage assessment

Methodological process

- Data collection & pre-processing + LULC class definition based on the European Urban Atlas
- Backbone generation (road network manually refined from OSM)
- Artificial areas LULC classification from visual interpretation, with built-up density estimation
- Rural areas LULC classification from visual interpretation (considering the limited area to be analyzed)
- Internal quality control
- External quality control
Main characteristics of urban fabric

- Continuous urban fabric highly sealed – 15%
- Discontinuous urban fabric – 7%
- Commercial, tertiary and military units – 18%
- Construction, infrastructure or dumping sites – 14%

Main non-artificial areas

- Agricultural areas – 12%
- Natural areas – 17%

2013 Product overall accuracy = 90.2%
LULC change analysis

The overall distribution is very close to 2013, without using the condition status of the building blocks (destroyed, damaged, no visible damage); the evolution of the urban fabric is as follows:

+ 57 ha of discontinuous urban fabric with 10-30% sealing degree
+ 16 ha of construction sites

**2017 Product overall accuracy = 88.5%**
Analysis – Damage Assessment 2017

Main damages

<table>
<thead>
<tr>
<th>Class</th>
<th>Destroyed</th>
<th>Damaged</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government</td>
<td>46%</td>
<td>46%</td>
</tr>
<tr>
<td>Educational</td>
<td>12%</td>
<td>33%</td>
</tr>
<tr>
<td>Health</td>
<td>84%</td>
<td>4%</td>
</tr>
<tr>
<td>Commercial - tertiary</td>
<td>43%</td>
<td>36%</td>
</tr>
<tr>
<td>Industrial</td>
<td>66%</td>
<td>9%</td>
</tr>
<tr>
<td>Airport</td>
<td>100%</td>
<td>-</td>
</tr>
<tr>
<td>Military</td>
<td>99%</td>
<td>-</td>
</tr>
<tr>
<td>Continuous urban fabric</td>
<td>4%</td>
<td>25%</td>
</tr>
<tr>
<td>Discontinuous medium density</td>
<td>6%</td>
<td>21%</td>
</tr>
<tr>
<td>Religious</td>
<td>25%</td>
<td>23%</td>
</tr>
</tbody>
</table>

Damage assessment:
- Destroyed
- Damaged
- Potentially damaged
- No visible damage
Reconstruction monitoring
Map tracking and assessing the efforts yearly
Methodology - overview

### Input data

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<td>20.5°</td>
<td>0.4 m</td>
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</table>

Other data: Open Street Map dataset + Wikimapia + UNOSAT Mosul damage assessment

### Methodological process

- Data collection and pre-processing
- **Status 2020 classification update from UNOSAT damage assessment** + new building inventory
- Status 2018 and 2019 classification
- Internal quality control
- Social media and online sources comparison
Results

- 72% of the inventoried buildings show no signs of change
- Rebuilding work started near the Old Bridge and Bab al-Saray market
- Temporary installations visible in the Ghazlani Military base
Analysis – Reconstruction efforts in 2019

Results

- 46% of inventoried buildings show no signs of change
- **34% are repaired or rebuilt**
- 8% are under construction
- 12% are cleared or dismantled
Analysis – Reconstruction efforts in 2020

Results

- 41% of inventoried buildings show no signs of change
- 44% are repaired or rebuilt
- 3% are under construction
- 12% are cleared or dismantled (total of 57.7 ha available)
Massive ongoing efforts for rebuilding Mosul, at different levels

In 2020, out of almost 17,000 buildings inventoried:

- Only 7,000 showed no signs of evolution
- 2,000 were cleared or dismantled
- 7,900 repaired or new

Most buildings reconstructed are in former high density urban fabric areas. The old city district - the most affected one - also benefited from intense efforts to rebuild, especially in the market area.

About 40% of new constructions took place in less dense former urban fabric, or spaces that were dedicated in 2013 to tertiary activities.
Infrastructure monitoring
Map tracking and assessing the work progress
Methodology - overview

Input data
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Methodological process
- Data collection and pre-processing
- Large-scale analysis of the assets of the water purification station in 2013
- Large-scale analysis of the evolution of the infrastructure in 2017 and 2019
- Overview scale analysis of the surroundings (water bodies, communities and other assets) in 2019
- Internal quality control
- Comparison with the documents and pictures provided by the WB team
Analysis – Infrastructure status in 2013

Main entrance

Traces of low wall or fence

100 m

Main building

Settling basin (empty)

Settling basin (filled)
Analysis – Infrastructure status in 2017
Analysis – Infrastructure status in 2019

1. Main entrance building

2. Main building

3. Clarifying settling basin

New structure

Main entrance

Tarpaulins

Settling basin (filled)
User feedback collected through online survey

High level of satisfaction expressed through online survey or by email

“We worked with the EO4SD-Fragility, Conflict & Security team (CLS) for a demonstration in Iraq. The team had a fairly rigorous approach yet was still flexible and able to incorporate our suggestions and guidance. We had regular virtual meetings and the communications have been very good.” Judy Jia

“While many staffs are in my organization have heard/used the EO based products; however, their views on implementing EO based product to project and/or analytical work are limited. Since EO technology keeps involving, it would be good to update the recent updates. Additionally, it is critical to inform the caveat (or limitation) of EO based product at the early stage to better manage the project expectation and design the scope.” Hogeun Park

Suggestions also expressed

“It has been our great pleasure working with you and team this year on the EO4SD-Fragility initiative. The process has demonstrated significant potentials in using EO-based solutions for supervision and preparation of operations, reconstruction progress assessment, and damage assessment.” Judy Jia
Potential for mainstreaming and scaling up

N°1 KEY DECISION is related to the analysis method of satellite images...
Visual interpretation vs. Automated classification using Artificial Intelligence (AI)

Main criteria for making the most cost-effective choice

- Time availability
- Potential for replication
- Reference dataset availability
- Requirements in terms of area to be covered and features/information to be extracted (level of detail)

EO-based analysis at building level for damage assessment or infrastructure construction

- Visual analysis for emergency situations and/or limited area coverage
- Worth to explore AI methods in case of large areas and/or long-term monitoring even if ready-to-use algorithms available
Thank you!

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