Disastrous landslides under changing forcing factors triggered end 2019 in West Kenya

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Natural hazards in Kenya

Humanitarian Rapid Mapping Service
  ▪ International Response
  ▪ Case of West Pokot in December 2019

Satellite Imagery Analysis
  ▪ International Charter (UNOSAT)
  ▪ Geohazard Exploitation Platform (GEP/ALADIM)

Discussion and Conclusion
Natural hazards in Kenya

- **INFORM (Index for Risk Management):**
  - useful tool for risk assessment developed by the UN Inter-Agency Standing Committee Task Team for Preparedness and Resilience and the EC
  - assesses risk at country and sub-country level based on indicators to measure hazards and exposure, vulnerability & coping capacities
Natural hazards in Kenya

- Heavy rains, flash floods, mudslides and landslides
  - Undated: 39 land/mud slides and 566 (flash)floods from the national disaster inventory (shown on map)
  - Non-geolocated: 756 floods and 51 landslides (2002 and 2016) from the DesInventar catalogue
  - Time limited: 44 land/mud slides (2007 and 2013) from the NASA Landslide geodatabase
→ Incomplete natural hazards inventories in Kenya
→ Western region at risk

Hydro-geohazards in Kenya with flood affected people layer from http://riskprofilesundrr.org
Kenyan climate and forcing meteorological factors

- Short (Nov-Dec) and long (April-May) wet seasons
- In April 2018: extremely wet season with > 8 mm/day over Kenya
- In April 2019: unusual low rain while in December 2019 downpour with mean rainfall > 4 mm/day over Kenya

- Positive Indian Ocean Dipole or "El Niño" effect: colder than normal in the Pacific Ocean and warmer than normal along the Horn of Africa with storm clouds becoming heavier and lasting longer (BBC communication)
Humanitarian Rapid Mapping Service

- Provides satellite image analysis during humanitarian emergencies, both natural disasters and conflict situations
- 24/7 operational service
- Team of experienced analysts ensure timely delivery of satellite imagery derived maps, reports and data
- 2019: 41 activations following major disaster events
Satellite Imagery Analysis - UNOSAT Products

UNOSAT's latest maps for current events are listed here. Older maps and data can be found in the Map Library.

**LATEST MAPS**

[Link to UNOSAT Maps](https://www.unitar.org/maps)
UNOSAT Operational Satellite Imagery Analysis & Mapping Support to Humanitarian Emergencies & Post Disaster Recovery

Rapid Mapping Satellite Imagery Workflow

Submit requests via e-mail to emergencymapping@unosat.org followed by a phone call to the 24/7 hotline +41 75 411 4998 to confirm submission to UNOSAT on-call officer.
UNOSAT: tasks and processing flowchart after International Charter activation in Dec 2019, Kenya

1. [25-11-2019] Request on behalf of the Kenyan government

2. [25-11-2019] Activation of the Charter to acquire VHR satellite images

3. [25-11-2019] UNOSAT Rapid mapping service activated

4. [26-11-2019] Task satellites over the ROI

5. [28-11-2019] Pleiades image acquisition

   - Supervised NDVI classification to detect changes
   - Post-editing to discard low NDVI values and low slope angle
   - Intersect with roads and bridges
   - Photo-interpretation in Northern populated areas (200 km²)

7. [29-11-2019] Output
   - Impact and damage assessment
   - Maps and reports
Mapping Activities

- Floods
- **Landslides**
- Earthquakes
- Cyclones
- Refugee and Internally Displaced Persons Mapping
- Cultural Heritage Sites
- Conflict Damage Assessment
- Etc.
Satellite Imagery Analysis

ALADIM Service on the Geohazards Exploitation Platform
ALADIM-S2/VHR: a service for Landslide Detection on GEP

ALADIM: Automatic Landslide Detection and Inventory Mapping from multispectral images

This service is developed by CNRS-EOST (Strasbourg, France). It allows to detect and map new landslides triggered by large forcing events (earthquake, heavy rains) from the analysis of pre- and post-event imagery, and is based on change detection methods. It allows the processing of High Resolution multispectral data (ALADIM-S2; Sentinel-2 SAFE files) and Very-High Resolution multispectral data (ALADIM-VHR; typically Pléiades and Spot 6/7). The set of pre- and post-image should be accurately co-registered in order to use the service. A training dataset of manually mapped landslides (by digitalization), the extent of the training areas, and the extent of the region of interest (ROI) should be provided as inputs (shape file format) by the user. The outputs consist in a database of landslide polygons that can be assimilated to an Earth-Observation derived landslide inventory. ALADIM builds on the change detection methodology partially described in [1] and [2].

Input specifications

Beside the service parameters an archive folder containing the training set, the training areas (and aoi) in shapefile format is needed. See the tutorial (tutorial) to create these inputs.

Output specifications

- A shapefile (*shp files) containing the landslides detected at an F2 optimal threshold.
- An image (geotiff file format) containing all landslides detected at an F2 optimal threshold.
- Two documents (*pdf files) presenting the cross-validation quality control (precision-recall curves and accuracies of the parameters).

A machine learning based service for Sentinel-2 and VHR images

Parameters

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→ Link to ALADIM data preparation
ALADIM-S2/VHR: processing flowchart

**Image selection**
- Mandatory: A pair of Sentinel-2 images (pre and post-event, from the GEF catalog)
- Optional: One multi-spectral (4 bands: R, G, B, NIR) image post-event

**Input images** (mandatory input)
- Pre-event
- Post-event

**Mask creation**
- Cloud mask
- NDVI threshold mask

**Segmentation** (mean shift algorithm)

**Feature extraction**
- Texture
- Color
- Topography
- Shape

**Supervised Machine Learning (Random Forest)**

**Product**
- Inventory map
Study case and image coverage: S2 vs. Pléiades

Typical landscape in West Pokot (Kenya)
- Difficult for EO automatic landslide detection
- Bare soils, agricultural fields and landslides have similar spectral behaviour
- Presence of previous landslides
Landslide detection: area 1 – S2 vs. Pléiades vs. reference

S2: 19/09/2019

Sentinel-2:
Pre-event: 19/09/2019
Post:event 28/11/2019

Pléiades: 28/11/2019
Landslide detection: area 1 – S2 vs. Pléiades vs. reference

S2: 28/11/2019

Sentinel-2:
Pre-event: 19/09/2019
Post:event 28/11/2019

Pléiades: 28/11/2019
Landslide detection: area 1 – S2 vs. Pléiades vs. reference

Pléiades: 28/11/2019
(available by International Charter and CIEST)

Sentinel-2:
Pre-event: 19/09/2019
Post:event 28/11/2019

Pléiades: 28/11/2019
Landslide detection: area 1 – S2 vs. Pléiades vs. reference

Unitar: reference mapping

Sentinel-2:
Pre-event: 19/09/2019
Post: event 28/11/2019

Pléiades: 28/11/2019
Landslide detection: area 1 – S2 vs. Pléiades vs. reference

S2: detection

Sentinel-2:
Pre-event: 19/09/2019
Post:event 28/11/2019

Pléiades: 28/11/2019
Landslide detection: area 1 – S2 vs. Pléiades vs. reference

Pléiades: detection

Sentinel-2:
Pre-event: 19/09/2019
Post:event 28/11/2019

Pléiades: 28/11/2019
Landslide detection: area 1 – S2 vs. Pléiades vs. reference

- Unitar reference mapping focuses on the largest landslides and most impacted areas
- ALADIM detects all the Unitar reference mapping, and also smaller landslides on the upper slopes
Landslide detection: area 2 – S2 vs. Pléiades vs. reference

S2: 19/09/2019

Sentinel-2:
Pre-event: 19/09/2019
Post: event 28/11/2019

Pléiades: 28/11/2019
Landslide detection: area 2 – S2 vs. Pléiades vs. reference

S2: 28/11/2019

Sentinel-2:
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Post:event 28/11/2019

Pléiades: 28/11/2019
Landslide detection: area 2 – S2 vs. Pléiades vs. reference

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Landslide detection: area 2 – S2 vs. Pléiades vs. reference

S2: detection

Sentinel-2: Pre-event: 19/09/2019
Post-event 28/11/2019

Pléiades: 28/11/2019
Landslide detection: area 2 – S2 vs. Pléiades vs. reference

Pléiades: detection

Sentinel-2:
Pre-event: 19/09/2019
Post-event: 28/11/2019

Pléiades: 28/11/2019
Landslide detection: area 2 – S2 vs. Pléiades vs. reference

- **Sentinel 2**: post-event
- **Pléiades**: post-event

**ALADIM detection**
- **Sentinel 2**: landslide area: 18 km$^2$
  - landslide number: 3622
- **Pléiades**: landslide area: 3.8 km$^2$

**UNOSAT detection**
- **Pléiades**: landslide area: 2.8 km$^2$

**Sentinel 2**: detection
- **Pléiades**: detection
- **Unitar**: reference mapping
Discussion and Conclusion

- Recurrence of landslides affected by climate change in Kenya
  - Swapping long and short term rainfall seasons
  - Areas less-prone to natural hazards newly affected (due to land use changes?)
  - It is important to document the hazard events after each meteorological events for landslide hazard management and disaster risk reduction to minimize fatalities
  - Earth Observation data and user-oriented mapping tools are necessary in various phases of disaster risk management (preparedness, emergency, recovery) such as for hazard mapping, impact and damage assessment

- International Disaster Charter for Major Disaster and Rapid Mapping initiative (UNOSAT) : impact and damages assessment maps within 1 day (3 to 5 days after the disaster happens according to satellite data availability) for emergency response purpose in populated areas

- Landslide Detection Services: ALADIM is currently being upgraded by the service provider CNRS/EOST (management of the training sets, other satellite sensor, mono-date vs. bi-date vs. time serie detection) for further flexibility. Landslide mapping ready after preparation of training datasets, processing and mapping of individual event over a larger area in about 1.5 days

Link to study brief