

Earth Observation Methodologies for Humanitarian Applications: A Guide

This guide explores key Earth Observation (EO) methodologies utilized in humanitarian contexts, with a focus on climate, environment, and disaster response.

Types of Data for Humanitarian Applications

Earth observation for humanitarian applications depends on a diverse set of satellites, including NASA's Earth observation fleet, to capture data needed to predict and inform disaster response and recovery. [Optical satellites](#), such as the Landsat program, collect imagery in near-infrared and visible wavelengths. These are best for analyzing vegetation health and surface features when skies are free from cloud cover or haze.

Thermal imaging is used by some satellites to detect heat emitted from the Earth's surface. This provides temperature variation data, often collected from the Thermal Infrared Sensor (TIRS) on Landsat 8/9 or the MODIS instrument aboard NASA's Terra and Aqua satellites.

Light Detection and Ranging (LiDAR) data uses laser pulses to measure surface elevation, producing 3D terrain models that can support flood mapping. NASA's ICESat-2 provides LiDAR data for glaciers and sea ice thickness.

Another important consideration is spatial resolution. Public satellites provide medium-resolution imagery suitable for most assessments, while commercial satellites offer very high-resolution imagery that can provide more detail in damage assessments.

These data types form the foundation for humanitarian EO workflows. Choosing the right combination depends on the crisis context, the urgency of response, and the level of detail needed.



Data Acquisition for Humanitarian Workflows

Access to timely EO data is essential for effective humanitarian applications. Numerous free platforms provide satellite imagery archives, such as [NASA Earthdata Search](#) and [Copernicus Open Access Hub](#). Additionally, [Google Earth Engine](#) takes imagery a step further and provides analysis tools in its cloud-based platform as well.

For rapid disaster response, portals like the [Global Disaster Alert and Coordination System \(GDACS\)](#) and [Copernicus Emergency Management Service](#) provide specialized data and alert systems for first responders.

Also critical in an ever-changing climate, is capacity building. Programs like [NASA's Applied Remote Sensing Training \(ARSET\)](#) and UN-SPIDER's Knowledge Portal offer trainings and resources to further skills for using EO data in humanitarian applications.

Key EO Methodologies for Humanitarian Applications

Once Earth observation data is acquired, applying the right methodology transforms raw imagery into actionable insights. These techniques help humanitarians detect hazards, monitor ongoing disasters, and support recovery efforts.

Monitoring Changes Over Time

Change Detection

Comparing satellite imagery taken over time allows analysts to detect meaningful changes in land use, vegetation cover, water distribution, and infrastructure. This methodology, known as change detection, can be applied in various humanitarian contexts. Common uses include assessing flood impact, monitoring deforestation, evaluating damage after disasters, and tracking the progress or recovery and reconstruction efforts. Identifying shifts in the landscape can inform decision-makers during response efforts and assist in effectively distributing resources for climate disasters.



[Landsat images of Amazon deforestation and land-use change in Pará, Brazil](#) (NASA Earth Observatory, 2019)

Time Series Analysis

Longer-term monitoring often relies on time series analysis, which tracks trends for a specific location over extended periods of time. Using consistent satellite imagery over years or decades, analysts can monitor droughts, [track vegetation](#) regrowth after wildfires or other disasters, and assess food security risks in agricultural regions. This methodology can integrate multiple datasets, like precipitation and vegetation indices, to provide a more detailed insight into overlapping disaster risks.

Detecting Hazards and Anomalies

Hotspot Mapping/ Anomaly Detection

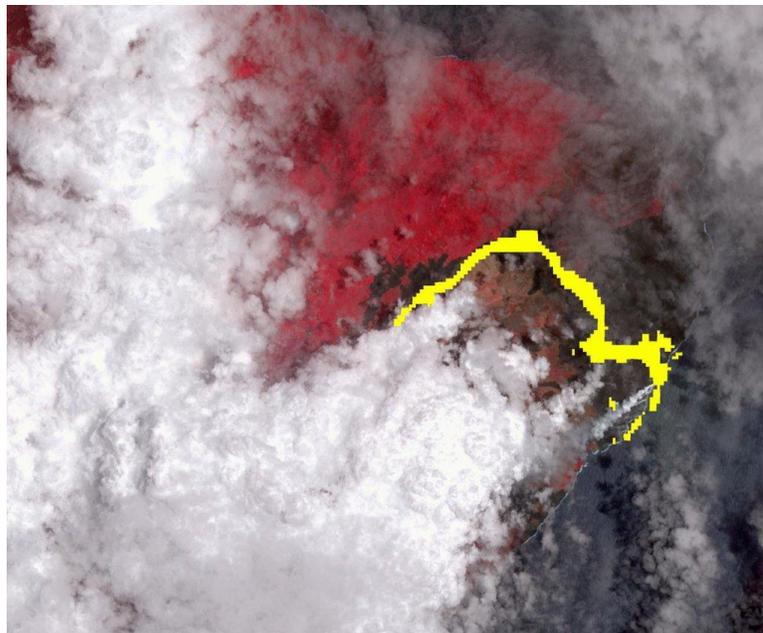
Hotspot mapping, or anomaly detection, is a valuable approach that identifies areas with unusual patterns. This methodology pinpoints variations such as temperature spikes and nighttime light anomalies that may signal a significant event on the ground. It can be used to [identify conflict zones](#) by spotting fire



anomalies from explosions, detect emerging disease hotspots, monitor flare-ups in forest fires, and detect sudden agricultural losses. By pinpointing these anomalies as early as possible, humanitarian experts can act quickly in unexpected emergencies, as well as prevent any worsening conditions.

Thermal Anomaly Tracking

Temperature-based monitoring is another powerful methodology in humanitarian applications. Thermal anomaly tracking identifies deviations in surface temperature patterns, which can reveal wildfires, volcanic activity, and other hazardous heat events. Detecting these anomalies early enables faster response times and assists emergency response teams to direct emergency resources where they are needed most.



Example: [Satellite imagery of Hawaii volcano lava flow](#) (NASA JPL, 2018)

Classification and Mapping

Image Classification

Image classification is the process of assigning land cover classes to pixels, such as water or forest. This methodology can utilize supervised classification, where algorithms are trained with known sample areas, or unsupervised classification, where pixels are grouped based on similar properties. This is often enhanced through further methodologies such as object-based analysis. These techniques are essential for tracking climate change impacts and assessing damage to infrastructure.

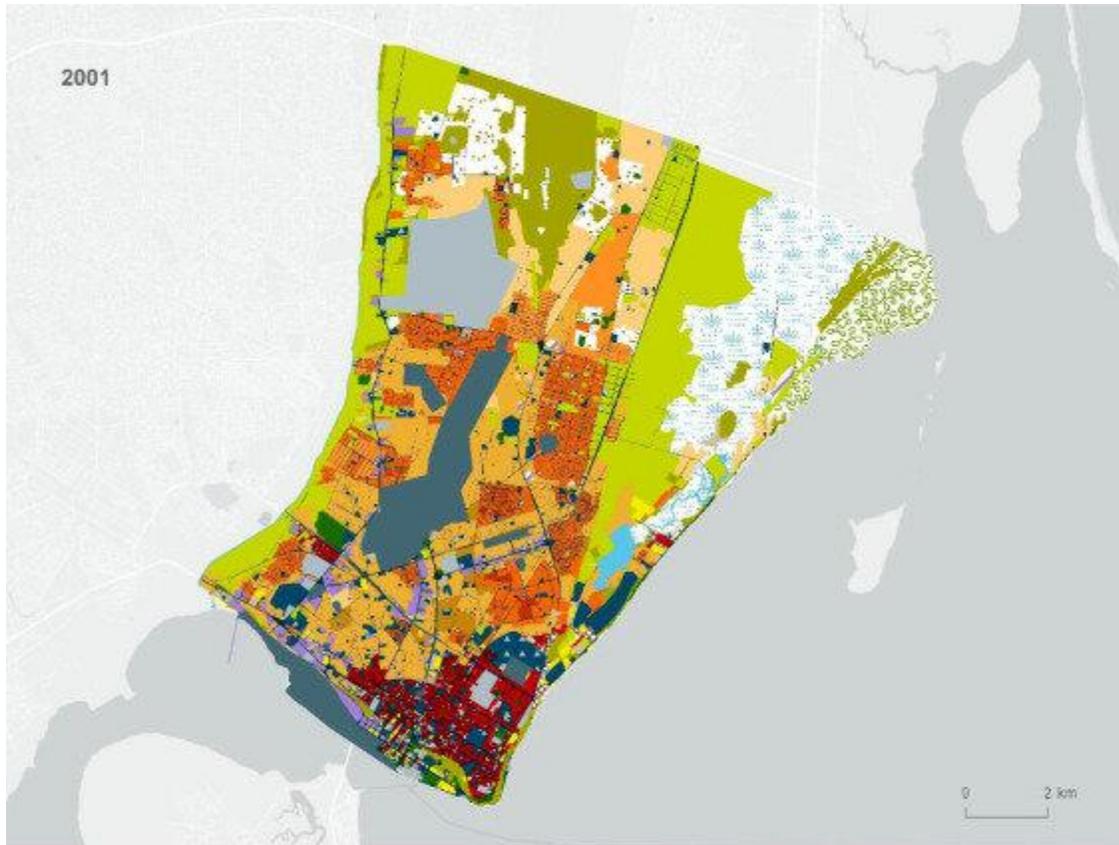


Object-based image Analysis

Analyzing images by grouping pixels into objects to improve classification accuracy for complex landscapes. This method is useful for mapping urban areas and damaged infrastructure after a disaster strikes. Analysts can produce more detailed neighborhood maps by considering the context of the objects, assisting in more reliable decision-making for targeted relief and resource distribution.

Land Use Classification

Land use classification maps the distribution of human activity across natural landscapes, offering insight for disaster response and recovery. By analyzing shifts in urban development, humanitarian teams can detect infrastructure vulnerability and guide aid distribution in various phases of disaster recovery.



Land Use - Level II



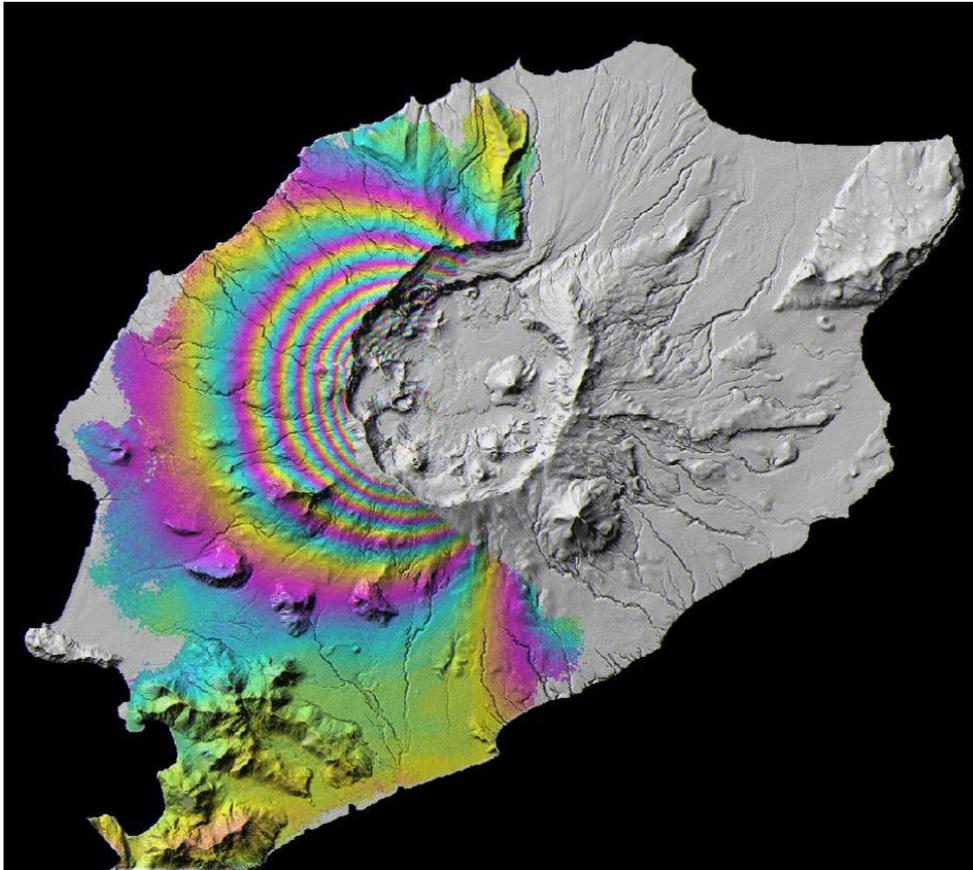
Example: *Land use of Maputo in 2001* (ResearchGate, 2023)



Specialized Imagery

Synthetic Aperture Radar

In crisis situations where imagery is limited by weather or smoke, synthetic aperture radar (SAR) is invaluable. The radar-based imaging can penetrate cloud cover and darkness, providing consistent and reliable observations. This can be particularly effective for analysts mapping terrain changes after earthquakes or landslides, as well as assisting in flood damage assessments.



Example: [Surface deformation on Okmok volcano using InSAR imagery](#) (NASA ASF DAAC) . Each color cycle represents 2.8 cm of ground surface movement.

Earth observation methodologies produce essential tools for humanitarian response, offering actionable insights into climate, environmental, and disaster-related events. By leveraging various types of satellite data and integrating multiple methodologies, decision-making in disaster response can be more informed. This helps first responders provide vulnerable communities and distribute aid effectively, as well as build resilience in a rapidly changing climate.