LIFELINES

Explore Two Case Studies

Flood Early Warning

Human Rights

Is Satellite Data Right for Your Needs?

HUMANITARIAN GUIDE

A practical guide to help the humanitarian decision maker determine if and how to work with satellite data and tools.

JULY 2025

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Acknowledgements

We are grateful to individuals from our working group; Alison Hall, Alice Almond, Richard Brittan, Olivier Cottray, Robert Emberson, Aaron Eubank, Mark Iliffe, Nicki McGoh, Samapriya Roy, and Amanda Weigel for their guidance.

We would like to give special thanks to the attendees of our Supper Club discussion: Ziad Al Achkar, Liana Bernt, Ryan Engstrom, Jessica Ertel, Jake Godin, Arrabi Nandakumar, Ezinwa Osuoha, Brian Perlman, Eric Reading, Corrine Rojas, and Susan Wolfinbarger.

We also would like to acknowledge the following individuals for taking the time to have discussions with us about the guide: Andrew Kruczkiewicz, Youri van der Weide, and those that offered their thoughtful feedback on earlier versions of this document: Joseph A, Adedoyin Samuel Ajeyomi, John De Armas, Joseph Ashmore, Victoria Baxter, Molly Brown, Patrick Culver, Martin Garcia, Andi Gros, Amanda Markert, N3LSON, Kalu Okigwe, Jessie Pechmann, AA (Raha), Jacob Ramthun, Emily Reinstein, Chalermchai Rodsangiam, and Saidi Slimane.

We deeply appreciate support during the editing, design, and publication process from Laura Guzmán and Seamus Geraty.

Introduction

Who this guide is for and what value it serves

Have you ever thought about the possible use cases for satellite data? Have you wanted to incorporate satellite data and tools into your programming but didn't know where to start? Is it challenging to keep up with the latest trends in satellite data and Earth science and what's applicable to the humanitarian context?

This guide is designed to help the **humanitarian decision-maker** (e.g., Information Management Officers, Technology Advisors, Program Managers, and others) determine if and how to work with satellite data and tools. This guide is an entry point for any humanitarian decision-maker who is ready to improve their outcomes using satellite data. With an increasing evidence base and level of need, humanitarian decision -makers cannot afford to ignore opportunities where satellite data and tools can make a greater impact.

Do you need to allocate scarce resources and make strategic choices that shape humanitarian programs? Do you have experts on your team or partners that can navigate the technical details?

While you may not be a technical expert, you recognize the importance of data and emerging technologies in improving efficiency, scalability, and outcomes. This resource will be most beneficial for decision-makers who have a basic understanding of geospatial concepts (e.g., ability to interpret map outputs) and who have access to subject matter experts who can help them answer technical questions related to their specific use case. Don't have access to the right kinds of experts? Activate our community through the NASA Lifelines Earth Science Review Board where you can submit questions to a panel tailored for your needs and get unbiased recommendations. Even if you are not working with satellite data (yet), this guide hopes to inspire your next steps and a strategy to operationalize these immense resources.

By providing a structured framework of key questions and case studies demonstrating real-world applications, this guide provides a repeatable method and community examples to make informed choices. Questions to consider range from evaluating the benefits and risks of satellite data to understanding ethical considerations, cost implications, and capacity requirements. Beyond technical guidance, this resource also helps organizations assess the expertise needed to work with geospatial data, manage expectations about data accuracy and limitations, and ensure that satellite-driven insights align with humanitarian principles. Finally, it offers practical recommendations, training resources, and strategies for effectively communicating findings to stakeholders. Using the knowledge in this guide, decision-makers can unlock more value from satellite data, making their work more effective, data-driven, and impactful.

Community Profile

HUMANITARIAN DECISION-MAKER

Goals:

- Improve humanitarian outcomes through resource allocation decisions that ensure effective use of technology – while securing more funding for program implementation.
- Identify interventions that are evidence-based, scalable, and eficient to me et urgent needs while building long-term resilience.
- Avoid unnecessary risk in their investments, ensuring that any use of new technologies or approaches are justified and meet actual needs.
- Align with global trends in data-informed crisis response.

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What satellite data and tools are revelant for Humanitarians?

There are many different kinds of satellites imaging different parts of the world at different cadences and swath sizes and resolutions. While one satellite might be designed for detecting heat islands and temperature extremes, another satellite might be better suited for monitoring smallholder farms. Some satellites are designed to monitor the same places around the world at consistent revisit rates, others are tasked to capture on-demand locations as needs arise.

The range of satellite data includes optical and hyperspectral imagery, synthetic aperture radar (SAR), LiDAR, thermal imagery, weather and climate data - all useful for various humanitarian needs from flood monitoring to planning evacuation routes to air quality assessments to infrastructure damage assessments - to name a few. There are also a few different ways to access satellite data, depending on how you want to use it (e.g., directly from providers and in various formats, from third party platforms hosting many satellite data providers, open data programs, etc).

In addition to a wide range of satellites and data types, there are also many derived models, datasets, services, and tools that are relevant for humanitarian applications. Many times, these are the best place to start, especially if your team has limited internal capacity or time to work directly with satellite data.

Explore Caribou Space's Beyond Borders report to learn more about different types of satellite data, applications and tools in the humanitarian context.

Suitability Assessment Framework for Satellite Data

By systematically navigating questions related to evaluation, scoping, analysis, and communication, humanitarian organizations can better determine when satellite data is fit for purpose, identify appropriate data sources and tools, address ethical considerations, manage expectations, and ensure responsible use.

Throughout the framework, you'll be encouraged to consider privacy and ethical implications, accuracy and uncertainty in the data, data accessibility, analytical capacity, costs, and partner availability, and much more. The framework emphasizes transparency, community engagement, and rigorous evaluation of impact to ensure humanitarian principles–humanity, impartiality, neutrality, and independence–remain central to decisions informed by satellite imagery.

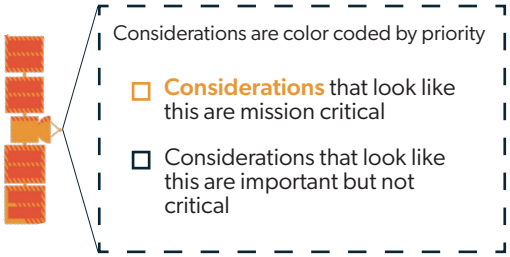
A few important notes:

- **This is the beginning of a living framework that will evolve as more case studies are added and more decision-makers operationalize this resource.** As others apply the framework to their own work, we will update the questions and considerations and pressure test this resource in other domains, complementing our flood resilience and human rights examples.
- **Given the broad range of humanitarian applications for the framework, consider this a guide and not a set of explicit instructions** - everything might not apply to your case study in the same way our first two case studies have tackled these questions. Please consider them both a reference in how to interpret the framework.

- **Questions are not always linear, and you may need to revisit questions you previously answered as your data collection, analysis, and implementation unfolds.** For example, your requirements might evolve as situations change (e.g., shifting area of interest, changing population of need, etc.). Or perhaps you aren't able to task and collect imagery as you expected and need to adjust plans, or your team's bandwidth shifts. Be sure to document decisions along the way to streamline the process later.
- **Engage your team and partners – and affected communities where possible – throughout the process.** They can inform your evaluation, approach, and how to communicate and share results.
- **Consider the broader effects technology adoption can have across your programs and partners.** As you'll see in the framework, the process of identifying, implementing and evaluating a new data source is multifaceted. Maximize the efficiency of this process by creatively adding to existing internal knowledge, leveraging partnerships, and reaching out to others who may have experiences you can learn from. While this framework helps you assess satellite data for specific uses, taking a broader view is critical to unlock the full potential and value of a technology that applies to so many problems. Many of the questions answered here will hopefully serve you in considering other technologies.

Is Satellite Data Right for Me?

Questions	Considerations
What decisions could Satellite data support?	☐ **Define** clearly the decision-making process (emergency response, resource allocation, planning), including when decision(s) are made and by whom. ☐ **Identify** the hazard(s) involved as different types of satellite data and tools are designed for specific hazards (e.g., wildfire detection or water detection). ☐ **Note** if there is a specific trigger or threshold that results in decision-making or if these are ongoing and/or routine decisions Always consider your end user(s) and how they want data to be shared. ☐ **Understand** what other data and tools are involved in the decision-making process and where satellite data and tools could/should complement existing workflows.
Are there any precedents for this use case? Are there relevant resources we could use?	☐ **Research** case studies using satellite data and tools documented by organizations like **UNOSAT**, **UN OCHA's Humanitarian Data Exchange**, **NASA's Applied Remote Sensing Training (ARSET)**, **ReliefWeb**, and **GeoEvidence Explorer**. ☐ **Review** the data and tools used across these case studies in case there are resources you can use - either as turnkey solutions or part of your approach. These will be good to share with your technical experts so you don't duplicate previous efforts and can take advantage of existing resources. ☐ Consider tapping humanitarian GIS networks or communities (e.g., GISCorps, Missing Maps, NASA Lifelines Earth Science Review Board) for precedents and advice.



What are the ethics and risk considerations of introducing the use of satellite data?	☐ **Consider** the ethical and risk considerations at each stage of your work from design through implementation and follow-up. How might adding a layer of satellite data intersect with these? How might it introduce new risks? Consider aspects like the potential that imagery is misused by other parties, that it is misinterpreted, that it exposes information on vulnerable populations (e.g. their location) to malicious actors, and more. More example questions to consider in our appendix resource labeled the ethics and risk audit. ☐ Is additional local data needed? Is this data openly available? Are data owners willing to share the data? Is a data sharing agreement needed, and do you have relationships in place to broker that access? Are there sensitivities in sharing local data? ☐ Refer to established ethical guidelines (e.g., **Humanitarian Data Exchange's (HDX) Data Responsibility Framework**, **Berkeley Protocol on Digital Open Source Investigations**, **International Committee of the Red Cross (ICRC) guidelines for digital humanitarian action)**. ☐ More example questions can be found in the appendix under the Ethis and Risk Audit section.
What data could support these decisions? What are "must have" requirements for the data for these use cases? Is commercial imagery or tasking needed? What are our alternatives?	☐ **Identify** with technical advisors the key data characteristics needed like spatial resolution, frequency of revisit, latency, geographic coverage, and accuracy needed to support these decisions. ☐ Note which are "must have" vs "nice to have". ☐ Consider what ancillary datasets you'll be using along with satellite data and derived tools and where remote coverage complements existing assets. This may also inform your satellite data requirements (e.g., covering areas where you have other data, time periods of data collection, etc). ☐ Evaluate the need for commercial data vs. publicly available imagery based on required resolution and latency.

What's Our Approach?

Questions	Considerations
Do any existing solutions meet our requirements? If not, what gaps exist regarding data access and analysis to support our use case?	☐ Evaluate any turnkey solutions (ie. ready-made, pre-existing). There are a few catalogues of satellite data-driven applications, including **Space for Development** and the **NASA Lifelines Gallery**. ☐ Consider if any ground truthing or validation has been done. Does this include your area of interest or similar geographies? If this validation hasn't been done, consider including this in your in-country work. ☐ **Explore** ways to involve affected community voices.

- ☐ Clearly identify gaps where existing solutions don't meet your specifications and explore any analysis required (e.g., custom image processing, analysis pipelines).

What types of skills and expertise are needed? Based on our internal capacity and bandwidth, can our teams take on this work? What kinds of partnerships do we need?

- ☐ **Identify** essential expertise needed: GIS analysts, remote sensing specialists, data scientists, field validators.
- ☐ If expertise does not exist in-house, consider partnerships with experienced providers, especially in your application area (e.g., Earth observation companies, academic institutions, volunteer mapping communities like **Humanitarian OpenStreetMap (HOT)** or **GISCorps**).
- ☐ Communities of experts like **NASA Lifelines**, **H2H Network** and **START Network** are also good options for technical services and support.

What data, tools, standards and techniques are already adopted and trusted by humanitarians? What is my team familiar with? How can we know we've covered everything?

- ☐ **Liaise** with your team to assess what they have experience with and bandwidth to take on themselves and if/where they want to partner.
- ☐ Consider using widely adopted tools (e.g., Google Earth Engine, HDX platform, OpenStreetMap (OSM), UNOSAT standards, ESRI ArcGIS and standards (e.g., Common Operational Datasets, HXL standards, Cloud Optimized Geotiffs, REST APIs) that are most likely used by your partners.
- ☐ Consider leveraging technical, community-driven shared learning platforms (e.g., Women in Geospatial or AID Arena) or efforts like NASA Lifelines' Earth Science Review Board to provide up-to-date, tailored technical advice for your needs.

Which data is open and accessible for us and our partners? Who needs access to the data? Any sensitivities on who gets access or when?

- ☐ Check with your team that they've made the most of free and open data and tools (considering their capacity, bandwidth, and your program needs).
- ☐ Consider sources of openly available imagery and derived datasets (e.g., NASA, ESA, HDX data repositories, Google Earth Engine catalog / GEE community catalog, open data programs from commercial providers, OSM).
- ☐ **Ensure** your team has a sustainable data management plan, with access, security, updating, and more included (easier with open data sources).

What will this approach cost (in people time, time spent, data purchases, travel, etc)? Is it worth the investment? Are there free/more affordable alternatives?

- ☐ **Scope** resources needed and estimate a budget with the technical team. Consider a few scenarios including a "good enough" analysis and the ideal scenario.
- ☐ Explore cost-saving options (open data programs, cloud credits from Amazon/Microsoft, imagery donations through partnerships). Consider trade-offs of various options (e.g., data is free but takes more time/skills to prepare).

	☐ Take a "value for money" approach to evidence the contributions of satellite data/tools to the impact achieved; there are great examples in the **VALUABLES** consortium's work and, more recently, **CONVEI**.
How much time do you need to gather data? For analysis?	☐ **Clearly** specify data collection timelines and how they align with your decision-making timelines.
What are your needs for analysis like cloud computing, internet bandwidth, team time, other expertise, and in-country partners?	☐ **Clarify** what infrastructure you currently have access to and what you'd need to procure for analysis (compute, cloud resources, GIS licenses) and potential logistical barriers (internet connectivity, field validation). Consider whether this is compatible with your required timelines for decision-making.

Sharing and Communicating Results

Questions	Considerations
How accurate are the data, analysis, and findings? What is our confidence in this data?	☐ **Adopt** and document a methodology for assessing the accuracy of the satellite data (e.g., ground-truthing, historical validation, peer-reviewed models). ☐ **Communicate** uncertainty levels and confidence intervals in analysis to decision-makers. ☐ **Identify** known biases (coverage gaps, classification errors, sensor limitations), assess how they impact the data, and proactively disclose them. Explain how these factored into your confidence assessment.
How should we communicate about risks and uncertainty and how to apply data?	☐ Define known risks and uncertainties in simple language, avoiding technical jargon when communicating to non-technical audiences. ☐ **Recommend** clear decision guidance (what kinds of actions to take/not take based on data).
Are there elements of our approach that should be shared? (e.g., lessons learned, data, tools)	☐ Document your methodology, tools, data processing techniques openly (e.g., blog post, brief reports, forums like HDX). ☐ Share data openly where possible, following responsible data sharing principles and protecting sensitive data.

What was the impact of our decision-making using this data/analysis?	☐ **Establish** clear impact measurement criteria (e.g., lives saved, faster response, improved resource allocation). ☐ **Conduct** post-action reviews to capture lessons learned and integrate these into future protocols and training.
In retrospect, would we use satellite data again? What do we want to do differently next time?	☐ Plan ongoing feedback loops with end-users to improve continuous application of satellite imagery. ☐ Invest in time for teams to iterate on approaches.

Case Studies Applying the Framework

In this guide, the framework has been applied to two different case studies - one of flood early warning systems and another on human rights investigations and accountability. These case studies were developed alongside the framework from an early stage. They are examples of how the framework may be used and consulted, though they should not be considered prescriptive or limiting. Finally, even if your work is not related to flood resilience or human rights, we encourage you to review both case studies to understand the breadth of humanitarian needs satellite data can address, as well as the differing approaches taken to tackle them.

Case Study

FLOOD EARLY WARNING

Using Satellite Data and Tools for Humanitarian Decision Making

Introduction

Early Warning Systems (EWS) alert residents to incoming hazards, helping communities to evacuate high-risk areas and save lives. Earth Observation (EO)-based flood forecasts allow for rapid and precise warnings that enable timely evacuations and protection of assets. Humanitarian organizations leverage these forecasts for preemptive resource deployment, such as cash transfers, food, water, medicines, and shelter, ensuring aid for the most vulnerable. Effective end-to-end EWS incorporate four key components–disaster risk knowledge, warning service, communication, and response capacity–and are characterized by being multi-hazard, comprehensive from detection to action, and people-centered, empowering communities to act effectively to reduce harm. Despite a United Nations goal for universal EWS coverage by 2027, only half of countries reported having such systems by 2023.

What decisions could satellite data support?

Satellite-supported workflows and systems to support flood early warning systems are increasingly common and **for good reason**; EWS can save lives and reduce economic losses. Satellite data can support and inform several decisions type, such as:

- Flood warnings
- Identification of potential settlements and populations at risk
- Visualization and understanding of flood risk
- Supporting existing warning response plans
- Key decisions like evacuation and shelter-in-place

Are there any precendents for this use case? Relevant resources we could use?

There are **many examples** of humanitarian organizations adopting satellite data-derived flood forecasts for early warning systems. A few examples include:

- The World Food Program (WFP) team in Somalia provided pre-emptive cash transfers along with weather warnings, helping thousands of families in flood zones to move to safety and purchase the food and essential items they needed to survive.
- The International Federation of Red Cross and Red Crescent Societies (IFRC) utilizes satellite data to enhance its EWS for natural disasters. In 2020 the IFRC used satellite imagery to track the movement and intensity of storms, enabling better-prepared emergency response teams.
- The Uganda Red Cross in collaboration with the Uganda National Meteorology Authority and the German Red Cross distributed materials, and alerted residents who started to build protective trenches in advance of a flooding event in 2016, using in part the Global Flood Awareness System (GloFAS).
- In Bangladesh in 2020, the Bangladesh Red Crescent Society used GloFAS data to prepare residents in regions that would be affected by floods, and supported them with evacuation, food, and water. They also released funds for anticipatory action.

- SERVIR-Mekong/Asian Disaster Preparedness Center (ADPC)'s satellite-based rainfall data increased the accuracy of flood forecasting and gave first responders fifteen days lead time (as opposed to six days previously) in the Lower Mekong. In addition, the WFP Cambodia Office used SERVIR Mekong/ADPC's regional flood extent data to understand flood impacts in near real-time and target life-saving emergency assistance in October 2020.

In countries without end-to-end EWS, humanitarian organizations can work with governments to build systems. **The UNDP outlines steps to successfully implement EWS** that include leveraging technological advances, focusing on community-based solutions, engaging the private sector, and cooperating and sharing data across borders and organizations.

What are the ethics and risk considerations of introducing the use of satellite data?

Due to the uncertainty inherent in forecasting, there are risks associated with evacuation recommendations. Organizations issuing these warnings must be as clear and accurate as possible. If the recommendation is not conservative, those that trusted in the system could be exposed to the danger of the storm, face personal and property harm, and lose faith in the system. Conversely, if the system is too conservative it could burden those with little resources to take on financial and personal safety costs. For example, for each family that evacuated from hurricane Harvey in Texas, USA **the cost ranged from $1,500 to $3,000.** Evacuating can also be **particularly dangerous for girls and women**.

One challenge of humanitarians, foreign governments, and private companies releasing their own warnings is that these organizations don't have the same accountability to their citizens as the national government would. Humanitarians using these systems must heavily weigh the ethical considerations of these alert triggers.

What resources are available for ethical use of satellite data in this context?

The Locus Charter	Ensures location data is used responsibly, and that users of geospatial data can make more informed decisions and work with people affected by those decisions.
The Sphere Humanitarian Charter	States that all should have the right to life with dignity; the right to receive humanitarian assistance; and the right to protection and security.
The Signal Code	States that the human rights people have to information during disasters include 1. The Right to Information; 2. The Right to Protection; 3. The Right to Privacy and Security; 4. The Right to Data Agency; and 5. The Right to Rectification and Redress.
Bringing Satellites Down to Earth: Six steps to more ethical remote sensing	Lays out questions and steps to censure using EO-data is ethical and responsible.
Space Data Ethics: The Next Fronteir in Responsible Leadership	Urges for developing principles of space data ethics.

Click on each resource to learn more

Also keep in mind…

Does the analysis follow humanitarian principles?

Using satellite-based flood forecasts can directly reinforce humanitarian principles–Humanity, Impartiality, Neutrality, and Independence–in the following ways:

Humanity: Flood early warning systems can save lives by triggering evacuations or the building of protective structures. Post disaster mapping, such as flood extent data or imagery can also ensure that lifesaving material can be directed to those most impacted as efficiently as possible.

Impartiality: Humanitarians should ensure that marginalized communities also have access to EWS, their assets are represented in any triggers for evacuation, understandable alerts and communication reaches them, they have safe shelters and equal support to evacuate and have equal support to rebuild. Using EO-based systems can support impartiality as they can provide wider coverage instead of relying on varied investment. However, there are factors to improve this impartiality, like validating the system in vulnerable areas or tasking satellites to the most impacted areas following a disaster regardless of standing or wealth.

Neutrality: Ensuring all people have access to the system regardless of if they support or are under the jurisdiction of rival political leaders. Satellites cover broad geographic areas, reducing biases or omissions caused by human factors or subjective decisions. This helps humanitarian actors deliver assistance based on vulnerability and risk exposure. Satellite data is verifiable, helping humanitarian actors demonstrate neutrality clearly to all stakeholders, minimizing perceptions of bias or favoritism.

Independence: Access to satellite data provides humanitarian actors with an independent, unbiased source of information, allowing them to plan responses without relying solely on local authorities or governments, which may have competing interests or biases.

What data could support these decisions? What are "must have" requirements for the data and use case?

The domain of flood early warning systems is broad, comprising different subfields:

- Disaster risk knowledge
- Flood forecasting
- Warning dissemination and communication
- Response capability

Though related, these disciplines require specialist approaches and often have different satellite data needs and techniques.

For disaster risk knowledge

Humanitarian organizations can work with local communities so that they properly understand their level of hazards. Incorporating local knowledge of flood hazards, with satellite imagery, digital elevation models (DEM), building data, and infrastructure like evacuation routes can improve disaster risk knowledge. Local leadership and capacity are essential to capture hazard mapping, and will support incorporating local data & knowledge, with more contextual information than EO-data alone can offer. In

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Mozambique, the **Institute of Social Communication (ICS)** educates communities on storm preparedness and response, through community debates, distributing educational information, slogan caravans, SMS, meteorological and hydrological bulletins, and messaging on flood risks on the country's primary river basins.

Staff or partner capacity needed to build disaster risk knowledge include:

- Flood mapping skills (Geographic Information System (GIS) tools, remote sensing, crowd-sourced & field data).
- Local engagement and capacity building: Working with local agencies, NGOs, and communities to validate and use flood models and training government officials, disaster response professionals, and local volunteers on flood mapping, preparedness and response.

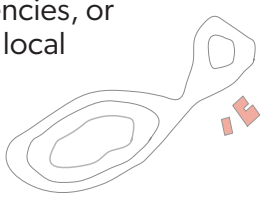
Questions to consider:

1. What is the built environment? Newer or less formal settlements may not be captured on human settlements data, and this could lead to underestimations of affected populations. Also are there structures, like wastewater treatment facilities or nuclear power plants in the area, that may need special attention or cause additional damage or health risks? **Google's Open Building data** can support this work.
2. Are there biases or gaps in the data that may disadvantage certain communities?
3. How is climate change impacting hazard zones? Is the land in a hazard zone growing or shrinking? Will different infrastructure or populations be affected?

For Flood Forecasting

Consider using an existing forecast system or partnering with a country's meteorological service to implement EWS, as National Hydro-Meteorological Services are usually the only agency officially **mandated** to issue warning messages. In the absence of a full coverage local EWS – that includes disaster risk knowledge, warning service, communication, and response capacity – consider applying the global systems that are in use today. These systems are not a replacement for local operational hydrological forecasting systems, but can assist when no system exists, or can work in tandem with local systems where global coverage can provide more data upstream or upwind from the local system's coverage. Many global early warning systems are freely available, but the quality often improves with incorporating higher resolution data and models.

Expert advice on flood forecasting can help your organization operationalize these tools. Consider working with the flood forecast system developers to best understand the opportunities and limitations of operationalizing their forecast in your location. In addition to partnering with the local government, partnerships with universities, humanitarian organizations, meteorological agencies, or specialized NGOS can expand your organization's technical expertise, ensure local validation, and help in accessing satellite data.



Examples of Global Flood Systems:

Copernicus Global Flood Awareness System (GLoFAS)

The Copernicus Global Flood Awareness System is a flood EWS with global coverage that releases flood forecasts daily. GloFAS is used daily as the main information source to monitor existing and upcoming river flood events and report back potential risks of flood impacts to the Emergency Response Coordination Centre (ERCC) of the European Commission. GLoFAS is used by the Aristotle-ENHSP project (European Natural Hazard Scientific Partnership), and supported the humanitarian response to the devastating floods that affected large parts of Mozambique, Malawi, and Zimbabwe in the wake of tropical cyclones Idai in March 2019, and was used during the 2020 monsoon season by the Bangladesh Flood Forecasting and Warning Centre (FFWC).

Though GloFAS is promising, it must be tested in the region and must be used as one tool of an

end-to-end EWS. Disaster risk awareness, developing thresholds for evacuation,communicatio, and response rely on additional components such as educational staff, volunteers or brigades, local hydrological experts, social scientists, and financiers.

Google Flood Hub

Another flood EWS is the relatively new Google Flood Hub. It produces a shareable map of river gauge data updated daily and forecasts of up to seven days advance notice. Flood Hub currently covers river basins in over 100 countries worldwide, providing critical flood forecasting for over 5,000 locations. This EWS also surfaces alerts on Google Search and Google Maps and shares android notifications to those in affected areas, where applicable. The model has challenges in arid watersheds, and there is no pattern where GloFAS or Google Flood Hub is stronger, so it could be helpful to consult both systems. Google Flood Hub partners with Give Directly and the International Rescue Committee to support people affected by floods through anticipatory action cash transfers, allowing residents funds to safe-guard property or evacuate. Flood Hub data is also available via API to beta testers who have non-commercial use cases. This system currently has limited coverage, focusing only on riverine flood types, but could support humanitarian efforts as it increases coverage.

These two systems were evaluated due to the presence of GLoFAS in EWS reports and articles. Google's Flood Forecasting was reported as it includes state-of-the-art approaches: AI and benchmarks its forecast against GloFAS. Other global flood datasets are available as well.

To implement forecasts, work with partners who have experience with near real-time EO data sources, understanding of hydrological models to assess flood risks and experience integrating global hydrological datasets.

Questions to consider:

1. Are there locally validated flood models? If so, those are often the highest resolution, provided they are tested and validated.
2. What type of catchment is this? The strength of flood EWS like GloFAS differ widely in different catchments. Weak catchment types for GloFAS include tropical Africa, western coast of South America, and catchments dominated by snow and ice in high northern latitudes.
3. How do we integrate in-situ data (e.g., river gauges, community reports) with satellite-based forecasts? Many satellite products already include in-situ data and would welcome a partnership if you are able to provide a verified data source.
4. What spatial resolution is necessary? Special attention should be paid to the resolution and accuracy of the data. Flood maps that cover low-income areas often use low to medium resolution data for flood extent maps like MODIS (250m) or VIIRS (375 m) or have **challenges** with clouds in optical imagery or interference or inconsistencies with Synthetic Aperture Radar (SAR).
5. What is the lead time of the forecasts, and does it align with operational decision-making? **Flood systems are divided** into flood alerts with longer lead times, or emergency warnings with shorter lead times.
6. Are these models underestimating flood risk? Climate change is causing changing precipitation patterns and severe flooding in places that haven't seen it before. Models may not account fully for this change.
7. What are the risks of false alarms, and how do we minimize them? All flood forecasts are uncertain, but frequent clear communication of the latest data, and actionable information can reduce the risk of false alarms.

For warning dissemination and communication

Communication activities are crucial to saving lives and property in an emergency. Humanitarian organizations can support communication by mobilizing community brigades that can reach areas with no reception for warnings, and ensure warnings reach those residents in other ways. In Mozambique, **brigades** trained far in advance of storms alerted community members of the approaching Cyclone Freddy in 2023 with enough time to gather belongings and move to safety. Other tools like Google Maps can share where roads are already closed, or alternative routes for evacuation to avoid heavy traffic. There are also standards like the **WMO Common Alerting Protocol (CAP)** to follow in communication.

Questions to consider:

1. Are there different communication approaches needed for different groups? Communications methods include both the message and the medium in which they are distributed.
   Sending a message with the thresholds of risk anticipated can support people in deciding whether to evacuate. For example, **Google** shows 'warning', 'danger' and 'extreme' levels, and maps of likely inundation. The structure and contents of the message are also important; In Germany, a **study** found that 96% percent of residents prefer communications with graphics, and especially maps of intensity and extent of inundation 85% preferred structuring recommendations on action in a bullet point format.
   The medium of communication will determine if certain groups receive and understand the message. In Bangladesh, a **UN Women study** found that different communications methods will affect marginalized groups, like transgender people, women, girls, and the elderly differently. TV, phone calls, community announcements and other mechanisms will be more well received by certain groups. In addition, literacy is a challenge, and text alerts aren't always feasible. Ensure these communications are multi-channel, multilingual, accessible. In the Mozambique case, community brigades going door-to-door was necessary for the warning to reach some community members.

2. What kind of risk profile do community members have? Flood warnings are hindered by people underestimating the risk or perceive themselves as unequipped to mitigate the risk. Communication should be altered to the risk profile and the specific barriers that prevent people from taking appropriate action.

For response capability and forecast based financing

Forecasts are used primarily for warnings and evacuations but can also be used by humanitarians to link these forecasts to forecast-based-financing, releasing cash or material supplies like food, water, medicine, or sandbags to support communities to weather the storm and prevent excess damage to assets.

Questions to consider:

How are different groups impacted by the hazard? Evacuating can be particularly dangerous for girls and women. Many prefer not to leave their homes after receiving early warnings due to a desire to protect their homes. Further, they may face sexual harassment or assault at shelters. Displaced people are also often disproportionately impacted by flooding events. Humanitarian organizations often do not have time to adequately place refugee camps away from natural hazards. However, in places like Bangladesh, both host communities and refugee camps may be susceptible to flooding, so it's important to ensure both are reached by services for peaceful co-existence and local flood risk knowledge.

Do any existing solutions meet our requirements? If not, what gaps exist regarding data access and analysis to support our use case?

There are no existing turnkey global flood early warning systems because every EWS needs to have clear location-specific validation of flood forecasts from historical data, but some countries have functioning multi-hazard systems, and many have components of an EWS. Consider investigating if the national government has a functioning system, and where your organization can fill gaps to achieving and end-to-end EWS.

What types of skills and expertise are needed? Based on our internal capacity and bandwidth, can our team take on this work? What kinds of partnerships do we need?

It is important to thoroughly evaluate both the technical requirements of the project and the capabilities of your organization and team. Refer to the section above on 'What data could support these decisions? What are "must have" requirements for the data and use case?" for a sample of capacity needed for each of the four pillars of a flood EWS. Local engagement and capacity building skills are essential for all parts of a flood EWS. Flood mapping skills are particularly helpful to build disaster risk knowledge. Flood forecasting requires hydrological modeling experts who can assimilate both local and satellite data and can leverage advances in technology like AI-based models that can improve predictions. Technical partner organizations can support this pillar. Communication activities require social science skills and in-depth community knowledge to reach all community members, even those with varied levels of literacy or radio, phone, or internet service. Finally response activities can be led by forecast based financing experts and rapid response teams.

How much time do you need to gather data? For analysis?

This is dependent on the intended goals of the project. It could also be affected by the project location, as there is a shortage of in-situ meteorological and hydrological data in many places.

Is commercial imagery or tasking needed? What are our alternatives?

Consider working with commercial satellite data providers or specialized forecasts if:

- existing free products lack the necessary spatial resolution or frequency,
- real-time, cloud-free satellite images are necessary to capture detailed flood extent, or
- you need highly accurate forecasts or risk assessments that require advanced processing not available openly.

What are your needs for analysis like cloud computing, internet bandwidth, team time, other expertise, in-country partner?

In the context of Flood EWS, some high-priority needs can be fulfilled by accessible and readily-available tools and resources. This includes open-source GIS software, high-resolution satellite imagery, technical support and training.

GIS Software

For risk assessment and mapping, free GIS options software like **QGIS** or **GRASS GIS** can be used. Private companies like **Esri** also provide low-cost ArcGIS licenses for the humanitarian user. **Google Earth Engine** offers cloud computing and a satellite image catalog to document flood zones or perform calculations on raster data with some operational use restrictions.

Imagery

Maxar and **Planet Labs** offer high resolution data to assist humanitarian response to disaster events. The **International Charter: Space and Major Disasters** tasks satellites like the 30 cm resolution **Airbus Pléiades Neo** to assess damage and assist with recovery after dis asters.

Technical Support

UNOSAT Emergency Mapping Service (UNOSAT- EMS) is a 24/7 service that provides satellite imagery analysis support following rapid on-set disasters, complex emergencies, and crises. The UNOSAT-EMS is free of charge for the emergency phase of the response. It can be activated by UN agencies and humanitarian entities operating in line with the UN policies.

The **Humanitarian OpenStreetMap Team** organizes volunteers to come together online and on the ground to create open map data that enables disaster responders to reach those in need. Through the Missing Maps project, the HOT global community creates maps of high vulnerability areas where data is scarce on OpenStreetMap.

Trainings

The IFRC has a **training module** to support humanitarians using EWS. The **NASA Disasters program** shares information on projects that apply Earth observation data to support decisions across the disaster cycle. NASA's ARSET program offers training on how satellite-derived data can practically support humanitarian **flood forecasts**. UN-SPIDER has a training on **Flood Hazard Assessment** using geospatial information. Caribou Space has a module on **geospatial data for flood preparedness**.

Forecast Based Financing

The Red Cross Climate Centre's **Handbook for Forecast-based Financing (FbF)** offers practical guidance on how satellite-derived forecasts can trigger humanitarian action.

How accurate are the data/analysis/findings? What is our confidence in this data? How should we communicate about risks and uncertainty and how to apply data?

Satellite-based flood early warning systems should be validated in a particular region before operationalizing. Validation with historical flood records can consist of imagery, local stream gauges, or high-resolution imagery. There are also skill scores and statistical metrics that can set thresholds of whether to use a model for an early warning system.

Generally, the lower the lead time to the event, the higher the accuracy of a forecast is. GloFAS is one of the leading and most widely used flood forecasting tools to date. It is accurate in **93% of catchments** for short- and medium-range predictions but decreases with longer lead times. AI-based models, like Google Floods Hub can improve flood predictions, but are only as good as the historical data that they digest, which may not cover some areas. Rare, severe events like a one in 150- to 200-year event may be predicted but with a high degree of uncertainty.

The **AI based Google global floods model** improves predictions from the Copernicus GloFAS tool up to five days in advance, though the authors still call for increasing the availability of hydrological data to continue to improve flood warnings globally. Regions that the model has confidence in include South America, especially the Amazon basin, the US, southern Africa, central Asia, and eastern Australia. However, regions with poor performance include smaller catchments, tropical Africa, the western coast of South America, and catchments dominated by snow and ice in high northern latitudes.

A challenge with global early warning systems is that there are critical gaps in meteorological observations across Africa, parts of the Pacific and West of Latin America, impeding the improvements and ground-truthing of these early warning systems. There is unknown skill in parts of the world where there are no in situ observations to evaluate against. When determining whether to use GloFAS for your area, consult a **confidence layer** on the tool.

Are there elements of our approach that should be shared? (e.g., lessons learned, data, tools)

Many of these systems are already developed and being improved. Sharing use cases and success stories with those developing these systems could support sustainable funding. In addition, a major challenge in flood prediction is access to in-situ data to validate models. The team at Google Floods asks that researchers with access to streamflow data share it in an open source **Caravan project.**

What was the impact of our decision-making using this data/ analysis?

When monitoring and evaluating the effectiveness of EWSs, organizations use the **Sendai Framework**. It details specific monitoring and evaluation targets for EWS. These include mortality, injuries, shelter damage, livelihood loss, and additional economic indicators.

In retrospect, would we use satellite data again? What do we want to do differently next time?

Some noted methods to improve the accuracy of Flood EWS include:

- Use multiple data sources (e.g., satellite imagery + river gauges + weather models).
- Downscale global models to regional/local scales.
- Conduct continuous validation using historical and real-time flood data.
- Ensure local collaboration.

Case Study

HUMAN RIGHTS

Using Satellite Data and Tools for Humanitarian Decision Making

Introduction

Satellite imagery was first used in a human rights context during the Yugoslav Wars, where it led investigators to mass graves, and was first used as evidence during the related International Criminal Tribunal for the former Yugoslavia trials. It was subsequently pioneered by the Satellite Sentinel Project (on Sudan), and it was quietly adopted by the likes of Amnesty International and Human Rights Watch. Catalyzed by the increased democratization of satellite imagery and data, coupled with the popularization of open-source investigations and methods, human rights investigations have been fundamentally transformed by organizations that deploy satellite imagery and analysis in different and often novel ways.

The human rights applications of satellite data are vast, varying greatly over scale, resources, context, capacity and more. At present, projects and organizations exist that use satellite data to effectively cover numerous serious human rights situations and issues worldwide, often operating through the lenses of justice and accountability, journalism, and advocacy. To effectively illustrate this variety, this case study includes two separate project examples - one a project of limited means working on an obscure conflict, the other well-resourced on a situation of global importance and interest.

Case A
Cameroon

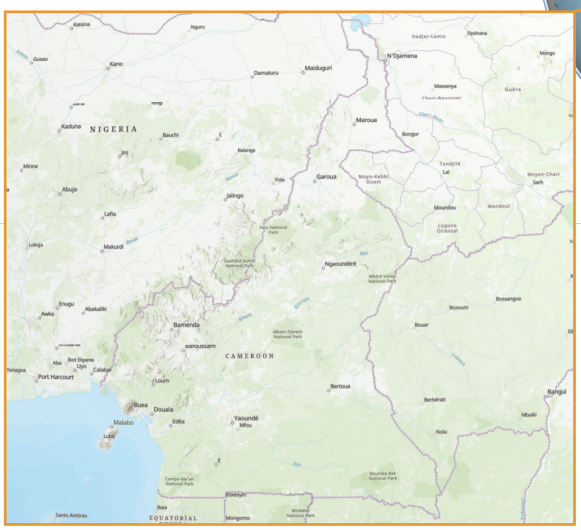
Focused, Limited and Local Investigations into Individual Actions or Incidents.

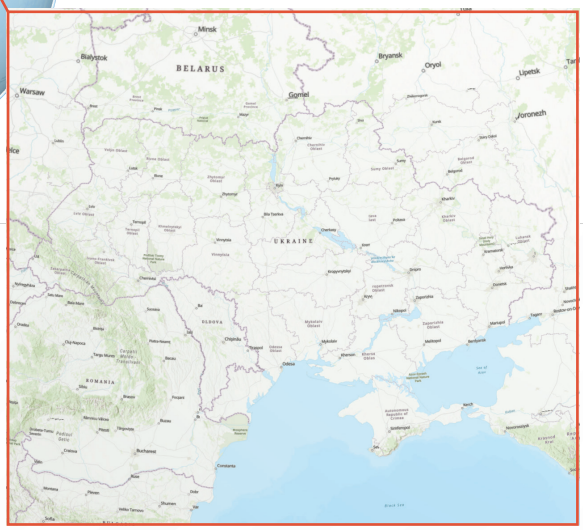
In February 2021, an attack in the isolated area of the North-West region of Cameroon le° 21 civilians dead. Investigators used satellite imagery to geolocate the incident and identify mass graves, contributing to reports accusing the government of Cameroon as responsible.

Case B
Ukraine

Large Investigations Covering Significant, Complex and / or Long-Term Incidents.

In 2022, the City of Mariupol was effectively destroyed during a months-long siege. Popular investigations used satellite imagery and geospatial analysis to identify human rights abuse and illustrate the situation.





What decisions could satellite data support?

Satellite data and tools offer unique, vital insights in human rights investigations. They are increasingly a routine part of investigations by numerous human rights organizations and investigative journalism outlets, from the most humble to the most powerful. These tools make meaningful and, at times, transformative contributions to the human rights field, advancing human rights by facilitating monitoring, advocacy, accountability, and the prevention of violations. It is the cutting edge.

Satellite data can support numerous decision types:

- ☐ Commitment of additional assets and resources to an investigation based on findings.
- ☐ Identifying and validating incidents for investigation.
- ☐ Launching advocacy campaigns in response to an incident / issue.
- ☐ Deployment of human rights officers or observers to the affected area.
- ☐ Building local relationships to facilitate current and future investigations.
- ☐ Identifying conflict and human rights violation hotspots.
- ☐ Visualizing otherwise often invisible situations, like environmental destruction.
- ☐ Decisions to prosecute (or not to prosecute) individuals or factions for human rights violations.
- ☐ Decisions to collaborate with other human rights organizations or media outlets.

Are there any precendents for this use case? Relevant resources we could use?

As demonstrated below, satellite imagery and data is used across a myriad of specific applications and contexts in the human rights field. It has become increasingly mainstream, riding a wave of popularity through high-profile investigations. There are numerous precedents for this specific use-case, spanning time and space.

Including the use cases listed below, three core examples include:

- Conflict and War Crimes: **Sudan – RSF Targets Civilians, Human Rights Watch**
- Journalism: **Mapping the Las Vegas Massacre, NYT**
- Accountability and Justice: **How Bellingcat Collects, Verifies and Archives Digital Evidence of War Crimes in Ukraine, Reuters Institute, Oxford**

Conflict & War Crimes	Documenting incidents, attacks, and impacts
Journalism	Advancing investigative journalism including into major events

Accountability & Justice	Capturing and developing robust evidence for courts and transitional justice mechanisms
Environmental Justice	Identifying and monitoring illegal mining, deforestation and pollution
Humanitarian Access	Verifying access, blockages, assistance needs, and assessing risk to humanitarians
Refugee Rights	Identifying and predicting refugee flows and assessing camp conditions
Indigenous Rights	Evidence of land claims and resource exploitation
Disaster Response	Rapid assessment of humanitarian needs
Transparency	Investigating issues objectively to support accountability

What are the ethical and risk considerations of introducing the use of satellite data?

There are many ethical and risk considerations in using satellite data and tools for human rights investigations. The below prompts might be useful:

- Is the source of the imagery important?
- Is how you access the imagery important?
- How are you going to use the data?
- Does your data need to be secured? How will you secure it?
- Could access to this data and analyses of this data put individuals and communities at risk?
- Could this data and analyses influence dynamics on the ground?
- If operationalized in the field, what risks could it pose to teams and communities on the ground, and how current does a product need to be to be safe & useful and not potentially misleading and dangerous?
- Could the possession of such documents be perceived as evidence of spying or espionage by on-the-ground actors?

Categories of Risk Examples:

- Privacy and Data Protection
- Risk of Misinterpretation or Misuse
- Bias, Equity and Selectivity
- Increased Risk to Vulnerable Populations
- Political Manipulation and Propaganda
- Cultural Sensitivity and Local Context
- Overreliance and Neglect of Ground Data
- Consent, Agency and Representation
- Accountability and Transparency in Satellite Data Use

Case A: Cameroon

The Anglophone Crisis in Cameroon is very poorly known, and Cameroon rarely has high quality, publicly available satellite imagery. It is not uncommon to be working with data that is more than 5 years old. To perform these investigations, it is not possible to be picky about the source. This can produce a difficult ethical dilemma.

The conflict is highly localized, often varying from settlement to settlement, and is punctuated by sharp outbreaks of lethal violence. This means that the specific victims, perpetrators and witnesses are likely to be known within the local community. It is vital to not disclose those that have provided evidence – like videos – and those affected by and implicated in the violence, as this could place them at great risk of harm.

Relatedly, the time frame is important. Releasing details of where refugees have fled or the suspected location of an armed group could again lead to lethal harm. Such information should be shared – if at all – only with explicitly trusted organizations and bodies. The question of when to release information and who to is difficult to answer in any context.

Applying the **do-no-harm** humanitarian principle means that we must proactively limit the risk our investigations and work presents to any individual or organization both inside Cameroon and outside. Again, this might mean redacting certain details and limiting sharing only to trusted partners.

The **Humanitarian Charter established by the Sphere Standards** is a throughline throughout these investigations.

Case B: Ukraine

The provenance of imagery matters here for several ethical reasons. Here are three relevant examples:

Firstly, accessing and using imagery or other geospatial products from the same state that is actively and likely committing crimes against humanity in the area you are considering is almost certainly unethical. What if it was the only imagery available?

Secondly, accessing and using imagery or other geospatial products from a company that has perhaps restricted access over certain areas of a conflict zone either independently or at the whim of another institution or agency is also ethically and operationally problematic.

Thirdly, it is hard to know whether the geospatial data or imagery has been edited or altered in ways to protect the interests of that state or other states with interests.

These are important considerations that have become increasingly relevant in response to recent conflicts. In cases like this, where imagery and geospatial data is available from a range of providers and humanitarian partners, it is unethical to source it from the country in question. The golden thread of do-no-harm remains in place here, but it is easier to collaborate and communicate with other partners to understand what that means, collectively, in this conflict – and address it.

An increasingly urgent, significant challenge is the impact that political instability and shifts can have on major digital human rights investigations and projects. The very high-profile Conflict Observatory, a project documenting Russian war crimes in Ukraine, was supported by the US State Department, National Geospatial Intelligence Agency, and academia. It involved massive collaboration, pioneering and effort between numerous partners to build a class-leading platform and body of evidence. Following the US Presidential transition in 2025, the project was taken entirely online and remains inaccessible, raising difficult questions about the reliability of government partners and the perils of dependency upon them, suggesting that independent approaches - even though often less well-resourced and funded - may offer more resilience in the long-term.

There are also numerous risks to consider:

- Privacy and Security Risks to Vulnerable Populations
- Risk of Misinterpretation or Incorrect Analysis
- Unintentional Bias or Selectivity
- Increased Risk of Retaliation or Violence
- Politicization and Misuse of Imagery
- Ethical Risks of "Distant" or Remote Analysis
- Consent & Community Agency

In summary, good practices to address these risks include:

- Always undertake a formal ethical & risk assessment before releasing satellite-based analyses publicly.
- Clearly communicate the limitations and capabilities of satellite imagery.
- Prioritize local collaboration and "ground truth" satellite data with direct eyewitness accounts or local reporting.
- Proactively consider consent as a feature of investigations, not a bug.
- Consistently adhere to established ethical and methodological frameworks (**Berkeley Protocol**, **Amnesty guidelines**, **Signal Code**).
- Proactively educate stakeholders about what satellite imagery can and cannot reliably document.

Case A: Cameroon

- Reputational – as the only game in town working on a very complex, online conflict, there is a very fine line of legitimacy and reputation both from civil society, partners, and the international community. One error could likely destroy everything.
- Safety, Local – the database has privileged access to information that could put victims and vulnerable people at risk. Our risk may also threaten the safety and security of on-the-ground partners.
- Safety, Team – working intimately with traumatic, graphic material can be damaging to mental health. Communicating online about the work and conflict may expose individuals to doxing or other online harm.

Case B: Ukraine

- Reputational – high-profile conflict and high-profile partners create a razor edge of risk and reward.
- High profile nature of the conflict may expose the project to the interests of malign actors like country-linked hackers or diplomats.
- Potential (but not a given) reduced risk to life of collaborators, witnesses, civilians, and perpetrators.
- Risk of digital and physical harm to team.

What data could support these decisions? What are "must have" requirements for the data and use case?

Conditions are a critical initial factor to consider before initiating the geospatial components of an investigation. This is especially significant when latency - like how long it takes to access the satellite imagery post-event and post-capture - is the priority, such as with a serious and rapidly-evolving event.

Conditions	Best Satellite Data	Providers
Clear skies	Optical	Maxar, Planet, Airbus
Cloudy	Synthetic Aperture Radar (SAR)	Sentinel-1, ICEYE
Night	Synthetic Aperture Radar (SAR)	Sentinel-1, ICEYE

Human Rights Issue		
Conflict documentation	Optical high-resolution imagery	Maxar, Planet, Airbus
Forced displacement, refugee crisis	Optical imagery, SAR for cloudy/ night context	Planet, Sentinel-1
Mass graves, mass killings	High-resolution multi-spectral and optical imagery	Maxar, ICEYE, Capella Space
Environmental rights	Medium-resolution multispectral and optical imagery	Sentinel-2, Landsat, Planet
Infrastructure attacks	High-resolution optical, SAR for weather / cloud cover	Maxar, Planet, ICEYE, Capella
Fires, village burnings	Thermal Infrared (MODIS/ VIIRS), optical	NASA MODIS, Planet, Maxar, VIIRS

You can also consider frequency, timeliness, and cost. For example, commercial providers often offer daily imagery, however, high resolution data and tasking can be cost prohibitive. In-kind high-resolution imagery is accessible through Google Earth but often not recent enough to be useful for human rights. For some cases, purchasing imagery is worth it to acquire high-quality detailed evidence. Public sources like Sentinel and Landsat are ideal for budget-constrained investigations or large-scale documentation.

Type	Example	Max Resolution	Cost
Commercial Optical	Maxar, Planet, Airbus	0.3m max	High
Commercial SAR	ICEYE, Maxar	<1m	High
Commercial Partner Optical	Planet	3.7m	Free
Commercial SAR	ICEYE, Maxar	ˇ0 .15m	Free
Public Optical	ESA Sentinel - 2	10m	Free
Public Optical	NASA Landsat	30m	Free

Do any existing solutions meet our requirements? If not, what gaps exist regarding data access and analysis to support our use case?

Some existing, valuable and accessible products include:

- **Google Earth Pro** – provides global historic imagery and several basic geospatial tools that can help your investigations.
- **Google Streetview** – provides street-level photography often over a range of dates, but is limited only to the specific countries it covers.
- **Google My Maps** – is an excellent tool for investigation that facilitates real-time collaboration using maps and imagery.
- **Bing Maps** – is an alternate source of satellite imagery.
- **Satellites.Pro** – is an alternate source of satellite imagery.
- **Apple Maps** – is an alternate source of satellite imagery.

- **NASA FIRMS** – the NASA Fire Information for Research Management System provides global coverage of fires / hotspots that it has detected via satellite. Major human rights incidents – like the burning of a village, or an explosion at an oil refinery – can be readily identified and cross-referenced by appropriately using this tool.
- **Planet Labs** offers high-frequency, high-resolution imagery at 50cm via SkySat, but imagery shared as standard with human rights organizations is only 3.7m resolution via a different satellite constellation.

These basic resources provide the initial framework to identify zones of interest and locations disclosed by informants, the press, and collaborators. These resources require minimal training or geospatial understanding, meaning that anybody with a stable internet connection can contribute towards a case. Google Earth Pro (Desktop preferred) offers an easy introduction to GIS software with high-quality service-based imagery. There are many easily accessible, quality training resources available on YouTube for using this software and there are numerous further useful sources of satellite imagery – many are free or mostly free. These include NASA's **Earth Explorer** and **Worldview**, and the EU's **Copernicus Data (Sentinel) Browser**. Commercial imagery is also available.

Disruptors in the field like SkyFi (optical), UP42, Skywatch and Umbra (SAR / InSAR) are making satellite tasking and data access from commercial satellites far easier than ever before. In this sector, **Caribou Digital's GeoEvidence Explorer and GeoPlatform Finder** offer highly intuitive ways to identify and access data for your use case.

Case A: Cameroon

The quality and quantity of imagery of Central Africa is o°en poor and limite d, making even basic work hard. Commercial high resolution, high frequency imagery offers the most viable investigation route, but it is usually only available if organizations have existing relationships as a beneficent with providers, or if providers offer free imagery. Purchasing imagery has been found to be cost prohibitive – with the uncertain quality and accuracy of imagery matching the very limited budget typical of these project types.

Case B: Ukraine

This high-priority situation of great international defense interest and concern generated a huge geospatial response. High-quality imagery was ubiquitous, provided by commercial imagery providers like Maxar. Access to this imagery facilitated dozens of high-profile human rights investigations by international bodies, the media, and human rights organizations.

What types of skills and expertise are needed? Based on our internal capacity and bandwidth, can our team take on this work? What kinds of partnerships do we need?

All of these elements can vary wildly between organization and investigation. Among other challenges, groups may seek to mislead investigations using satellite imagery. Though often intended to challenge impunity, the value and accuracy of satellite imagery can sometimes be deliberately obfuscated by armed groups on the ground. This could include hiding evidence before a satellite orbits overhead and reducing the visual profile of their activities from above. It is important that analysts are able to identify these challenges where possible, a task made easier by collaboration with local experts and community members.

Case A: Cameroon

This context is highly local, with very little access to high-quality data or software. Working with local collaborators, aid organizations, and other civil society organizations, we work with familiar, easily accessible file types and data formats like KML and shapefiles. This data is the most accessible – but we often just provide a finished product because our partners often do not have the geospatial expertise or capacity to work with it. In the opposite direction, we apply their vital, on-the-ground data collection efforts to geospatial products and investigations, working together. This then furthers the work of accountability and advocacy while also supporting local partners as finished products to inform their work. An example of a similar investigation using very limited resources would be: **Burning of Mamfe District Hospital, Manyu (Cameroon)** Cameroon Database of Atrocities.

Case B: Ukraine

This situation is high-profile and the subject of great international interest and concern, meaning that leading human rights organizations and earth observation agencies / companies are in the process of responding. Through collaborating with fellow cutting-edge organizations, we can provide more advanced data and analysis to support their work and vice versa – ideally across a constellation of journalism, advocacy, and accountability. This can facilitate excellent shared geospatial products for others to refer to or to provide timely, much-needed analysis. This can include AI/ML methods, imagery that we (or our partners) may have privileged access to, and ground truthing. We can collaborate more technically when working on major situations with more data available and geospatially-advanced partners, and can set more complex and ambitious investigation objectives.

Two examples of an investigation along these lines would be:

Map Lab: Mapping Gaza's Destruction Bloomberg / Dr. Jamon Van Den Hoek

A City Devastated (Mariupol) Human Rights Watch / SITU / Truth Hounds

How much time do you need to gather data? For analysis?

A 'rapid response' to an atrocity would likely involve quickly investigating an individual act – say a single massacre, village burning, or airstrike. Speed is an important consideration for awareness-raising and advocacy as close to the 'moment' as possible. The end product might be an alert to the international community and high-profile media coverage.

This is different from a longer-term investigation of atrocities during a phase of a conflict or over a wide area. This approach is usually typified by more advanced and developed techniques, a closer adherence to guidelines on digital evidence, and collaboration both between technical / investigative organizations and partners on the ground. The end product might be a comprehensive report on a situation submitted to international legal bodies.

They both have the same root and borrow from each other, but they remain different in approach and end product. There are competing priorities and significant new atrocities occurring around the world all the time. An unfortunate reality is that complex, time-consuming analyses might be overtaken by the need for a rapid response to bigger issues. Media coverage is important for organizations and projects old and young, big and small, because it can build their legitimacy, help gather support and awareness for / of their cause and highlight their expertise. This is very important for securing funding, partnerships, and future resources for the project. In this sense, for better or worse – and in terms of news cycles – speed is crucial and time is money.

Case A: Cameroon

In the Central African Human Rights EO world, the challenge is that while you might be the only organization working on a situation – and you are the only organization with information about important atrocities – the conflict is rarely, if ever, covered in the international press. In the absence of news coverage, advocacy can thus often be behind the scenes, working in diplomatic backchannels. This also makes funding either hard to come by or non-existent.

With this heightened responsibility of leadership in a context comes a clear need for fast-turnaround assessments to facilitate immediate confirmation and advocacy around an event – and to ideally inform international accountability mechanisms. With good imagery and great fortune, it is possible to issue a flash report detailing an atrocity with geospatial products within 24 hours of it occurring – even in remote Central Africa. Yet it usually takes much longer, especially working with volunteer teams, with investigations taking upwards of two months. The longer it takes, the less value it has in advocacy and raising awareness, beyond specialist groups. But if done well, it retains its value for accountability. These timelines are almost entirely contingent on the availability of good, timely geospatial data – which is rare.

Case B: Ukraine

With so many organizations competing for coverage, importance, and influence during major incidents, the need for speed is matched by a need for complexity, technical prowess, and uniqueness. Being fast and novel is usually the only way to be cutting-edge and exciting enough to make the news. This pushes us to produce advanced work at pace, something best achieved with partners. Time is everything, but in a different way – it is harder to get your work noticed, but there is greater opportunity to do so because the conflict is already a major focus of the international media. In this case, investigations placed in the media can become an interest of organizations or agencies – the parallel development of interactive dashboards and tools is a way to root investigations in human rights as opposed to media.

In short, the question often isn't how much time you need, but how much time you have.

Is commercial imagery or tasking needed? What are our alternatives?

Yes… but?

Case A: Cameroon

Traditional, publicly available imagery sources rarely update and are often too lo w quality to be used effectively. Companies offering high frequency orbit offer access and capability that otherwise would not be possible. Traditionally purchasing imagery commercially is economically unviable.

Case B: Ukraine

Exceptionally high-quality commercial data was made available during the peak of this crisis through public-private partnerships, relationships, and acquisition. It played a key role in a groundbreaking, broad human rights investigation response by numerous organizations, entities and individuals. Note that many major human rights organizations have existing relationships with commercial providers like Planet, including HRW and Bellingcat.

However, commercial imagery for human rights is usually at the behest of the provider, and this, as recently proven, is a serious risk. The provider could substantially increase the cost of the imagery. The provider could turn off access to imagery over a certain area at any time, or could be pressured to do so by a state. The provider could turn off access to imagery for a specific organization, or could be pressured to do so. The provider could restrict access under pressure from a state directly involved in a situation of concern. The provider could be manipulated to support the goals of a nation-state or other entity. Examples of these have occurred very recently in the contexts of Russia-Ukraine and Israel-Palestine.

With this in mind, it is wise to consider earth observation more closely. Will new satellites, constellations and capabilities come online from the likes of NASA and the ESA? Will new open-source data - and potentially an independent humanitarian satellite - come online? Are there compelling new technologies that could support your work?

What are your needs for analysis like cloud computing, internet bandwidth, team time, other expertise, in-country partner?

In the human rights field, it can be difficult (if not impossible) to address all of these issues perfectly, cohesively and simultaneously as independents. It is necessary too to consider what in-kind resources and benefits may be available.

For Most / Most Likely

- Guides from fellow organizations and specialists
- Webinars
- Open Source Software – QGIS +
- YouTube Training and Online Courses
- Networks like Bellingcat
- Volunteers

Rarely / Needed

- Imagery donations & collaboration
- Geospatial Support for larger-scale problems like conflict analytics beyond organization and team
- Advanced Technical Education
- So°w are Licenses – ArcGIS +
- Professional / Academic Courses

Key Questions to Consider:

1. How Complex are your Analysis Needs?
2. Required Skills and Expertise?
3. Where Can Volunteers Help?

Complexity Level	Analysis Type	Recommended Approach
Basic	Visual analysis, simple annotations, mapping, change detection	In-house or volunteers
Moderate	Detailed change detection, displacement tracking, multispectral imagery interpretation	In-house (trained GIS analysts or partners
Advanced	SAR interpretation, environmental modeling, large-scale analyses	Partners or specialized in-house expertise

Analysis Type	Resources Recommended	Skills Needed	Earth Science Expert Needed?	Volunteer Contribution
Visual mapping, annotation	In-house or volunteers	Basic GIS skills (Google Earth Pro, QGIS)	No	Yes
Simple change detection	In-house or volunteers	Moderate GIS skills	No	Yes (Supporting)
Complex displacement monitoring	In-house trained analyst or partner	Moderate/ Advanced GIS Skills	No	Yes (Initial mapping)
SAR & radar data analysis	Partner or specialized in-house analyst	Advanced SAR inter-pretation, remote sensing expertise	Yes	No
Multispectral (environmental)	Partner or advanced analyst	Remote sensing/ multispectral image analysis	Yes	Limited (Basic annotation only)
Flood or environmental modeling	Specialized partner (academia, UNOSAT, NASA)	Advanced environmental modeling and Earth science expertise	Yes	No

How should we communicate about risks and uncertainty and how to apply data?

By proactively managing expectations and clearly communicating the capabilities and limitations of satellite imagery analysis, human rights organizations build trust, credibility, and ethical clarity, ensuring stakeholders have realistic expectations and maintain confidence in satellite-supported human rights investigations.

Key ways to communicate certainty and uncertainty:

- Always clarify upfront what satellite imagery can realistically provide.
  - Possibilities (what satellites typically can show)
  - Limitations (what satellites cannot typically show)
- Identify and maintain standard communication practices.
- Clearly communicate timelines and latency.
- Be transparent about ethical considerations & risks.
- Clearly explain what analysis techniques you use.

Are there elements of our approach that should be shared? (e.g., lessons learned, data, tools)

The contemporary digital human rights investigation field was effectively founded on the open-source exploitation of satellite imagery, and it continues to operate as such. Many tools are open-access and are shared freely, and training is available on YouTube from anywhere. There is a very low barrier for entry, and this is matched by a usually collaborative field. In this spirit, sharing lessons learned and more should ideally be considered a constitutional part of any organization or investigation.

With that in mind, the below terms detail foundational techniques for the use of satellite imagery in the context of human rights.

Geolocation: the practice of finding the location of an incident anywhere in the world, usually using visual source material including photographs and videos. It is at the heart of almost every digital human rights investigation, facilitating the additional analysis to complete it. There are numerous accessible guides on how to do this, **including this one by M_OSINT**.

Chronolocation: the practice of identifying the time an incident took place, often using shadows and the weather in the source material. This process requires a close examination of the source material and usually uses the **Suncalc software**. **This guide by Youri van der Weide** at GIJN is particularily accessible. It can also be performed with satellite imagery more broadly, especially to identify major changes during an incident over time.

Visual Interpretation & Annotation: Manual analysis of satellite images for evidence of: destroyed infrastructure, burned villages, forced displacement, mass graves or burial sites, refugee camp growth and conditions.

Change Detection Analysis: Comparing satellite imagery from before and after an event to detect and quantify changes (including optical and SAR imagery), such as damage assessments, environmental harm, camp growth, detecting fires and burning villages, or industrial activities using thermal imagery (NASA MODIS, VIIRS thermal infrared data via NASA Worldview or FIRMS; visualization through Google Earth Engine or QGIS).

Leveraging AI models to rapidly detect features on larger scales (e.g., damage assessments, settlement mapping). TensorFlow, PyTorch-based machine learning algorithms (typically via partners/academia). Automated detection of burned areas, refugee settlements, and environmental degradation.

Working with volunteers: Mobilizing volunteer mappers to quickly annotate imagery during crises using OSM, or the HOT Tasking Manager and/or MapSwipe.

What was the impact of our decision-making using this data/ analysis?

Case A: Cameroon

As evidenced here, satellite imagery and data has been critical for human rights investigations into Cameroon's Anglophone Crisis. Even with humble means, the Database of Atrocities has had a considerable impact.

Reports have been routinely shared with and engaged with by international organizations, legal bodies, governments, diplomats and humanitarians. The Database has directly contributed to key submissions to international legal bodies by major legal organizations, and it has also directly contributed to international legal efforts to target key figures and conflict dynamics. It has routinely collaborated with major news agencies and media outlets. Through this, the database has built a strong reputation of expertise and accuracy on this conflict, and it is often the first port of call for those seeking to work on it. This is the direct impact of satellite imagery and related investigations on the Anglophone Crisis.

The database has built a strong, resilient network of partners within Cameroon and remains engaged in broader discussions of justice and accountability. These relationships have included joint investigations and lending geospatial (and satellite imagery) expertise to support their work. The database also maintains a strong network in the global north, with major human rights organizations and investigative outlets.

The Cameroon Database is proof of concept of what can be done with very limited resources – how to evolve, how to grow, and how to have meaningful impact despite that – and perhaps because of it. It also follows that the Database shows the light that can be shone on forgotten crises and conflicts – where the suffering is no less important for not being known.

Case B: Ukraine

The Russian Invasion of Ukraine was a seminal moment in the use of satellite imagery for human rights investigations. It pioneered private-public partnerships of satellite imagery and showed the art of what is possible to organizations and media outlets – related to the vast public, governmental, and defense interests involved. The satellite-imagery focused collaboration involved in investigations spread far beyond traditional human rights, including environmental destruction, food security, and damage assessments.

In retrospect, would we use satellite data again? What do we want to do differently next time?

It is important to regularly and consistently assess the impact of value of existing satellite data products and analysis in both the context of existing human-rights investigation methods and outputs as well as looking to the future. This could include improving a data acquisition process to provide more recent imagery, more efficiently; developing processes and protocols in advance to respond to specific types of violation; and identifying emerging technologies that could significantly advance technical capabilities, like InSAR.

Appendix: Ethics and Risk Considerations

This is not an exhaustive list but hopefully will guide your thinking as you consider your specific use case and context. We recommend consulting the more in-depth resources like Signal Code, the Berkeley Protocol, the Locus Charter, and others when reviewing with your team.

Mission Purpose & Transparency

Is the primary purpose of the satellite or EO data mission humanitarian, climate, or development-oriented?

Is the mission clearly not dual-use for military or intelligence purposes?

Are the satellite operators, data providers, and funding sources publicly disclosed?

Are usage restrictions clearly stated and understandable to non-technical users?

Data Access & Equity

Is the data freely available or priced affordably for non-commercial humanitarian use?

Are interfaces or tools accessible to users in low-bandwidth or low-resource environments?

Are local languages, regional formats, or relevant cultural contexts considered?

Can local actors request tailored products or coverage based on their needs?

Are the benefits of the data reaching vulnerable or marginalized communities?

Consent, Privacy & Data Governance

Was community input solicited or respected before data collection or use?

Is there a mechanism for communities to opt-out or control their data visibility?

Are measures in place to avoid identification of individuals or groups?

Does the platform follow humanitarian data protection standards?

Is there a way for communities to challenge or appeal data misuse?

Technical Integrity & Bias Mitigation

Are core algorithms open source or reviewable?

Can local experts verify or reproduce results?

Are assessments in place to check for bias in the data or outputs?

Have known data gaps been acknowledged and addressed?

Accountability & Partnerships

Are local actors involved in co-designing or interpreting the data?

Are private-sector partners held to community-centered standards?

Is there a documented log of data decisions?

Are impact assessments or after-action reports publicly shared?

Is there a neutral oversight body or community advisory council?

Is there a way to monitor ethical compliance over time?