IMPACT SYNTHESIS OF GEOSPATIAL DATA ON HUMANITARIAN OPERATIONS:
Methodology Document

Caribou Space

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As a UK-based humanitarian initiative, hosted by Elrha, the **UK Humanitarian Innovation Hub (UKHIH)** leverages expertise from the UK and across the globe to improve international humanitarian action, connecting the people equipped to bring about systemic changes that will strengthen and support humanitarian response.
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Accessibility
This report has been designed using Adobe’s PDF accessibility evaluation tool, a checklist of considerations to align to Web Content Accessibility Guidelines (WCAG) 2.1 Level AA.

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Caribou's approach to interactive impact evidence synthesis

Impact and contextual evidence synthesis is a core service offering of Caribou's Measurement and Impact practice. Using our signature approach to interactive impact evidence synthesis, Caribou has rigorously synthesised impact and contextual evidence to create evidence-based strategies, inform portfolio benchmarking, and advance thinking through continuous interactive synthesis.

Caribou has conducted impact and contextual evidence synthesis on the following topics:

1. Generative AI in Africa in the sectors of 1) agrifood systems and climate, 2) education, 3) entrepreneurship/finance, and 4) digital economy (internal-facing database)
2. Digital Financial Services for customers
3. Digital and data-first interventions on small businesses
4. Digital interventions to support women's economic empowerment (internal-facing database)

As proponents of interactive and ongoing evidence synthesis, Caribou has innovated with evidence outputs to support greater access to insights from our synthesis work. We share our evidence synthesis outputs in three ways:

1. The **interactive impact database** holds the raw coded data. Guided by a code book, we can filter, search, and access extracted summary insights and data points from the impact database.
2. **Interactive evidence maps** provide visual overviews of the entire impact evidence landscape, plotting interventions to outcomes and the direction of impact.
3. **A Chatbot-based conversational interface** queries the impact evidence database using natural language queries.

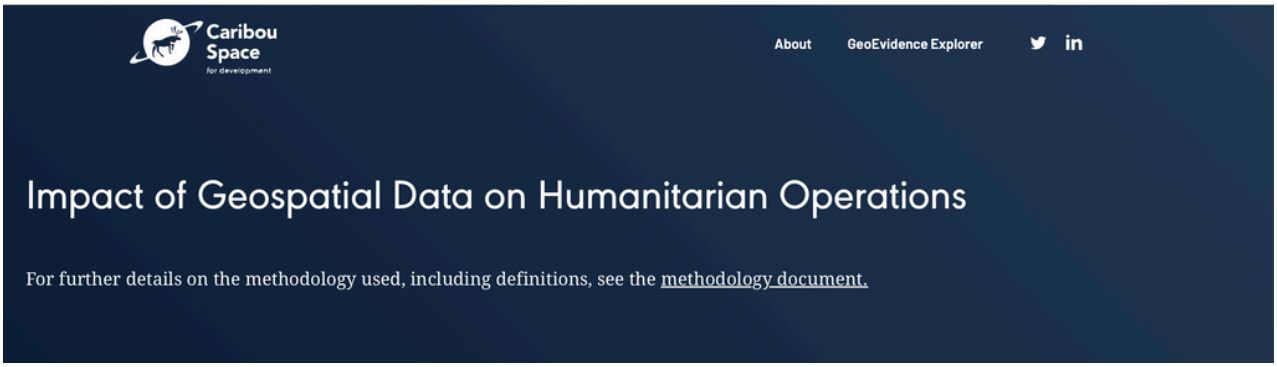
Grounded in our overall approach to impact evidence synthesis, Caribou adapted our methodology to support the Humanitarian Innovation Hub in expanding their and the broader humanitarian ecosystems, understanding of the impact of geospatial data on humanitarian operations.

Background to the GeoEvidence Explorer

Caribou has partnered with the UK Humanitarian Innovation Hub (HIH) since 2021 to understand the use of satellite technologies in humanitarian operations and to identify any ongoing barriers to their uptake. In 2022, Caribou published a comprehensive review of the 'state of play' in using satellite applications for humanitarian emergencies. In 2023, Caribou designed and rolled out an ideation process to bring members of the humanitarian community together to understand their experiences using satellite technologies and geospatial data. Three ideation workshops invited ideas on possible initiatives that might further promote and facilitate the adoption of these tools.

Discussions at Caribou's ideation workshops highlighted frustration at the lack of publicly available information to support the use of geospatial information in humanitarian decision-making. Practitioners remarked on the need to equip themselves with information to justify directing precious time and financial resources toward new technologies and data sources.

Caribou's GeoEvidence Explorer project aims to distil this information into a user-friendly and accessible tool.



Geospatial Data | Domain | Event Type | Country | Study Quality | Methodology | Reset

Use Case	Types of impact realised				
	Faster Response	Cost Savings	Better Access	Improved Preparedness	Supported Decision-Making
Access Routes And Evacuation Plans	2			1	4
Cash Distribution	1	1		3	1
Damage Assessment	3				5
Disaster Risk Financing And Insurance		2		2	
Disease Prevalence And Transmission				1	
Early Warning System	9	5	2	17	7
Hazardous Event Detection And Severity	1				2
In-Kind Distribution	2	1		2	2
Infrastructure Mapping And Exposure					2
Infrastructure Reconstruction	1				3
Microplanning For Health Interventions		2	2	1	3
Refugee Camps Awareness And Planning					1
Risk Assessment	3	2	3	5	9
Stockpiling & Resource Allocation	1			2	2
Water Sanitation & Hygiene (WASH)		1			3

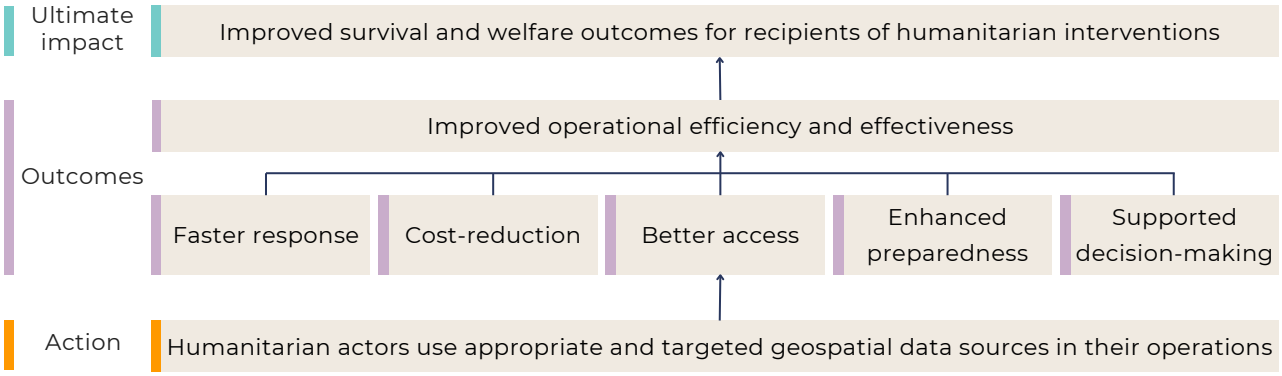
GeoEvidence Explorer methodology

Our impact insights synthesis methodology included the following stages.

1. Outline the impact hypothesis.
2. Set inclusion criteria.
3. Develop the coding framework.
4. Curate, screen, and code information.

Impact hypothesis

The impact hypothesis was developed to provide a structured representation of the hypothesised pathways through which geospatial data can contribute to operational efficiencies, ultimately leading to better outcomes for recipients of humanitarian interventions.



The team developed the inclusion criteria and coding framework in alignment with the theory of change to ensure that the evidence synthesis captures resources addressing primary pathways and contributing factors. This approach allowed for a comprehensive understanding of how interventions operate within complex systems while identifying opportunities for further research.

Inclusion criteria

The following inclusion criteria were established to align with the strategic interest of the HIH project. All requirements needed to be met for an insight to be included.

1. Research needs to be either practitioner literature or academic literature.
2. Research needs to be directed at a) humanitarian operations, b) outcomes, and c) an intervention that is aimed at preparedness, response, or recovery in any of the five humanitarian domains (disasters, security and conflict, food insecurity, population displacement, and health emergencies).
3. The research explores the use of geospatial data.
4. At least one of the five types of impact is assessed.
5. All countries were in scope.
6. To screen out technology that may now be obsolete, insights must have been produced in the last 10 years (since 2014).
7. Resources must meet our credibility standards of richness, relevance, and rigour.

Coding framework

Beyond compiling basic information such as author, year of publication, and country, available insights were reviewed to extrapolate intervention design, geospatial data used, and a host of contextual factors; the coding framework for the substantial categories is outlined below.

The review encompassed all research methods that met the inclusion criteria, including experimental, quasi-experimental, and non-experimental designs. For a nascent sector like geospatial data in humanitarian operations, we believe that incorporating resources employing various methods enhances the sector's knowledge, particularly when evidence remains limited.

Intervention design

METHODOLOGY	
Administrative /system data	A study that routinely analyses information that organisations or systems collect to evaluate patterns, outcomes, or performance.
Cost/benefit analysis	A study that compares the costs and benefits of a decision or project to determine its overall value or feasibility.
Cross-section	A study that analyses data from a population at a single point in time to provide a snapshot of characteristics or outcomes.
Formative study	A research approach to gather insights and inform the design or improvement of a program, product, or intervention before its full implementation.
Meta-analysis	A statistical technique that combines results from multiple studies to identify overall trends and effect sizes.
Mixed methods	A research approach that combines quantitative and qualitative methods to provide a more comprehensive understanding of a research problem.
Propensity score matching	A statistical technique used to estimate a treatment's causal effect by pairing treated and untreated units with similar characteristics.
Qualitative study	Research focused on exploring and understanding phenomena through non-numerical data, such as interviews, focus groups, or observations.
Randomised control trial	An experimental study where participants are randomly assigned to either a treatment or control group to assess the effect of an intervention.
Simulation study	Research involving models or simulations to replicate and analyse complex systems or scenarios to predict outcomes or explore phenomena.
Validation study	Research is designed to assess the accuracy, reliability, or validity of a specific tool, method, or model, often against established standards.
QUALITY OF METHODOLOGY [1]	
High	Rich descriptive methodological information was provided such that the study could be replicated.
Medium	An indication of the methodological approach is provided, but it is insufficient to replicate or enable deeper engagement with the findings.
Low	Limited to no information was provided on how findings were reached.

[1] Given the variety of insights included, we rated methodological quality based on the richness of the methodological details provided by the researchers.

Geospatial data use

GEOSPATIAL DATA SOURCE	
Aerial photography; drones	Rich descriptive methodological information was provided such that the study could be replicated.
Ground-based instruments and infrastructure (sensors, cell towers, etc.)	Ground sensors, cell towers, and other infrastructure collect localised data on environmental factors. They provide detailed, proximity-based monitoring and complement aerial and satellite data.
Open data portals	Open data portals offer free access to geospatial datasets from satellites, drones, and ground sensors.
Portable instruments	Handheld tools like GPS units and spectroradiometers enable on-site, real-time data collection.
Satellite imagery	Satellites provide consistent, broad-area land, ocean, and atmosphere monitoring data.
Satellite navigation	Systems like GPS and Galileo deliver precise geolocation for mapping, navigation, logistics, and emergency response operations.
USE CASE EXAMPLES	
Cash distribution	Providing cash transfers in emergency settings Providing connectivity for rural/remote banking
Damage assessment	Identifying destroyed infrastructure in conflict settings Identifying burned buildings from wildfiresEvidencing impact of the event on natural resources
Disaster risk financing and insurance	Supporting property underwriting and recommendations Predicting how many claims insurers will receive
Disease prevalence and transmission	Predicting the location and spread of diseases
Early warning system	Identifying conditions for disease outbreak, famine, or disasters Monitoring dams as part of flood early warning systems
Access routes and evacuation plans	Identifying traversable routes based on debris and roadblocks Assessing access to markets and trade hubs in rainy season
Evidencing conflict-related violence	Providing before and after images of destroyed communities and property destruction Evidencing mass burial sites
Hazardous event detection and severity	Detecting conflict-related events, natural disasters, and crop failures Forecasting disaster intensity and impacts
In-kind distribution	Distributing goods (e.g., food, clothing, school materials, etc.)
Information dissemination	Sending SMS with recommendations for prevention and response to COVID-19 Disseminating emergency alerts via satcomms
Infrastructure mapping and exposure	Mapping roads to determine access to resources/servicesReducing seismic risk for buildings Quantifying financial exposure of assets

Microplanning for health intervention	Guiding immunisation campaigns and distribution of vaccinesNavigating community health workers to reach every household
Infrastructure reconstruction	Evidencing progress of reconstructed infrastructure Increasing infrastructure resilience based on reconstruction
Microplanning for health intervention	Guiding immunisation campaigns and distribution of vaccinesNavigating community health workers to reach every household
Refugee camp awareness and planning	Assessing quality of life in campsMonitoring camp growth and effects on host communities
Risk assessment	Identifying areas most vulnerable to a climatic event
Stockpiling and resource distribution	Accumulating and distributing food in areas forecasted to be affected by hazardous event
Water, sanitation, and hygiene	Setting up hand-washing facilitiesImproving or installing latrines

Contextual factors

DOMAIN	
Disasters	Natural hazards that can lead to humanitarian situations include floods, storm surges, earthquakes, landslides, droughts, wildfires, and extreme temperatures. These events can lead to a humanitarian crisis if they restrict a large group from accessing fundamental needs, such as food, clean water, or safe shelter.
Security and conflict	When the protection of the territorial integrity, stability, and vital interests of states through political, legal, or coercive instruments at the state or international level fails, violent conflict and insecurity result. Violent conflicts lead to death and destruction, the crumbling of weak states, local and international insecurity, a vicious cycle of underdevelopment, instability, and large-scale humanitarian crises.
Food insecurity	Food security means that all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their preferences and dietary needs for an active and healthy life. Natural hazards, conflict, and supply chain inefficiencies can disrupt access and contribute to food insecurity. Existing food insecurity is often exacerbated by conflict that displaces communities that cannot carry out day-to-day activities, such as managing crop fields.
Disasters	Natural hazards that can lead to humanitarian situations include floods, storm surges, earthquakes, landslides, droughts, wildfires, and extreme temperatures. These events can lead to a humanitarian crisis if they restrict a large group from accessing fundamental needs, such as food, clean water, or safe shelter.
Health emergencies	Public health emergencies include: significant outbreaks of infectious diseases; epidemics, in which a disease affects a large number of people within a community, population, or region; and pandemics, when an epidemic spreads over multiple countries or continents (e.g., COVID-19).

EVENT TYPE	
Civil unrest	Civil unrest is an umbrella term for violent and nonviolent group acts such as riots, protests, and isolated sporadic acts. It includes limited political violence and collective action, typically during peacetime, but it can also occur in armed conflict contexts.
Construction / Infrastructure / Industrial failure	The catastrophic failure of load-bearing structural elements can lead to the complete or partial collapse of buildings or infrastructure.
Cyclone	Tropical-origin cyclones are characterised by violent winds and torrential rain, with a low-pressure centre often called the 'eye.' They are synonymous with hurricanes or typhoons, depending on the region.
Drought	A drought is a period of abnormally dry weather marked by prolonged deficiency in precipitation over a large area for longer than a month. It includes meteorological, hydrological, agricultural, and socioeconomic droughts.
Environmental degradation	Environmental degradation involves a loss in biological or economic productivity due to processes such as soil erosion or vegetation loss caused by human activity.
Flood	Floods result from excess water, leading to submersion of land areas. Health impacts include immediate injuries and displacement-related long-term effects like the destruction of homes and water shortages.
Food security, nutrition, and famine	Food security entails access to sufficient, safe, and nutritious food, whereas famine involves extreme food scarcity, leading to widespread mortality.
Infectious diseases	Transmissible diseases affecting living organisms often require specialised management during outbreaks.
Insect infestation	Invasive or excessive insect populations can cause damage to crops, livestock, or habitats.
Marine	Storm surges involve abnormal rising sea levels caused by cyclones or tropical storms. Tsunamis result from seismic activity or underwater landslides. Ice flows pertain to the movement of ice masses that impact marine and coastal systems.
Post-conflict recovery	Explosive remnants of war include unexploded ordnance left by parties to an armed conflict after its cessation
Precipitation-related	Hail involves balls of ice formed in thunderstorm updrafts. Snowstorms feature heavy snowfall and wind, reducing visibility.
Refugees and internally displaced persons	Persons are forced to flee their homes due to conflict (refugees) or disasters (internally displaced persons).
Seismogenic	Earthquakes entail sudden shaking of the ground caused by the passage of seismic waves through Earth's rocks due to tectonic activity. Liquefaction occurs when saturated soils lose their strength and stiffness due to stress, often from earthquake shaking, causing the soil to behave like a liquid.
Temperature-related	In a freeze, air temperatures are equal to or less than the freezing point of water, which can damage plants and crops when intracellular water freezes. Heatwaves involve prolonged periods of unusually high temperatures over a region, typically lasting two days or more. It can have significant impacts on health, agriculture, and infrastructure.
Wildfire	Wildfires occur in vegetation areas and are influenced by human activities, droughts, and extreme weather. Wildfires can have cascading impacts, including soil erosion, flash floods, and air quality degradation.

Wind-related	Storms involve high winds associated with specific atmospheric conditions, often part of larger systems such as tropical cyclones or extratropical depressions. In a tornado, a rotating column of air extends from the base of a cumuliform cloud to the ground, often visible as a condensation funnel accompanied by a debris cloud.

Impact insights

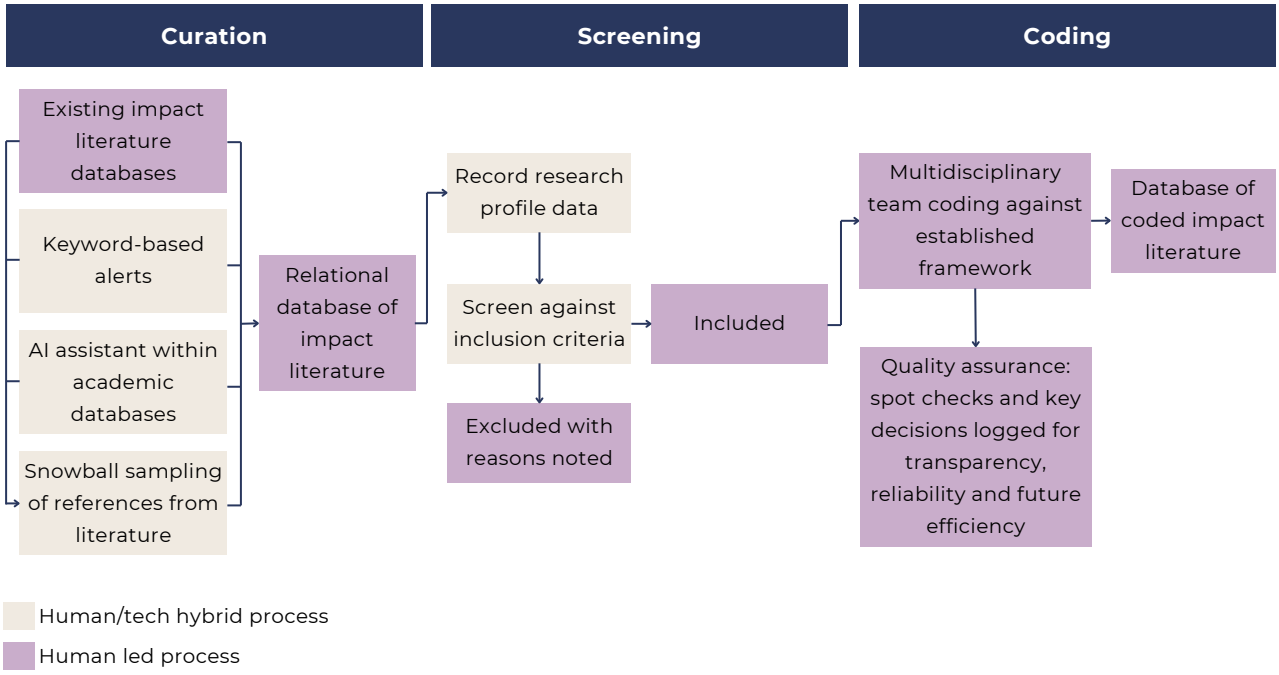
Impact insights were coded against these five areas:

1. **Faster response:** Geospatial data enables faster action in a crisis.
2. **Cost-reduction:** Geospatial data allows organisations to do more with less.
3. **Better access:** Geospatial data facilitates reach of areas that are difficult to access, making it easier to assess needs and provide support where it's needed most.
4. **Enhanced preparedness**: Geospatial data supports forecasting and planning for risks, vulnerabilities, and anticipatory action.
5. **Supported decision-making:** Geospatial data supports decisions about where to allocate resources and how to plan effectively.

Likely due to the nature of the topic under study, all published insights were positive regarding impacts observed. As a result, we did not classify findings based on positive, negative, or null effects, which is standard in Caribou's evidence synthesis approach.

Curation, screening, and coding process

Our curation and coding process is visualised in the diagram below and further described in the approach narrative.



Curation: The evidence database was coded using existing impact literature databases from Caribou and other resources previously identified by the team during the preliminary research phase. Throughout the literature review and coding, the team continued to identify and curate relevant literature through tech-assisted snowball sampling (particularly for grey literature) to identify cornerstone literature, keyword-based search engine alerts for new literature, and AI-assisted search of academic literature databases.

Screening: Building on the curated database of impact literature, each identified resource was screened based on the inclusion criteria. Literature that did not meet the inclusion criteria was coded for the basic research profile, and the rationale for exclusion was listed to avoid duplication of future work and for transparency within the approach.

Coding: Impact insights were coded against all criteria in the coding framework to capture a holistic picture. Some codes were developed (or adapted) iteratively during the process. Quality assurance: A second reviewer coded and verified entries. A feedback loop was established to discuss inconsistencies. When a coder had doubts or questions about the appropriate codes for an edge case, two coders discussed them and decided how to proceed.

Credibility standards

Richness: Enough information is provided to be able to fill in all the primary columns of the database without having to infer or guess.

Relevance: Resources covered how the use of geospatial data in the context of humanitarian operations helped (or did not) improve operations.

Rigour: In order of 'traditional causal' rigour, the sources used would be quantitative data, qualitative data, and observations. Due to sector/thematic specificities, we encountered predominantly observational evidence. In response, the quality of the methodology was coded as low, medium, or high in line with methodological transparency.

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