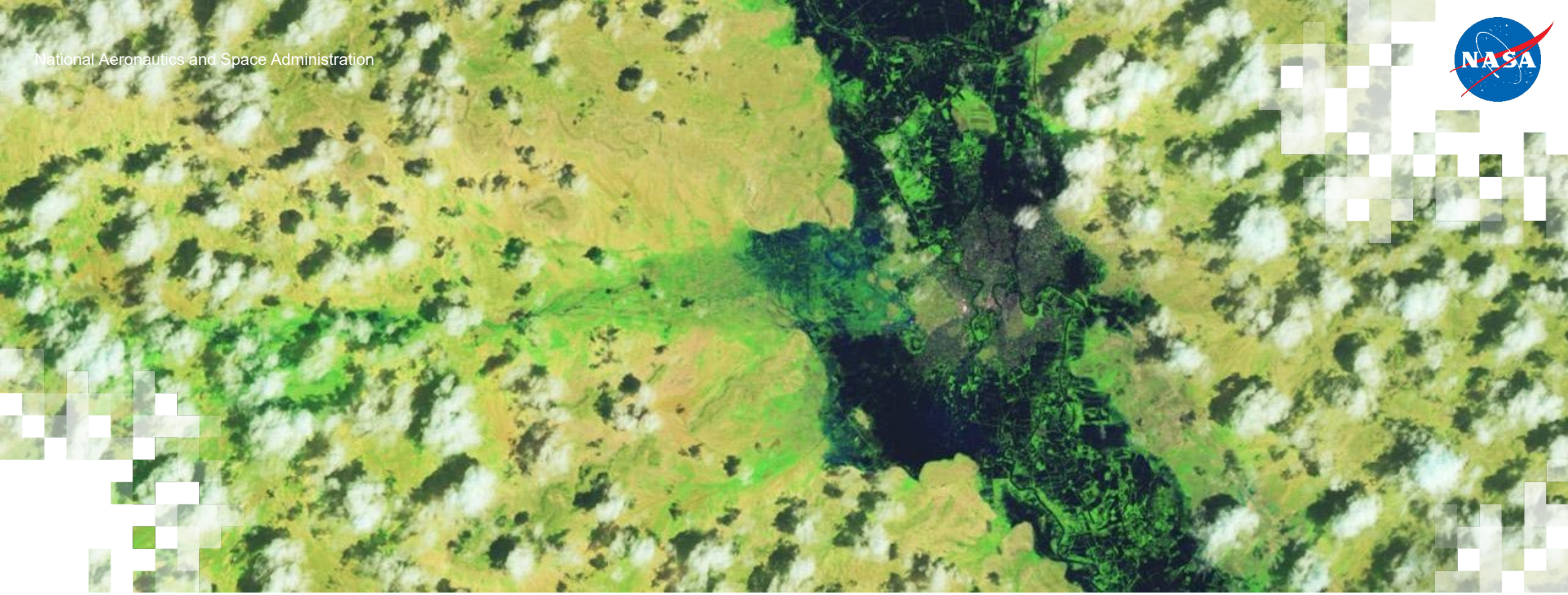
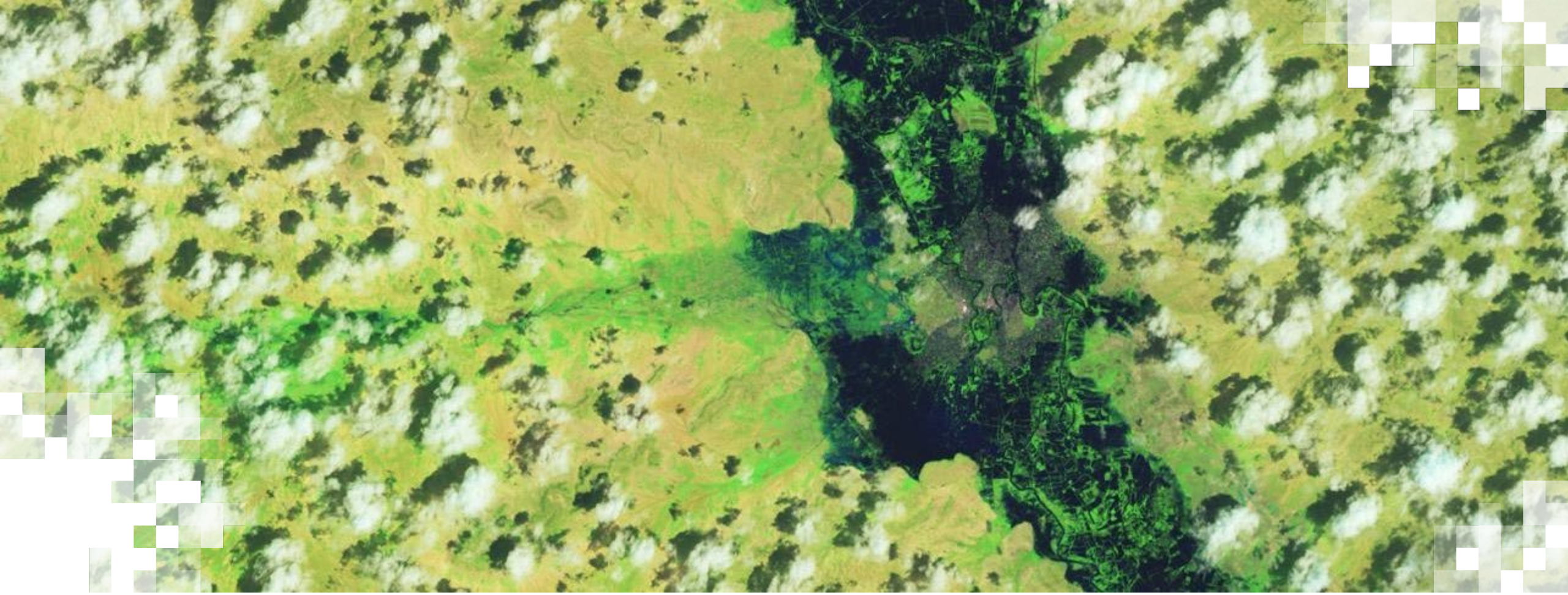


# Earth Observations for Humanitarian Applications

## Part 1: Assessing Flood Risk in Refugee Camp Settings

Mark Trigg (University of Leeds), Mark Bernhofen (University of Oxford), Ruby Paterson (University of Leeds), & Luckson Katsi (UNHCR)

June 6, 2024



# About ARSET

# About ARSET

- **ARSET provides accessible, relevant, and cost-free training on remote sensing satellites, sensors, methods, and tools.**

- Trainings include a variety of applications of satellite data and are tailored to audiences with a variety of experience levels.


AGRICULTURE


CLIMATE & RESILIENCE


DISASTERS


ECOLOGICAL CONSERVATION

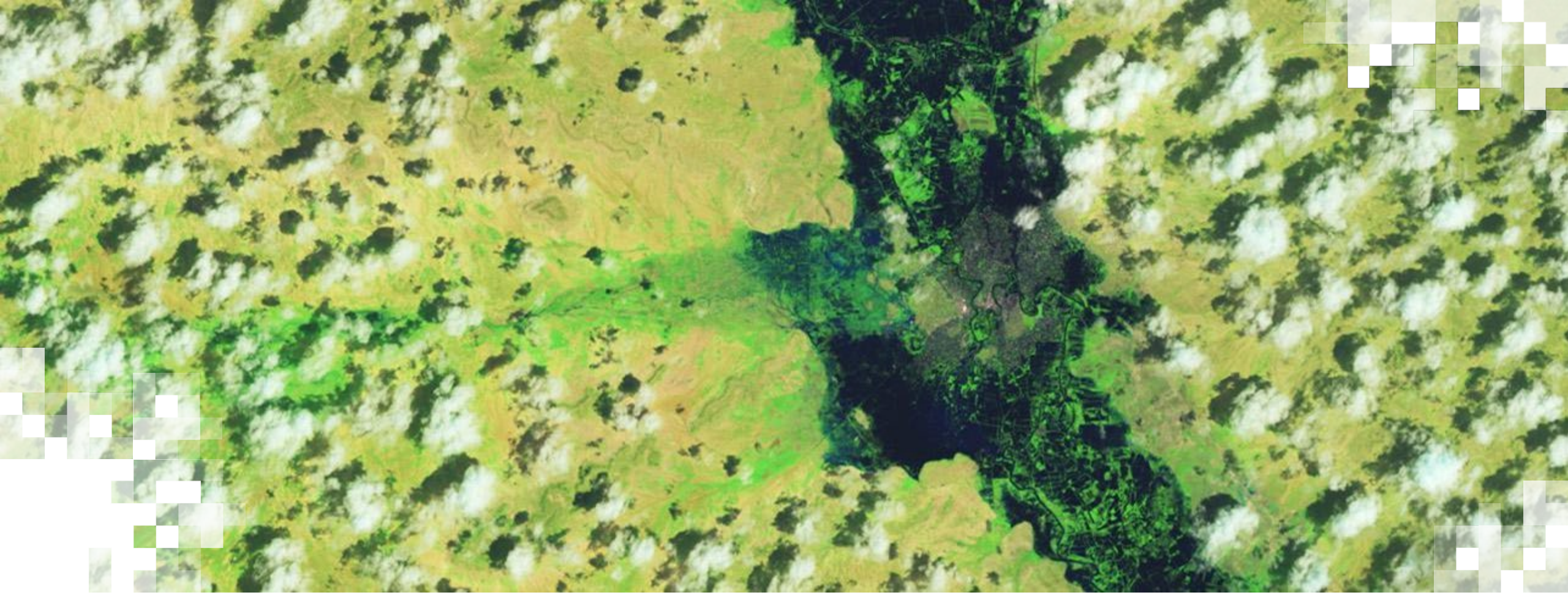

HEALTH & AIR QUALITY


WATER RESOURCES

# About ARSET Trainings

- Online or in-person
- Live and instructor-led or asynchronous and self-paced
- Cost-free
- Bilingual and multilingual options
- Only use open-source software and data
- Accommodate differing levels of expertise

- Visit the ARSET website to learn more.



# Earth Observations for Humanitarian Applications
# **Overview**

# Motivation for Training

- More than 114 million individuals have been forcibly displaced worldwide as a result of persecution, conflict, violence or human rights violations (UNHCR).
- Refugees, internally displaced people (IDPs), and other displaced populations are made more vulnerable to climate change impacts due to their socio-political marginalization.
- Recent Earth observation (EO)-driven research that recognizes this has made progress towards characterizing the manner and magnitude of climate-related risks in humanitarian (refugee and IDP) settings.


In the outskirts of Thata in Pakistan, women displaced by the 2010 flooding line up to fetch water.
Credit: Asian Development Bank

# Training Learning Objectives

By the end of this training, participants will be able to:

- Recognize the importance of measuring flood risk, long-term heat stress, and drought effects in refugee and IDP communities around the world
- Apply workflows incorporating Earth observations, geospatial, and demographic data to identify localized climate risk in refugee and IDP settings
- Discuss decision making strategies for mapping and managing climate conditions with risks faced by refugee and IDP communities
- Summarize opportunities and shortcomings of specific Earth observations and geospatial datasets for climate risk and development indicators in humanitarian settings

# Prerequisites

- Humanitarian Applications Using NASA Earth Observations
- Monitoring and Modeling Floods using Earth Observations
- Satellite Remote Sensing for Agricultural Applications
- Satellite Remote Sensing for Measuring Urban Heat Islands and Constructing Heat Vulnerability Indices

# Training Outline

**Part 1**

**Assessing Flood Risk in Refugee Camp Settings**

**June 6, 2024**

**Part 2**

Gauging Long-Term Heat Stress in Refugee Settings

June 13, 2024

**Part 3**

Tracking Drought Effects on Agricultural Landscapes in Refugee Settings

June 20, 2024

**Homework**

Opens June 20 – **Due July 5** – Posted on Training Webpage

A certificate of completion will be awarded to those who attend all live sessions and complete the homework assignment(s) before the given due date.

# Part 1 Objectives

By the end of Part 1, participants will be able to:

- Identify and apply open geospatial datasets (global model outputs and EO data & products) to undertake flood risk assessments for refugee camps anywhere in the world.
- Recognize specific humanitarian challenges when assessing flood risk in refugee camps.

# How to Ask Questions

- Please put your questions in the Questions box and we will address them at the end of the webinar.
- Feel free to enter your questions as we go. We will try to get through all the questions during the Q&A session after the webinar.
- The remainder of the questions will be answered in the Q&A document, which will be posted to the training website about a week after the training.

# Part 2 – Trainers

**Mark Trigg**

Professor

University of Leeds

**Mark Bernhofen**

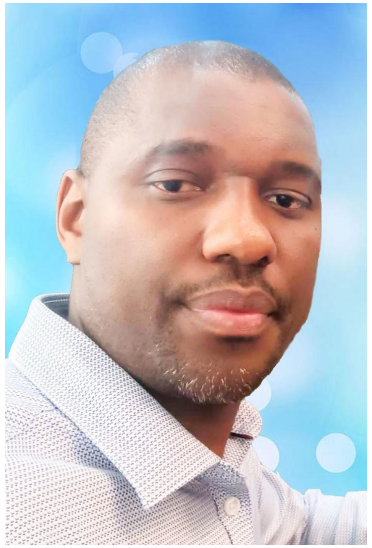
Research Associate

University of Oxford

**Luckson Katsi**

WASH Sector Lead

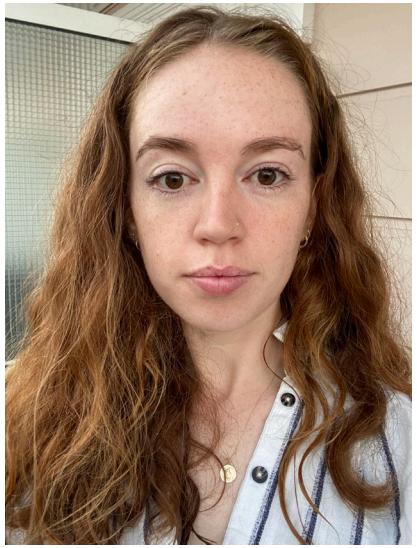
UNHCR

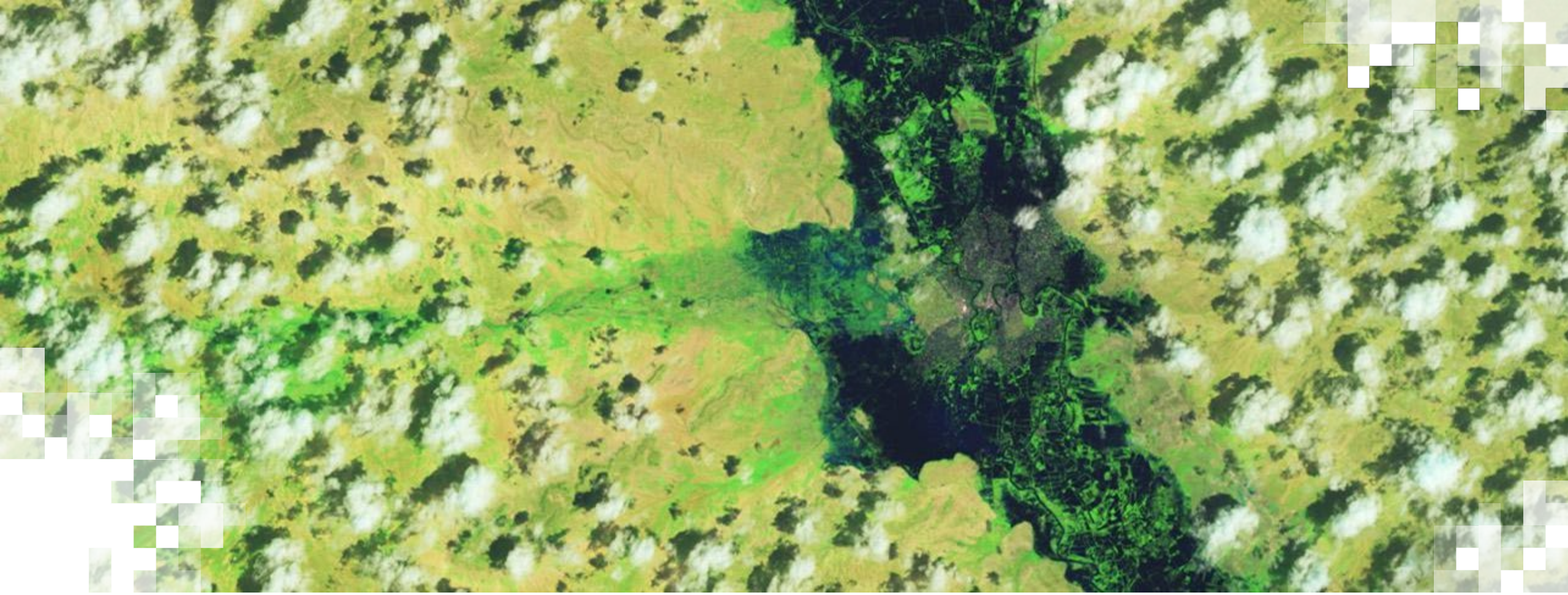


**Ruby Paterson**

MSc(Eng) Water and Sanitation Health

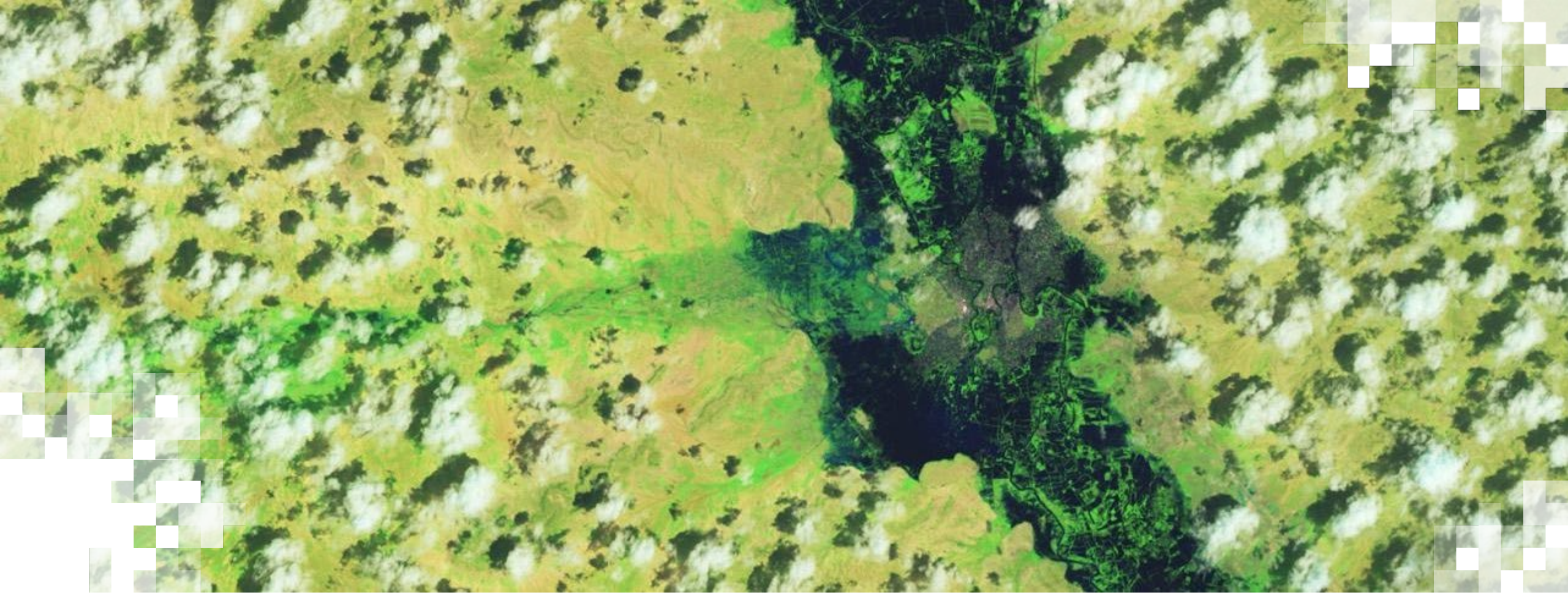
University of Leeds





Earth Observations for Humanitarian Applications

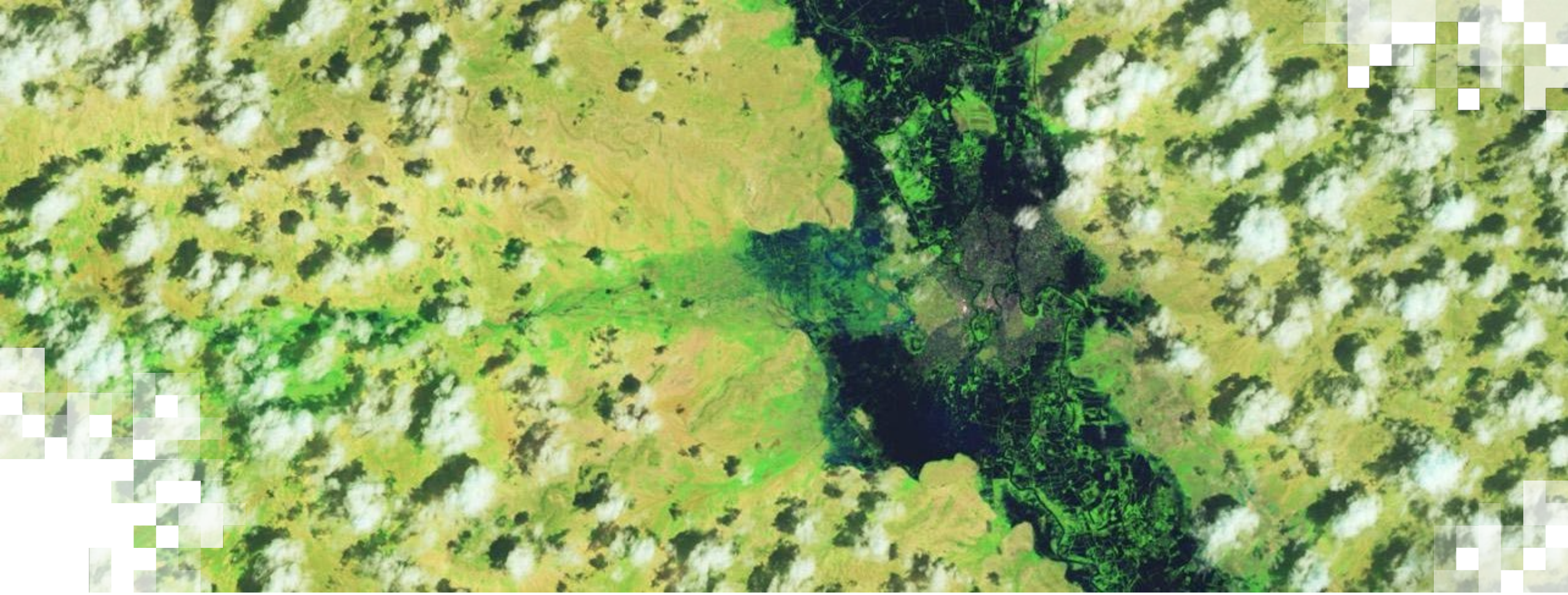
# **Part 1: Assessing Flood Risk in Refugee Camp Settings**



# Section 1: Introduction
# Flood Risk Assessments and the Refugee Camp Context

# Outline

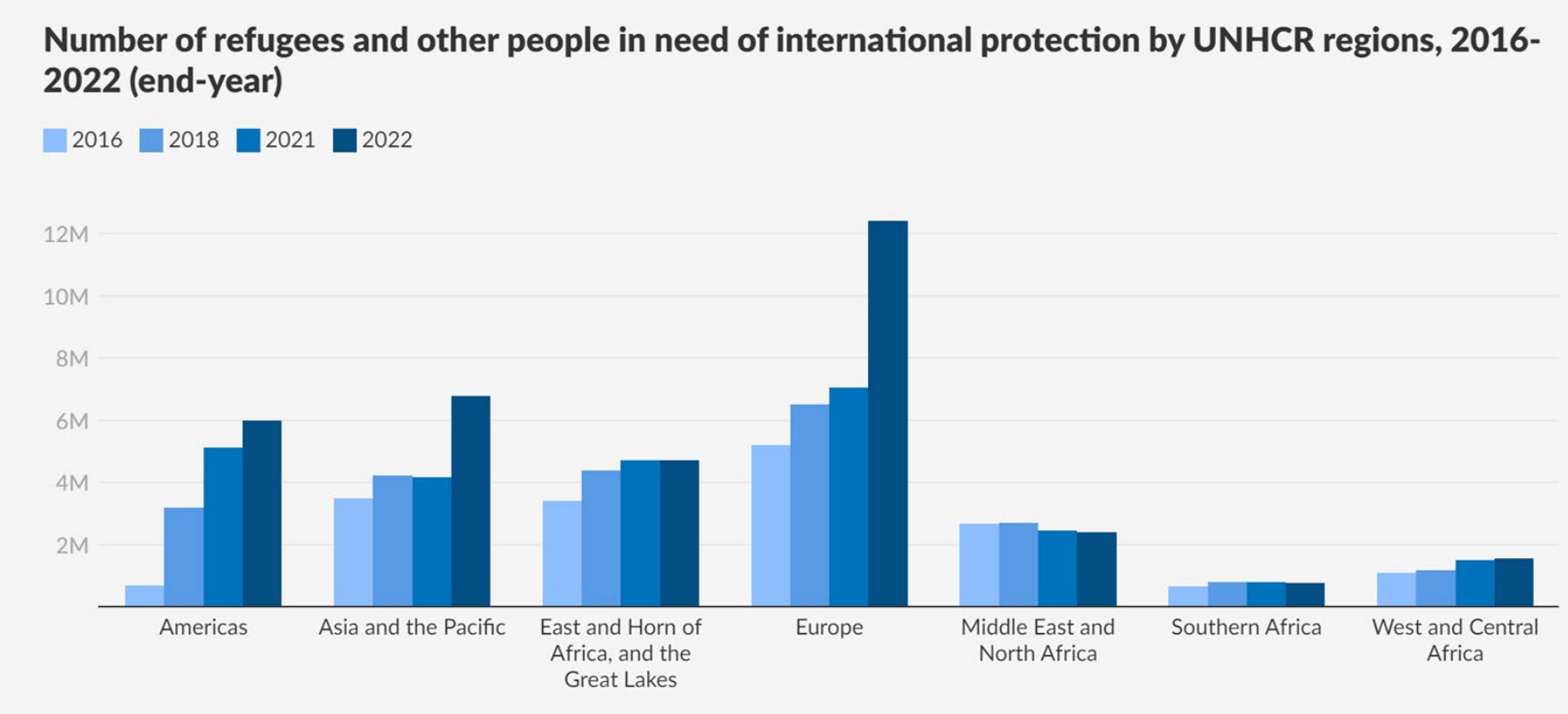
- Section 1: Introduction
  Flood Risk Assessments and Refugee Camp Context
- Section 2: Practical Session
  Camp Flood Exposure Assessment Application
- Section 3: On the Ground Realities
  Current Camp Flood Risk Management



# Section 1.1
# Refugee Flood Risk Context

# Scale of Refugee Flood Risk Issue

- 1/200 people is a refugee
- Number of refugees has doubled since 2016
- At end of 2022
  - 108.4 million people forcibly displaced
- 20% of refugees are living in camps (UNHCR)




*Source: 2023 Global compact on refugees, Indicator report, UNHCR*

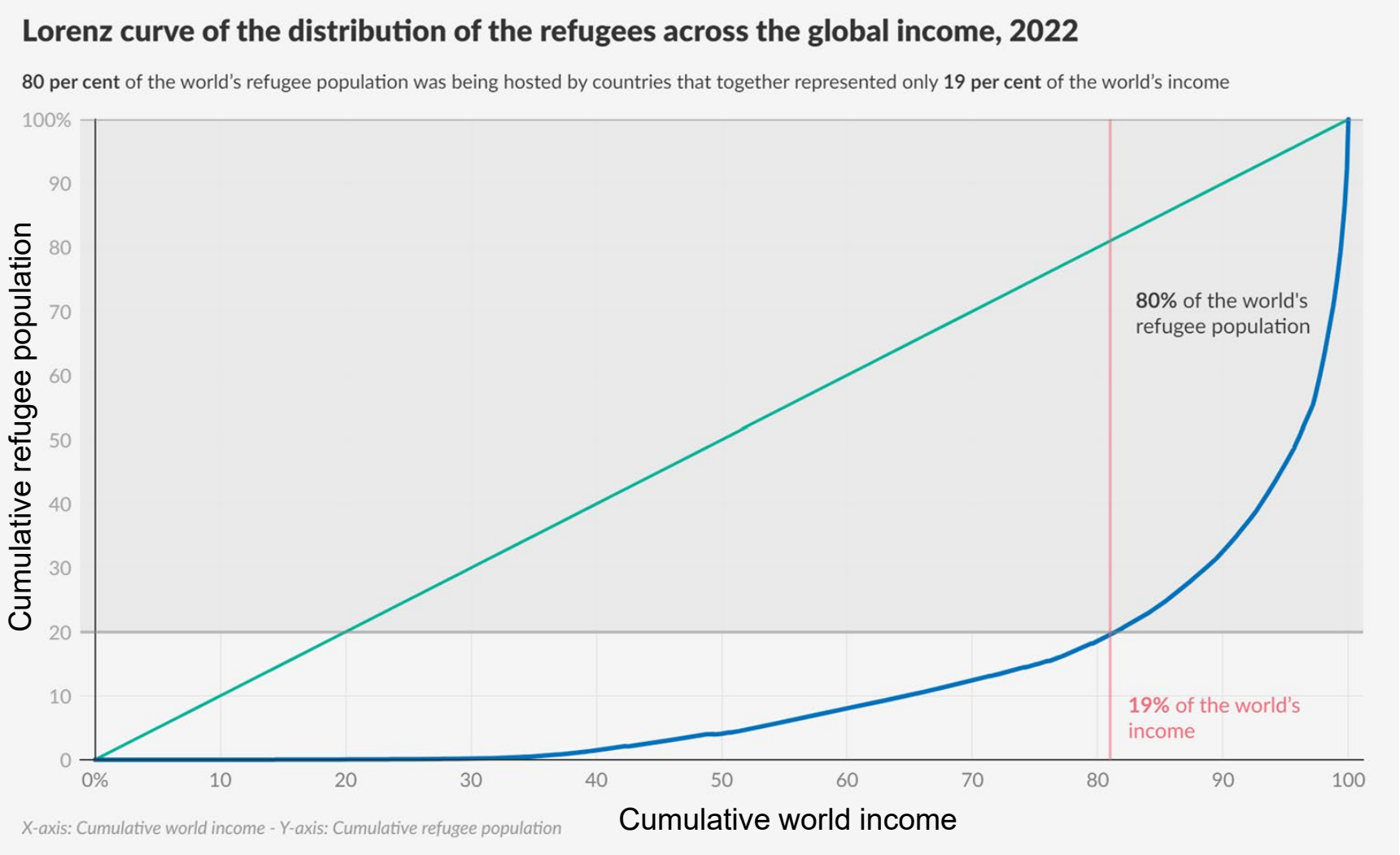
# Refugee Flood Risk Context – Host Countries

Host Countries:

- are less likely to have the capacity to prepare for or respond to flood events.
- are among those most likely to be impacted by climate change.

76% refugees are hosted in low- and middle-income countries near their countries of origin.

Population displacement due to climate change is projected to increase.

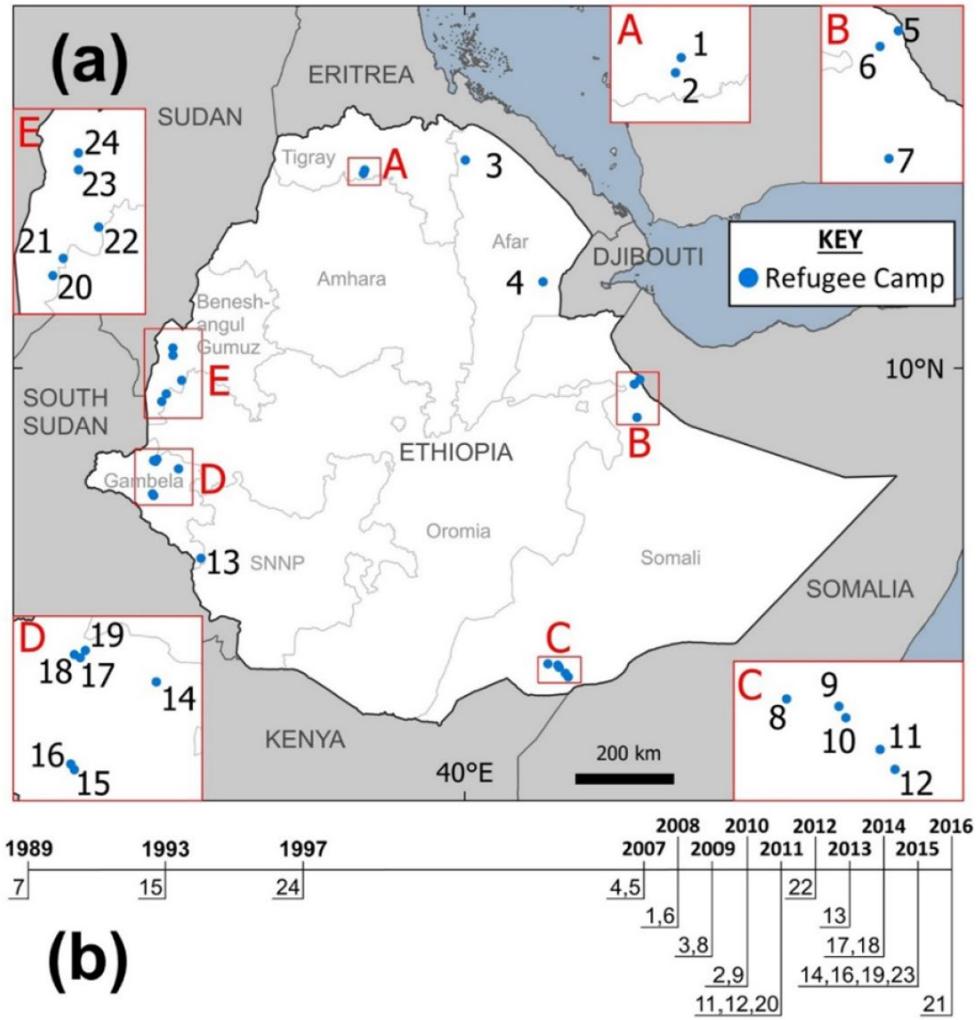



*Source: 2023 Global compact on refugees, Indicator report, UNHCR*

# Refugee Flood Risk Context – Location of Camps

- Placement dictated by complex decision choices, including political components, and may not include a full understanding of risks
- Choice often related to land that is available rather than optimum low risk locations assessed rigorously
- Commonly located close to international borders rather than main populated areas
- Often in remote locations, so there is minimal infrastructure and data/information about locations

**Ethiopia example:**
(a) Camp locations and (b) establishment timeline 1989-2016



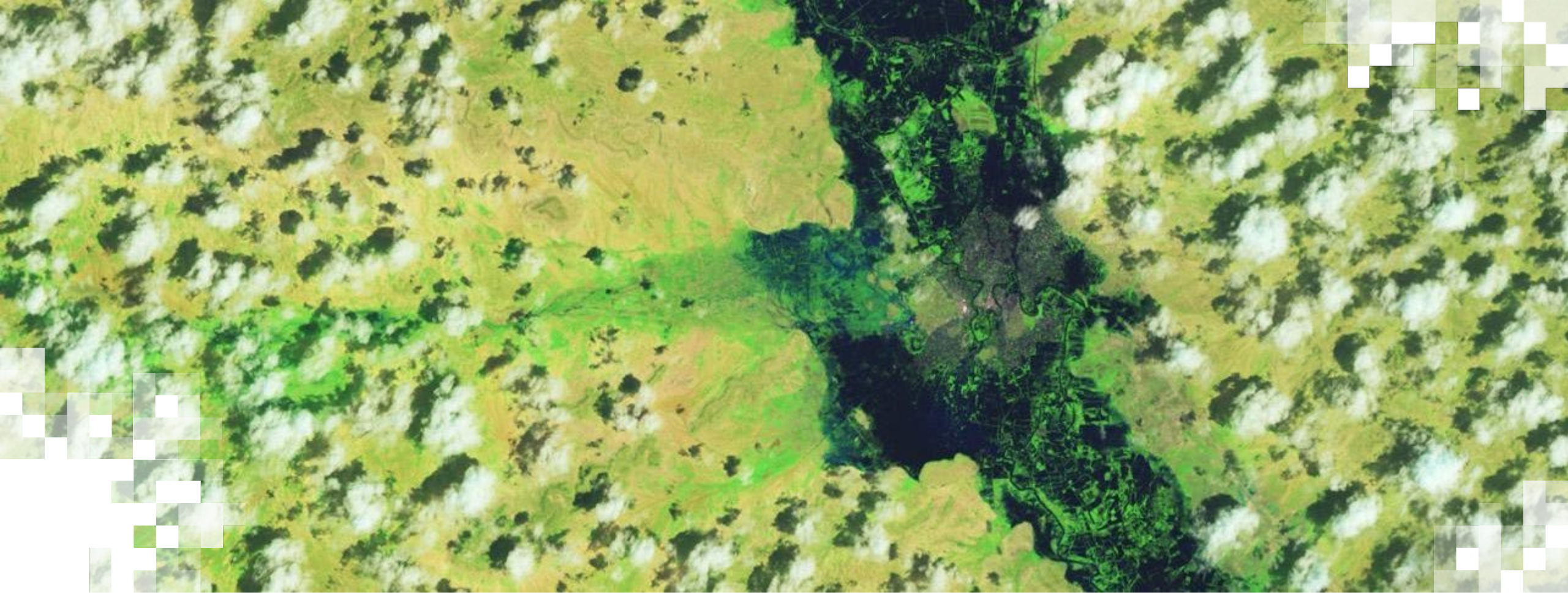



*Bernhofen et al. 2023. Unknown risk: assessing refugee camp flood risk in Ethiopia, ERL*

# Refugee Flood Risk Context – Heightened Vulnerability

- More vulnerable population (more: young, old, those with malnutrition, gender, health and disability issues)
- Limited mobility (legal and bureaucratic constraints)
- New to location, no sense of place, and without normal coping mechanisms and resources
- Past experience may also modify behavior to risks
- Temporary structures especially vulnerable to flood
- High population density and criticality of support infrastructure (access, stores and health centers)
- Many refugee camps lack adequate drainage systems

UNU-MERIT: Climate vulnerabilities in refugee camps: Impacts and policy solutions



# Section 1.2
# Refugee Flood Risk Assessment

# Flood Risk Assessments (FRAs)

What is a Flood Risk Assessment?

- A process of quantifying flood risks based on likelihood and consequences
- Allows mitigation of flood hazards by prioritizing actions
- They are essential for understanding and managing flood risks globally
- Informs decisions on land use, infrastructure, and emergency preparedness

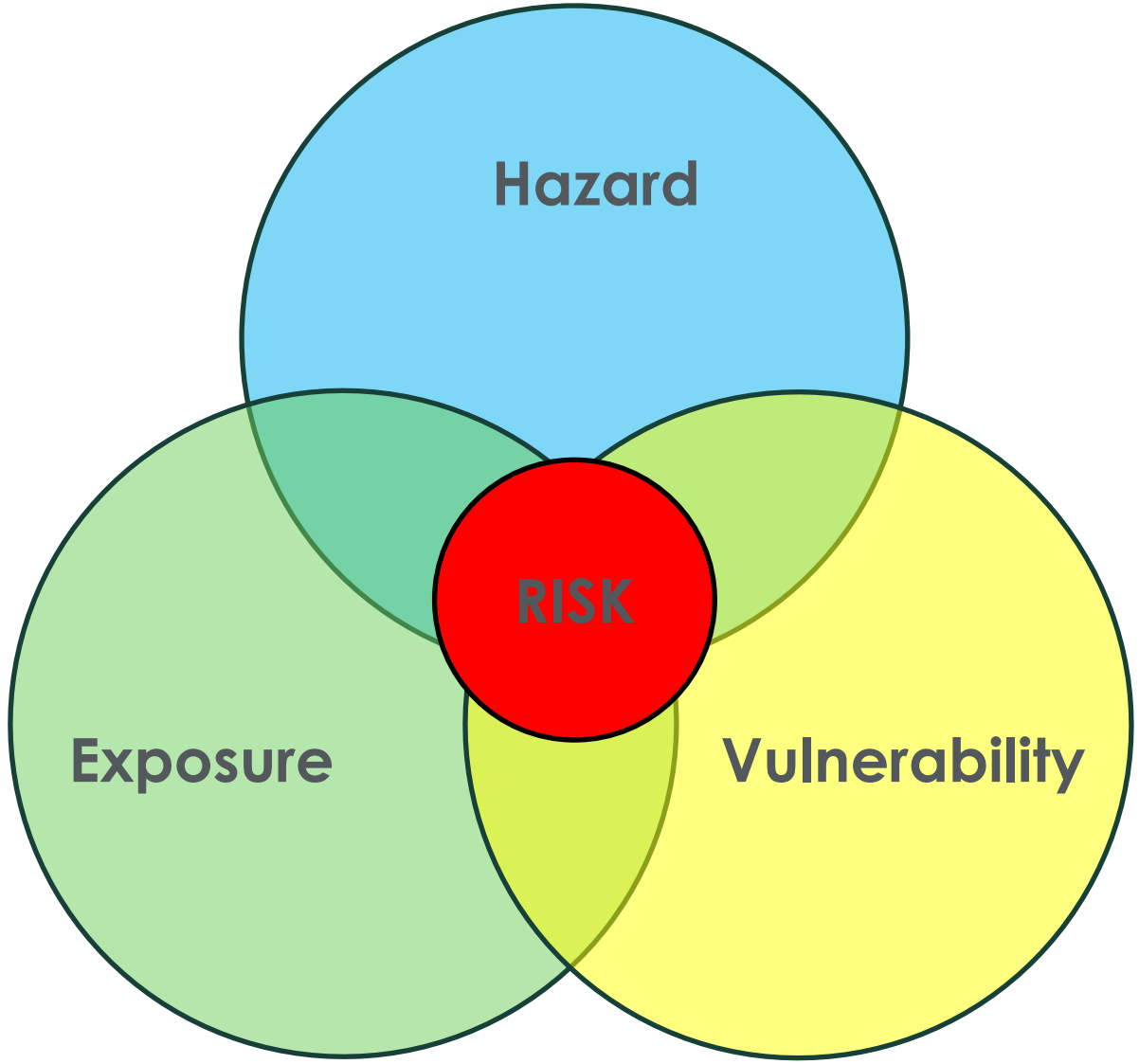
*Photo: M.A.Trigg*

# What is Risk?

- Risk generally refers to the possibility of something bad happening.
- **Humans are bad at assessing Risk.**
  - limited personal experience
  - Biases
  - rare events
  - other psychological reasons
- We tend to favour an objective assessment process.
- Each sector can define risk differently (and methods of assessing it also vary).

We focus here on **Flood Risk.**

# Components of Risk

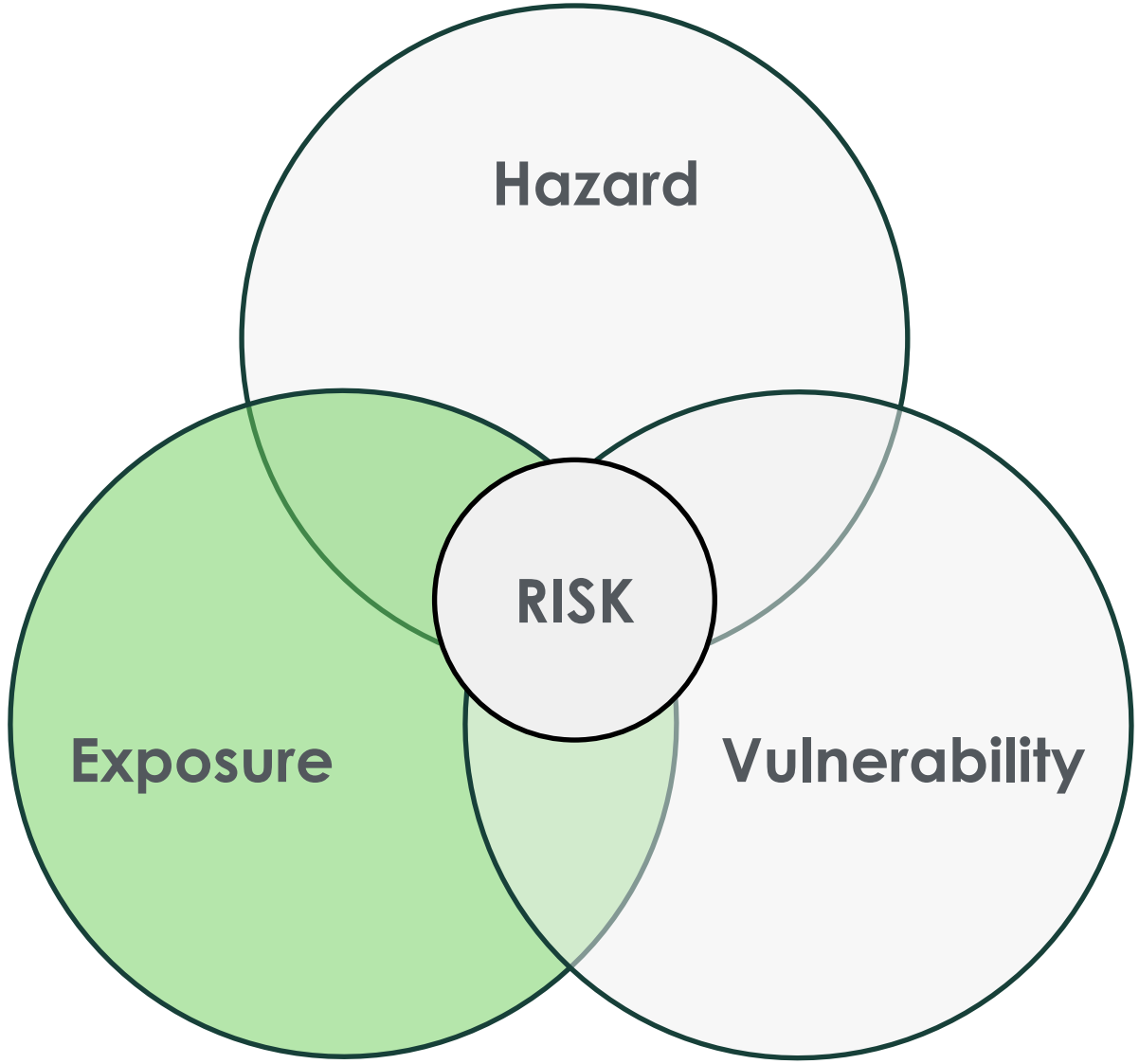


# Components of Risk – Flood Hazard

- Has a specific source (river, rain, etc.)
- Is relatively uncommon (rare probability)
- Has a specific size (magnitude or intensity)
- Is measured with specific variables related to risk (e.g. Depth, Velocity, and Extent)
- Often quantified with a numerical computer flood model

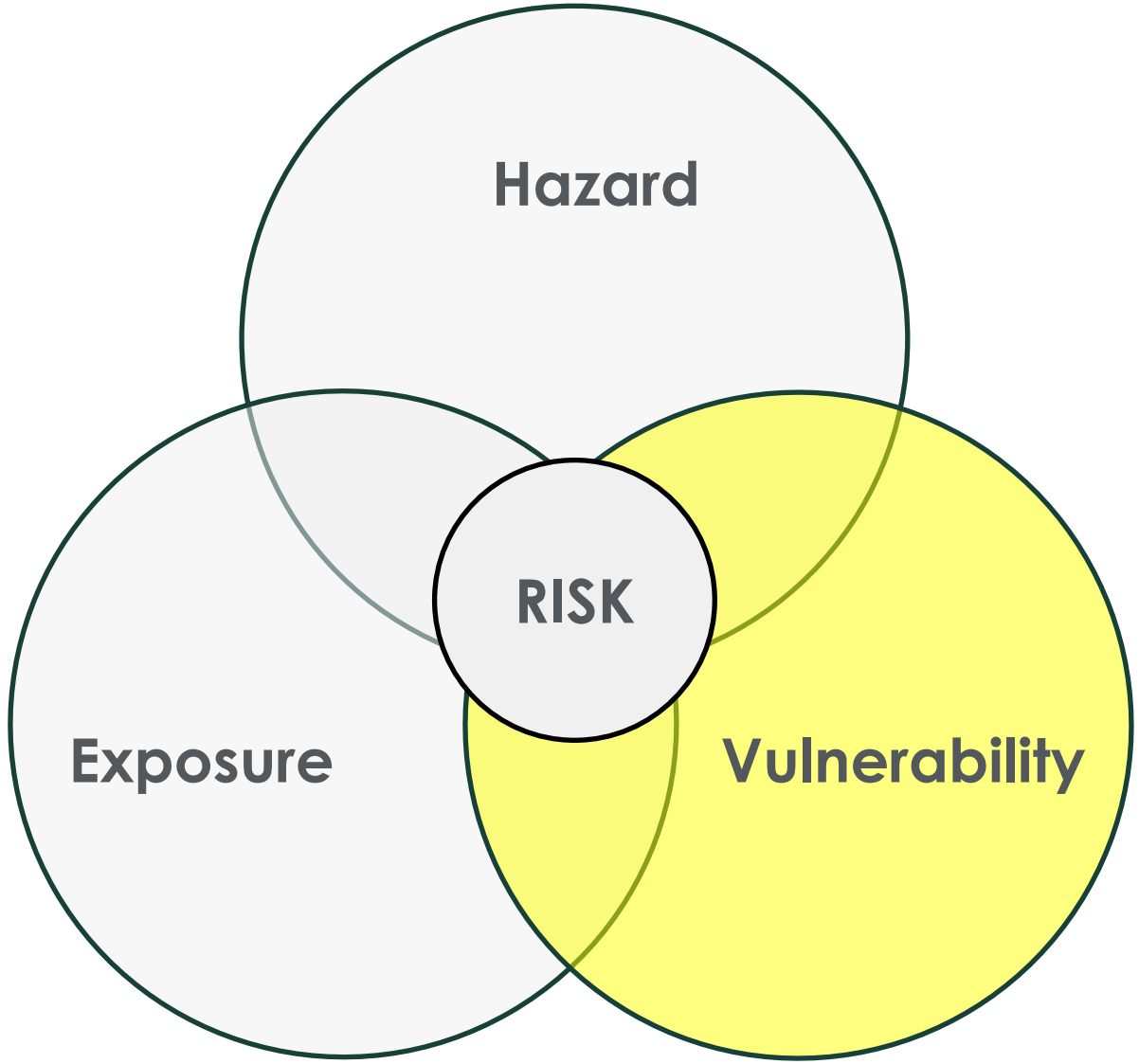
# Components of Risk – Flood Exposure

- Specific things that might be exposed to a flood hazard (e.g. people or buildings) – that you want to assess
- If there are none of these things in the flooded area, then there is no flood risk to them



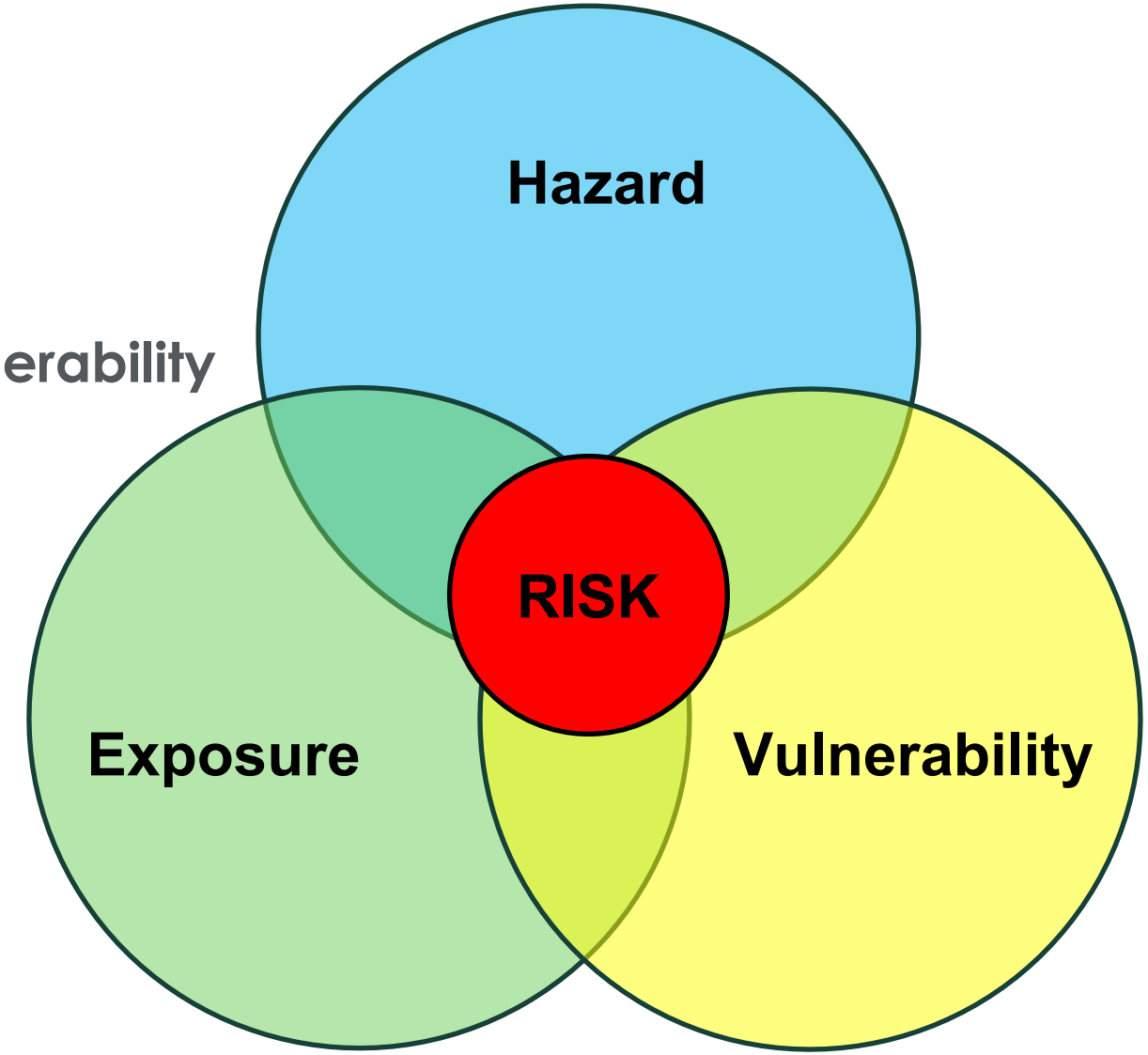
# Components of Risk – Flood Vulnerability

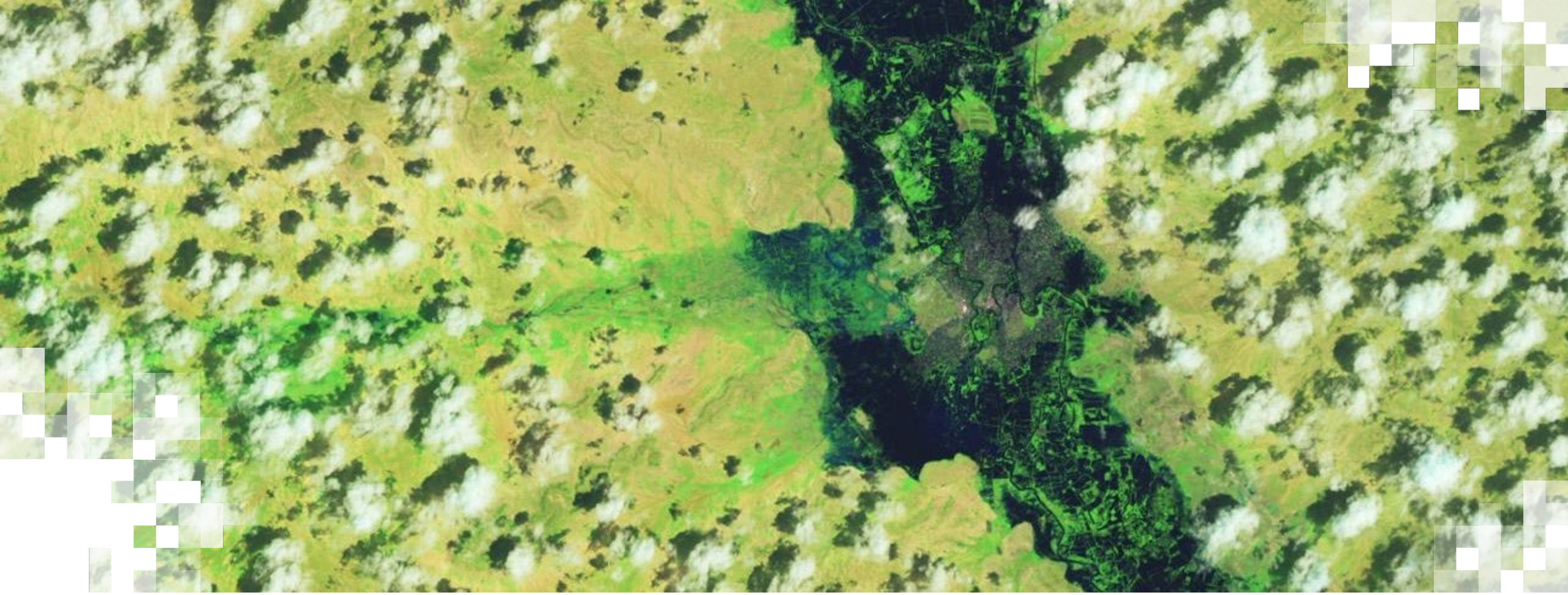
- A measure of the negative flood impact on the thing you are assessing
- Can be measured in loss of life, health, structure damage or economic losses, depending on what you are assessing as being at risk



# Risk is Composed of Three Components

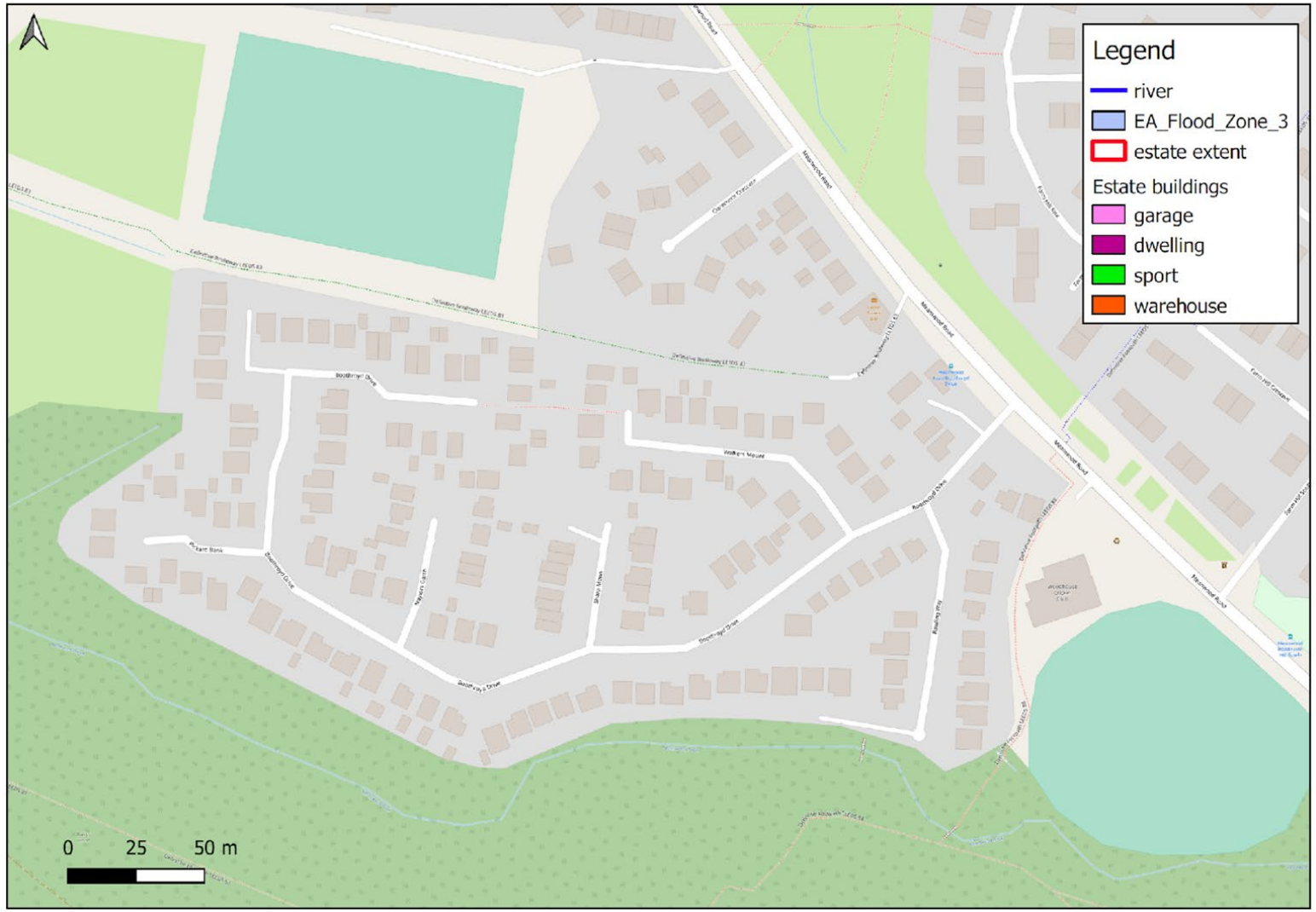
Flood Risk = Hazard × Exposure × Vulnerability



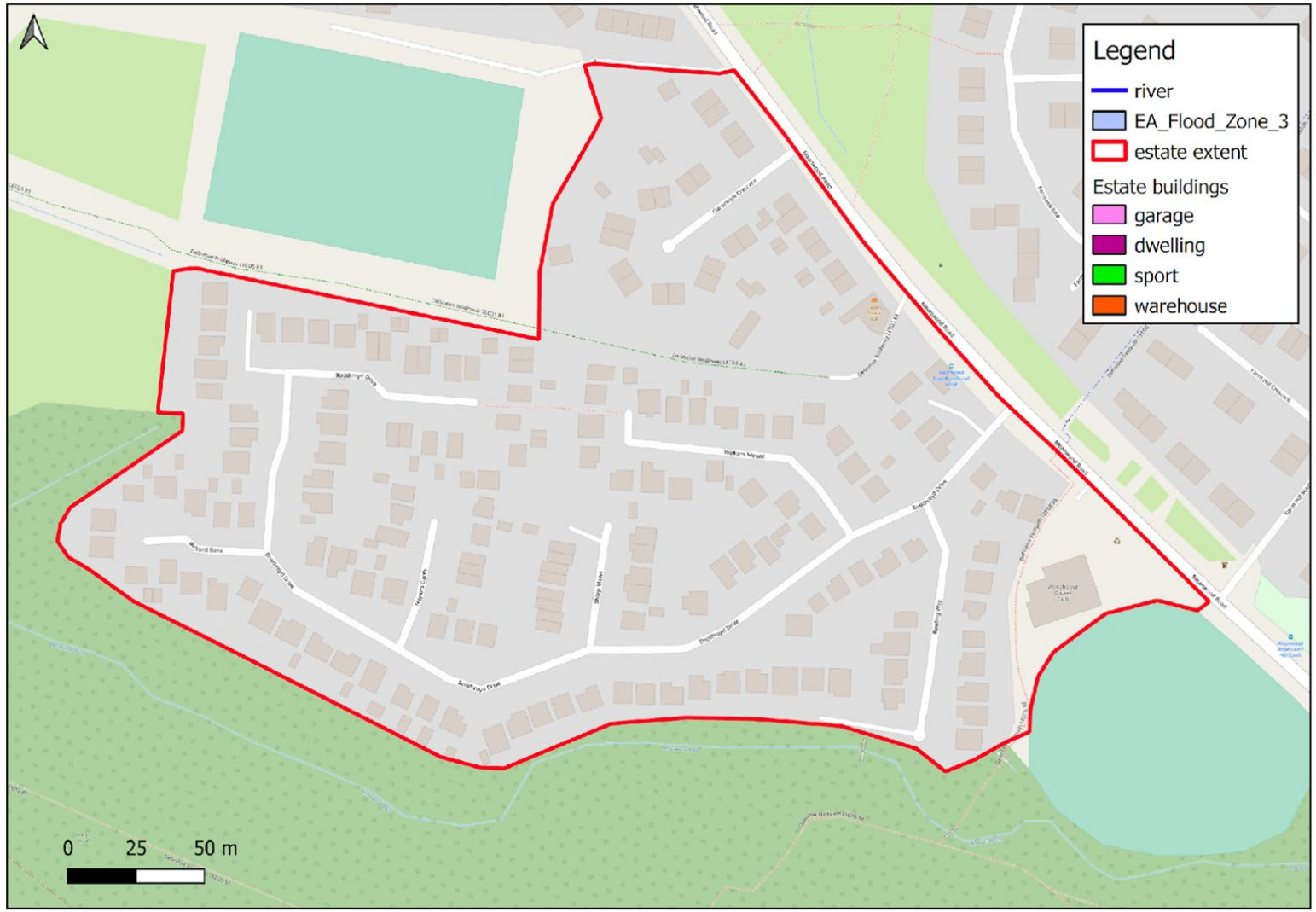


# Section 1.3
# Simple Visual Flood Risk Assessment Example

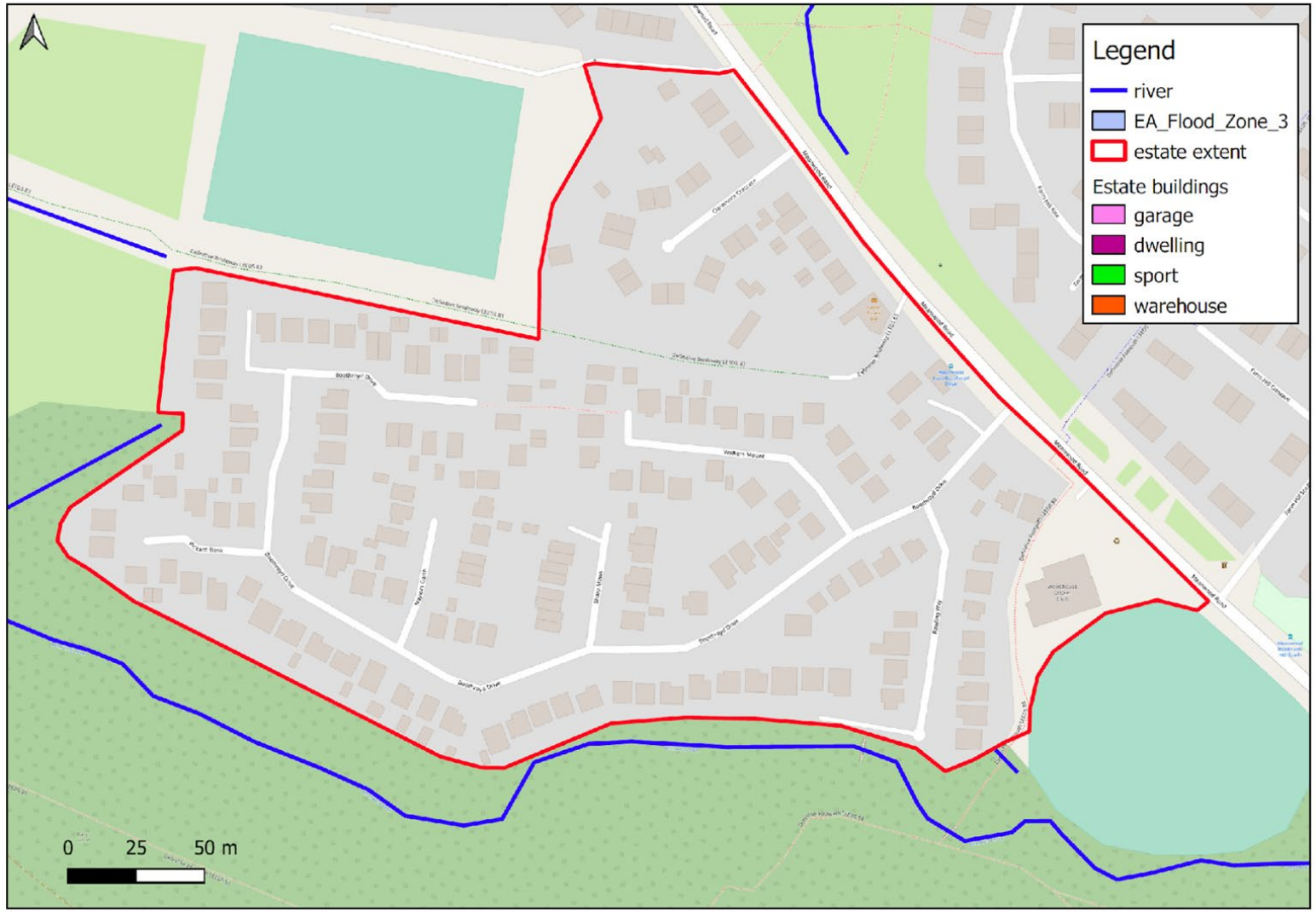
# Flood Risk Assessment for Housing Estate



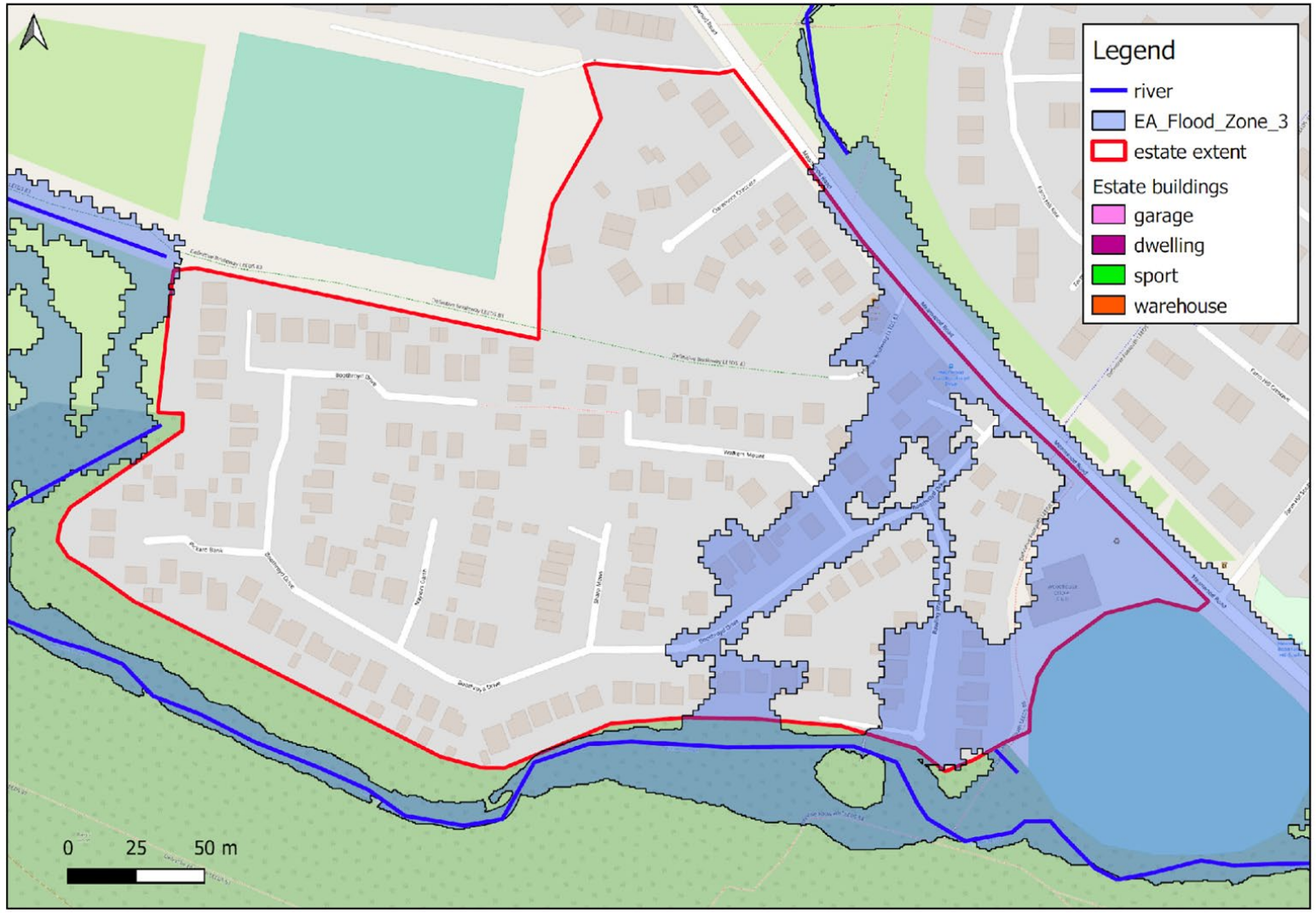
# Identify Area for Assessment



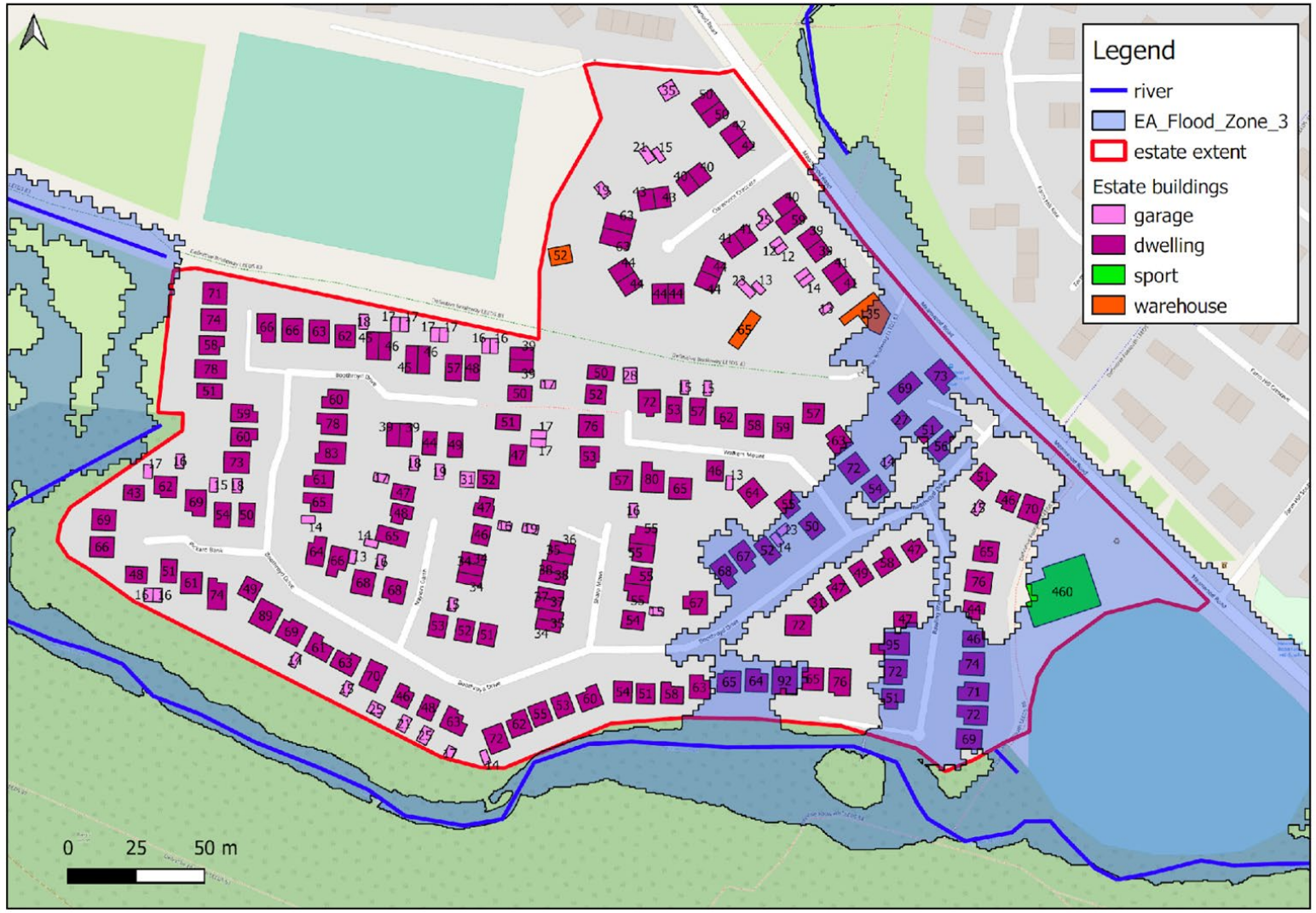
# Identify Sources of Flood Hazard



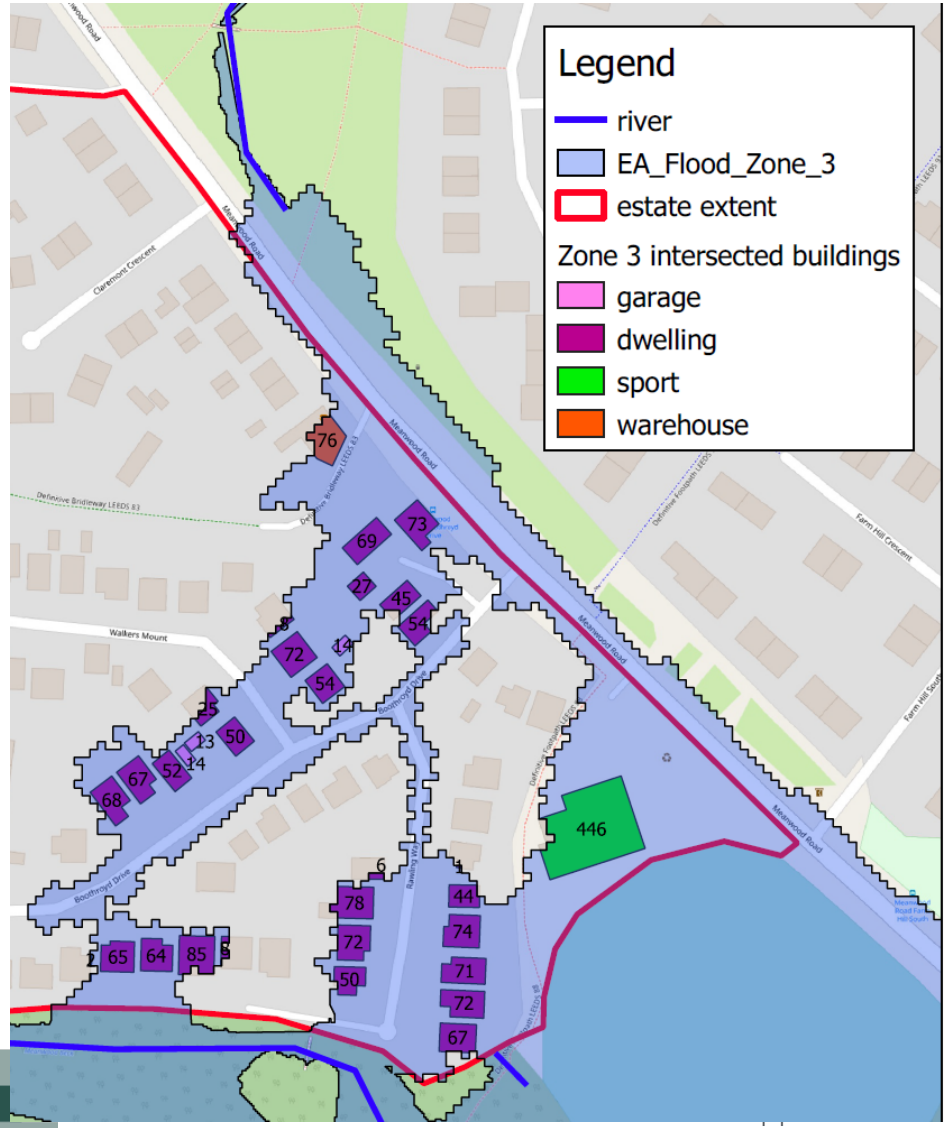
# Quantify Hazard (Flood Model)

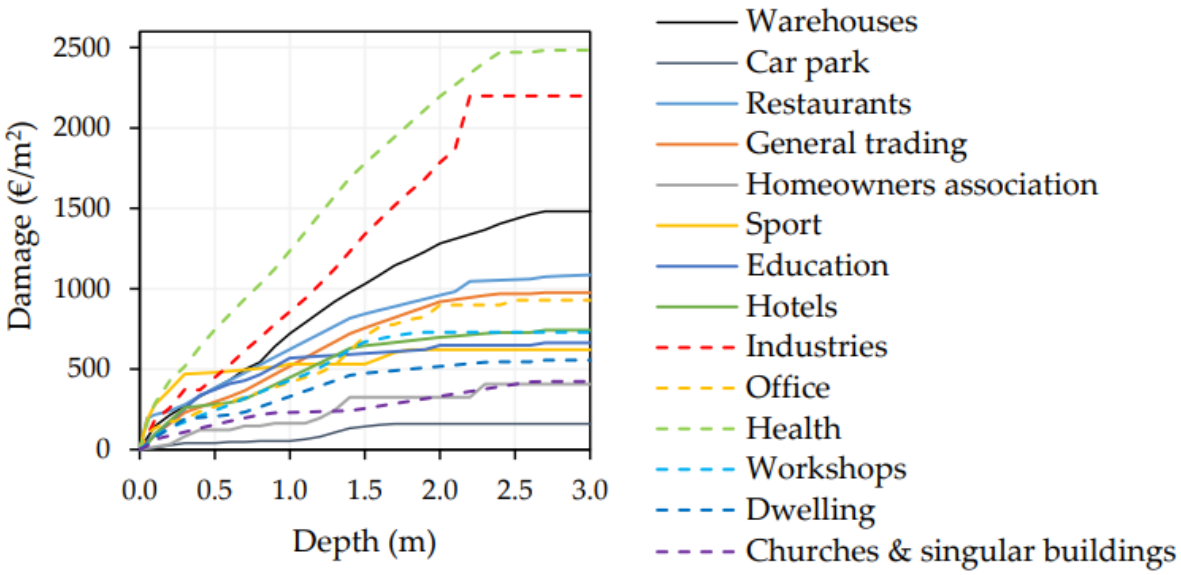


# Identify Exposure to Hazard



# Quantify Risk Through Vulnerability (Numbers, Economic Value)

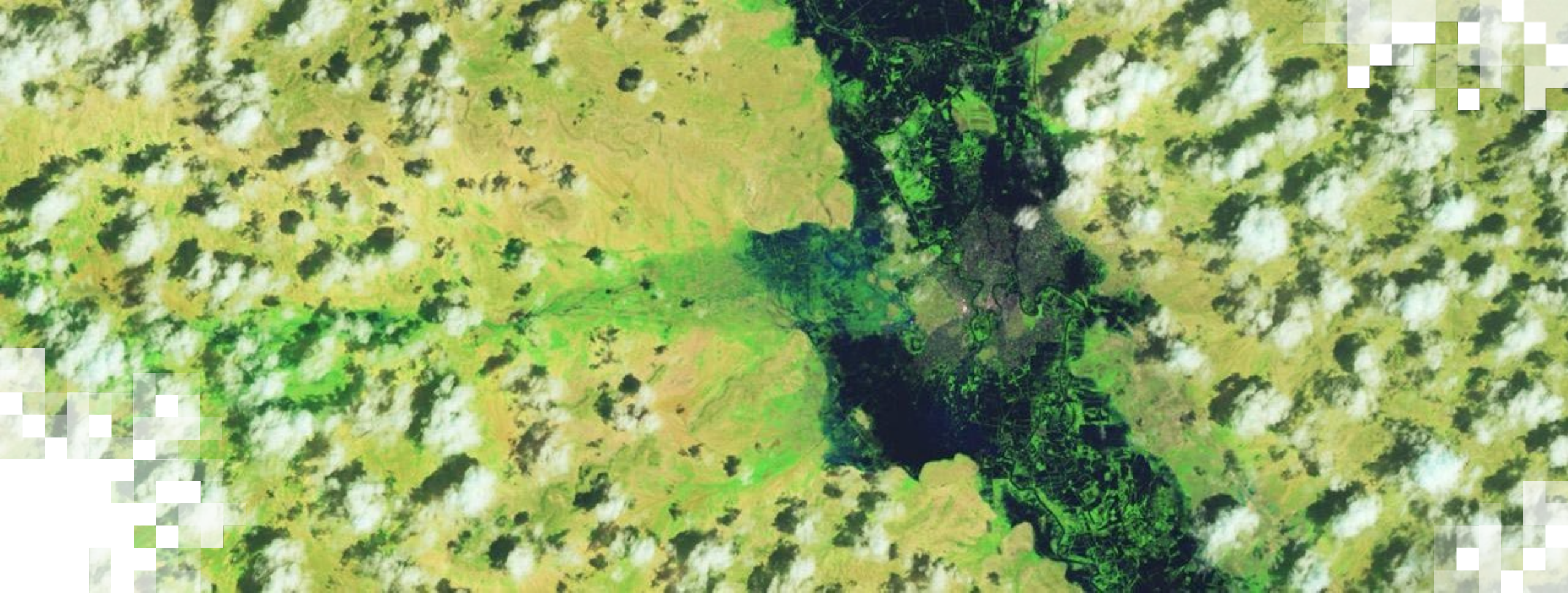



*Martínez-Gomari et al., (2020)*

Can quantify potential flood impact through:

- Number of buildings exposed
- Number of people living in buildings exposed
- Building footprint area exposed
- Economic value of building exposed to hazard (risk)



# Section 1.4
# Flood Risk Challenges & Opportunities for Refugee Camps

# Flood Risk Assessment (FRA) Challenges for Refugee Camps

## Specific context issues

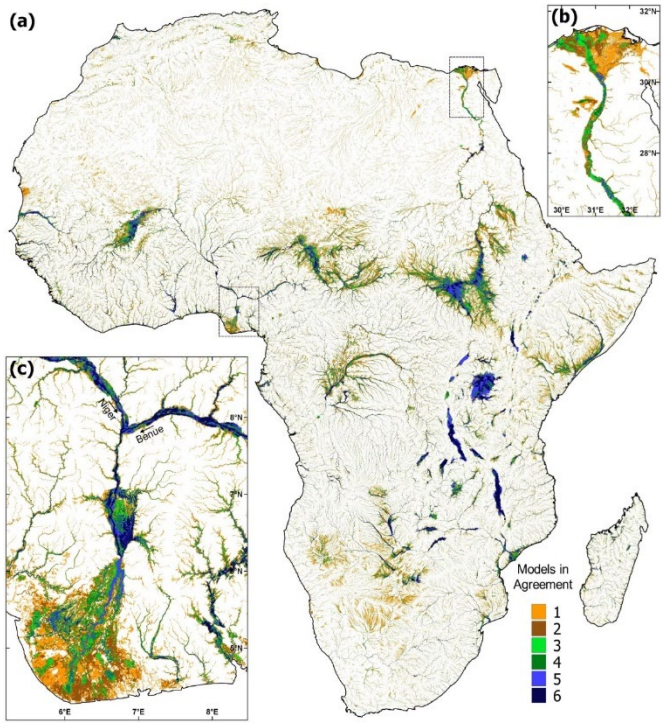
- FRAs rely on good data and analytics.
- But … camps are often in remote areas suffering from data scarcity, and in countries where even flood risk to the settled population is unknown.
- **Hazard:** Often no flood hazard data and modelling is rarely carried out. Primarily, good records of rainfall, river flow and the data to build flood models are rare.
- **Exposure:** Camps change, and good, up-to-date maps are rare, with camps often missed out of global exposure data.
- **Vulnerability:** Different flood vulnerability issues to those of a settled population and there are no studies of this, so it is hard to assess vulnerability, in particular.


*Credit: Dall.E*

# FRA Assessment Challenge - Structure Vulnerability Comparison


# Advances in Data Availability - The Role of Earth Observation Data

- Recently, global data availability for flood risk assessments has improved significantly.
- This is due to several factors:
  1. Improvements in types of EO data, sensor resolution & coverage
  2. Increases in computing power
  3. New rapid flood modelling algorithms
- Higher resolution flood hazard models everywhere – even in data scarce regions.
- EO data underpins this global coverage, proving globally consistent, higher resolution topography (e.g. SAR data), land cover/use (e.g. Landsat/Sentinel), and rainfall data (e.g. GPM), all of which are key to a good flood model.

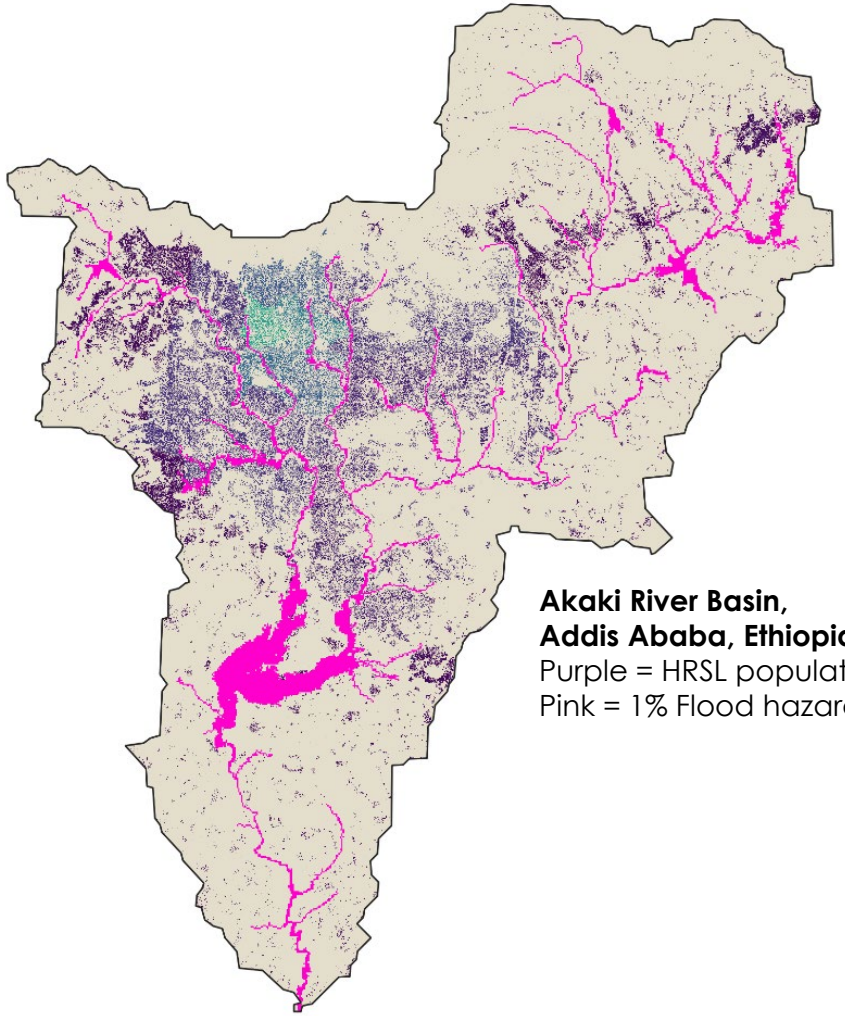



*Trigg et. al. 2016. The credibility challenge for global fluvial flood risk analysis, ERL*

# Advances in Data Availability - Exposure Data Improvements

- Exposure data has also improved due to higher resolution remote sensing imaging and machine learning.

- Initiatives such as Humanitarian OpenStreetMap which are especially important for fusing local crowd sourced knowledge with high resolution remote sensing.

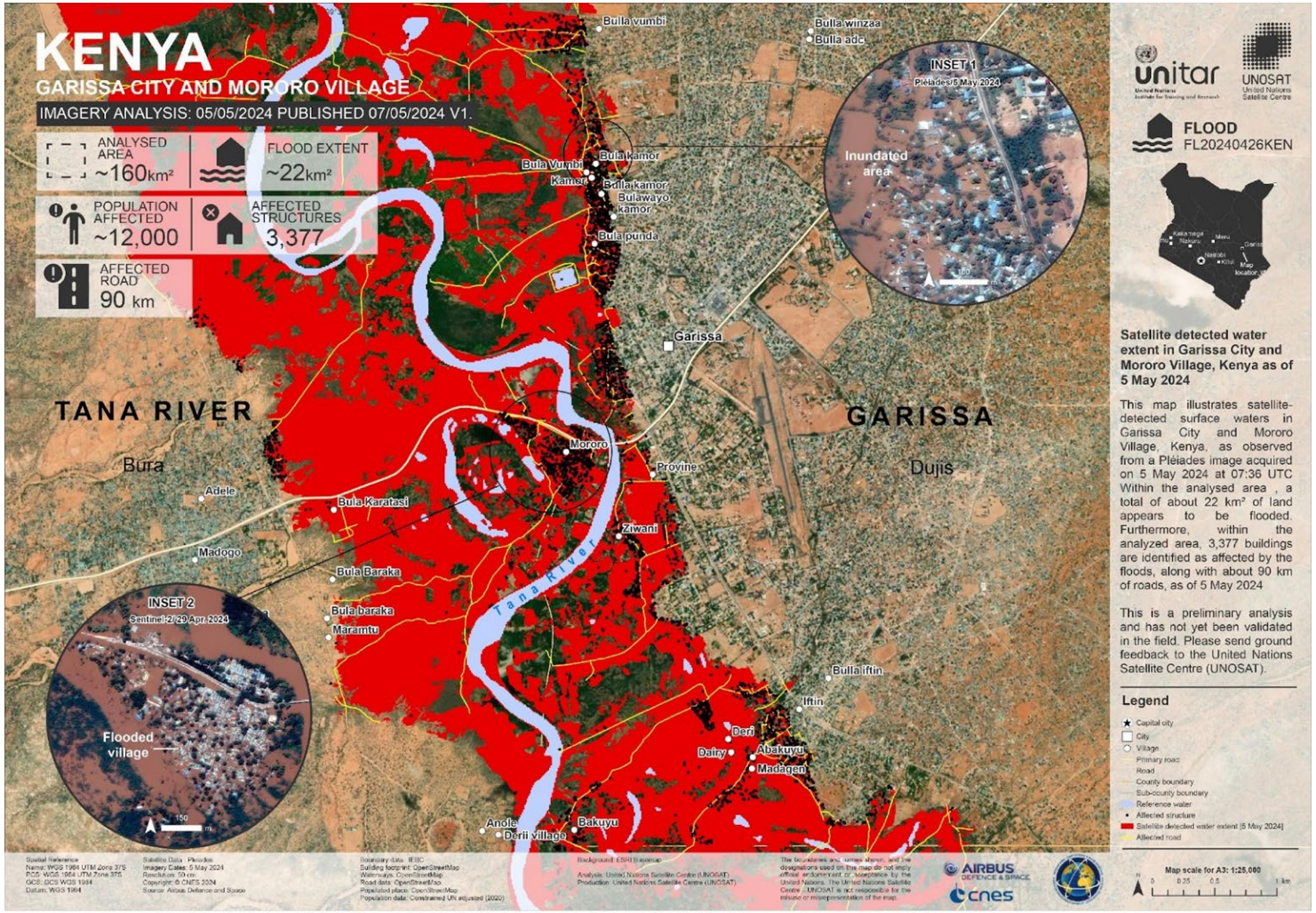


**Akaki River Basin,**
**Addis Ababa, Ethiopia**
Purple = HRSL population data
Pink = 1% Flood hazard probability

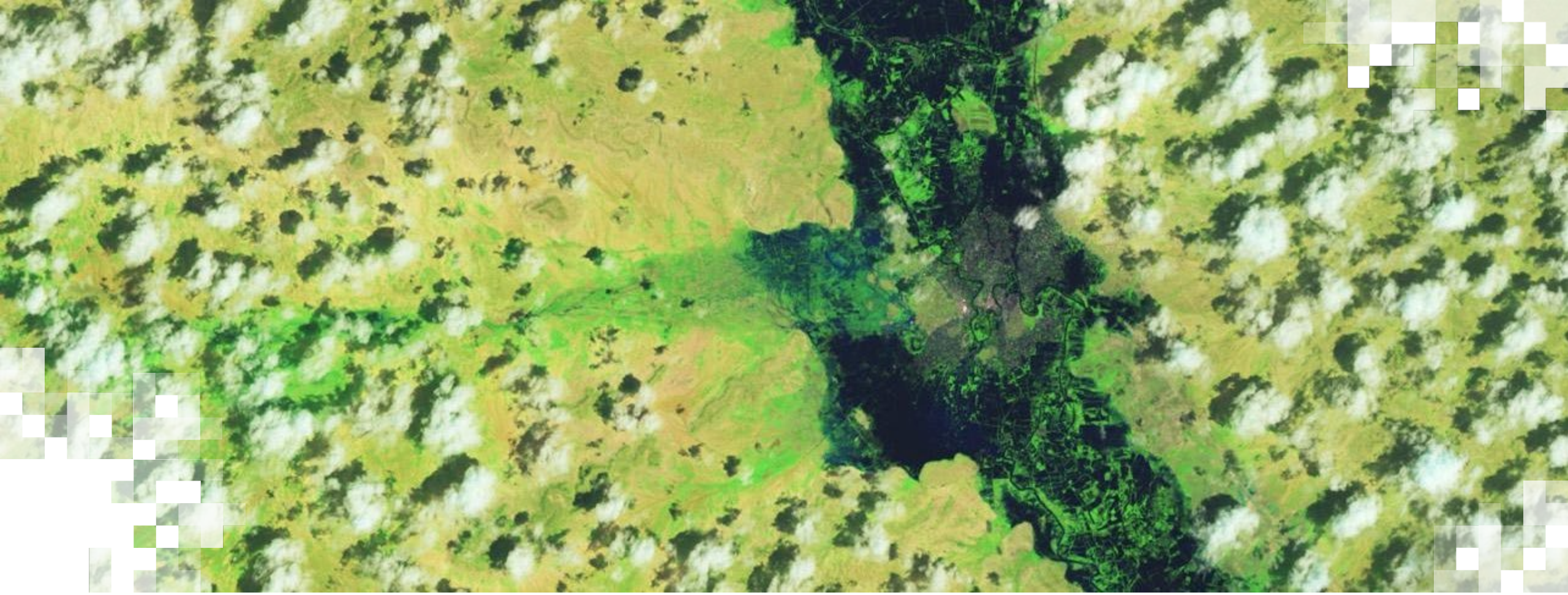
*Bernhofen et. al. 2022. The role of global data sets for riverine flood risk management at national scales. Water Resources Research*

# Advances in Data Availability - Remote Sensing of Flooding

- Observations of flooding from space also play a crucial role.
- It allows the new hazard models to be validated against real events.
- Allows ongoing monitoring of flooding for disaster response and management.




*Bernhofen et al. 2018. A first collective validation of global fluvial flood models for major floods in Nigeria and Mozambique. ERL*



# Section 2: Practical Session
# Camp Flood Exposure Assessment Application

# Prerequisite Account and Data

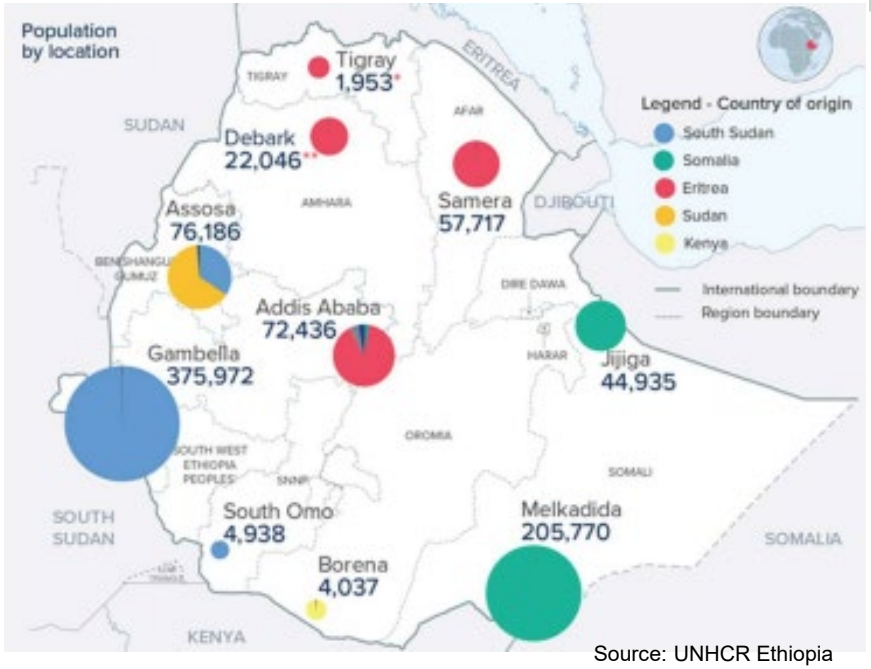
- A geographical information software. We will be using QGIS. This can be downloaded for free from www.qgis.org.
- Data for conducting a flood exposure assessment:
  - Flood Maps
  - Camp locations and boundaries
  - Camp information
  - Building footprint data
- The documentation and data required to follow along in the practical session can be downloaded from the following repository: https://zenodo.org/records/11203929.

Use this QR code to download the data:

# Background

- Ethiopia hosts the third largest population of refugees in Africa. Over 90% live in 24 camps.
- Camps have a history of flooding. In 2014, two camps in the Gambela region had to be evacuated and camps abandoned.
- In 2023, we wrote a paper asking: **can global flood risk data be used to understand camp flood risk?**
- What did we find?
  - Global population data inappropriate.
  - Global data needs to be supplemented with local data.
- What can these datasets be used for?
  - Identification of high-risk camps
  - Preliminary understanding of risk within camps

**Figure 1.** Location and Origin of Refugees in Ethiopia




Source: UNHCR Ethiopia Operational Update, Nov 2022

**Figure 2.** Flooding of Leitchuor Camp in 2014


*Bernhofen et al. 2023. Unknown risk: assessing refugee camp flood risk in Ethiopia, ERL*

# Data

## Camp Boundaries and Information

- Manually delineated using UNHCR camp locations and satellite imagery

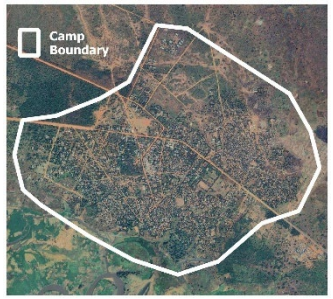



**Figure 1.** Camp boundary delineation for Pugnido Refugee Camp.

- Information on camp populations and demographics extracted from UNHCR camp profile reports

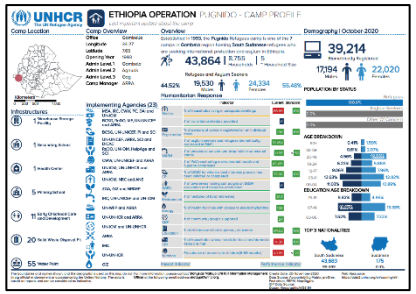
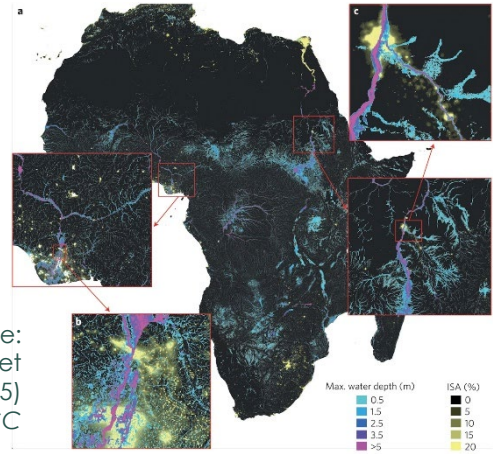



**Figure 2.** UNHCR camp profile for Pugnido Refugee Camp

## Global Flood Data

- We use global flood maps produced by Fathom Global (v2).
- These maps cover both fluvial (river) and pluvial (rainfall) flooding for a number of return periods.
- For our analysis, we combine the fluvial and pluvial flood maps into one *combined* flood map.




Source: Ward et al (2015) *NCC*

**Figure 3**. Fathom flood hazard map in Africa

## Building Footprint Data

- To understand where buildings are located within the camps, we use satellite derived and community mapped building footprints.
- We use two sources of building footprints:

1. Open Street Map extracted footprints
2. Google Open Buildings footprints

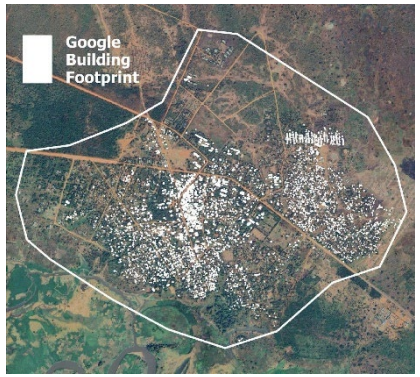



**Figure 4**. Google Building Footprints – Pugnido Camp

# Flood Exposure Risk Assessment Exercise Overview

## Exercise 1: National Camp

- Overlay global flood maps with camp boundaries to conduct a preliminary assessment of camp flood exposure
- This assessment allows you to answer questions such as:
  - how many camps are exposed?
  - which camps are most exposed?
  - where shall I conduct more detailed assessments?

## Exercise 2: Individual Camp

- Assess the flood within an individual camp
- Integrate building footprints into the analysis, to understand which buildings are exposed.
- Incorporate vulnerability information to understand how different flood depths might impact the camp

**Table.** Simple vulnerability thresholds for the risk analysis.

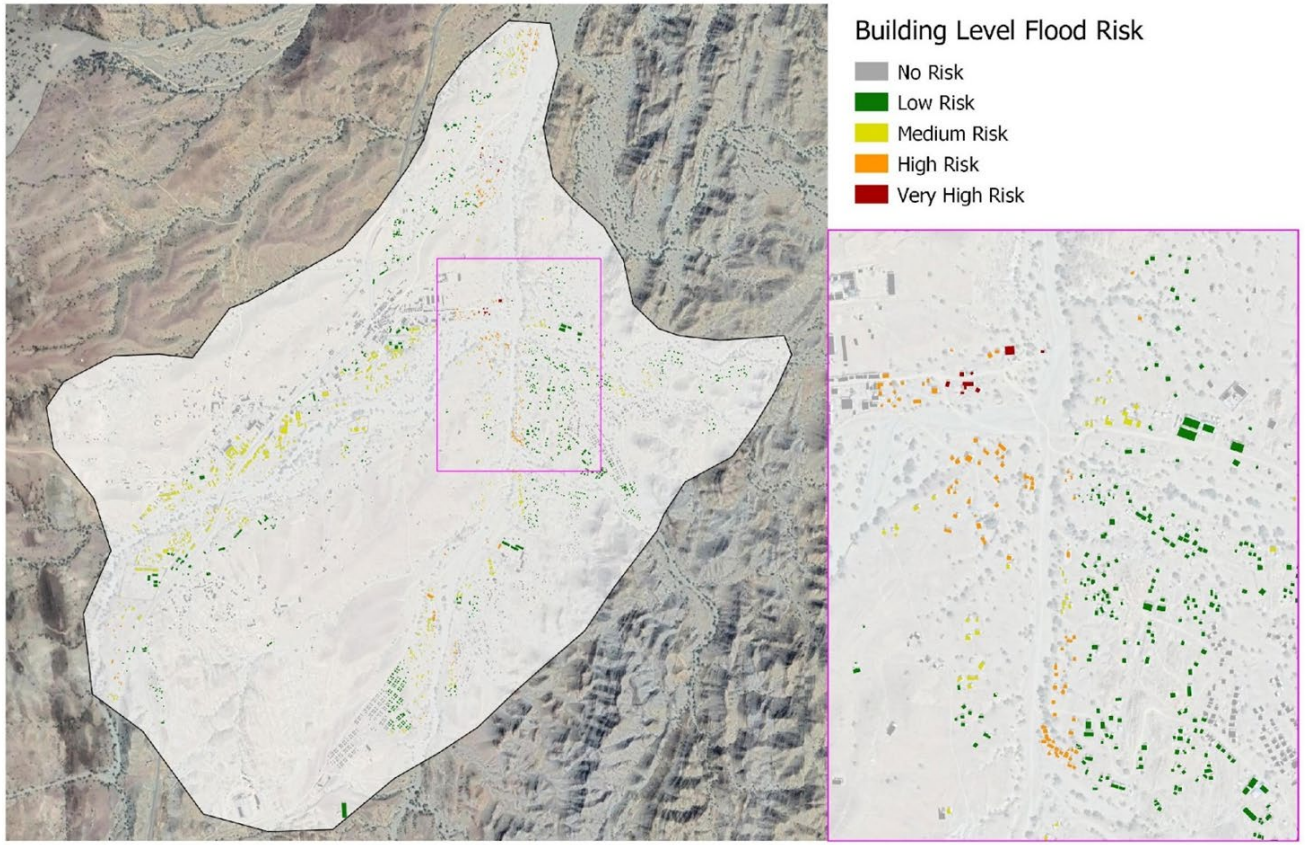
| Risk | Depth (m) |
|---|---|
| Low | < 0.15 |
| Medium | 0.15 - 0.5 |
| High | 0.5 - 1.5 |
| Very High | > 1.5 |

# Summary – Outputs from the Camp Flood Risk Analysis

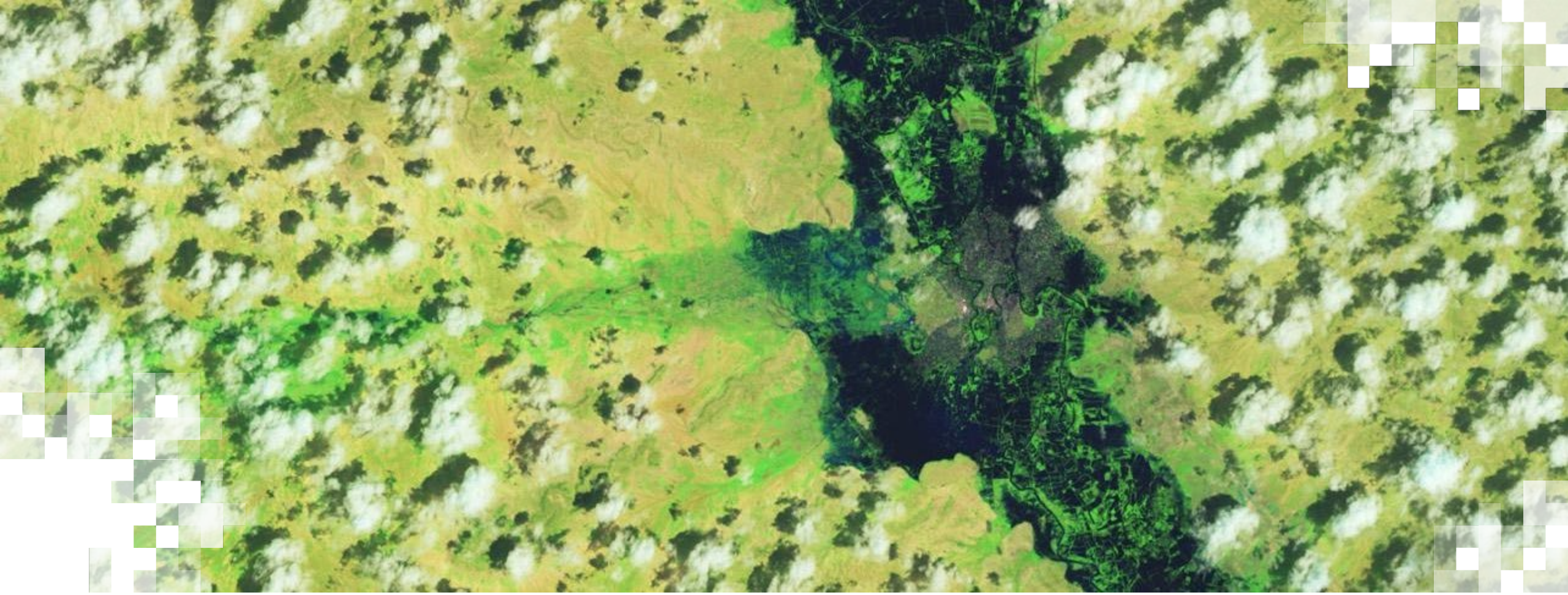
## Exercise 1: National Camp Flood Exposure Assessment

| Camps | Flood Exposed | % Exposed |
|---|---|---|
| Adi-Harush | 3,414 | 32.2% |
| Aw-Barre | 2,829 | 21.9% |
| Aysaita | 9,789 | 42.6% |
| Bambasi | 1,665 | 9.1% |
| Barahle | 14,450 | 46.5% |
| Bokolmanyo | 4,430 | 13.4% |
| Buramino | 8,942 | 19.8% |
| Gure-Shembola | 2,480 | 25.5% |
| Helaweyn | 8,658 | 18.2% |
| Jewi | 9,584 | 16% |
| Kebribeyah | 0 | 0% |
| Kobe | 9,213 | 24.8% |
| Kule | 11,269 | 24.3% |
| Mai Aini | 958 | 5.4% |
| Melkadida | 5,031 | 12.2% |
| Nguenyyiel | 24,554 | 27.1% |
| Okugo | 1,840 | 15.4% |
| Pugnido | 19,644 | 44.8% |
| Pugnido 2 | 5,946 | 62.5% |
| Sheder | 124 | 0.9% |
| Sherkole | 321 | 2.9% |
| Tierkidi | 30,023 | 45.6% |
| Tongo | 0 | 0% |
| Tsore | 2,689 | 16.5% |

## Exercise 2: Individual Camp (Barahle) Flood Risk Assessment



# Demo of Camp Flood Assessment in QGIS



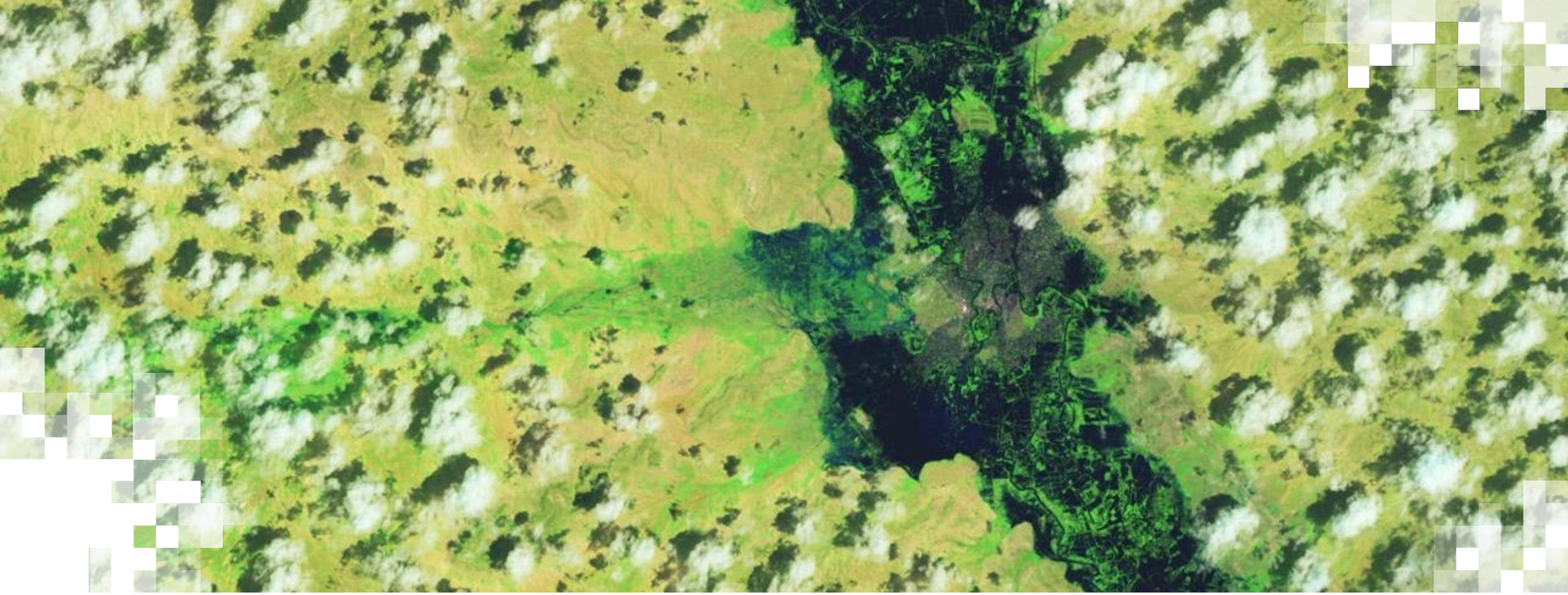
# Section 3: On the Ground Realities
# Current Camp Flood Risk Management

# Refugee Flood Risk - Current Example of Impacts

- Thousands, including refugees, are caught up in the ongoing El Niño-triggered heavy rains and severe flooding sweeping across East Africa.
- In Kenya, nearly 20,000 people in the Dadaab refugee camps have been displaced due to the rising water, many after fleeing severe drought in neighbouring Somalia. Several latrines have collapsed, putting refugees at risk of deadly water-borne diseases.
- In Burundi, around 32,000 refugees – nearly half of the refugee population in the country – are living in areas affected by the floods. Food and other basic services prices have gone up.
- In Tanzania, over 200,000 refugees in camps have been impacted. Shelters have been damaged, and UNHCR's office in Kigoma was flooded.


Neziya Nsananikiye © UNHCR/Bernard Ntwari

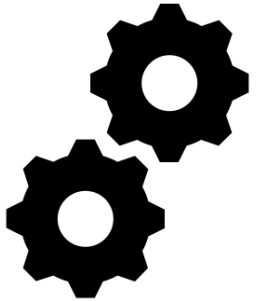
*Source: 3 May 2024 Briefing Notes, UNHCR*



# Section 3.1
# How is Flood Risk Currently Managed in Camp Settings

# Setting up New Camps

- Multifunctional Team (MFT) Risk Analysis and Evaluation for new camp set up
- Site assessment form
  - **Red** lines flag critical issues rendering the site unsuitable for development
  - **Orange** lines flag that heavy mitigation activities will be required to enable the development of the site
- TOPOGRAPHY AND DRAINAGE
  - slope %, soil condition, soil type, drainage patterns
- CLIMATIC CONDITIONS, ENVIRONMENT, PUBLIC HEALTH AND NATURAL HAZARDS
  - (Does historical data indicate that the area is prone to flooding?, What is the average rainfall per season, land use patterns etc.)
- Vulnerability status analysis
  - age, gender, disability
- Recommendations



# Existing Camps – Ongoing Management

*Source: 22 December 2022 Amhara Road & Building Design & Construction Supervision Works Enterprise*

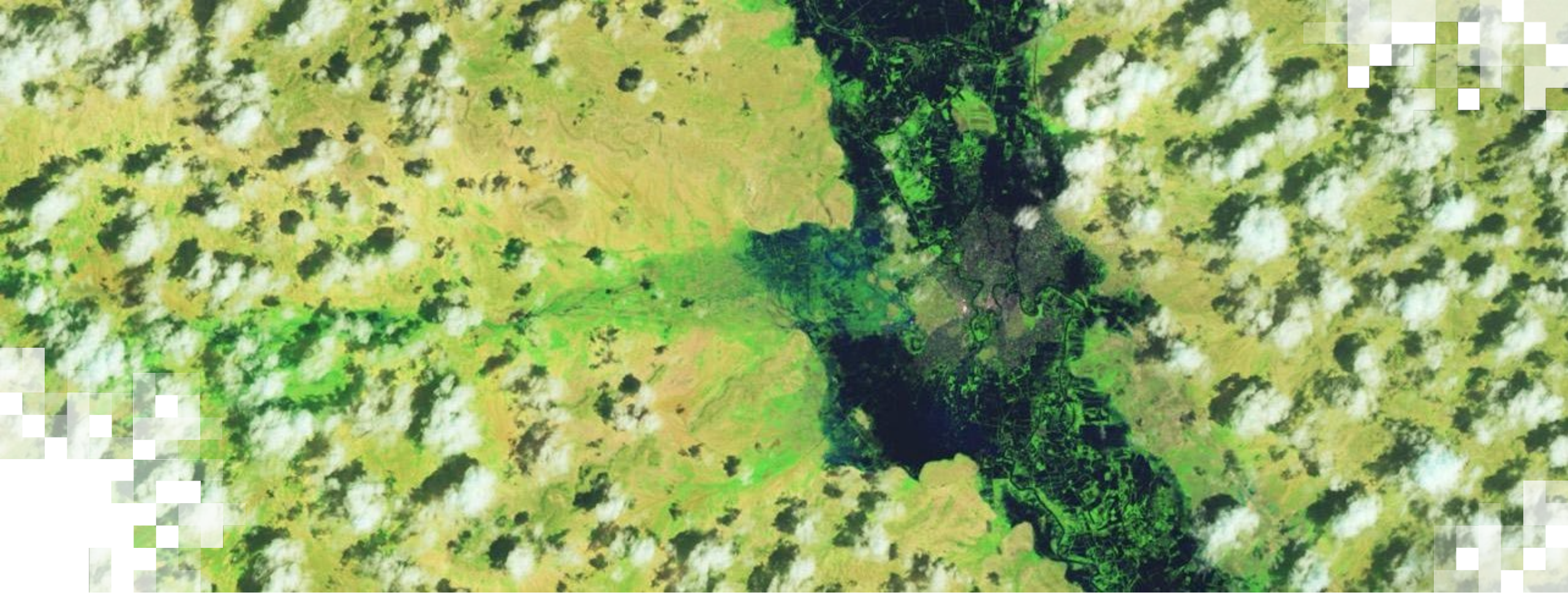
- Periodic Multifunctional Team (MFT) Risk Assessment
  - WASH, Shelter, Public Health, Education & Protection, government, local authorities, partners
- Flood Preparedness and Response Strategy
  - Preparedness → Mitigation → Response
- Vulnerability Analysis
- Structural and Non-Structural Measures
- Camp Coordination and Management

# Challenges of Flood Risk in Camp Settings

- Siting
- Overcrowding
- Reluctant refugees
- Family ties
- Security/protection concerns
- Funding

# The Future of Flood Risk Management in Camp Settings

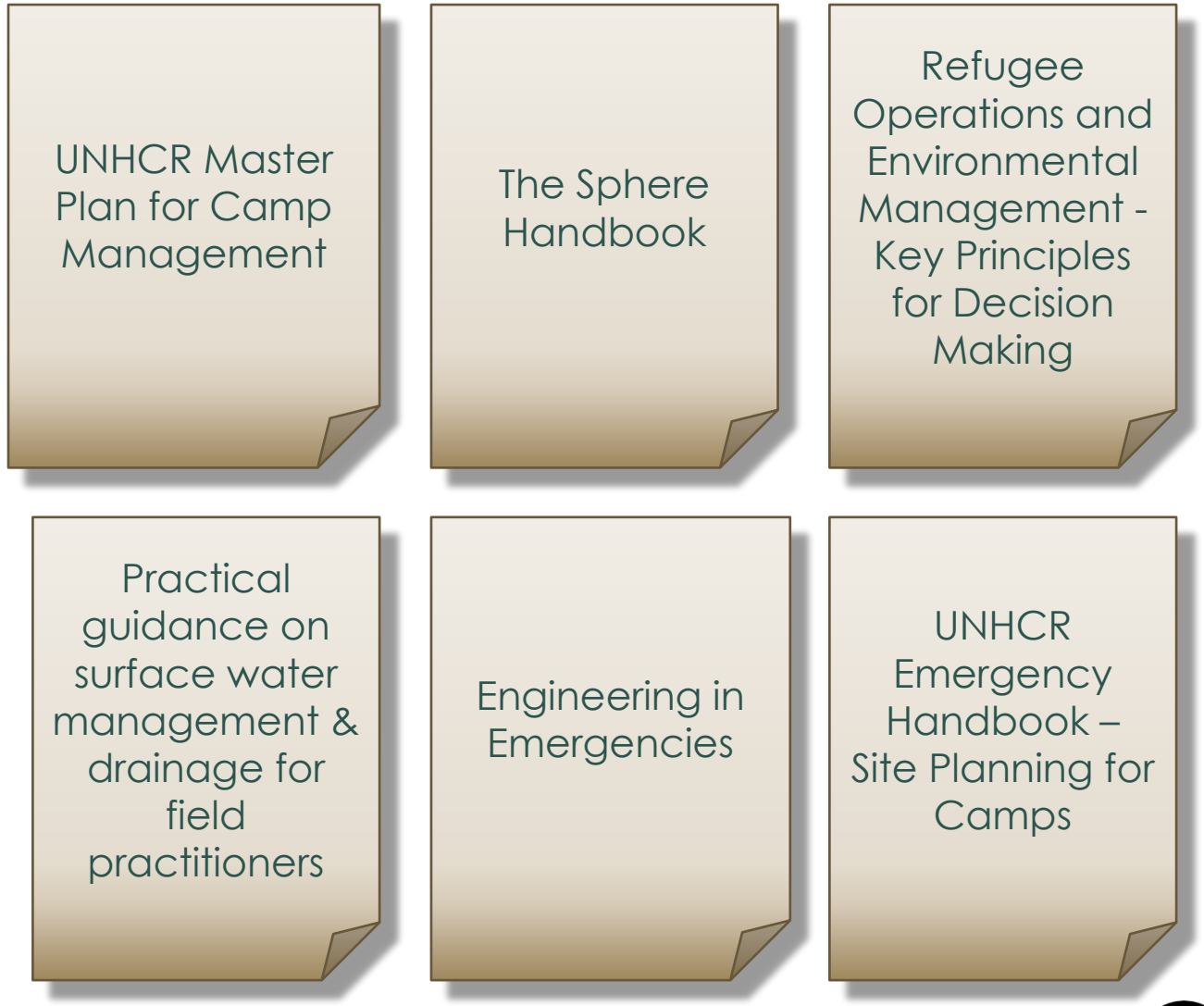
- Opportunity (flooding-Drought) – Nature Based Solutions & IWRM, enhanced recharge
- Science and technology complimenting Indigenous knowledge
- Siting camps
- Manage refugee/ host community perceptions
- Flood mapping – making data/information available to decision makers
- Invest in research, information archiving, sharing/dissemination



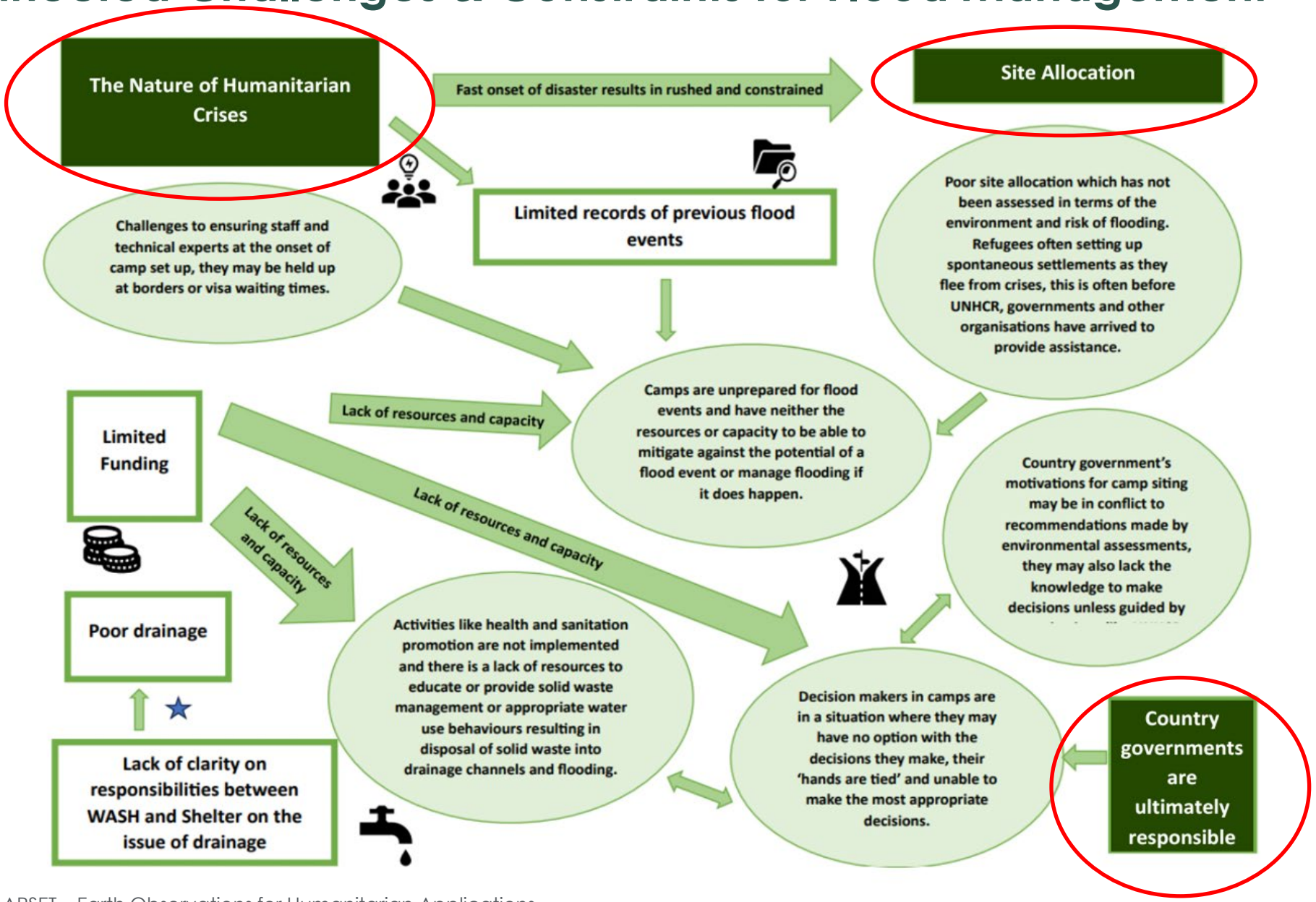
# Section 3.2
# What are the Realities of Flood Risk Management in Camp Settings?

# Research Investigation: Flood Risk Management Decision Making in East African Refugee Camps

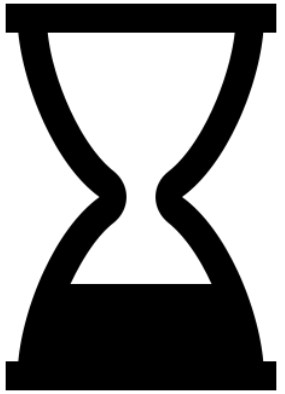
- Research investigation completed in 2023
- Interviews with professionals from UNHCR and UNICEF working across WASH, Shelter and a participant from a health NGO
- A critical analysis of guidance and policy literature



# Interconnected Challenges & Constraints for Flood Management



# Nature of a Humanitarian Crisis – Timing is Critical



- No one size fits all response
  - highlighted across the guidance literature analysed
- There are many moving parts:
  - timing can be critical
  - camp managers deal with multiple contending issues
- For example:
  - One interviewee highlighted that tools were beneficial but often timing and the spontaneous nature of humanitarian crises meant that refugees settled in camps before these assessments could be completed, or this data used.
  - Interviewees noted a significant lack of recorded data, one respondent shared a particular experience where they believed that response could have been timely and effective if more data has been available.
- Evidence-based learning appears critical in flood management decision making.

# Supposed Temporary Nature of Refugee Camps

- Interviewees described how there was no proper investment in the construction of the camp, no proper road access, no proper drainage or flood mitigation and that issues like solid waste management had not been considered.

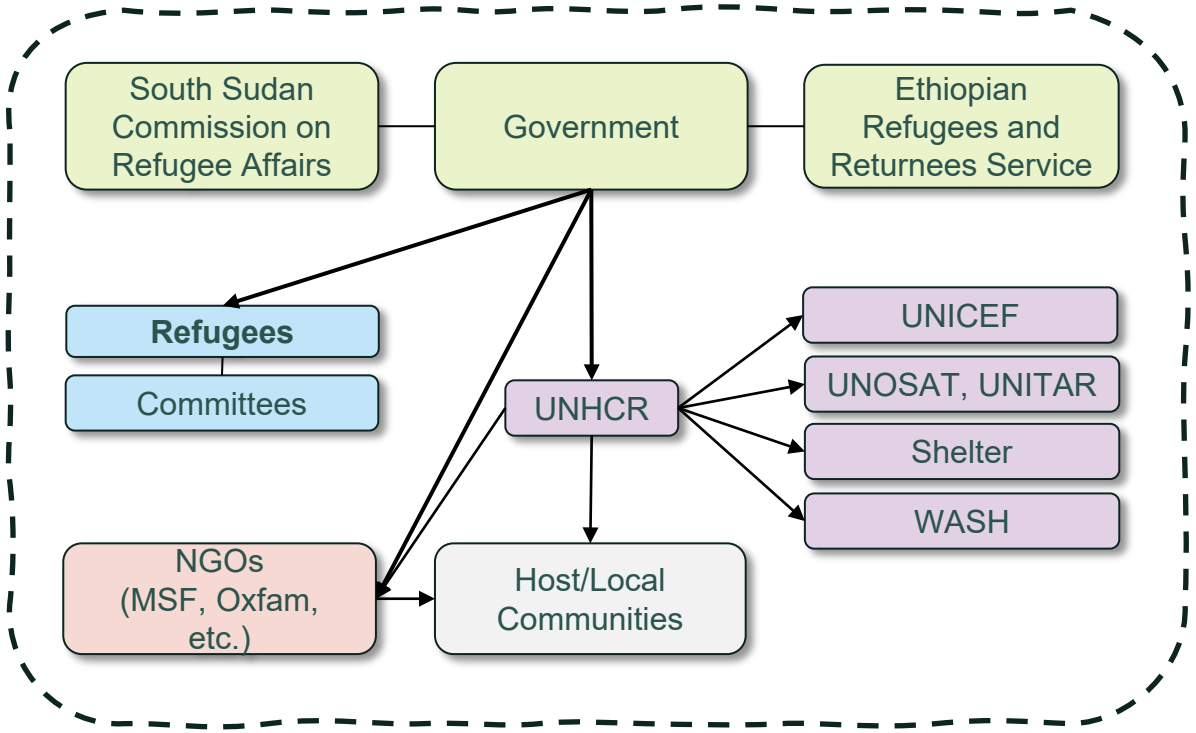
- Displaced people living in camps have mechanisms to cope with flooding themselves but there are many concerns because of a lack of consideration given to decisions made at the outset of camp construction.

- UNHCR's mandate commits them to ensuring camps are designed as a temporary solution but this is far from the reality, the temporary measures to manage flooding prevents long-term solutions to the issue.

*Photo: Sadik Gulec, 2013*

# Hierarchy of Responsibility, UNHCR and Hosting Governments

- No one individual was responsible for any decision, and coordinating platforms worked together to come to a decision.
- UNHCR is never meant to be solely responsible for coordination but is the responsibility for the government. UNHCR and partners are there to support coordination, however, this is not always the case and UNHCR may co-lead in events where the government requires support, but nothing can be achieved without support from the government.
- The issue of camp siting was the only exception to any potential for disagreement in coordination and decision making relating to the issue of flood management in refugee camps.



# Site Assessments and Site Allocation

- One respondent discussed in detail that they provide recommendations based upon their assessments as a technical expert, but this is often not followed because of the constraining factors of lack of humanitarian actors and limited funding.
- They noted that site and environmental assessments are a critical tool in supporting camp location decision making.
- Respondents shared that often the expert recommendations made as part of these assessments are unable to be taken by decision makers or ignored, noting that 'hands are often tied' due to funding constraints, the nature of the emergency and a difference in motivations for site allocation between organisations and governments.

*Photo: R Bradenbrink, 2020*

# Flood Risk Assessment for Refugee Camps

## Summary

- Important to assess flood risk for refugee camps due to heightened exposure and vulnerabilities.
- It has been challenging in the past to apply flood risk assessment methods due to data availability.
- Recent advances in global datasets, generated by global models and remote sensing observations are transforming what is possible.
- Technology is helping us begin to understand flood risk in camps anywhere.
- Still some big gaps in understanding the unique vulnerabilities around refugees and camps.
- Analytical assessments on their own do not solve the problem due to the complex context of refugee camp management.

Drawing by a street kid. Photo: Special Arrangement The Hindu

# Homework and Certificates

- **Homework:**
  - One homework assignment
  - Opens on 20 June 2024
  - Access from the training webpage
  - Answers must be submitted via Google Forms
  - **Due by 05 July 2024**

- **Certificate of Completion:**
  - Attend all three live webinars (attendance is recorded automatically)
  - Complete the homework assignment by the deadline
  - You will receive a certificate via email approximately two months after completion of the course.

# Contact Information

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- ARSET Website
- Follow us on X (formerly Twitter)!
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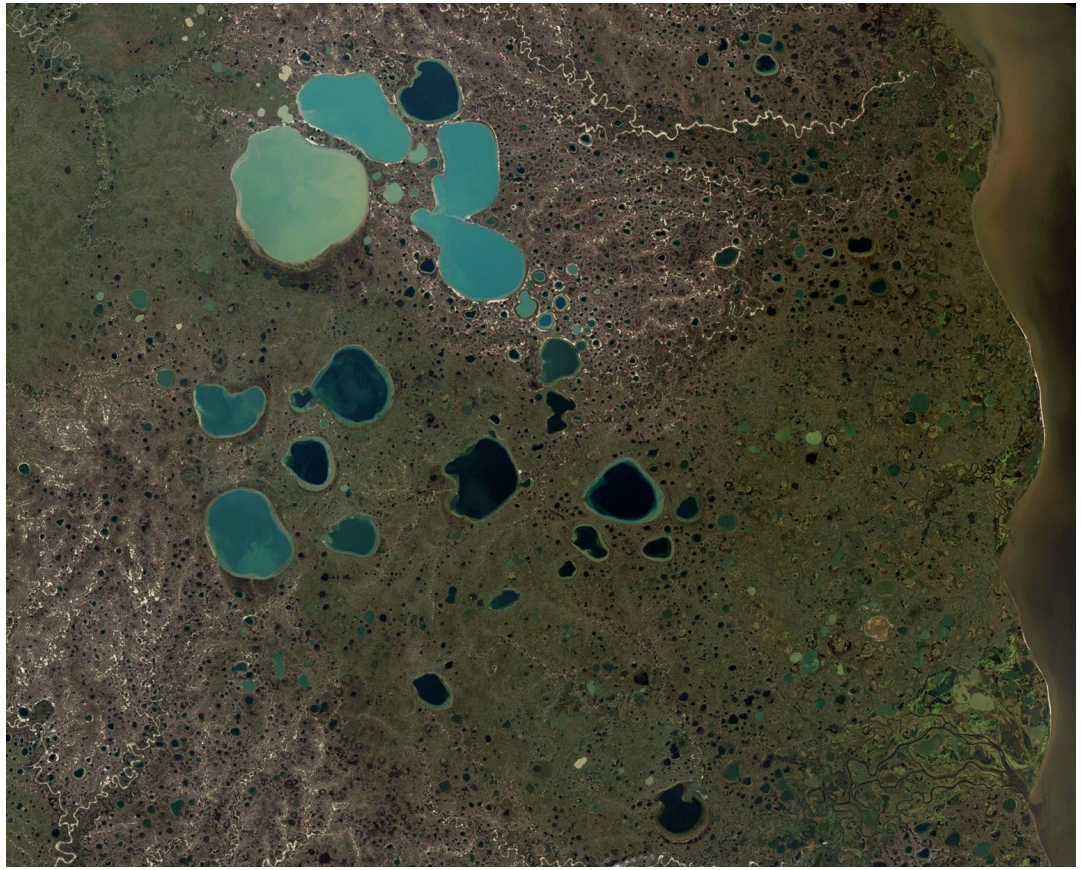
Visit our Sister Programs:

- DEVELOP
- SERVIR

# Questions?

- Please enter your questions in the Q&A box. We will answer them in the order they were received.
- We will post the Q&A to the training website following the conclusion of the webinar.



https://earthobservatory.nasa.gov/images/6034/pothole-lakes-in-siberia


APPLIED REMOTE SENSING TRAINING PROGRAM
TRAIN - EMPOWER - ADVANCE

# Thank you!