
Cox's Bazar, Bangladesh. N.Carlevaro, 2019

SSP

flood risk management workflow

SSP A series of practical guidance on Sustainable Settlement Planning

FLOOD RISK MANAGEMENT WORKFLOW

This booklet guides you through a six-step process to anticipate and reduce flood risks, by creating flood hazard maps using a geomorphological approach, identifying adapted mitigation measures and measuring their impact. Each step is clearly described and complemented with tools and tutorials, using open-source software (QGIS) and freely accessible data, to ensure practical application. Materials and tutorials can be found on the dedicated website: **https://humanitarian-risk.unhcr.org**

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00 Flood risk management workflow

Schematic representation

STEP	**1** **Context Analysis** compile baseline data	**2** **Remote Analysis** understand hazard	**3** **Field assessment** collect local information	**4** **Assets at risk** identify and prioritize	**5** **Mitigation scenarios** combine adapted measures	**6** **Strategy** compare and decide
ACTIONS	Define Area of Interest Sort existing data on: - boundaries, roads, ... - buildings - natural features - topography Use global sources and locally available data (drone, topo, maps, ...)	Analyze: - existing hazard maps - watersheds and natural drainage - lowlands - groundwater - past events Identify types of flood	Observe the terrain: - natural features - human footprint - silent witnesses Engage with community: - interviews - participatory mapping Verify/adapt remote data Compile information in consolidated hazard map	Identiy and categorize assets at risk (vulnerability / criticality) Define acceptability and prioritize intervention needs Receive propositions of mitigation measures	Analyze maps and measures generated at STEP4, understand type and effect Add local measures if adequate Adapt risk maps to estimate the impact of each mitigation scenario	Compare scenarios, estimate implementation cost, time, feasibility Compile information to allow for an informed decision on the strategy Prepare an action plan for implementation
OUTPUT	**BASE MAP**	**INDICATIVE HAZARD MAP** can be inserted in GPS or phone for site survey	**GEOLOCALIZED DATA** **FINAL HAZARD MAP** adapted with local info	**RISK MAP** **ASSETS AT RISK** **LIST OF PRIORITIES**	**SCENARIOS** combining adapted measures	**STRATEGY** **ACTION PLAN**
TOOLS GUIDES	Internet QGIS software Tutorials	Internet QGIS software Tutorials	Avenza, Timestamp Local data collection guide	QGIS Risk Strategy plugin Prioritization table (risk matrix)	Compendium of measures Decision tree	Cost-Benefit Analysis (risk matrix)

00 Introduction
Preliminary steps

0.1 I Understand the objective of this workflow

The flood risk management workflow is designed to identify and mitigate flood hazards through a structured process. It involves several key steps:

- identifying and spatializing flood hazards (STEPS 1 to 3)
- identifying and quantifying assets at risk (STEP 4)
- identifying mitigation measures and comparing their impact (STEP 5)
- proposing a mitigation strategy (STEP 6)

The schema on page 3 of this booklet provides an overview of each step, the main actions, output and supporting tools related. This workflow has been developed for technicians, particularly settlement planners, as well as shelter officers, environmental or WASH (Water, Sanitation, and Hygiene) specialists involved in flood risk mitigation. It provides a structured approach to analyzing flood hazards using a geomorphological approach, and developing effective response strategies.

To implement this process, QGIS, an open-source geographic information system (GIS) software, must be installed. While advanced expertise is not necessary, a basic understanding of QGIS is essential for effective use. Beginners are encouraged to take an introductory course to familiarize themselves with its functions. Supporting resources, including video tutorials and PDF step-by-step user guides, are available to help users navigate the workflow. These materials can be accessed through the provided links, ensuring that users can effectively apply QGIS for flood risk management.

This project has been developed and tested between 2022 and 2025 through the Geneva Technical Hub (GTH), as a collaboration between UNHCR, the Federal Institute of Technology of Zurich (ETHZ), and the Swiss Agency for Development and Cooperation (SDC).

PRESENTATIONS

Executive summary of the project (4-pager) in PDF:
add link to this document once available on updates website

Videos presenting the project:
Community of Practice 13.02.25: https://www.youtube.com/watch?v=TLVkmpHFhsk
Flood Risk Toolbox: https://humanitarian-risk.unhcr.org/learning-section/introduction-toolbox
https://humanitarian-risk.unhcr.org/learning-section/flood-risk-mitigation-gis-tool-introduction

0.2 I Install QGIS on your computer

The workflow heavily relies on using QGIS.

QGIS is a free, open-source GIS tool for mapping and spatial analysis. It's ideal for flood mapping because it integrates various data formats, supports hydrological analysis, enables automation with Python, and provides clear visualization of flood risks. Its cost-effectiveness and flexibility make it a powerful choice for flood risk assessment and planning.

DOWNLOAD qGIS here: https://www.qgis.org/download/

If you are using a UNHCR computer, you may need to ask your IT colleagues to support for authorization

TUTORIAL for installing QGIS:
https://youtu.be/ck4PjoOIwMQ?si=AxsC7GYKc6k3Dslf

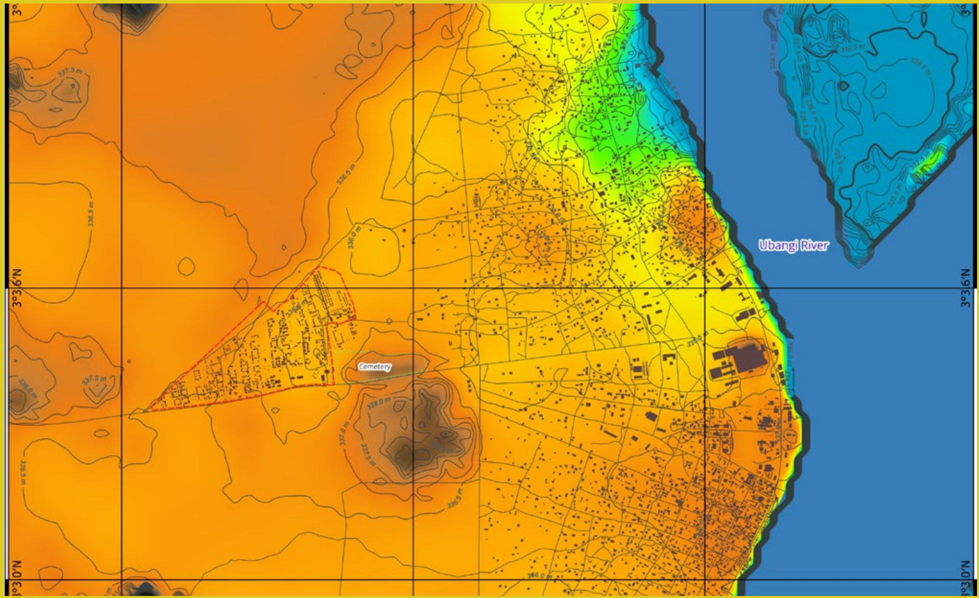
0.3 (opt) I Take a Basic QGIS crash course

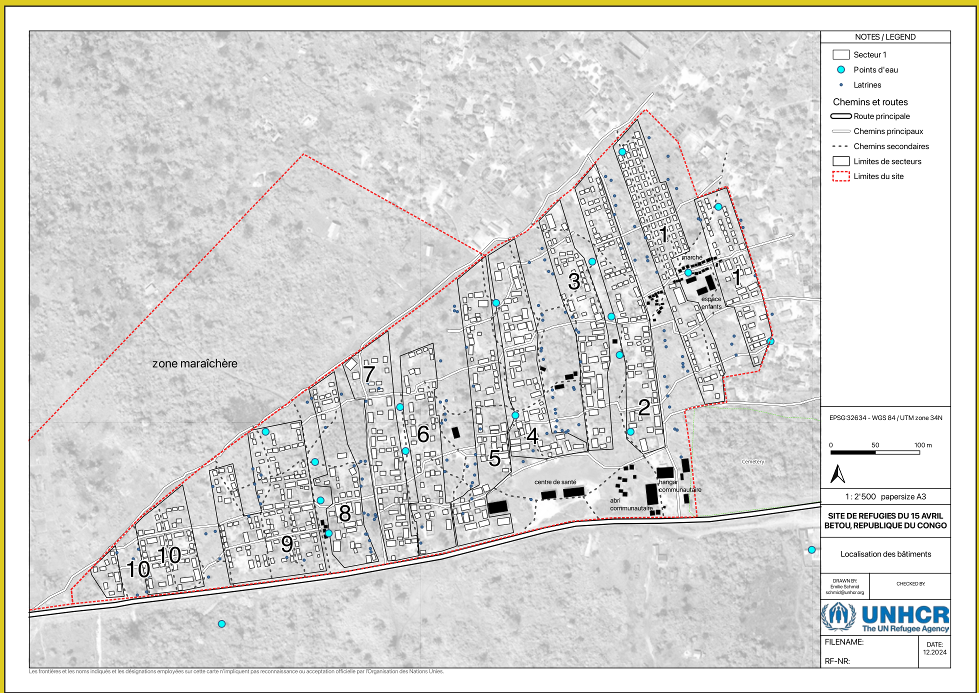
For people who are not previous users of QGIS or need a refresher, a crash course where the basic use of QGIS are explained is necessary.

You don't need to be an expert to use this software, but having a basic understanding is essential. If you're unfamiliar with it, the proposed material will guide you through the fundamentals, helping you get started quickly. These steps will cover essential functions, key features, and best practices to ensure you can navigate the software with confidence. Whether you're a beginner or looking to refresh your knowledge, the tutorial and the Crash Course will provide the foundation you need to use the software effectively.

TUTORIAL: lots of tutorials exist; the one below covers most main topics:
https://youtu.be/NHolzMgaqwE?si=6Z4Jfok5sqj45hHI

CRASH COURSE: GTH developed a crash course for basic mapping in GGIS, axed towards settlement mapping, with step-by-step guide and exercises:
https://humanitarian-risk.unhcr.org/learning-section/basic-mapping-in-qgis





Examples of base maps of Betou, Republic of the Congo (UNHCR, A.Cippa, 12.2024)
up: extract of context map including the town with topographical analysis from DTM
down: detailed map of refugee site of 15 Avril, including infrastructure and buildings

01 Context analysis
Compile baseline data

The first step in flood mapping is to gather baseline data and generate a *BASE MAP* in QGIS. This map provides an overview of the existing conditions and serves as a foundation for further analysis.

Defining the Area of Interest (AoI)

Start by establishing the Area of Interest (AoI), which will be used for spatial analysis. Define the AoI at two different scales:

- ***Enlarged Context Scale*** *for a* broad view to understand regional influences, water flow patterns, and surrounding infrastructure.
- ***Detailed Assessment Scale*** with a fine resolution for in-depth analysis of flood-prone areas.

Data Collection and Organization

Once the AoI is set, gather and organize relevant spatial data, focusing on:

- ***Infrastructure Data****,* such as administrative boundaries, roads, infrastructures, buildings, facilities, amenities.
- ***Natural Features***, such as rivers, topography, vegetation and soil types

Sources of Data

To ensure accuracy and completeness, use whenever possible a mix of global and local data sources:

- ***Global Data Sources*** *(accessible online)* include: satellite imagery (e.g., Sentinel, Landsat), OpenStreetMap (OSM) for infrastructure, DTM (Digital Terrain Models) from sources like FathomDem, FabDEM or Copernicus, and Global hydrological databases
- ***Local Data Sources*** *(more precise and up-to-date)* include: drone surveys (which can provide high-resolution imagery and terrain data), topographic surveys (conducted with high-precision tools like total stations or LiDAR for precise elevation measurements) and local site plans and maps (paper-based or digital maps from municipal agencies or field surveys).

OUTPUT

By combining these data sources in QGIS, you can produce several high-quality **BASE MAPS** that serve as the foundation for flood risk analysis, mitigation planning, and decision-making.

1.1 I Georeference the location

Georeference the area of interest (AoI) and insert the boundary of the site. With coordinates, in GIS, Google Earth or AutoDesk suite, draw the perimeter of the site and of the extended Area of Interest.

Convert it into a shapefile and insert it in QGIS.

If you need help for this step, take the **QGIS basic mapping crash course** (see STEP 0.3, p.4)

INSTALL PLUGIN: for inserting coordinates, use the plugin: Lat Lon Tools

TUTORIAL: https://youtu.be/CF8lKvPSxH4?si=u6T9lW610dZDesHw

1.2 I Identify the Administrations of the AOI

Different levels of geographic administration enable a structured approach to governance by identifying the responsible entities for managing resources, services, and policies. This ensures that the needs and issues of various populations are effectively addressed.

DOWNLOAD: Humanitarian Reference Maps

You can find in these portals administrative boundaries of all levels for the whole world, population figures, country codes, developped and recognized by the humanitarian comunity. These UN Common Operational Dataset represent the latest available data for humanitarian operational use.

You need to do once only, but the file to download is very heavy.
https://fieldmaps.io/data

https://data.humdata.org/group

1.3 I Identify projection and tile

Identify the right projection for your AoI and the right tile for the digital terrain model. The UTM projection is important in fields like GIS, mapping, and site planning. Here are some key points explaining its significance:

- **Minimizes Distortion:** UTM minimizes distortion for small areas, providing accurate distance, shape, and area measurements within each zone. This makes it ideal for detailed mapping and local surveys.

- **Uniformity:** Because UTM divides the world into a series of standard zones, it ensures consistent mapping and data collection across different regions. Each zone uses the same projection method, simplifying data integration and comparison.

- **Compatibility** between GIS software and Autodesk suites is ensured when all georeferenced information is converted into the correct UTM projection.

TUTORIALS

UTM projection: https://youtu.be/UWCnDfMF9gw?si=KNscP636BtuD7L5t

Identifying the right tile: https://youtu.be/KWwg4EmJMkk?si=3OPKd__k3RPEdzjE

1.4 I Identify existing features

Identify existing features such as roads, houses, water bodies, landcover and special structures and download them in VECTOR (shape) format.

Find and download all available information from OSM and other sources in vector format (shape files): building footprints, roads, waterbodies, landuse, and much more.

The website BBBike allows to download, for the AoI, OSM available data differentiated by category. Steps are well explained in the website. To get the most accurate and updated data you can crosscheck with other sources.

Use this website: https://extract.bbbike.org/ (natural, landuse, buildings, roads, railwaiy, waterways, points)

Other possible source: http://download.geofabrik.de/ (full country, buildings, landuse, natural, place, pofw, pois, railway, road, traffic, transport, waterway)

For landcover, use this website: https://viewer.esa-worldcover.org/worldcover/ n

TUTORIAL: https://youtu.be/OricknTaJ6c?si=BrV0c8WyCErbrlAS

1.5 (opt) I Convert features from CAD to GIS

If available, convert features from CAD site plan in .dxf format and import them in vector format in QGIS, using the importing dxf command. You may have CAD site plans with features more accurate and up-to-date than global available data such as OSM. In this case, it is better to use them to improve the result of analysis.

If the CAD file is not georeferenced, it needs to be placed at the right location in QGIS by overlapping at least three recognizable features.

1.6 I Add a background map

Add a background map to visualize existing features in raster format (satellite imagery / maps). Background aerial images and other maps will give the necessary context and inform on the environment.

Different sources have different levels of resolution and are better up-to-date depending on the region: find and download globally available satellite images like Google earth, Bing, ESRI, Yandex and others. Find and identify historical images from Google Earth.

INSTALL PLUGIN QuickMapService in QGIS for access to many backgrounds. Alternatively, use xyz_tiles in QGIS and link to other such as WMS services, SAS Planet, Google Engine.

The aim is to have and display as many satellite imageries and raster maps as possible with different providers and date for better comparison.

TUTORIAL: https://youtu.be/Yp5dLZcLD1w?si=61v4k5qG42yPY6AP

TUTORIAL: https://youtu.be/xSpHvvgWNxQ?si=y0nWZZDTXU-7GxvQ

1.7 (opt) I Insert high resolution imagery

If available, insert high resolution satellite imagery in QGIS and vectorize the most updated features. You may have or request access to recent, high resolution aerial imagery from UNHCR HQ mapping unit / UNOSAT. It allows to manually update and complete the features you inserted in STEP 1.4 by drawing the missing buildings, roads and others directly in QGIS.

1.8 I Identify the DTM (digital terrain model)

Identify the most accurate DTM (digital terrain model) of the AoI and download it. DTMs are invaluable tools in hydrological and environmental studies. They inform you on the topography and help in identifying watersheds and natural streams. They are crucial for water management and flood prediction, and more generally, for terrain analysis.

The most commonly used and usually best globally available Digital Terrain Model (DTM) is FathomDEM. You may find higher quality DTMs through dedicated country-specific websites, USGS Earth Explorer, or Google Earth Engine.

TUTORIAL
FathomDEM: https://youtu.be/KWwg4EmJMkk?si=W2Z6sAPJyINSggpq

INSTALL PLUGIN SRTM-downloader for finding the right tile
https://youtu.be/6qnquU9mzpg?si=PXWyOyUao_E-i29J

1.9 I Create contour lines based on DTM

Contour lines are a widely used method for representing the topography of a landscape on a map. These lines connect points of equal elevation, providing a visual depiction of terrain features such as slopes, flat areas, hills, and depressions. By analyzing the spacing and shape of the contour lines extracted from a Digital Terrain Model (DTM), one can intuitively interpret the gradient and nature of the terrain. Closely spaced lines indicate steep slopes, while widely spaced lines suggest flatter areas. Circular or elliptical patterns may represent hills or depressions, making contour lines a valuable tool for terrain analysis.

TUTORIAL: https://youtu.be/6t5NrWDYOiU?si=5-9HL3-JNR49Cz83

1.10 I Better accuracy topographical information

Especially in flat terrains, it is important to have precise and accurate topographical information. A topographical survey will allow to verify if the DTM is accurate and to increase the precision.

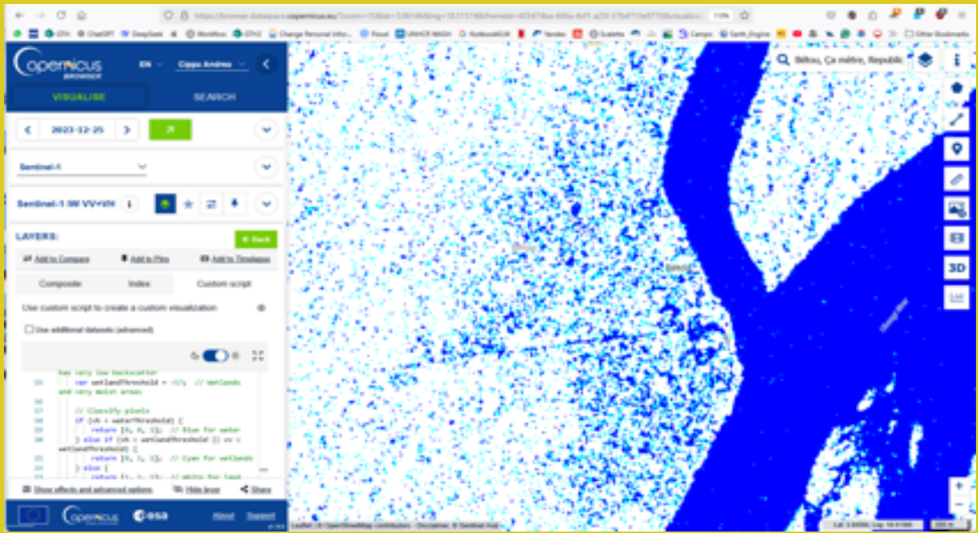
Preliminary and remote analysis can, if necessary, be performed only with remote information, keeping in mind that there can be an important error margin.

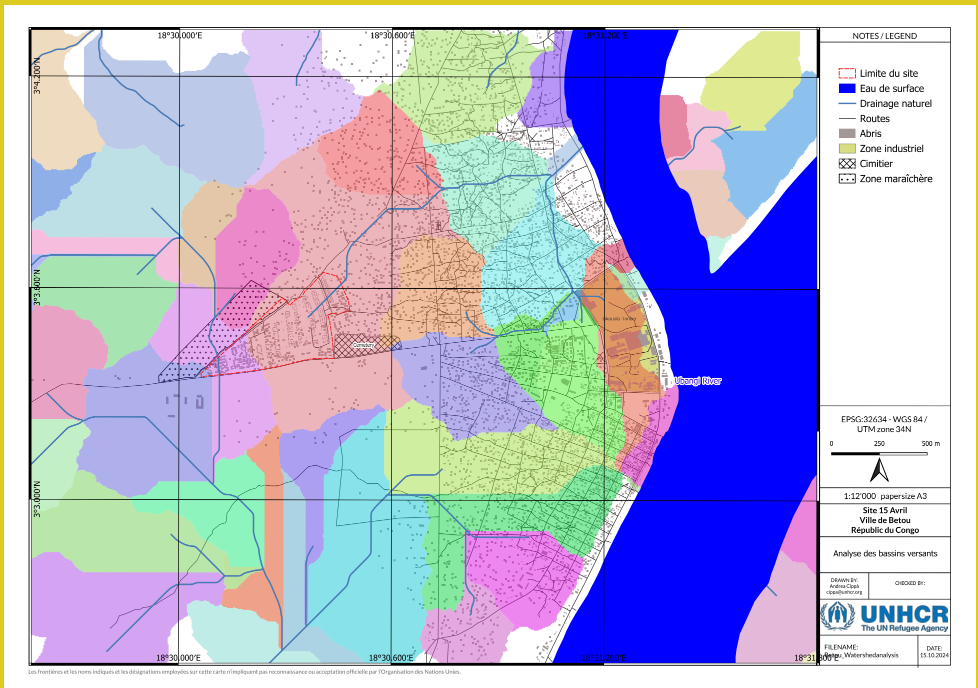
For later stages such as design and implementation of any mitigation measure, it is crucial to verify the accuracy and to have precise information, since planning with the right slopes is paramount for the efficiency of any flood mitigation measure.

Common tools for on-site survey include: total station, teodolite, drone.

In certain cases, high resolution satellite imagery can be used. It is important to treat the information removing obtacles such as buildings and trees when using aerial imagery (drone/satellite)

02 Remote Flood Analysis
Understand the hazard





Examples of remote flood analysis for Betou, Republic of the Congo
up: flooded areas on 25.12.23, captured through Sentinel-1 satellite, in Copernicus Browser
down: watershed analysis based on DTM information (UNHCR, A.Cippa, 12.2024)

Once the base maps are created in QGIS, they can be used for remote flood hazard analysis, leading to the development of *INDICATIVE HAZARD MAPS*. These preliminary maps help guide field assessments by identifying areas with varying levels of flood risk.

This step focuses on terrain analysis (geomorphology) and remote sensing (using freely accessible satellite and elevation data) rather than hydrologic or hydraulic modeling. By examining landforms and aerial imagery, you can estimate likely hazard zones and their severity. However, since remote data has limitations, all findings should be verified on-site to ensure accuracy.

Key Steps in Remote Flood Hazard Mapping

- ***Existing Hazard Data Incorporation:*** integrate hazard zones from previously developed flood risk maps, comparing various sources.
- ***Watershed and Dainage Path Identification:*** use Digital Terrain Models (DTM) to analyze water flow, identify natural watersheds and drainage paths to understand how water moves through the landscape.
- ***Lowland and Floodplain Analysis***: detect low-lying areas prone to flooding using terrain analysis tools, and assess how these areas interact with nearby rivers, streams, and drainage systems.
- ***Groundwater and Soil Saturation Assessment***: use groundwater maps and borehole data to determine groundwater levels. High groundwater levels can increase flood susceptibility, especially in prolonged rainfall events.
- ***Historical Flood Event Analysis***: examine satellite imagery for evidence of past floods. Identify areas with recurring flood patterns, water stagnation, or sediment deposits.
- ***Flood Types Classification:*** based on the collected data, define the most probable types of flooding in the area, such as riverine floods, flash floods, urban floods, groundwater flooding and coastal floods.

OUTPUT

By combining these analytical techniques in QGIS, you can develop **INDICATIVE HAZARD MAPS** that highlight potential flood-prone zones. This preliminary mapping is a critical tool for prioritizing field assessments, validating remote findings, and designing mitigation strategies.The maps can be inserted on GPS or mobile phone to guide field verifications.

2.1 I First global insight of the hazard

The website «ThinkHazard» provides a general view of the hazards in a given location, that should be considered before any project design and implementation, to increase disaster and climate resilience.

RESOURCE: https://thinkhazard.org

The site provides the brief and is self expalantory. It also gives the contacts to the national or regional authorities in charge.

2.2 I Collect and analyse global flood maps

The Global Flood Database provides detailed information on flood events worldwide from 2000 to 2021, including extent, duration, frequency, and impact. It integrates satellite imagery and modeling to support disaster risk management, climate analysis, and policy-making.

The «Global Flood Monitoring Portal» provides near real-time flood data and maps based on satellite imagery and hydrological models, enabling users to monitor, assess, and respond to flood events worldwide.

RESOURCE:

https://global-flood-database.cloudtostreet.ai/
https://portal.gfm.eodc.eu/
https://fastflood.org/

2.3 (opt) I Analyse national or regional hazard maps

If available, digitalize, georeference, refer to maps sourced from national or regional contacts (find contacts in Thinkhazard). Ensure each zone uses the same projection method, simplifying data integration and comparison.

Compatibility between GIS software and Autodesk suites is ensured when all georeferenced information is converted into the correct UTM projections.

2.4 I Natural drainage, watersheds and subsheds

Identify natural drainage paths, main watersheds and subsheds, using the DTM. This process allows to identify natural streams occurring after a rainfall in case that there is no manmade waterdrainage built. It helps to identify watersheds for the whole area as well subsheds for more detailed analyis. Use FathomDEM digital terrain model (better accuracy than FabDEM).

The process can be done with QGIS, HEC-HMS, Global Mapper and other softwares. This process allows to extend the area of interest to the whole watershed, where potential mitigations measures are envisagable.

TUTORIAL: https://youtu.be/SHB3JOffL7M?si=cwTqcL0TznjC2Led
FathomDEM: https://youtu.be/KWwg4EmJMkk?si=FuYdL_gHUUB2bQON

2.5 I Lowlands and natural sinks

Identify lowlands, natural sinks, depressions and flat / low points using the DTM. Identifying depressions is essential for pinpointing pluvial flood-prone areas because the low-lying spots naturally collect and retain excess rainwater, increasing likelihood of localized flooding during heavy rainfall.

Create profiles of the AoI, estimate according to topographies the flood prone areas, make a water rise analysis.

This process can be done with QGIS or HEC-HMS and other software

TUTORIAL: https://youtu.be/IB5YUAenGf8

2.6 I Compare DTM analysis with imagery

Assess the reliability of your DTM by comparing it and the analyses performed so far *(such as watershed boundaries, streams, sinks, and hills)* with observable features like streams and lakes derived from high-resolution imagery *(e.g., Google Earth, Bing)* and vector layers *(e.g., OSM).*

Additionally, compare sinks or depressions with visible changes in vegetation or soil cover, which may indicate water accumulation or terrain irregularities. You can also compare contour lines with visible landscape elements such as hills, forest boundaries, and even buildings to further validate the terrain model. Keep in mind that satellite imagery, DTMs, or OSM data may not always reflect the most current landscape conditions.

2.7 I Evaluate groundwater depth

Assessing groundwater depth is crucial for flood analysis, as shallow groundwater limits soil absorption, increases surface runoff, and raises flood risk. Shallow groundwater tables reduce soil infiltration capacity, leading to saturation and heightened peak discharge during flood events.

The UNHCR WASH boreholes database gives data on groudwater depth measured at most boreholes: https://im.unhcr.org/apps/wash-boreholes-map/

2.8 I Remote Sensing Analysis of Past Events

Map flood-prone areas using publicly available satellite data, including Sentinel-1/2, Landsat 8, and active/passive remote sensing. By analyzing imagery from known rainfall periods, different band combinations can help detecting flooded areas, improving the accuracy of flood mapping.

TUTORIALS

Sentinel-1 https://youtu.be/ZHxiacxm6k8?si=v0cwQ1GasxrTYspa
Sentinel-2 https://youtu.be/XzfyXbdp7hg?si=zqcdTTrmJjAsAv0Z

2.9 I Classify Potential Flood Types in the AoI

Estimating the potential flood types in your location requires analyzing geographical, meteorological, and hydrological factors. Using Digital Terrain Models (DTM), satellite imagery, and OpenStreetMap (OSM), you can assess natural drainage patterns, slopes, and elevation changes.

Based on this analysis, you can identify the most probable flood types in the Area of Interest (AoI):

- **River Flooding** – rivers overflowing due to heavy rainfall or snowmelt.
- **Flash Flooding** – rapid, intense flooding from heavy rainfall, common in hilly or urban areas.
- **Coastal Flooding** – caused by storm surges or high tides, often intensified by strong winds or hurricanes.
- **Urban Flooding** – results from poor drainage in built-up areas, leading to water accumulation on streets.
- **Pluvial Flooding** – happens when excessive rainfall overwhelms drainage systems, even away from water bodies.

By integrating these factors, you can estimate whether flooding is likely in your site and identify the dominant flood type affecting the area.

2.10 (opt) I *Expert-Level Modeling*

To enhance the accuracy of flood risk assessments and water management planning, this optional approach uses advanced hydrologic and hydraulic (H&H) modeling software such as HEC-RAS, HEC-HMS, SWIMM or similar tools. When available, these models can be integrated with high-resolution DTMs to provide detailed simulations of water flow, flood extents, and impact zones. This data-driven approach enables more reliable scenario planning and infrastructure design.

However, it requires access to high-quality datasets, including riverbed profiles, rainfall and rain intensity records, and soil characteristics, along with precise geospatial and hydrological information. The methodology also requires specific expertise in Disaster Risk Reduction (DRR) and Geographic Information Systems (GIS).

TUTORIAL HEC-HMS: https://youtu.be/dCPvvIAsgFI?si=F-qBATyLzrXudKAX

TUTORIAL HEC-RAS: https://youtu.be/x2TvMHhN-d8?si=52kWmsNL6uC50iq3

HEC-HMS models watershed hydrology, estimating runoff, peak flows, infiltration, and reservoir routing for flood forecasting, water resource management, and stormwater planning.

HEC-RAS if your project focuses on river and stream hydraulics, floodplain mapping, or you need a tool widely accepted by regulatory agencies. It is user-friendly and excellent for detailed riverine flood studies.

Delft3D FM if you are working on coastal, estuarine, or urban flooding projects that require high-resolution and 3D modeling capabilities. It is particularly strong in handling complex interactions between hydrodynamics, sediment transport, and morphology.

SFINCS if you need a highly versatile and scalable framework that can integrate multiple numerical models for a wide range of scientific and engineering applications. It is best for interdisciplinary projects that require a flexible and interoperable simulation environment.

Each tool has its strengths, so the best choice depends on the specific needs and goals of your project.

2.11 I Identify the key features to survey

The preliminary hazard maps function as a critical planning and coordination tool during the early stages of flood risk assessment. By providing an initial spatial overview of potential flood-prone areas (based on historical data, topographic analysis, and available hydrological indicators) it enables the project team to strategically prioritize field activities. This includes identifying high-risk or data-deficient zones that require targeted observations, site visits, and stakeholder engagement.

The maps allow the field team to allocate resources more effectively, ensuring that data collection and community consultations are concentrated in areas where flood impacts are most severe or uncertain. As a result, the preliminary mapping significantly enhances the efficiency, focus, and relevance of subsequent technical assessments, while also fostering informed dialogue with local stakeholders and decision-makers.

Examples field data collection in Betou, Republic of the Congo
up: technical measurements of lowland areas and flood marks; report on avenza maps app
down: participatory mapping workshop with the community (pictures: N.Antenen, E.Schmid)

03 Field data collection & final hazard mapping

Collect local information

The remote analysis needs to be verified and adapted after observations on the site and information gathered through local actors, allowing to prepare a FINAL HAZARD MAP.

This map provides a clear, data-backed representation of flood-prone areas and assists technicians and decision-makers in identifying high-risk zones and assets at risks, planning mitigation strategies (including impact reduction measures and potential relocation needs) and supporting preparedness for emergencies by highlighting escape routes and safe zones.

Field Observations and Measurements

Direct field assessments validate flood-prone areas identified in remote analysis. This includes:

- ***Topographical Surveys.*** Mapping terrain variations, elevation changes, and natural drainage centers using precision tools such as total stations, GNSS receivers, or drones.
- ***Silent Witnesses of Flood Events.*** Identifying physical indicators of past flooding, such as: watermarks on buildings and trees; deposits of silt, mud, or debris in low-lying areas; as well as erosion patterns along riverbanks and roads.
- ***Natural and Human-Made Features.*** Observing landscape characteristics that influence flood impact, including: vegetation cover and soil permeability; infrastructure such as drainage systems, embankments, levees, and roads; settlements located in flood-prone zones.
- ***Past Events and Recurrence Patterns.*** Understanding historical flood events, their causes, and the frequency of severe occurrences.
- ***Coping Mechanisms and Local Adaptations.*** Learning about flood management strategies used by communities, such as early warning systems, traditional drainage solutions, or evacuation plans.

Community Engagement and Participatory Mapping

Flood risk assessments must integrate local knowledge, as affected communities provide critical insights that may not be visible through remote sensing or GIS analysis. Participatory mapping workshops bring together residents, local authorities, and technical experts to:

- Identify flood-prone areas and vulnerable infrastructure, such as homes, roads, schools, and health centers.
- Improve community awareness of flood risks by discussing past flood events and their impacts.
- Encourage collective problem-solving, fostering collaboration between experts and local actors to enhance preparedness and responses.

The **Local Data Collection Guide** supports you in preparing interviews and participatory mapping workshops.

Data Integration and Final Hazard Map Production

Once field data is collected, it must be georeferenced using GPS or mobile mapping tools for seamless integration into GIS software like QGIS.

- Overlay field data with remote analysis to cross-check discrepancies and refine hazard zones.
- Adjust severity levels based on observed impacts and community input.
- Incorporate additional risk factors, such as groundwater levels, soil composition, and drainage infrastructure limitations.

OUTPUT

By combining technical data with local insights, the **FINAL HAZARD MAP** becomes a powerful tool for flood risk management, ensuring a more comprehensive and community-informed approach to disaster resilience. Several maps at different scales or showing different information can be produced both in GIS and PDF.

3.1 I Observe the terrain: natural features

Using the preliminary hazard maps as guide and background, conduct field analysis to compare initial remote results with reality. The preliminary map can be uploaded on your smartphone or GPS to help guiding the field visits.

If no detailed topographical survey is available, conduct a precise survey (total station/drone), particularly in flat terrain where small elevation changes can significantly impact water flow. In hilly areas, field observations may be sufficient to identify key features such as ridges and talwegs.

Georeference and inspect natural drainage patterns, rivers, lowlands, forests, and other landscape features that influence water movement. Ensure all collected information is geolocated (for example using apps like Avenza maps or Timestamp (geolocalized pictures)) for accurate mapping and analysis. Once back in the office, upload all information in QGIS.

TUTORIAL Import own maps in Avenza Map
https://youtu.be/uPUYA1h9RYM?si=K2aRMdQsow_3E2GA

DOWNLOAD: Timestamp camera app for android or Iphone
https://youtu.be/Dnf4VZQuF0o?si=5fNOYv15OZYqHD1U

TUTORIAL: Georeference paper maps into QGIS
https://youtu.be/XV62QEk0Cxg?si=XiLFdINWVYXNIsyZ

3.2 I Observe the terrain: human footprint

Human-made structures significantly impact flood risks by influencing water flow. Mapping drainage systems, roads, ponds, and critical infrastructure is essential for assessing vulnerabilities and improving flood prevention.

A detailed catchment of man-made structures cannot be done with remote mapping alone; on-site observations are necessary to assess their actual condition. Drainage networks may be blocked or poorly maintained, reducing their effectiveness. Roads can act as barriers or conduits depending on elevation and culverts. Ponds and reservoirs can store excess water but may overflow if mismanaged.

Additionally, the use, type, and condition of facilities must be documented and analyzed, as their functionality during flooding is crucial. Facilities like emergency shelters, health centers, power stations or water treatment plants must be assessed for accessibility, capacity, and structural resilience. Identifying weaknesses in these key facilities helps prioritize mitigation efforts and emergency response planning.

By integrating these elements into GIS and verifying their status in the field, planners can develop more effective flood mitigation strategies, ensure infrastructure functionality, and maintain natural water flow.

3.3 I Observe the terrain: silent witnesses

Silent witnesses (physical traces of past events such as watermarks on buildings, sediment deposits, erosion patterns, and damaged vegetation) provide critical evidence for hazard mapping. Unlike weather records or models, these indicators offer tangible, site-specific proof of flood extent, intensity, and recurrence. They help validate remote sensing data, refine hazard maps, and improve flood risk assessments by revealing areas prone to water accumulation, past peak water levels, and flow directions.

Identifying and mapping these silent witnesses ensures a more accurate and ground-truthed understanding of flood hazards. The height of flood marks can be measured to inform on the intensity of the flood at a given place, to be cross-checked with the topographical survey.

3.4 I Engage with community: Interviews

Perform interviews with local experts and affected people. Semi-guided interviews with open questions and walking interviews allow to gather targeted, spatialized data while keeping the flexibility to include any additional information.

GUIDANCE and templates with possible questions
https://humanitarian-risk.unhcr.org/files/Local_Data_Collection_Guide_with_Annex.pdf

3.5 I Engage with community: participatory mapping

Participatory mapping is crucial for hazard mapping, as it leverages local knowledge to identify flood-prone areas that remote sensing and field surveys might overlook. At the same time, community engagement is an opportunity for awareness raising and preparedness, and to advise on safety and durability of community-implemented mitigation measures.

The Local Data Collection Guide can help organizing a participatory mapping workshop, where residents can mark past flood extents, vulnerable infrastructure, natural drainage patterns and other information on mental maps and then translate the information on geographic paper maps. This process enhances data accuracy and ensures that hazard maps reflect real conditions and population needs.

GUIDANCE for organizing a participatory mapping workshop with the local community, including example
https://humanitarian-risk.unhcr.org/files/Local_Data_Collection_Guide_with_Annex.pdf

3.6 I Compile all geolocalized data

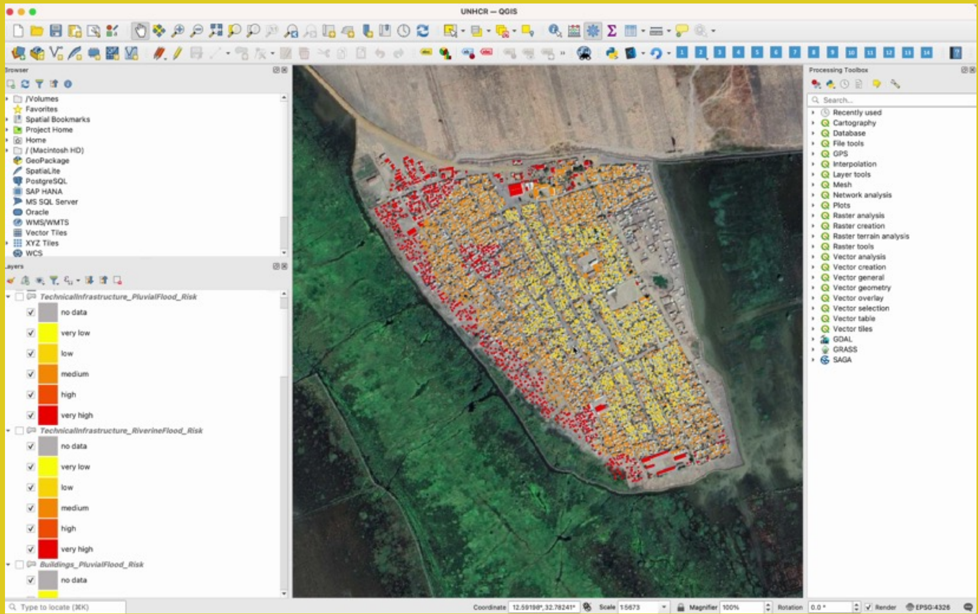
After gathering georeferenced data from remote sensing, field surveys, and community inputs, the next step is to compile and organize it into thematic layers within a GIS platform. Data should be structured across different scales to provide both detailed local insights and broader contextual analysis.

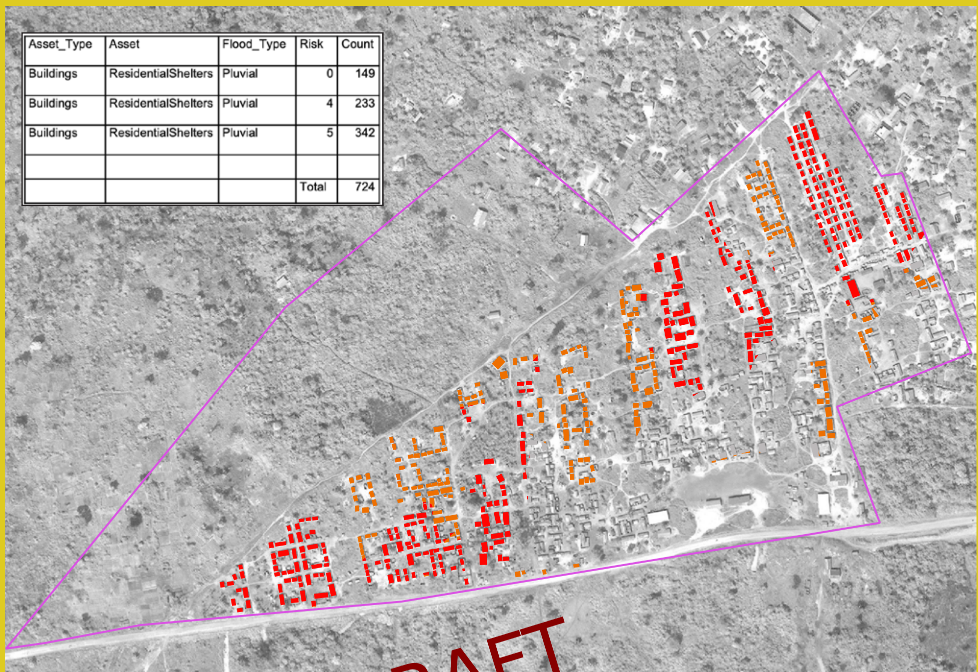
By categorizing information into thematic maps, such as river flooding, pluvial flooding, and coastal flooding, specific risks and flood dynamics can be better understood. Layering topography, land use, drainage networks, and past flood extents allows for a more comprehensive hazard assessment, supporting targeted mitigation strategies and improved decision-making.

3.7 I Verify and adapt remote analysis

Verification of the preliminary hazard maps from remote analysis is essential to ensure accuracy before they are used for risk and mitigation identification and for decision-making. Field validation helps confirm key features such as flood extents, drainage paths, and infrastructure vulnerabilities.

Once verified and adapted, maps should be finalized with a clear and simple layout, ensuring they are easy to interpret. Essential elements like a legend, scale, and north arrow should be included for clarity. The maps should also be prepared in a print-friendly format so they can be used in the field, during community workshops, or for planning purposes.





Asset_Type	Asset	Flood_Type	Risk	Count
Buildings	ResidentialShelters	Pluvial	0	149
Buildings	ResidentialShelters	Pluvial	4	233
Buildings	ResidentialShelters	Pluvial	5	342
			Total	724

Examples of risk calculations with the QGIS Risk Strategy Plugin (ETHZ, N. Antenen, 2024)
up: screenshot of qGIS using the risk strategy plugin for Al-Redis settlement, Sudan
down: extract of risk map and table for Refugee Site of 15 Avril, Betou, Rep. of the Congo

04 Assets at risk
Identify and prioritise

Assessing assets at risk is a crucial step in flood risk management, as it helps prioritizing mitigation efforts and emergency preparedness. This involves identifying exposed infrastructures, buildings, and services based on their location, vulnerability, and criticality. The analysis results in three output documents: a *RISK MAP,* providing spatial representation of flood-prone assets, showing the extent of exposure and risk levels. A *LIST OF ASSETS AT RISK*, inventoring the quantity and types of assets affected. A *LIST OF PRIORITIES* to organize implementation according to urgency.

Assessing Criticality and Prioritization

Not all assets hold the same level of importance during a flood event. To ensure an efficient response, assets must be categorized based on their criticality, which refers to their role in service continuity and disaster response. Critical assets include ***emergency services*** that must remain operational at all times *(such as hospitals or fire stations)*, ***lifeline infrastructure*** *(eg. power plants, water distribution and treatment systems, access roads)*, ***community facilities*** *(eg. schools, emergency shelters, food distribution centers)*, ***economic and administrative facilities*** *(eg. markets, government buildings, industries)*, and individual ***shelters.***

Once critical assets are identified, they can be sorted ranking them based on urgency of required interventions. The Prioritization Table included in the **Risk Mitigation Matrix** can help organize a LIST OF PRIORITIES. This allows authorities and planners to allocate resources strategically and reinforce key infrastructure before disasters strike.

GIS-Based Flood Risk Assessment with QGIS

The **QGIS risk strategy plugin** provides a semi-automated tool for highlighting, quantifying and spatializing assets at risk integrating the information gathered at previous steps. It consists first in overlaying flood hazard maps with infrastructure layers, then analyzing exposure and vulnerability based on predefined criteria, and finally generating structured reports to guide decision-making. The plugin provides a systematic approach to hazard assessment, exposure mapping, and risk quantification, ensuring the output (Risk Maps, List of Assets) are data-driven and actionable.

OUTPUT

- **RISK MAPS** (QGIS and PDF maps, automatically generated)
- **LIST OF ASSETS AT RISK** (excel table, automatically generated)
- **LIST OF PRIORITIES** (excel table, using the Risk Mitigation Matrix)

4.1 I Install QGIS plugin and setup project

The QGIS Risk Strategy plugin enables the semi-automatic generation of a risk map and list of assets at risk, streamlining the flood risk assessment process. To use the plugin, first install it in QGIS. It is designed to work exclusively with a predefined QGIS project template, which can be found in the provided .zip file. Ensure the template is correctly loaded for the plugin to function properly.

DOWNLOAD qGIS Risk Strategy Plugin and Project Template here:
https://humanitarian-risk.unhcr.org/files/gis_tool.zip

TUTORIAL general guide including installation and project preparation process:
https://humanitarian-risk.unhcr.org/images/pdf/learing_section/02_Risk_Mitigation_Tool_Manual_-_General.pdf

4.2 I Data Processing for Flood Risk Delineation

The data collected in STEPS 1 to 3 or the Workflow serves as the foundation for running the Risk Strategy tool in QGIS. This includes:

- *Riverine and Pluvial Flood Hazard Data* – Incorporate hazard maps produced in STEP 3, including different flood intensity levels if available. If only one hazard type is provided, leave the other input blank.
- *Feature Footprints* – Include buildings, transport infrastructure, and technical infrastructure compiled in STEP 1 to assess exposure. Local data is preferred for its accuracy and recency, but if unavailable, the tool allows for integrating globally available feature footprints.

After integrating these datasets, the tool generates a comprehensive risk analysis, supporting more informed decision-making for flood mitigation.

RESOURCE: QGIS Risk Strategy Plugin Steps 1-5

TUTORIAL: watch video or download step-by-step PDF user guide:
https://humanitarian-risk.unhcr.org/learning-section/flood-risk-mitigation-tool-local-data-and-risk-mitigation-strategy

IMPORTANT: the format of the file needs to be right, or the semi-automated plugin will not work. Consult the user guide to ensure the file format is right.

4.3 I Adjust vulnerability and criticality of features

The ***risk level*** of an asset depends not only on the ***hazard intensity*** but also on its ***vulnerability***. More vulnerable assets face higher risks even under the same hazard conditions.

To account for this, the assets vulnerability can be adjusted, based on construction type, using the QGIS Risk Strategy plugin. For example, a tent is far more susceptible to heavy damage in case of flooding than a brick shelter with concrete foundations.

Additionally, you can factor in criticality (the impact of an asset being temporarily or permanently unavailable) by increasing its vulnerability. Essential infrastructure, such as hospitals or emergency shelters, may require a higher vulnerability rating to reflect the severity of potential disruptions. Alternatively, you may choose to incorporate criticality adjustments later in the process at STEP 4.5, depending on the assessment approach.

RESOURCE: QGIS Risk Strategy Plugin Steps 6-9, same PDF user guide

4.4 I Calculate risk

The plugin automatically calculates risk. Manually adapt it if necessary and generate the RISK MAP and LIST OF ASSETS AT RISK.

RESOURCE: QGIS Risk Strategy Plugin Steps 10-12, , same PDF user guide

4.5 I Acceptability and prioritization

Depending on the human, economical and social impact, define a level of acceptability of risk. Often, besides the human and social impact, the scenario of doing nothing costs more on the long-term than mitigating the risk.

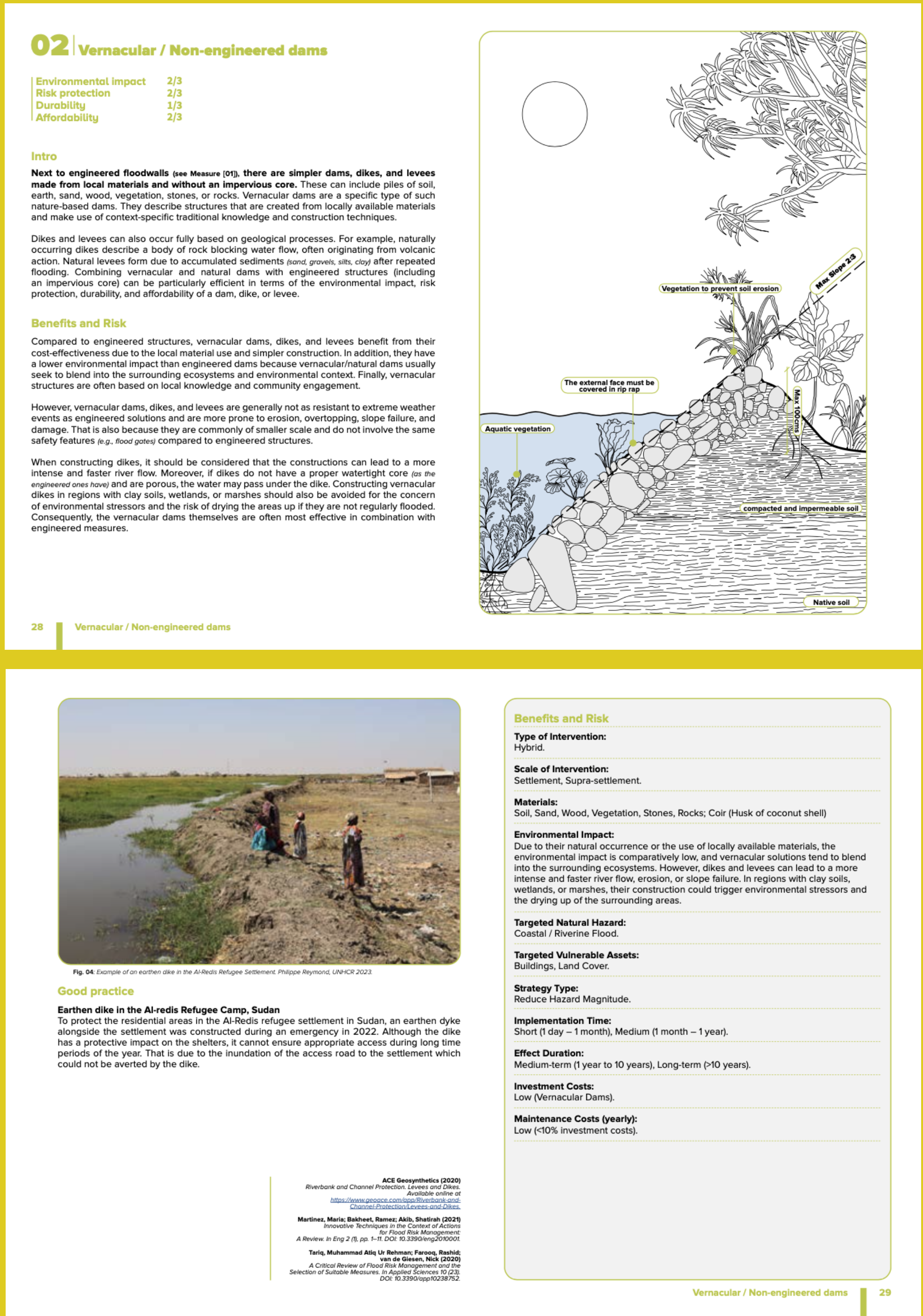
The «*Risk Identification and Prioritization table*» in the **Risk and Mitigation Matrix** proposes a structured way to classify all assets of a settlement and prioritize intervention needs, producing a LIST OF PRIORITIES.

RESOURCE: Flood risk identification and priorization table in the Risk and Mitigation Matrix: add link to this document once available on updated website

4.6 I Proposal of mitigation measures

Introducing base selection criteria, the plugin then generates propositions of adapted mitigation measures, which can serve as a base for developing mitigation scenarios in STEP 5.

RESOURCE: QGIS Risk Strategy Plugin Steps 13-14, same PDF user guide



02 | Vernacular / Non-engineered dams

Environmental impact 2/3
Risk protection 2/3
Durability 1/3
Affordability 2/3

Intro

Next to engineered floodwalls (see Measure [01]), there are simpler dams, dikes, and levees made from local materials and without an impervious core. These can include piles of soil, earth, sand, wood, vegetation, stones, or rocks. Vernacular dams are a specific type of such nature-based dams. They describe structures that are created from locally available materials and make use of context-specific traditional knowledge and construction techniques.

Dikes and levees can also occur fully based on geological processes. For example, naturally occurring dikes describe a body of rock blocking water flow, often originating from volcanic action. Natural levees form due to accumulated sediments *(sand, gravels, silts, clay)* after repeated flooding. Combining vernacular and natural dams with engineered structures (including an impervious core) can be particularly efficient in terms of the environmental impact, risk protection, durability, and affordability of a dam, dike, or levee.

Benefits and Risk

Compared to engineered structures, vernacular dams, dikes, and levees benefit from their cost-effectiveness due to the local material use and simpler construction. In addition, they have a lower environmental impact than engineered dams because vernacular/natural dams usually seek to blend into the surrounding ecosystems and environmental context. Finally, vernacular structures are often based on local knowledge and community engagement.

However, vernacular dams, dikes, and levees are generally not as resistant to extreme weather events as engineered solutions and are more prone to erosion, overtopping, slope failure, and damage. That is also because they are commonly of smaller scale and do not involve the same safety features *(e.g., flood gates)* compared to engineered structures.

When constructing dikes, it should be considered that the constructions can lead to a more intense and faster river flow. Moreover, if dikes do not have a proper watertight core *(as the engineered ones have)* and are porous, the water may pass under the dike. Constructing vernacular dikes in regions with clay soils, wetlands, or marshes should also be avoided for the concern of environmental stressors and the risk of drying the areas up if they are not regularly flooded. Consequently, the vernacular dams themselves are often most effective in combination with engineered measures.

28 Vernacular / Non-engineered dams

Fig. 04: *Example of an earthen dike in the Al-Redis Refugee Settlement. Philippe Reymond, UNHCR 2023.*

Good practice

Earthen dike in the Al-redis Refugee Camp, Sudan
To protect the residential areas in the Al-Redis refugee settlement in Sudan, an earthen dyke alongside the settlement was constructed during an emergency in 2022. Although the dike has a protective impact on the shelters, it cannot ensure appropriate access during long time periods of the year. That is due to the inundation of the access road to the settlement which could not be averted by the dike.

ACE Geosynthetics (2020)
Riverbank and Channel Protection. Levees and Dikes. Available online at https://www.geoace.com/app/Riverbank-and-Channel-Protection/Levees-and-Dikes.

Martinez, Maria; Bakheet, Ramez; Akib, Shatirah (2021)
Innovative Techniques in the Context of Actions for Flood Risk Management: A Review. In Eng 2 (1), pp. 1–11. DOI: 10.3390/eng2010001.

Tariq, Muhammad Atiq Ur Rehman; Farooq, Rashid; van de Giesen, Nick (2020)
A Critical Review of Flood Risk Management and the Selection of Suitable Measures. In Applied Sciences 10 (23). DOI: 10.3390/app10238752.

Benefits and Risk

Type of Intervention:
Hybrid.

Scale of Intervention:
Settlement, Supra-settlement.

Materials:
Soil, Sand, Wood, Vegetation, Stones, Rocks; Coir (Husk of coconut shell)

Environmental Impact:
Due to their natural occurrence or the use of locally available materials, the environmental impact is comparatively low, and vernacular solutions tend to blend into the surrounding ecosystems. However, dikes and levees can lead to a more intense and faster river flow, erosion, or slope failure. In regions with clay soils, wetlands, or marshes, their construction could trigger environmental stressors and the drying up of the surrounding areas.

Targeted Natural Hazard:
Coastal / Riverine Flood.

Targeted Vulnerable Assets:
Buildings, Land Cover.

Strategy Type:
Reduce Hazard Magnitude.

Implementation Time:
Short (1 day – 1 month), Medium (1 month – 1 year).

Effect Duration:
Medium-term (1 year to 10 years), Long-term (>10 years).

Investment Costs:
Low (Vernacular Dams).

Maintenance Costs (yearly):
Low (<10% investment costs).

Vernacular / Non-engineered dams 29

Extract of the Compendium of Flood Mitigation Measures (example measure 02, pp.28-29)

05 Mitigation scenarios
Propose mitigation scenarios

This step involves designing mitigation scenarios by combining different flood mitigation measures to reduce risk and enhance resilience. The scenarios are developed using combinations of automatically generated measures from the QGIS Risk Strategy plugin (see STEP 4) and additional locally used techniques that may not be captured in the tool but are relevant based on community knowledge and past interventions.

Developing and Classifying Mitigation Measures

To ensure an effective mitigation strategy, it is crucial to understand the types of measures available and their potential impact. Two key resources aid in this process:

- ***The Decision Tree*** helps classify mitigation measures based on their applicability and expected effects.
- ***The Compendium of Mitigation Measures*** provides technical guidance, classification criteria, best practices for various interventions.

Measuring the Impact of Mitigation Scenarios

To compare different mitigation scenarios, their impact can be quantified and visualized by modifying the *Hazard Map* based on the proposed interventions and re-running the *Risk Strategy Plugin* following these steps:

- ***Adjust the Hazard Map***: modify flood-prone areas to reflect the expected reduction of hazard based on the proposed mitigation scenario *(e.g. combining improved drainage, and retention basins)*.
- ***Run the Risk Strategy Plugin***: process the updated hazard data to generate a new risk map and an updated list of assets at risk.
- ***Compare Outcomes***: assess the difference between original and modified risk maps to determine the effectiveness of different scenariis.

This structured approach allows decision-makers to evaluate and prioritize mitigation scenariis based on their effectiveness in reducing exposure, protecting critical infrastructure, and improving flood resilience. By combining GIS-based modeling with local knowledge, the most feasible and impactful solutions can be identified for implementation.

OUTPUT

MITIGATION SCENARIOS including comparative evaluation of impact.

5.1 I Analyse maps and generated measures

The measures automatically generated by the GIS tool are detailed in the **Compendium of Mitigation Measures**. This resource includes best practices, technical drawings, evaluation scores on different criteria, and additional references, providing a comprehensive overview of each measure.

By referring to the Compendium, users can assess the feasibility of a measure in their specific context and determine where and how its implementation would be most effective.

Another key resource is the **Decision Tree**, a classification table helping users understand which assets or zones each measure impacts and how it addresses different types of hazards. This tool provides a structured approach to selecting the most appropriate mitigation actions based on local conditions and risk factors.

ACCESS the Compendium of mitigation measures online:
https://humanitarian-risk.unhcr.org/compendium

CONSULT the Decision Tree add link to this document once available on updated website

5.2 I Add local mitigation measures if adequate

The Compendium and Decision Tree provide a structured approach to mitigation but are not exhaustive. In some contexts, locally used measures may already have proven effective in reducing flood risks.

When such measures are identified, they should be added to the list of potential mitigation options. Incorporating existing, field-tested solutions ensures that the strategy remains relevant and adapted to local conditions. This approach allows for a more comprehensive and context-specific flood risk management plan that leverages both standardized best practices and community-driven solutions.

5.3 I Create scenarios of mitigation measures

Combining multiple mitigation measures is often more effective than applying a single one, as each measure addresses different aspects of flood risk (see Decision Tree), different temporalities and scales, allowing for phased implementation. Identify scenarios that integrate 2 to 3 complementary measures to enhance their overall impact.

5.4 I Estimate the impact of each scenario

Measuring the impact of each scenario on the hazard and on the assets at risk is necessary to compare their efficiency and choose the best mitigation strategy in STEP 6. For this, modify the analysis criteria and re-run the QGIS Risk Strategy plugin to spatialize and quantify the modified risk.

Some measures change the hazard level and extent (*eg. construction of a dyke)*; in this case the HAZARD MAP produced in STEP 3 can be adapted to reflect the estimated modified hazard extent or level.

Other strengthen infrastructure, reducing their vulnerability *(eg. reinforced walls)* or exposure *(eg. elevated structures)*. In this case the vulnerability or location of the modified infrastructure needs to be adapted.

Relocation of buildings reduce their exposure; for these measures also infrastructure can be manually adapted in the Risk Strategy plugin. Non-structural measures reducing casualties cannot be captured in the plugin but will be including in the cost-benefit analysis at STEP 6.1.

Compare the initial RISK MAP and LIST OF ASSETS AT RISK with the modified one according to each mitigation scenario to measure the impact of each of them.

5.5 I (opt) Re-run simulation (modelization)

In case of use of hydrologic and hydraulic modeling software re-run simulation after mitigation measures.

After simulating mitigation measures in hydrologic and hydraulic modeling software, re-running the software is crucial to assess their hydraulic impact. Changes in runoff volume and peak discharge affect water levels, velocities, and flood extents, requiring updated analysis. Structural modifications like levees or detention basins must be verified to prevent backwater effects, erosion, or increased downstream flooding. Re-simulating HEC-RAS ensures effectiveness, regulatory compliance, and safety, refining designs to avoid unintended consequences. This iterative process helps create sustainable and efficient flood mitigation strategies.

See STEP 2.10

SCENARIOS		COSTS		BENEFITS	
Scenario number	**Combination of measures**	**Investment costs**	**Annual costs**	**Financial (10 Y)**	**Human (xx Y)**
1	M1: EWS	200k $	xx $	200k $	20 %
	M2: elevated shelters	600k $	xx $	3'000k $	60 %
	total	**2'800k $ for 10 years**		**3'200k $**	**80 %**
2	M3: dyke	1'000k $	250k $	3'800k $	75 %
	total	**3'500k $ for 10 years**		**3'800k $**	**75 %**
3	M1: EWS	200k $	50k $	200k $	20 %
	M3: dyke	1'000k $	250k $	3'800k $	75 %
	total	**4'200k $ for 10 years**		**4'000k $**	**95 %**

Up: awareness raising session in the refugee site of 15 Avril, Betou, Rep. of the Congo (pictures N.Antenen, 10.2024)

Down: example of cost-benefit analysis for a fictional case study (E.Schmid)

06 Strategy
Compare, decide, implement

The sixth and final step is to define the strategy for implementation, considering multiple key criteria that influence feasibility and success chances. While planners rarely are the decision-makers, their role is crucial in compiling essential information to support decision-making. This includes:

- ***Financial feasibility*** (cost estimates, funding, cost-benefit analysis)
- ***Technical requirements*** (human resources, infrastructure, equipment)
- ***Operational feasibility*** (logistics, supply chain, resource availability)
- ***Regulatory and legal compliance***
  (laws, policies, environmental regulations, permitting, ...)
- ***Institutional and governance capacity***
  (coordination mechanisms, roles, mandates, ...)
- ***Stakeholder involvement and social acceptance***
  (engagement, participation, potential conflicts, ...)
- ***Environmental and social impact***
  (sustainability, ecological footprint, risks in case of relocation, ...)
- ***Risk and resilience factors***
  (disaster preparedness, climate risks, geopolitical stability, ...)
- ***Innovation, technology, implementation modes***
  (digital solutions, automation, upscaling, phasing, ...)
- ***Monitoring, evaluation, and adaptability***
  (performance indicators, feedback loops, flexibility, ...)

A well-structured **Cost-Benefit Analysis**, combined with a risk assesment of project implementation and stakeholder consultations, is essential to guide decision-makers towards the most viable options.

Once strategic choices have been determined, an action plan must be drafted. This should include a timeline, potential phasing with intermediate objectives, performance indicators, monitoring and evaluation mechanisms, funding sources, and clarify the involvement of each stakeholder to ensure a structured and coordinated implementation.

OUTPUT

STRATEGICAL REPORT
ACTION PLAN

6.1 I Detailed comparison of scenarios

Provide a detailed comparison of the proposed scenarios based on implementation cost, time, and feasibility. Each scenario consists of one or several combines mitigation measures, whose impact has already been assessed in STEP 5.4 and can be used to determine the benefits.

A Cost-Benefit Analysis (CBA) is a key tool for comparing solutions by comparing the costs for implementation and maintenance of a scenario in a given duration, and the expected benefits, whether financial (reduced damage costs) or human (affected people). A template for CBA is provided in the **Risk and Mitigation Matrix**.

Beyond cost and benefits, other factors influence the feasibility of each scenario, including implementation time, human resource requirements, operational priorities, strategic partnerships, and potential obstacles.

The case study presented in the *«Project Prioritization»* slides (21-24) provides a clear example of how scenarios can be analyzed and compared, along with the resulting outcomes.

RESOURCE: use cost-benefit analysis table in the Risk and Mitigation Matrix
add link to this document once available on updated website
TUTORIAL: Consult presentation on project priorization
add link to this document once available on updated website

6.2 I Strategical report for informed decision

Compile all information collected and produced in the previous steps in a synthetic document to support the decision-makers selecting the most suitable strategy.

This document, complemented with maps, tables and graphics, needs to allow non-technicians to understand the main issues and the scope of the problem, compare potential solutions and reach out to donors and/or partners for funding.

6.3 I Action plan for implementation

After strategy is decided, prepare an action plan for implementation.

The action plan should define: a timeline including milestones and implementation phases, indicators for success as well as partnerships including roles & responsibilities of each stakeholders.