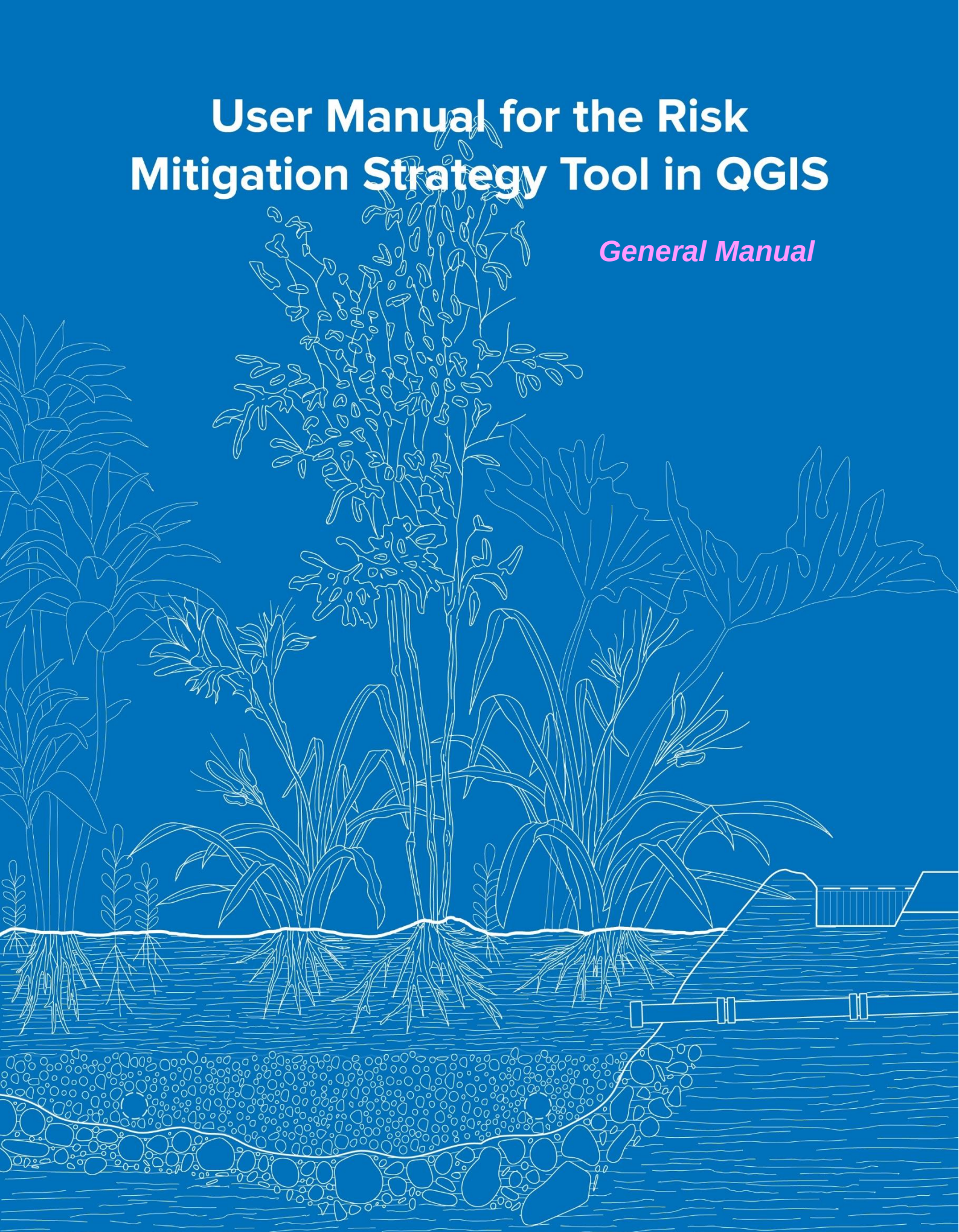
User Manual for the Risk Mitigation Strategy Tool in QGIS

General Manual



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SPUR
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PLANNING OF LANDSCAPE AND URBAN SYSTEMS

GENEVA TECHNICAL HUB

Co-convened by
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Background

About this Manual

The manual for the Risk Mitigation Strategy Tool consists of three documents:

- General Manual (this document)
- Tutorial Local Data
- Tutorial Global Data

The **general manual** explores the integration of the Risk Mitigation Strategy Tool into the broader context of the project. It also covers installation instructions, QGIS project setup, and provides additional insights to enhance your understanding of the analysis.

The step-by-step **tutorials** offer a hands-on experience in utilizing the Risk Mitigation Strategy Tool with local or global data and guide users through practical steps for effective implementation.

About the Project

Context

Flood risk mapping and analysis are essential to ensure sustainable and safe planning of settlements. With climate change, natural hazards such as floods occur more often, especially in regions that are unprepared to face them. Many of these regions host refugee or internally displaced people settlements. At the same time, refugee settlements tend to be less resilient to natural hazards due to their built environment and the socio-economic vulnerabilities of the refugees.

The project “Risk Mitigation Strategy” stems out of a collaboration of ETH Zurich, the Swiss Development Cooperation (SDC), and UNHCR through the Geneva Technical Hub initiative (GTH). The aim of the project is to support field staff in identifying and mapping flood risks for a given refugee settlement and provide general guidance on adapted mitigation measures. The project comprises three parts: 1) a GIS tool, 2) a compendium of risk mitigation measures for refugee settlements, and 3) local data collection guide and other supporting documents.

Project objectives

The project was created following guiding principles:

1. **Provide practical and operational results** that are implementable in humanitarian settlements while following an in-depth academic approach.
2. **Combine local and global data**, having in mind the limited data access and availability in refugee camps. The GIS tool is functional even if only globally accessible data from public data sources is available, however local data can be easily integrated, significantly improving the accuracy of the results.
3. **Utilize local knowledge** and foster cooperation and synergies between local actors, plans, and knowledge. The project provides guidance for local data collection, including

participatory processes with experts, staff, and residents in refugee settlements and host communities.

4. **Ensure the project outputs are user friendly**, adaptable to the context, and applicable to UNHCR technical field staff. The GIS add-in is easy to use even with basic GIS skills and no background in disaster risk management.

The risk mitigation strategy GIS tool

The project includes an easy-to-use GIS tool to create an operational and practical flood risk mitigation strategy for refugee settlements, combining local and global data. The extension (Plug-In), developed for the open source QGIS application, supports field staff in mapping and analyzing flood risk and vulnerable assets. Additionally, the tool helps identifying mitigation measures adapted to the context and operational priorities. The step-by-step process is divided in four main tasks: hazard mapping, vulnerability mapping, risk mapping and identification of mitigation measures (see Figure 1). The outcome provides support for deciding on the most suitable risk mitigation strategy, including a risk map and a range of appropriate risk mitigation measures.

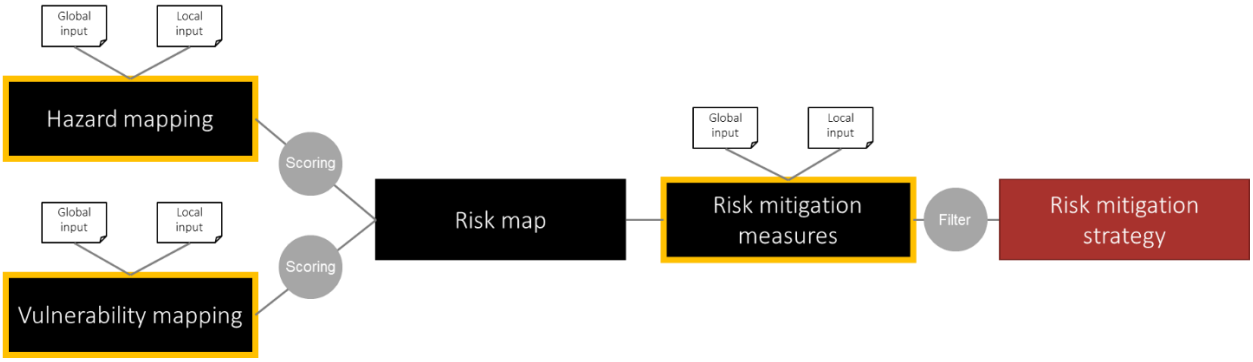


Figure 1: Concept of the Risk Mitigation Strategy Tool

Hazard mapping

The first of the four main steps of the GIS tool is the integration of flood hazard information in the area of interest (“hazard mapping”). The tool relies both on global data and on locally available data (such as hazard maps) and newly collected local data (e.g. through participatory workshops). Hazard levels generated through global data can be manually adapted with local data input.

Vulnerability mapping

The second main step is the mapping of buildings and infrastructures prone to hazards according to their vulnerabilities. Similar to the hazard mapping, this process combines automated global data input and locally-informed manual input. The user can then adjust (score) automated hazard and vulnerability levels according to their intensity and importance.

Risk map

The combination of the hazard and vulnerability maps results in a risk map, summing buildings, infrastructures and land uses in a given refugee settlement under different levels and probability of occurrence of flood risk. The map can then be exported for further use.

Risk mitigation measures

The fourth step is the generation of possible risk mitigation measures. Again, they come from two sources: a catalog of widely applicable mitigation measures provided by this project and the collection of mitigation interventions used locally. Based on the previous steps, the tool provides possible measures applicable to the identified hazards and vulnerabilities. The user can filter those measures according to criteria including the type, scale, durability, and affordability of intervention. The risk analysis can be computed again after modifying hazard levels according to the selected measures. The combination of initial and modified risk maps and the mitigation measures are the base for a risk mitigation strategy.

From the risk map to risk mitigation strategies

The risk mitigation strategy tool provides the user with an analysis of the current risk. The result presents the basis for the decision, whether certain risks are acceptable or not. If the risk is deemed unacceptable, the user, with the help of the tool, can define a strategy to reduce it, using the risk mitigation measures from the aforementioned catalogue and the collection of local and regional measures.

Different combinations and sets of risk mitigation measures are possible and can lead to multiple strategies and scenarios of risk mitigation. The user can define these strategies based on criteria like affordability or implementability in the context of a specific refugee settlement.

The GIS tool could then be helpful to choose the most adequate strategy. While the tool is not able to automatically create scenarios, the user can rerun the GIS tool process, manually including the respective risk mitigation measures and their expected impacts. The risk outcome might be a good basis for an estimate of the cost benefit analysis of each strategy, helpful for further decisions and negotiations.

Other documents of the toolbox

The other documents described below are helpful to implement the risk mitigation strategy. They are available here: www.humanitarian-risk.org.

The compendium of flood management in humanitarian settlements

A compendium of risk mitigation measures adequate to refugee settlements serves as the basis for the GIS tool but is also an independent knowledge product. The goal of this compendium is to support the UNHCR field staff with a comprehensive overview of risk mitigation measures against flooding in humanitarian settlements. Developed in parallel to the risk mitigation strategy GIS tool, the compendium identifies and lists globally applicable measures alongside design examples and good practices from local contexts. Every measure listed in this compendium has been classified based on a set of labels such as the type of measure, its scale, or use of materials. These labels can also be selected in the risk mitigation strategy tool (GIS Add-in) to find the measures considered most appropriate or helpful for the different contexts of the UNHCR refugee settlements. The compendium has been developed based on a systematic literature review alongside the consultation of experts in flood risk mitigation. The compendium will be published as an online platform (www.humanitarian-risk.org) and printed report.

A guidance for local data collection for the risk mitigation strategy

While global data and remote sensing are beneficial for getting a broader risk picture, local data is necessary for increased accuracy and verification of the global data. As part of this project, a Guidance on Local Data Collection was produced. This document provides guidance for collecting existing and new information on hazards, vulnerabilities, and mitigation measures. It also includes detailed information on how to conduct interviews and participatory mapping workshops in the framework of this project.

When to use the Risk Mitigation Strategy Tool – And when not

This tool helps combining hazard and vulnerability mapping, leading to a risk map and to a risk mitigation strategy with adequate risk mitigation measures. Its strength lies in the combination of local and global data and ease of use. However, in certain scenarios, the benefit of using the tool is diminished:

- The tool works best when there is global data input (automated) with added local data on flood hazards. If there is no local data on flood hazards, the quality of the outcome will be lower. At the same time, if global data shows no flood hazard, the risk map will be entirely based on the manual input. The tool will still provide meaningful results in both cases.
- The tool helps to prioritize mitigation measures. If the entire settlement area is equally affected by the same hazard with the same frequency and intensity, the tool provides prioritization only based on vulnerability mapping but no spatialized prioritization. In this case, it might be better to directly refer to the catalog of risk mitigation measures without using the tool.
- If there is no flood hazard in the settlement, this tool is not helpful, as it focuses solely on floods and no other natural hazards.

Practical Steps

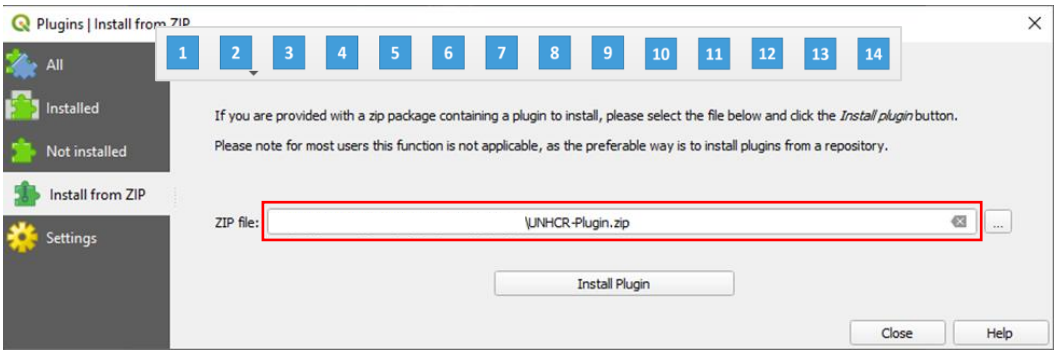
Installation of the plugin

Compatibility

The plugin has been developed for **QGIS 3.28 LTR**. We recommend using this long-term release version of QGIS, as it offers optimal stability and compatibility with the plugin. You can download it for macOS or Windows platforms. Download and install QGIS 3-28 LTR as a first step and before the installation of the plugin.

Download and Installation of Plugin

1. Download the Plugin to your device.
2. Open QGIS, navigate to the “Plugins”, and select “Manage and Install Plugins.”
3. Click on “Install from ZIP”. Select the downloaded “UNHCR-plugin.zip”-folder and press “Install Plugin”.



4. Click “yes” if a security warning appears.
5. Return to "Plugins" > "Installed" and check the box next to "UNHCR Risk Mapping." Ensure that the “Processing” plugin is also selected. Close the Plugin window.
6. The plugin should now be visible as buttons numbered from 1 to 14 in the top toolbar.

Setting up the Project

1. Download the “UNHCR.zip” folder to your device and extract its contents (unzip) to a folder of your choosing. Feel free to rename the folder but be sure to note its storage location for future reference.
2. Open QGIS 3.x, navigate to the Project tab, select Open, and browse to your unzipped folder. Locate the “UNHCR.qgz” file and open it. Avoid dragging the shape file into a newly created project.
3. Upon loading the “UNHCR.qgz” project, you should observe a map and preloaded data in the Layers panel.
4. If desired, rename the project at this stage.

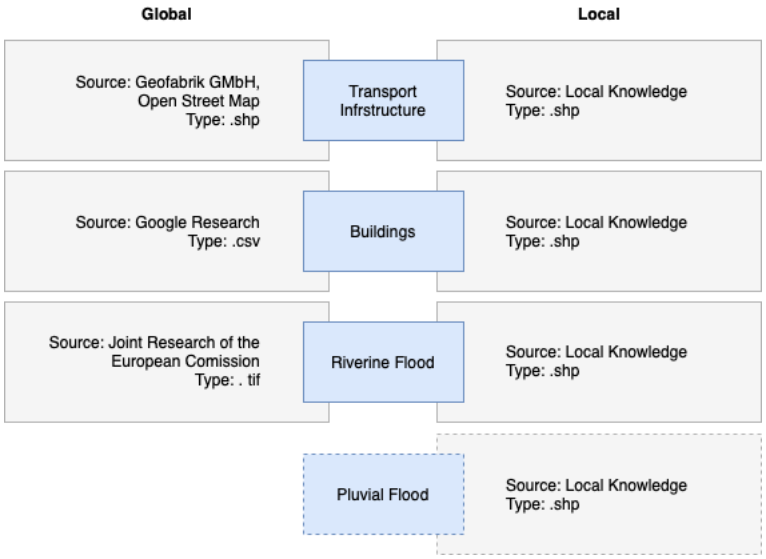
ⓘ Create a duplicate of the unzipped UNHCR folder to maintain an unaltered version for reference in case the data structure undergoes significant changes.

Creating a Risk Map and a Risk Mitigation Strategy

Here, we provide a concise explanation of the data requirements and steps, with optional tasks colored in grey. For a more in-depth explanation of the steps, refer to **Tutorial Global Data** or **Tutorial Local Data**.

Data requirements

To perform this analysis in QGIS, you need access to a variety of datasets, sourced either locally or globally, as listed below. Ideally, local data is recommended for more accurate results. In cases where local data is unavailable, you can refer to the **Tutorial Global Data** for guidance on downloading globally sourced data. It's important to note that global data for pluvial floods is currently unavailable. In the absence of local data for pluvial floods, integration into the analysis is therefore not required.



Procedure

Here you can find a brief overview of the analysis steps (Steps 1-14 in the GIS Plugin). The mandatory steps, crucial for the tool's functionality, are highlighted in black. Optional steps, intended for adjustments on data, are shaded in grey.

Hazard mapping

0. Adjust the map view so that the focus is on the settlement or area you intend to analyze.
1. Outline the extent of your settlement or area.
2. Upload Data.
    a. Global transport infrastructure data
    b. Global or local buildings data
    c. Global or local riverine flood data
    d. Local pluvial flood data
3. Add or adjust areas prone to riverine flood.
4. Add or adjust areas prone to pluvial flood.
5. Automated calculation of the hazard areas and its risk intensities.

Vulnerability mapping

6. Adjust type of building and construction.
7. Add buildings.
8. Add technical infrastructure.
9. Add transport infrastructure.
10. Automated calculation of the risk of vulnerable assets.
11. Adjust risk level of vulnerable assets.

Risk map

12. Export risk map.

Risk mitigation measures

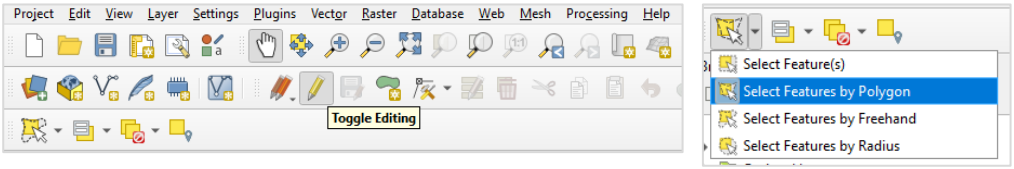
13. Select characteristics of risk mitigation measures.
14. Export risk maps of vulnerable assets including mitigation measures.

QGIS workarounds

Deleting existing features

If there is a building or a road in a dataset, which is not correct, you can delete them by following these steps:

1. Choose the layer you wish to edit by marking the respective box in the Layers Window.
2. Initiate the editing mode by clicking “Toggle Editing” and opt for “Select Features by Polygon”.



3. Outline the feature for deletion (left-click for edge points; right-click to conclude).
4. Execute the removal by clicking “Delete Selected”.

5. Complete the process by clicking “Toggle Editing” once again.

Additional Information / Glossary

Additional details provided in this section are not mandatory for tool operation but can contribute to a better understanding of its output. This section of the manual **can also serve as a glossary.**

Global data sources

This section provides information on source and content of global data.

Transport infrastructure

The data used for transport infrastructure is published by Geofabrik GmbH and OpenStreetMap contributors. Geofabrik's free download server has data extracts from the OpenStreetMap project which are normally updated every day.
See: https://download.geofabrik.de.

Buildings

The Open Buildings dataset provided by Google Research contains the outlines of buildings derived from high-resolution satellite imagery. It contains 817 million building detections, across an inference area of 39.1 M km2 within Africa, South Asia and South-East Asia.
See: https://sites.research.google/open-buildings/.

Riverine flood

The riverine flood data used is published by the Joint Research of the European Commission. It contains information on flood prone area worldwide for riverine flood events of different magnitude.
See: https://data.jrc.ec.europa.eu/collection/id-0054.

Flood attributes

Water depth and intensity

The intensity of a flood typically refers to the degree or severity of the flooding event. The greater the depth of water, the greater its volume, velocity and its damaging capacity.

Within the GIS tool the water depth of a flood event in cm correlates with the intensity of an event as follows:

a water depth $<$ 201 cm corresponds to an intensity of 1,

a water depth $<$ 501 cm corresponds to an intensity of 2,

a water depth $\geq$ 501 cm corresponds to an intensity of 3.

Return Period

Comprises the average time interval between occurrences of a specific intensity of a flood event at a particular location, i.e., the likelihood of a flood of a certain magnitude happening in any given year. For example, the return period 100 indicates that, over a long period of time, the likelihood of that specific flood magnitude occurring in any given year is 1 in 100.

Types of floods

Riverine floods

Riverine (or fluvial) floods take place when the water body of a river surpasses its capacities and overflows. That is mainly due to heavy rainfall over a long time, but also snow melt or ice jam can induce this overflow. Riverine floods show low deathliness but are apt to impact larger areas and more people, including a long-lasting inundation of the affected lands.

Pluvial floods

Pluvial or stormwater floods take place due to heavy rainfall events. When occurring in urban or built environments, they tend to inundate streets or basements, and are often aggravated by saturated drainage systems. Compared to other floods, pluvial floods occur frequently and are of short duration. Excessive rainfall can also cause flash floods that are characterized by high peak discharge, and (particularly in steep landscapes) intensive flow velocities.

Types of vulnerable assets

Vulnerable assets are elements in refugee settlements that are likely to suffer in case of a flood event. They face damage which will affect humans, infrastructures and ecosystems while constraining social, economic and operational processes.

Buildings

Vulnerable assets listed under ‘Buildings’ include residential shelters (individual or collective) and public services that comprise: Schools, Health facilities, Cultural/Community facilities, Youth/Women centers, Administrative buildings, Security (police), Nutrition centers, Distribution centers, and Storage of goods. In addition, open spaces that incorporate important social, organizational or economic functions (e.g. gathering spaces, spaces used for recreation, social events, religious functions, markets) are part of this label.

Transport infrastructure

Vulnerable assets listed under ‘Transport’ include transport infrastructure for internal and external mobility: Internal roads and walkways, access roads, bridges, and gas stations.

Technical infrastructure

Vulnerable assets listed under ‘Technical Infrastructure’ include sanitation facilities, power stations, power grids, sanitation network, water storage (tanks), drainage systems, and communication infrastructure. Any other built or non-built spaces that are deemed a vulnerability by local staff and community may be added.

Types of construction

Emergency

Habitable, covered living space providing the minimal standards in terms of secure and healthy environment, of privacy and dignity. The shelters are typically simple, one-room structures implemented to provide critical lifesaving emergency assistance.

Transitional

A range of shelter options that help populations affected by a humanitarian crises progress from an initial emergency arrangement to a more suitable shelter solution, better adapted to their needs in terms of habitability.

Durable

Beyond the emergency and transitional phase, shelters that are adapted and contextualized according to the following elements: climate, cultural practice and habits, local availability of skills, access to adequate construction materials and geographical context.

Refer to the Shelter and Sustainability Report from UNHCR (2021) for examples.

Types of vulnerability and risk matrix

Physical vulnerability

Refers to the physical damage of an asset when exposed to a flood event.

Socioeconomic vulnerability

Refers to the negative socioeconomic consequences when an asset is damaged due to a flood event.

Risk matrix

The risk levels represented on the risk map are calculated based on a risk matrix, combining vulnerability and hazard level of an asset. For detailed information on the calculations performed by this tool, please refer to the annex.

Sum of Physical Vulnerability + Social Economic Vulnerability				
	5 / 6	3	4	5
	3 / 4	2	3	4
	1 / 2	1	2	3
		1	2	3
		Hazard		

- 5 = very high
- 4 = high
- 3 = medium
- 2 = low
- 1 = very low

Annex

This section features underlying calculations, assumptions and standard values based on our research, literature, and expert interviews.

Riverine Flood Intensity

Water high (cm)	Intensity
< 201	1
< 501	2
≥ 501	3

Hazard

Repeat Period (Years)				
	0 - 3	2	3	3
	4 - 19	2	2	3
	20 - 99	1	2	3
	> 99	1	2	2
		1	2	3
		Intensity of single event		

Physical Vulnerability – Building

Construction				
	emergency	2	3	3
	transitional	1	2	3
	durable	1	1	3
		1	2	3
		Hazard		

Socio Economic Vulnerability – Building

Type	Intensity
Residential Shelters	2
Social Infrastructure	1
Open Space	1
Administrative Buildings	1
Logistics	1

Sum risk – Buildings (RISK map)

Sum of Physical Vulnerability + Social Economic Vulnerability				
	5 / 6	3	4	5
	3 / 4	2	3	4
	1 / 2	1	2	3
		1	2	3
		Hazard		

5 = very high

4 = high

3 = medium

2 = low

1 = very low

Physical Vulnerability – Transport Infrastructure

Type	**Vulnerability**
Road	2
Bridge	2

Socio Economic Vulnerability – Transport Infrastructure

Type	**Vulnerability**
Road	3
Bridge	3

Sum risk – Transport Infrastructure

Sum of Physical Vulnerability + Social Economic Vulnerability				
	5 / 6	3	4	5
	3 / 4	2	3	4
	1 / 2	1	2	3
		1	2	3
		Hazard		

5 = very high

4 = high

3 = medium

2 = low

1 = very low

Physical Vulnerability – Technical Infrastructure

Type	Vulnerability
Power Station	3
Power Grid	1
Sanitation Networks	1
Water Tanks	1
Drainage System	2
Communication Infrastructure	1

Socio Economic Vulnerability – Technical Infrastructure

Type	Vulnerability
Power Station	3
Power Grid	3
Sanitation Networks	3
Water Tanks	3
Drainage System	2
Communication Infrastructure	3

Sum Risk – Technical Infrastructure

Sum of Physical Vulnerability + Social Economic Vulnerability				
	5 / 6	3	4	5
	3 / 4	2	3	4
	1 / 2	1	2	3
		1	2	3
		Hazard		

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