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XIX WORLD WATER CONGRESS
International Water Resources Association (IWRA)
Marrakech, Morocco | 1-5 December 2025

Kingdom of Morocco



Ministry of
Equipment and Water

A Methodology to Assess the Risk of Riverine Flooding at Sub-Catchment Level

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Overview of Presentation



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- Introduction/Objectives
- Data/Methodology
 - Need for assessment
 - Hazard level assessment
 - Exposure level assessment
- Results and Discussion



Värnamo Municipality, Sweden



Introduction

- River flooding is one of the most **common natural hazards** worldwide.
- Frequency is projected to increase in the near future.
- Climate change further intensifies this hazard.
- Flood risk analysis (FRA) can be performed at both large and small scales.
- Catchment-scale analyses are valuable, but accuracy needs careful consideration.

Objective

- To develop a methodology to assess catchment-scale flood risk.

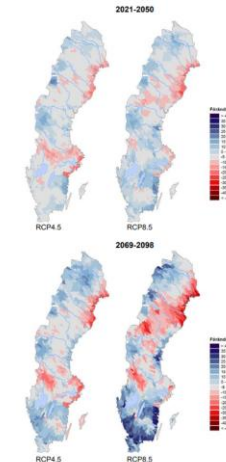


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Gnosjö Municipality, Sweden

3.4.6 100-årsflöde
I figur 3.26 visas förändringen (%) i vattenflöden med en återkomsttid av 100 år. Dessa flöden beräknas öka i stora delar av landet utom i Norrlands inland och norra kustland samt nordöstra Svealand där de högsta flödena skapas av snösmältning under vintern. På grund av detta beräknas 100-årsflödena minska eftersom vårflöden blir flöge.



(SMHI, 2015)

Figur 3.26 Förändring (%) av 100-årsflödet mellan referensperioden 1963-1992 och perioderna 2021-2050 respektive 2069-2098.



Methodology

The FRA is conducted through a three-step procedure that includes:

- (1) Determination of need for assessment
- (2) Hazard level assessment**
- (3) Exposure level assessment



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Determination of Need for Assessment (NA)

Defined by identifying locations with buildings and critical infrastructure within a 1-km zone from the riverbanks.



Hazard Level Assessment (HLA)



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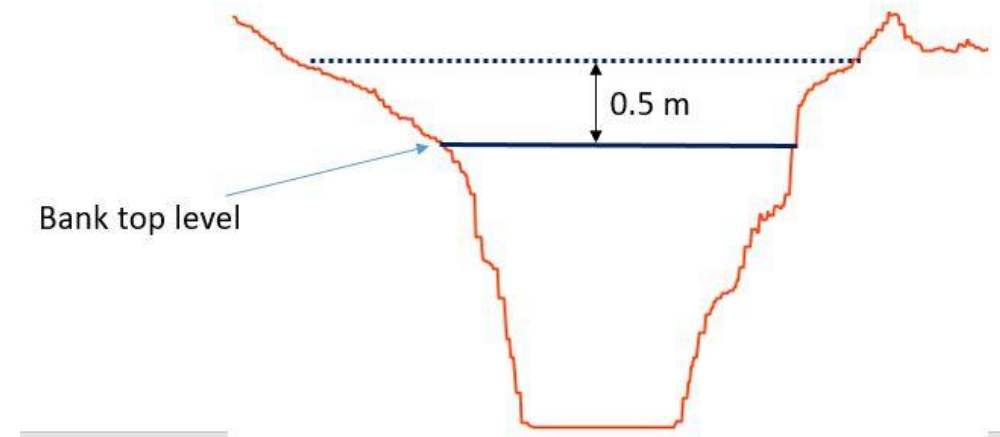
- Return floods that cause a critical **flood depth of 0.5 m** above the riverbank.

0.5 m: Flood mitigation by sandbags and other preliminary measures are no longer possible. This is a typical height of tables and light switches.
ThinkHazard

'The European joint research project RiskMap recommends four water depth classes: <0.5 m; 0.5-1.0 m; 1.0- 2.0 m; and >2.0 m.' Thinkhazard

- Conducted for each sub-catchment along a river
- Five flood hazard level (FHL) classes are developed based on return flood periods

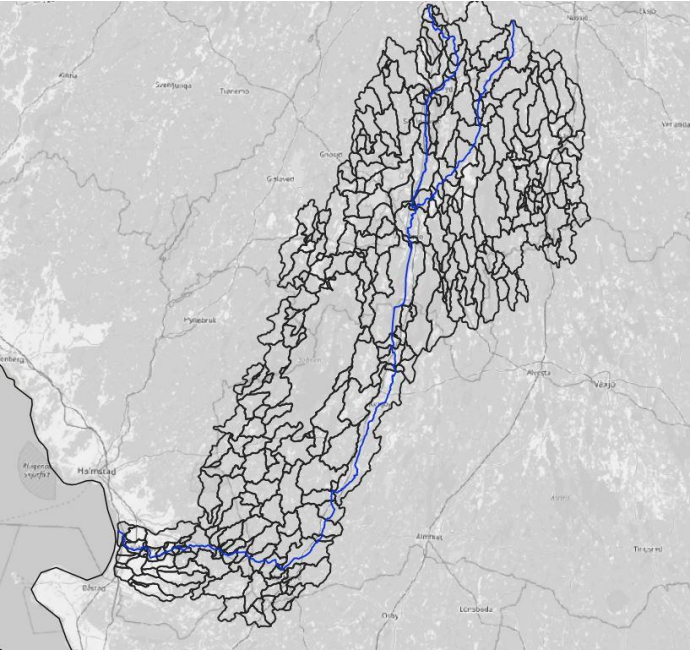
Flood Hazard Level	Criteria
FHL-1	0.5 m depth (above banks) by a flow (Q); and $Q < Q_2$
FHL-2	0.5 m depth (above banks) by a flow (Q); and $Q_2 \leq Q < Q_{10}$
FHL-3	0.5 m depth (above banks) by a flow (Q); and $Q_{10} \leq Q < Q_{25}$
FHL-4	0.5 m depth (above banks) by a flow (Q); and $Q_{25} \leq Q < Q_{50}$
FHL-5	0.5 m depth (above banks) by a flow (Q); and $Q \geq Q_{50}$



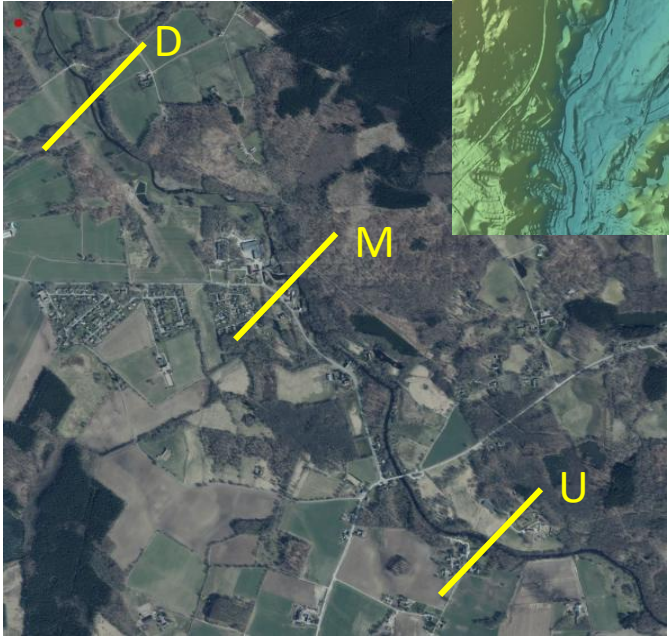
Hazard Level Assessment (HLA)



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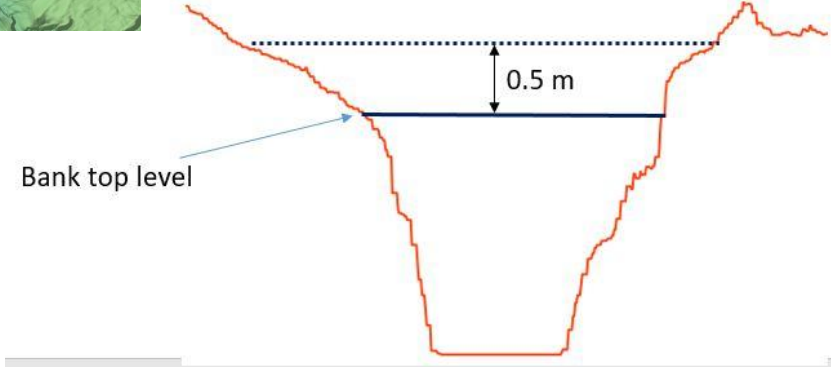
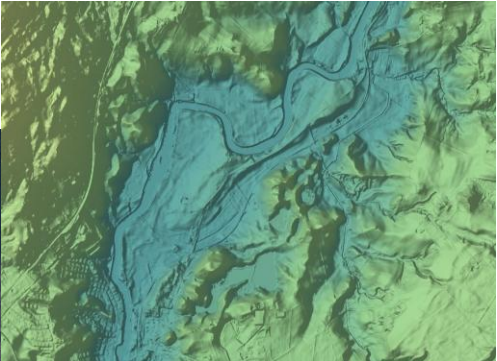


All sub-catchments



Single sub-catchment

Digital elevation model (DEM)



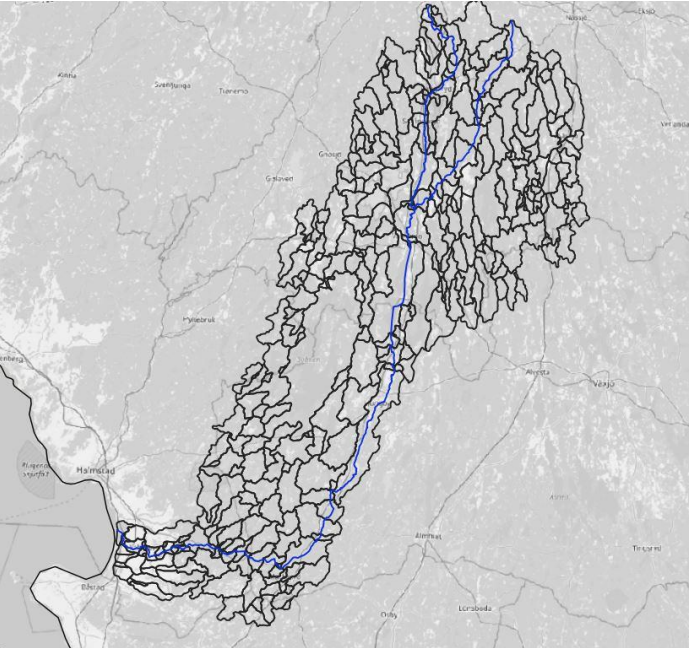
River section



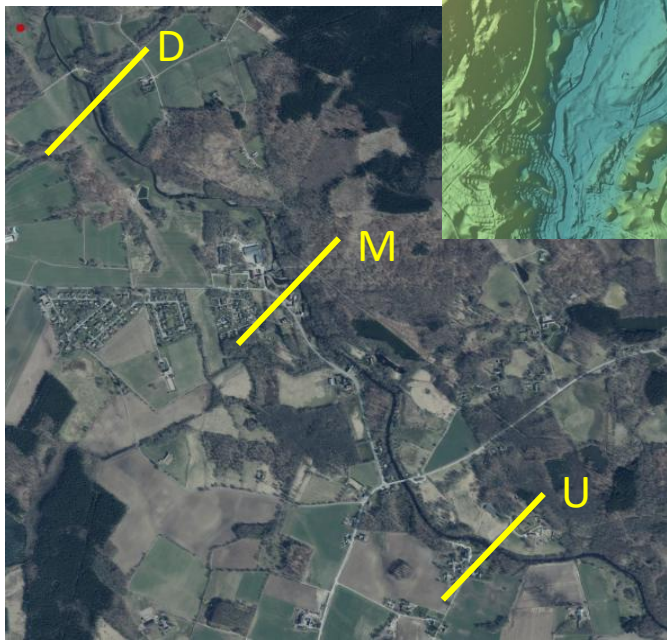
Hazard Level Assessment (HLA)



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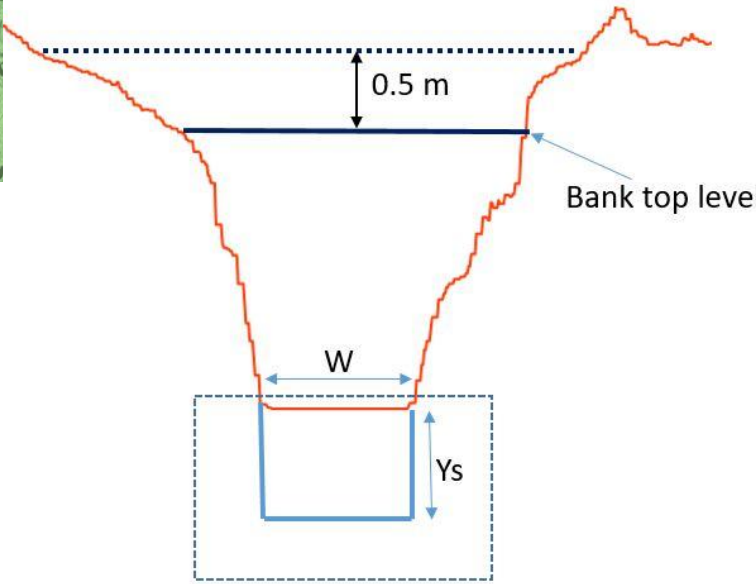
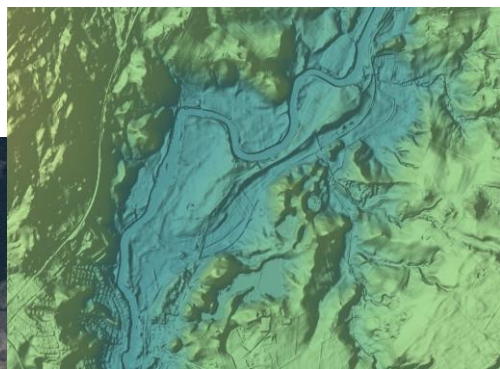
All sub-catchments



Single sub-catchment



Digital elevation model (DEM)



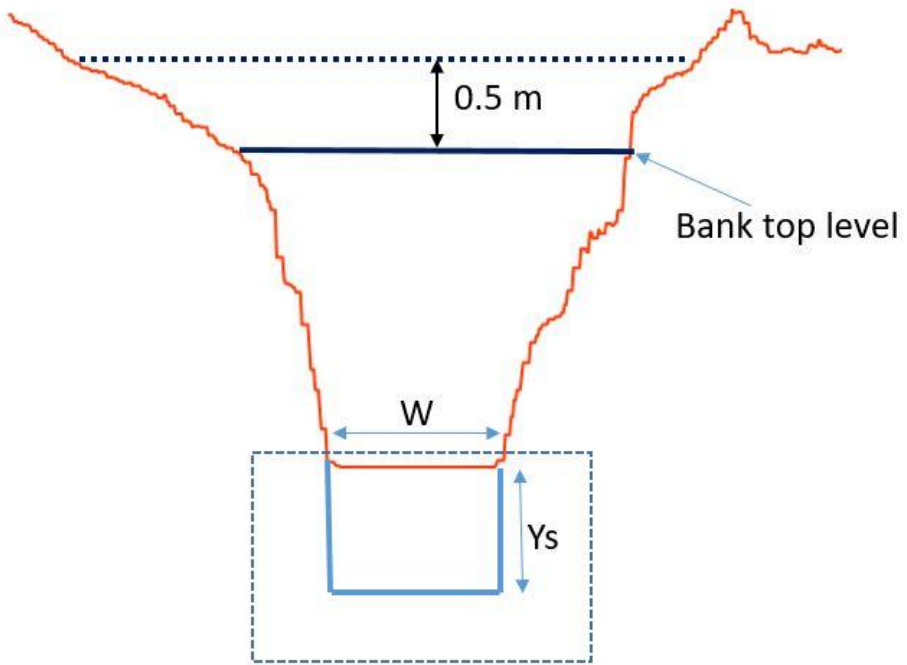
River section



Hazard Level Assessment (HLA)



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Step 1: Find subaqueous section ($W \cdot Y_s$)

$$Q = \frac{1}{n} AR^{\frac{2}{3}} \sqrt{S_0} \quad (\text{Manning's Eqn})$$



$$Y_s = \left(\frac{Q_s \cdot n}{B \cdot S_0^{\frac{1}{2}}} \right)^{\frac{3}{5}}$$



LiDAR survey (S_0 , Q_s , WSE)

- Y- water depth
- B- width
- Q_s - Known Flow
- S_0 - Channel slope
- n- Manning co-eff

Step 2: Find Q of flood depth of 0.5 m above the riverbank for combined section



Hazard Level Assessment (HLA)



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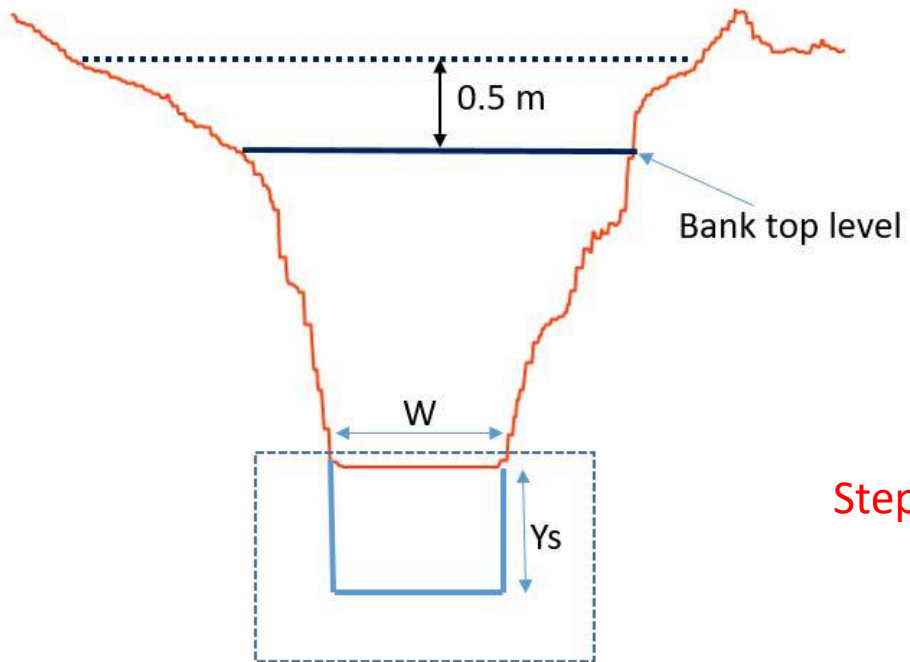
Step 3: Find the return period of Q

Flow data (sub-catchment)



Return flows

Flood Frequency Analysis



Step 4: Find Hazard Level for the cross section using HL classification

Flood Hazard Level	Criteria
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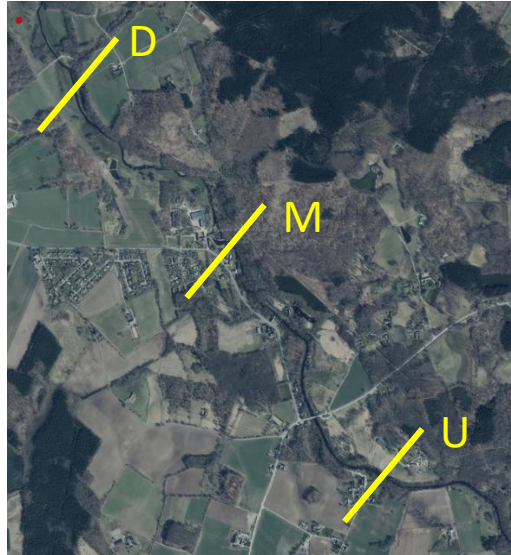
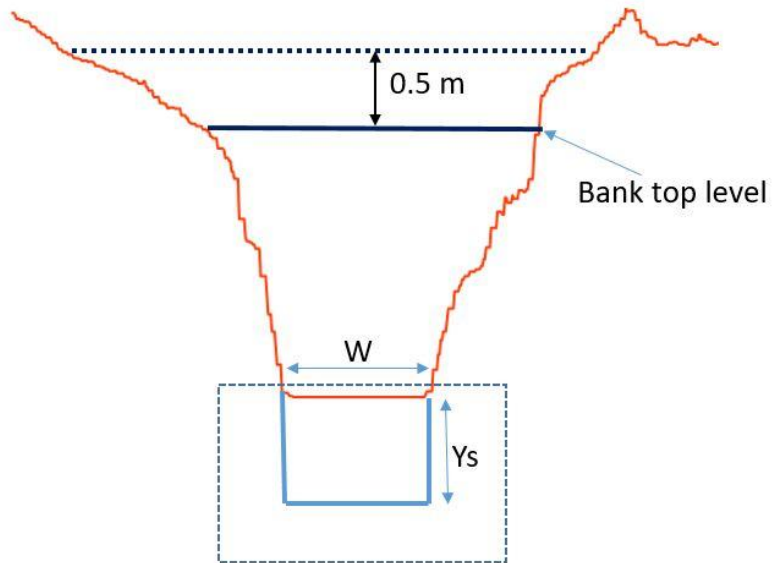


Hazard Level Assessment (HLA)



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Step 5: Find Hazard Level for the sub-catchment



FHL for each sub-catchment is determined by based on the following conditions:

1. If two or more cross-sections produce the **same FHL**, the sub-catchment is assigned the corresponding FHL.
2. If all cross-sections within a sub-catchment have different FHLs, the sub-catchment is assigned the **highest FHL** among those of the three cross-sections.



Exposure Level Assessment (ELA)



Exposure level (EL) is to **identify buildings** that are at risk of flooding for certain return flows.

Another challenging part is to find flooded area from a simplified method (to be developed)



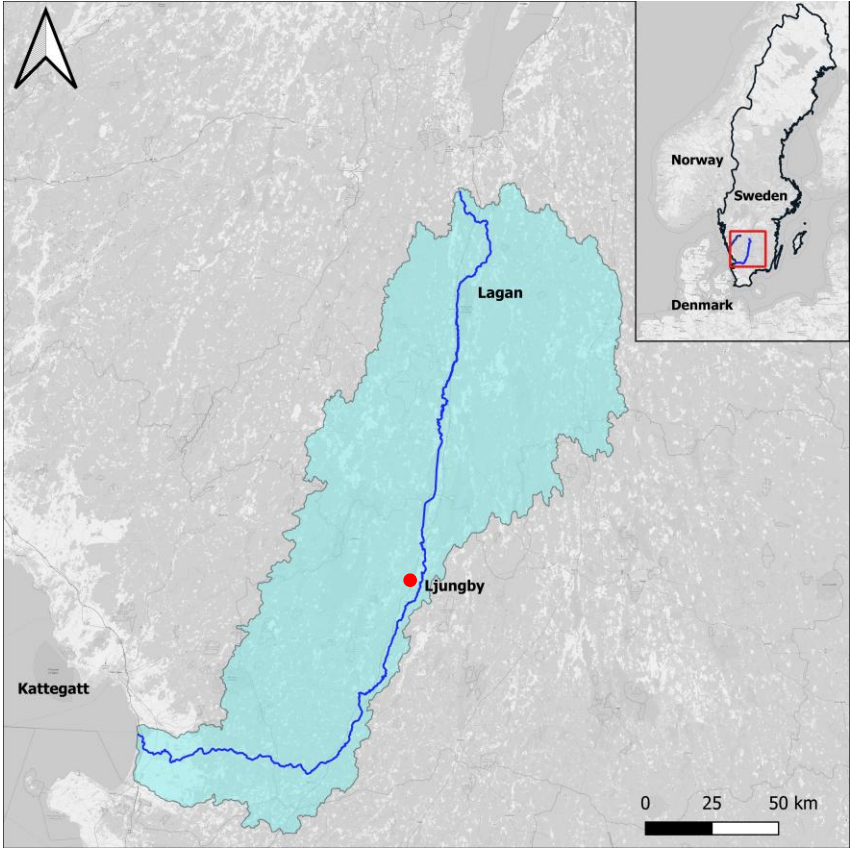
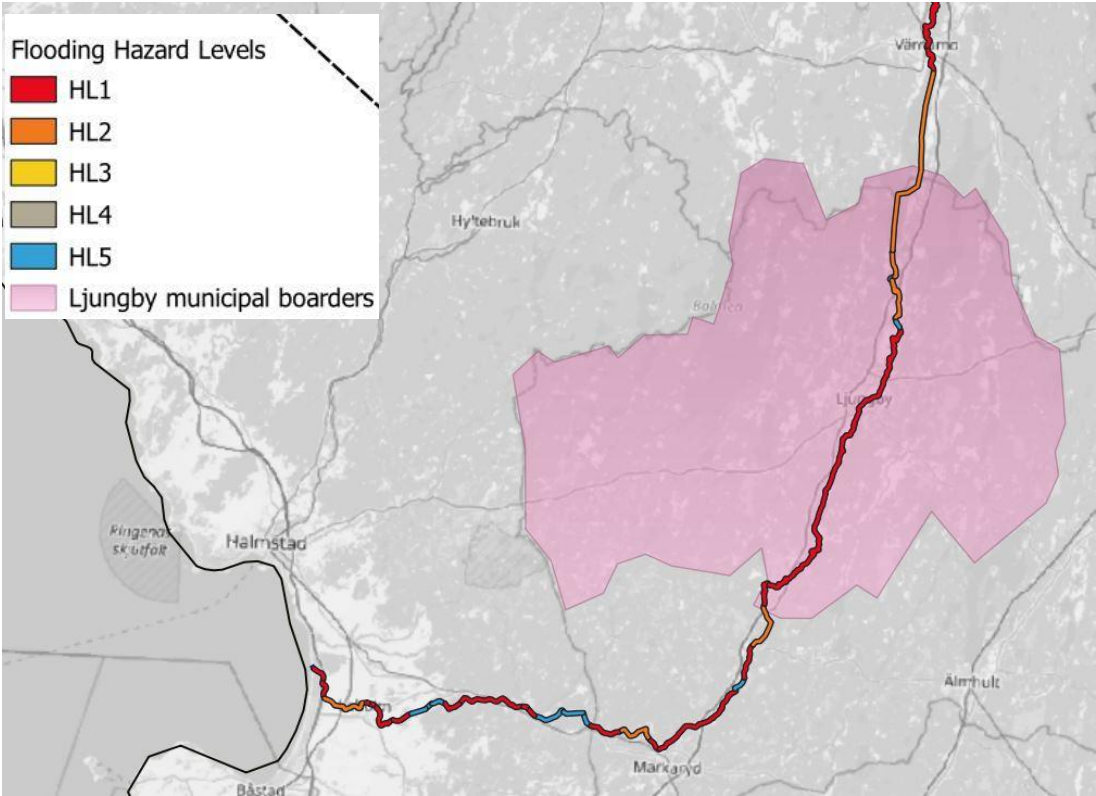
Results/Discussion

This FRA method was implemented in Lagan River in Sweden, focusing an area called Ljungby



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FHL Index Map- Lagan River



Published article:
Johan Björck, Margaret McNamee, Jonathan Wahlqvist, Magnus Larson, Fainaz Inamdeen,
A methodology for assessing multiple hazards applied to Sweden,
International Journal of Disaster Risk Reduction, Volume 114, 2024.

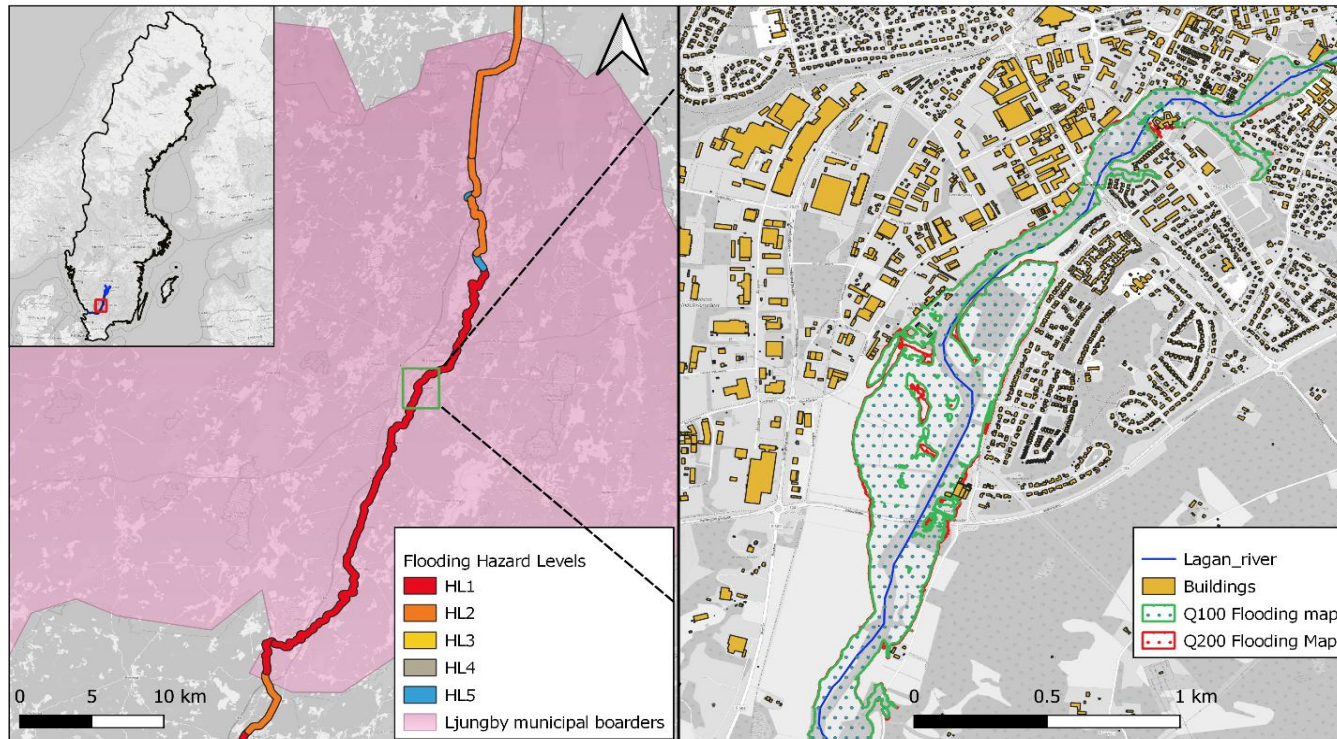


Results/Discussion...



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This study used flood maps based on the 100 and 200-year return flows to determine the flood exposure level in the Ljungby area



Sub_C	200 yr flooding		100 yr flooding	
	No of buildings	Area (m ²)	No of buildings	Area (m ²)
628089-137464	1	48.9	1	48.91
628147-137626	205	19977.2	174	14333.9
628358-137486	3	226.7	3	223.3
631021-139042	2	123.1	2	117.33
631021-438711	44	5422.0	40	5050.5
631028-138966	2	38.2	2	38.2
631512-440366	5	68.8	5	60.8
631570-138831	2	38.0	1	37.9
631831-138924	9	287.0	9	286.9
632358-139209	1	89.9	1	89.9
632625-439524	68	3175.0	66	3090.2



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Thank you!

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