EPFL

InVEST

Integrated Valuation of Ecosystem Services and Tradeoffs

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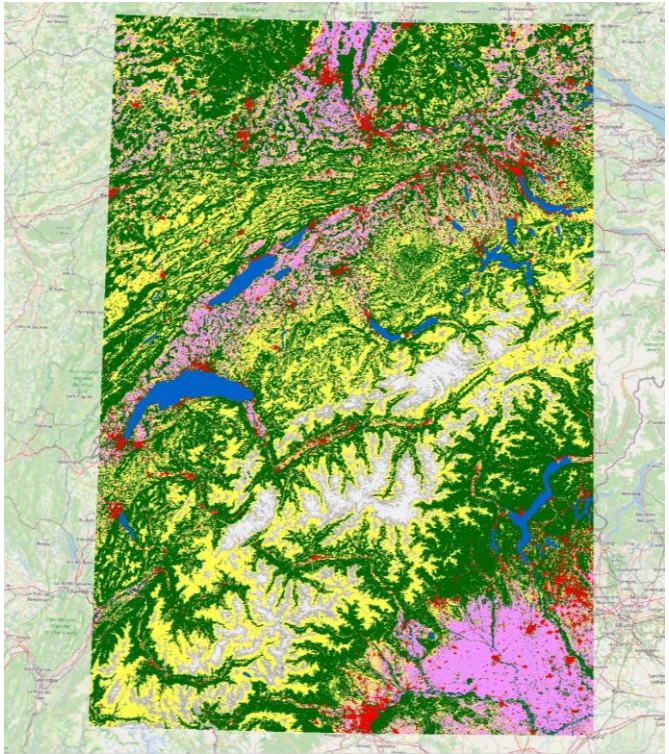
What is Invest?

InVEST

Integrated Valuation of Ecosystem Services and Tradeoffs

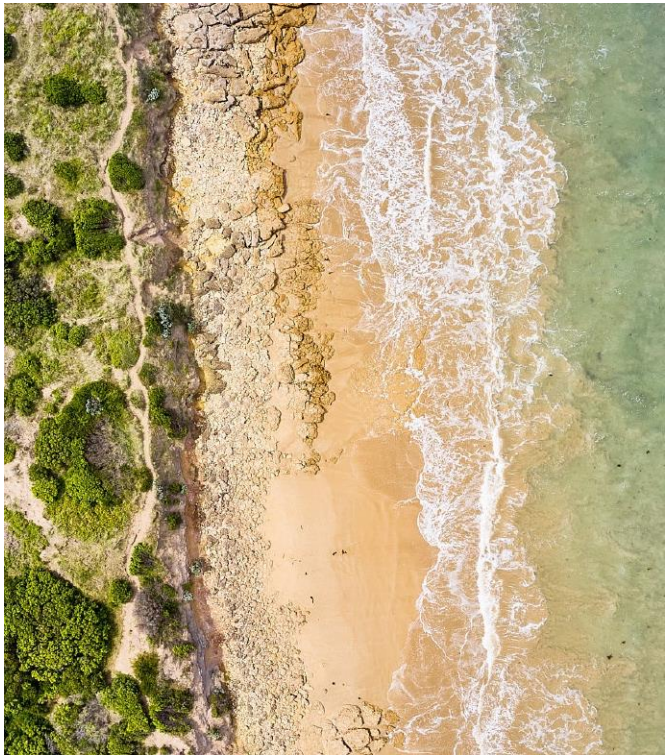
- Free and open-source software
- Models to map and value natural goods and services that sustain human life
- Decision makers
- Tool for balancing environmental and economic goals
- Asses quantified tradeoffs associated with alternative management choices
- Identify areas where investment in natural capital can enhance human development and conservation

How does it work?



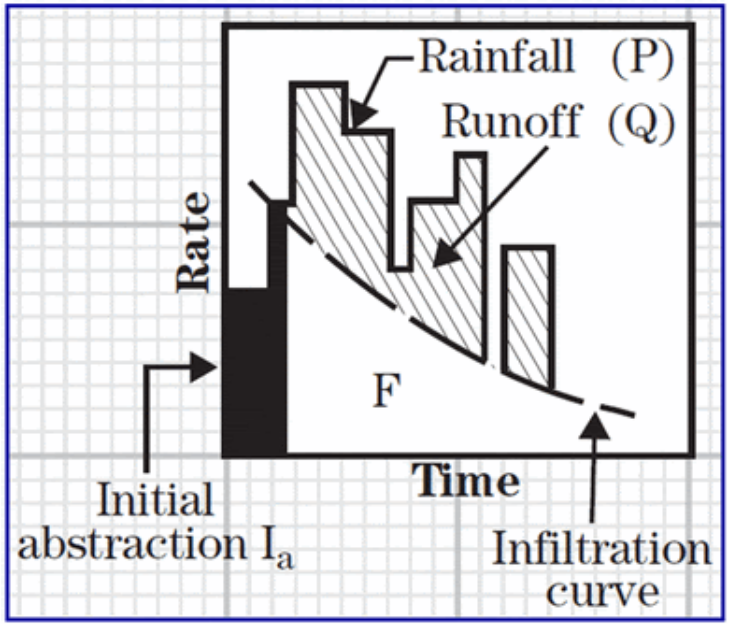
- Spatially-explicit
- Results in either biophysical or economic terms
- Flexible spatial resolution
- Models are based on production functions that define how changes in an ecosystem's structure and function are likely to affect the flows and values of ecosystem services across a land- or a seascape
- Standalone application independent of a GIS software
- Mapping software such as QGIS or ArcGIS is necessary to view results
- Running does not require knowledge of Python programming, but requires basic to intermediate skills in GIS software

Urban Flood Risk Mitigation



- Flood hazard
  - Riverine (or fluvial) flooding
  - Stormwater (or urban) flooding
  - Coastal flooding
- Related to stormwater, natural infrastructure operates mainly by reducing runoff production, slowing surface flows, creating space for water
- The UFRM model calculates the runoff reduction, i.e. the amount of runoff retained per pixel compared to the storm volume
- It also calculates, for each watershed, the potential economic damage

Runoff production and runoff attenuation index



- For each pixel i, defined by a land use type and soil characteristics, runoff is estimated with the Curve Number method
- The model then calculates runoff retention per pixel as ratio and volume
- Runoff volume (also referred to as “flood volume”) per pixel is also calculated

Potential service

- Calculation of sum of potential damage to built infrastructure for each watershed
- Calculation of potential service, an indicator of avoided damage to built infrastructure, for each watershed
- Optional

Workspace directory

File Suffix *(optional)* text

Area Of Interest vector

Rainfall Depth (mm) number

Land Use/Land Cover raster

Biophysical Table csv

Soil Hydrologic Group raster

Built Infrastructure *(optional)* vector

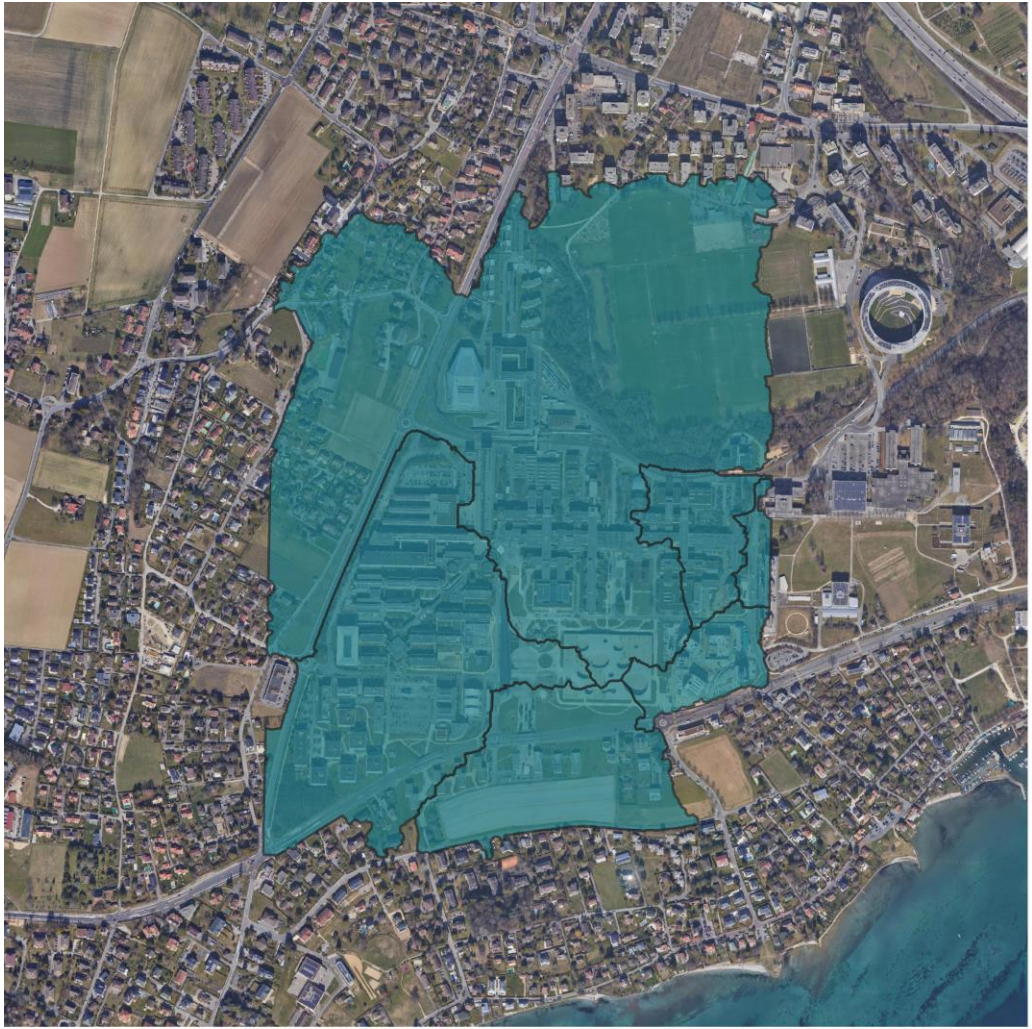
Damage Loss Table csv

Interface

Input data

Table of Required Inputs		
Input	**Input Type**	**Description**
Area of Interest	Vector	A map of areas over which to aggregate and summarize the final results. These may be watershed or sewershed boundaries.
Rainfall Depth	Number [mm]	Depth of rainfall for the design storm of interest. P in the equations below.
Land Use/Land Cover	Raster	Map of LULC. All values in this raster must have corresponding entries in the Biophysical Table. All outputs will be produced at the resolution of this raster.
Soil Hydrologic Group	Raster	Map of soil hydrologic groups. Pixels may have values 1, 2, 3, or 4, corresponding to soil hydrologic groups A, B, C, or D, respectively.
Biophysical Table	CSV	Table of curve number data for each LULC class. All LULC codes in the LULC raster must have corresponding entries in this table for each soil group. Each row is a landuse/land cover class and columns must be named and defined as follows: **lucode** (integer): LULC codes from the LULC raster. Each code must be a unique integer. **cn_a**, **cn_b**, **cn_c**, **cn_d** (number [-]): The curve number value for this LULC type in the soil group code A, B, C or D.

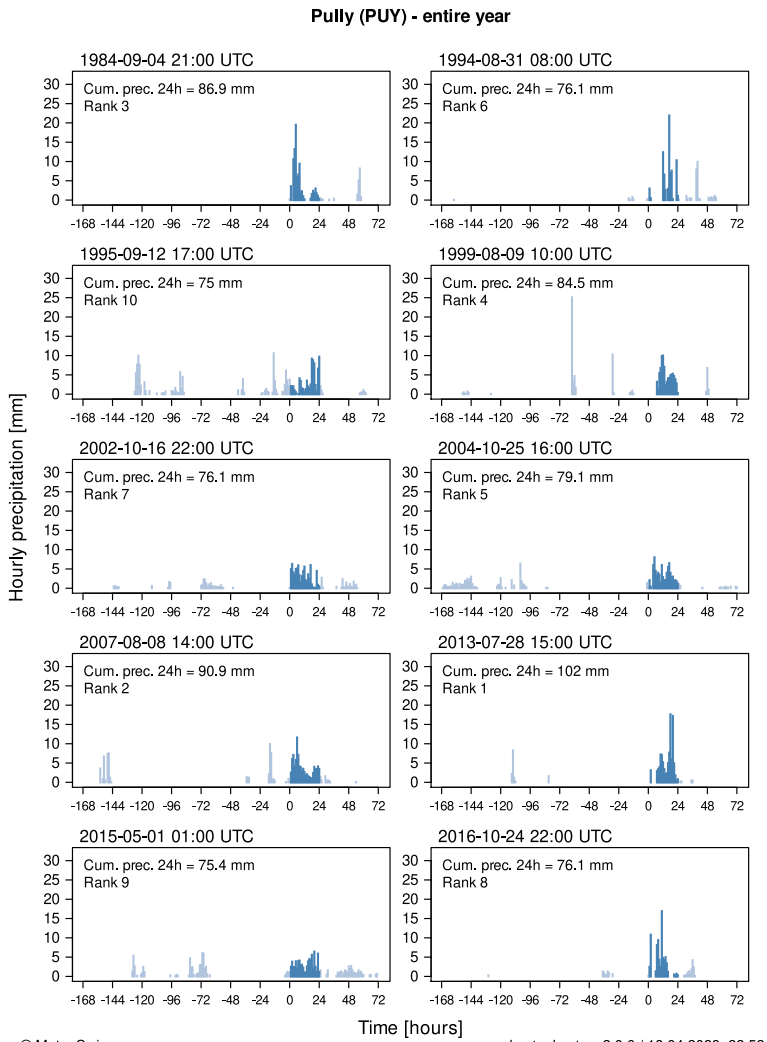
Table of Optional Inputs		
Input	**Input Type**	**Description**
Built Infrastructure	Vector	Map of building footprints. Field: **type** (integer, *required*): Code indicating the building type. These codes must match those in the Damage Loss Table.
Damage Loss Table	CSV *Conditionally required*	Table of potential damage loss data for each building type. All values in the Built Infrastructure vector 'type' field must have corresponding entries in this table. Required if the Built Infrastructure vector is provided. Columns: **type** (integer): Building type code. **damage** (number [currency units/m^2]): Potential damage loss for this building type. Any currency may be used.



0 100 200 300 m

Drainage Basins

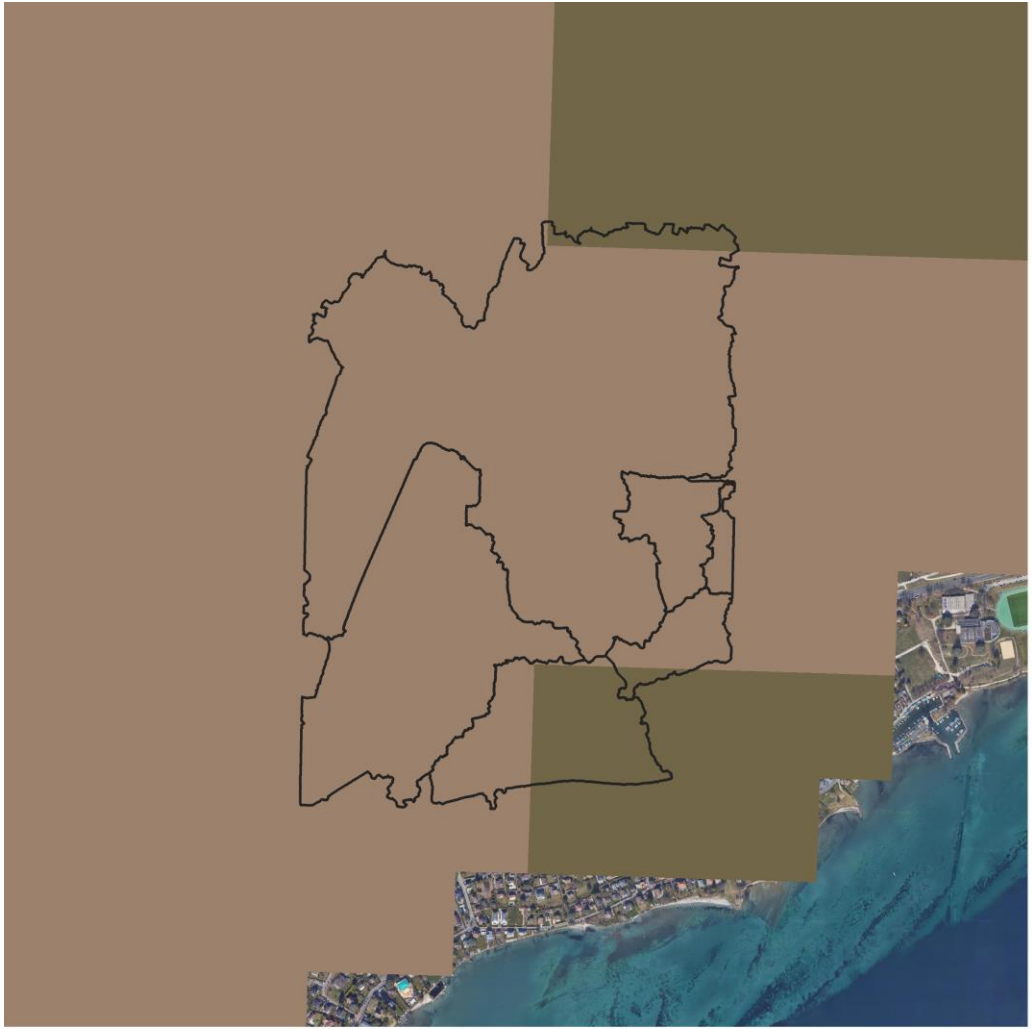
Rainfall depth



0 100 200 300 m

Land Use/Land Cover

- Allotments
- Farmland
- Forest
- Grass
- Meadow
- Park
- Recreation Ground
- Residential
- Vineyard
- Buildings
- Parking
- Roads
- Railways
- Waterbody
- Waterway
- Bare Land/Undefined



0 100 200 300 m

Drainage Basins

Hydrologic Soil Group

3: HSG C

4: HSG D

	A	B	C	D	E	F	G	H
1	lucode	cn_a	cn_b	cn_c	cn_d	Description		
2	1	51	67	76	80	Allotments		
3	2	67	78	85	89	Farmland		
4	3	30	55	70	77	Forest		
5	4	39	61	74	80	Grass		
6	5	30	58	71	78	Meadow		
7	6	39	61	74	80	Park		
8	7	39	61	74	80	Recreation Ground		
9	8	46	65	77	82	Residential		
10	9	51	67	76	80	Vineyard		
11	10	98	98	98	98	Buildings		
12	11	98	98	98	98	Parking		
13	12	83	89	92	93	Roads		
14	13	83	89	92	93	Railways		
15	14	98	98	98	98	Waterbody		
16	15	98	98	98	98	Waterway		
17	16	77	86	91	94	Bare Land/Undefined		
18								
19								

curve_number_table

0 100 200 300 m

Built Infrastructure Type

- Apartments
- Church
- Construction
- Container
- Detached
- Dormitory
- Farm
- Grandstand
- Hotel
- House
- Industrial
- Kindergarten
- Office
- Parking
- Roof
- School
- Semidetached house
- Service
- Shed
- University
- Area of Interest

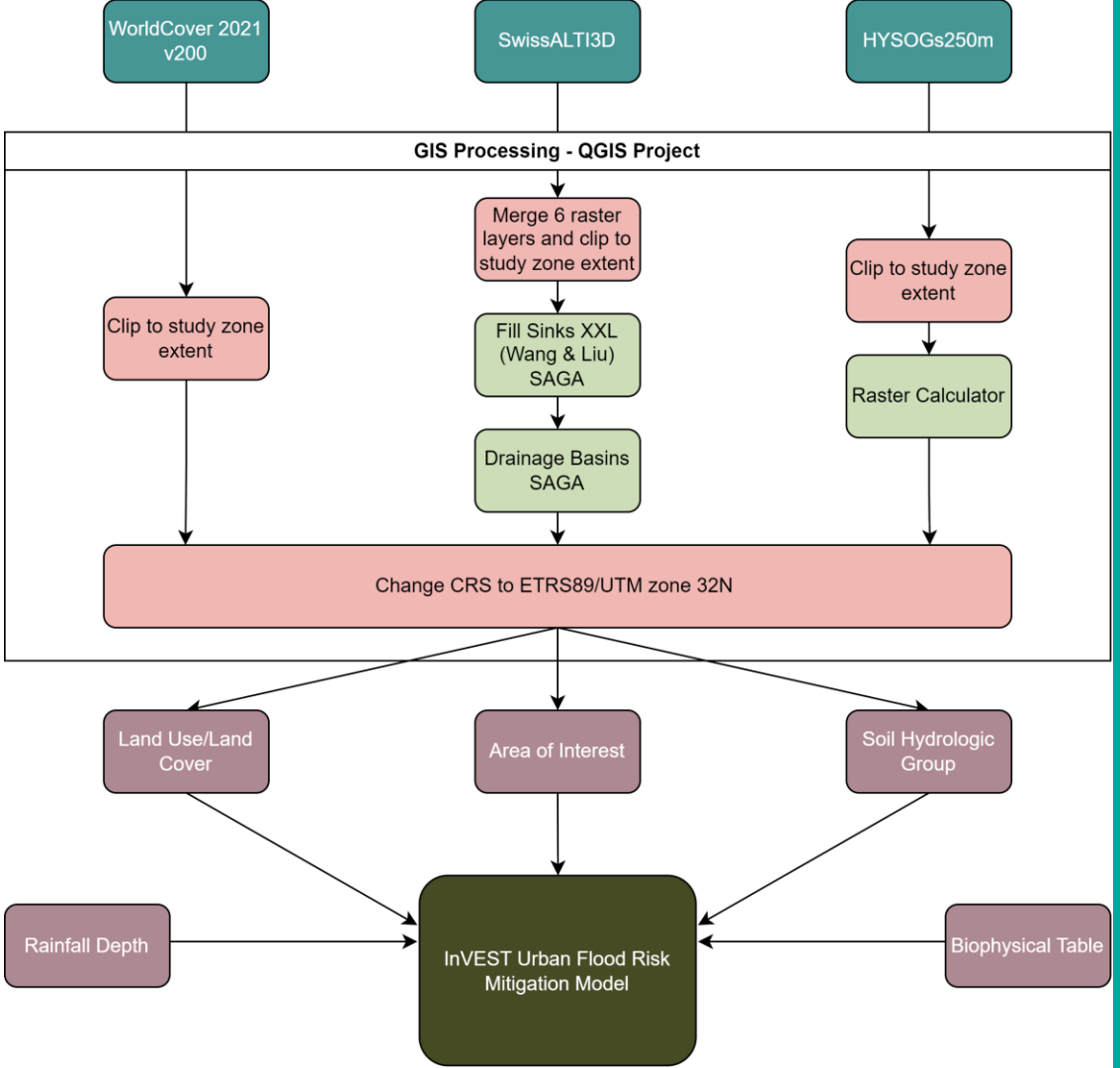
	A	B	C	D	E
1	type	damage	description		
2	1	986	apartments		
3	2	986	church		
4	3	32	construction		
5	4	32	container		
6	5	986	detached		
7	6	986	dormitory		
8	7	1	farm		
9	8	32	grandstand		
10	9	816	hotel		
11	10	986	house		
12	11	703	industrial		
13	12	986	kindergarten		
14	13	816	office		
15	14	32	parking		
16	15	32	roof		
17	16	986	school		
18	17	986	semidetached_house		
19	18	816	service		
20	19	1	shed		
21	20	986	university		
22	21	588	undefined		
23					
24					

infrastructure_damage_loss_tabl

Damage loss table

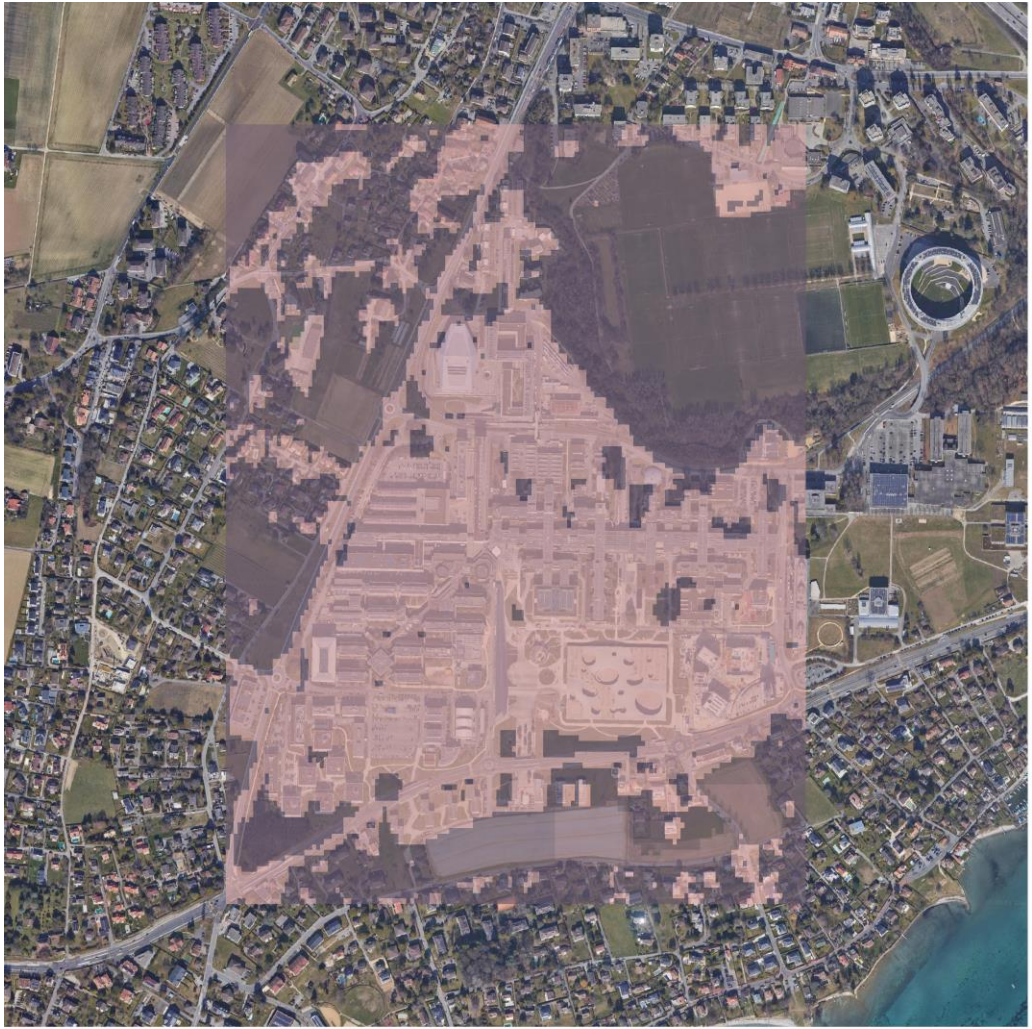
- Residential zones
- Commercial zones
- Industrial areas
- Transport
- Infrastructure
- Agricultural zones

Prepare the data



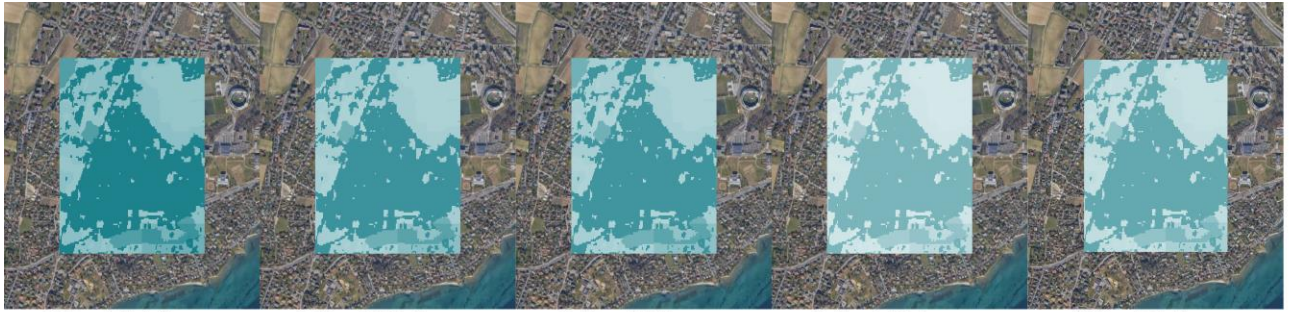
Model outputs

Table of Outputs	
Output	**Description**
Runoff_retention.tif	Raster with runoff retention values: [-], relative to precipitation volume.
Runoff_retention_m3.tif	Raster with runoff retention values: $[m^3]$.
Q_mm.tif	Raster with runoff values: $[mm]$.
flood_risk_service.shp	Shapefile with results in the attribute table: **rnf_rt_idx**: average of runoff retention values (R_i) per watershed. **rnf_rt_m3**: sum of runoff retention volumes (R_m3_i) $[m^3]$ per watershed. **flood_vol**: The flood volume Q_m3 per watershed. **aff_bld**: potential damage to built infrastructure in currency units, per watershed. Only calculated when the Built Infrastructure Vector input is provided. **serv_blt**: *Service.built* values for this watershed. An indicator of the runoff retention service for the watershed. Only calculated when the Built Infrastructure Vector input is provided.

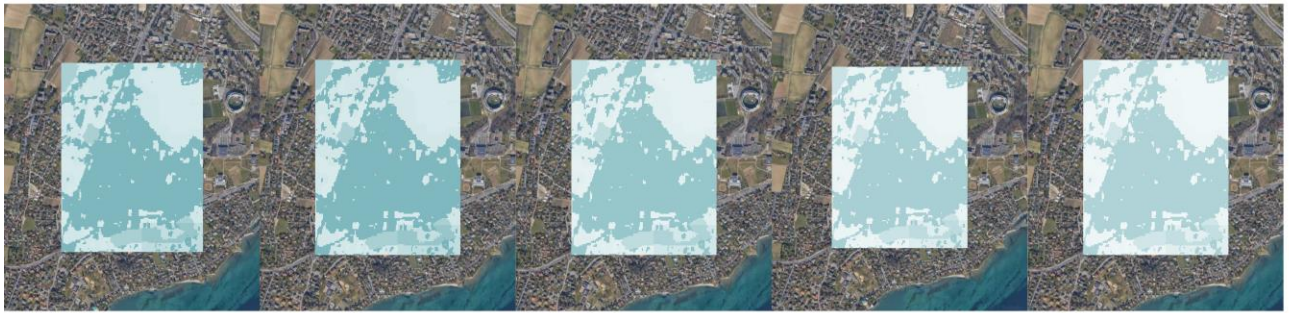


0 100 200 300 m

Runoff retention [m3]
0.518
0.805



48h: 117.4 mm | 48h: 103.3 mm | 24h: 102 mm | 24h: 76.1 mm | 12h: 85.7 mm



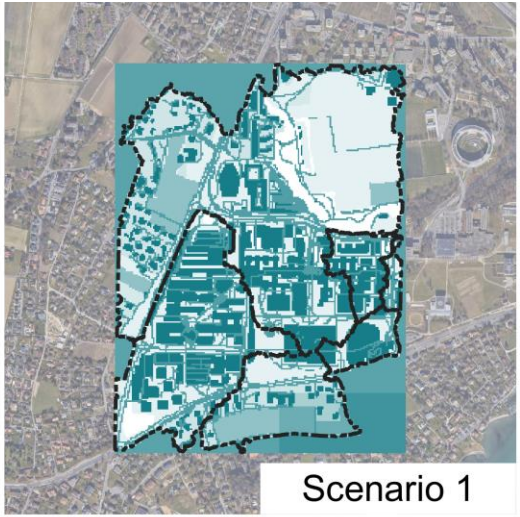
12h: 73.6 mm | 8h: 73.3 mm | 4h: 62.1 mm | 4h: 54.4 mm | 1h: 51.3 mm

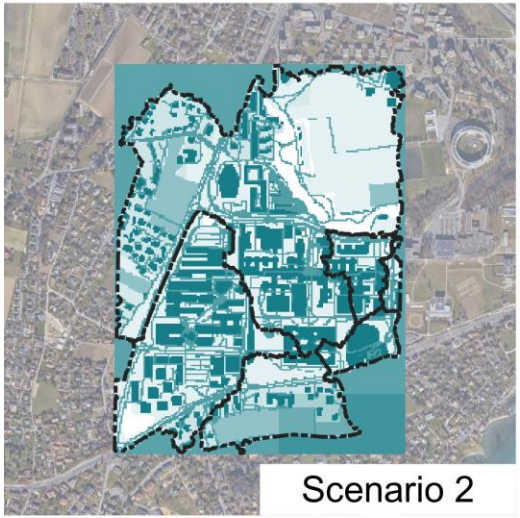
1h: 27.2 mm | 20min: 30.4 mm | 20min: 19.7 mm | 10min: 20.2 mm | 10min: 13.4 mm

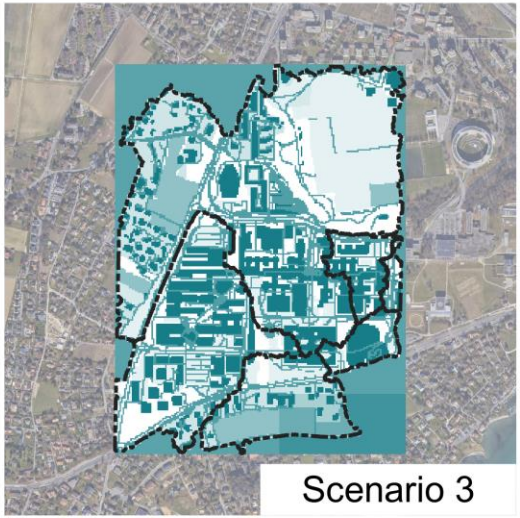
0 500 1000 m

Runoff [mm]

- 0
- 13.35789
- 26.71578
- 40.07367
- 53.43156
- 66.78945
- 80.14734
- 92.4777
- 102.753





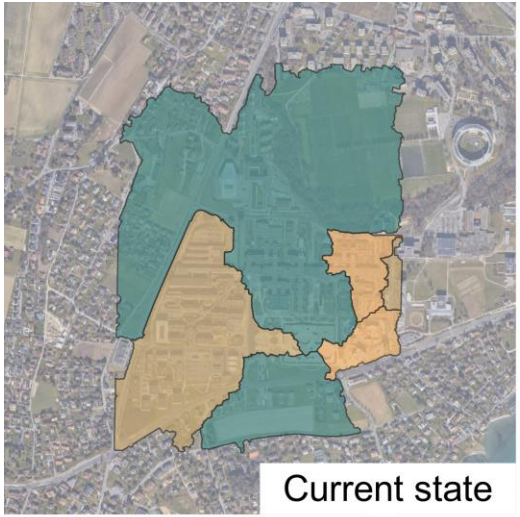


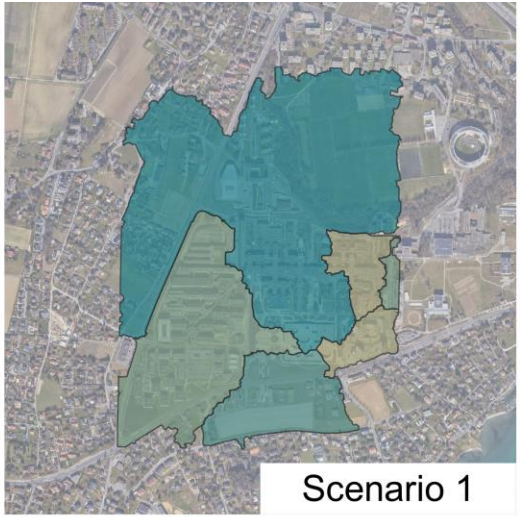
0 200 400 600 m

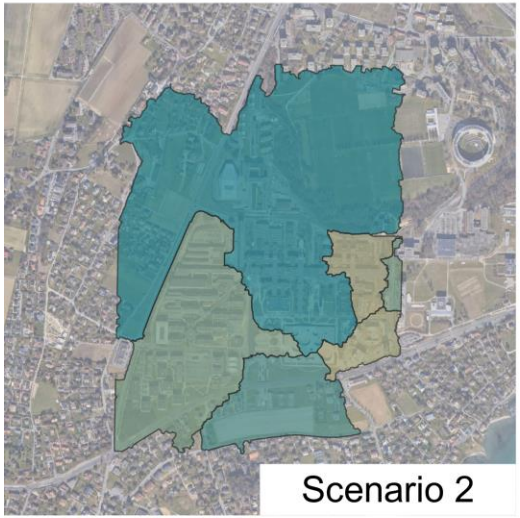
Area of Interest

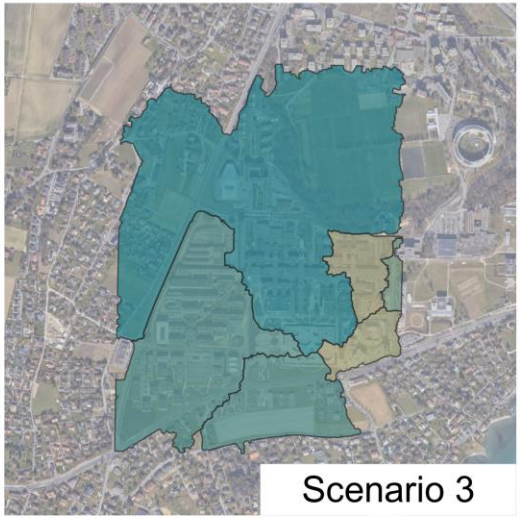
Runoff [mm]

45
53
62
71
79
88
97
105
111





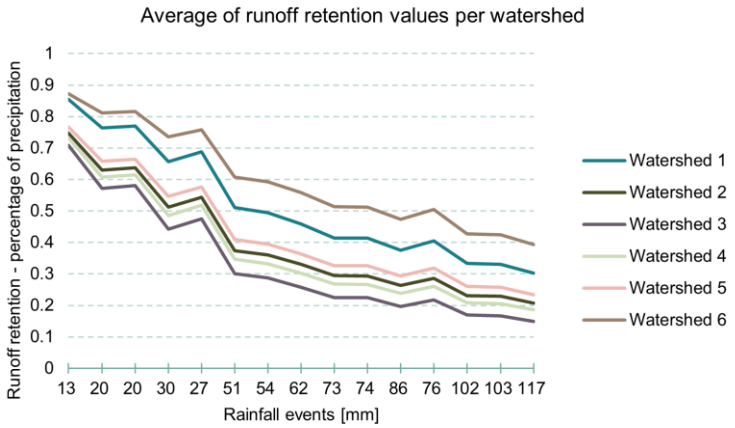


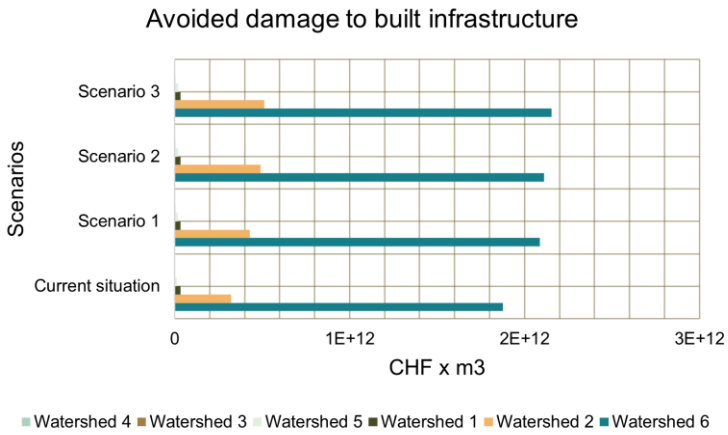


0 200 400 600 m

Runoff retention index ratio
- 0.1 - 0.15
- 0.15 - 0.2
- 0.2 - 0.25
- 0.25 - 0.3
- 0.3 - 0.35
- 0.35 - 0.4

Visualising and analysing the outputs





Model limitations

- SCS-Curve Number approach is simple and introduces uncertainties
- Valuation approaches
  - Currently, a simple approach to value flood risk retention is implemented, valuing flood risk as the avoided damage for built infrastructure
  - Alternative approaches (e.g. related to mortality, morbidity, or economic disruption) could be implemented