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Geospatial Insights of the 2021 European Flood

Understanding Risks, Vulnerabilities and Impacts

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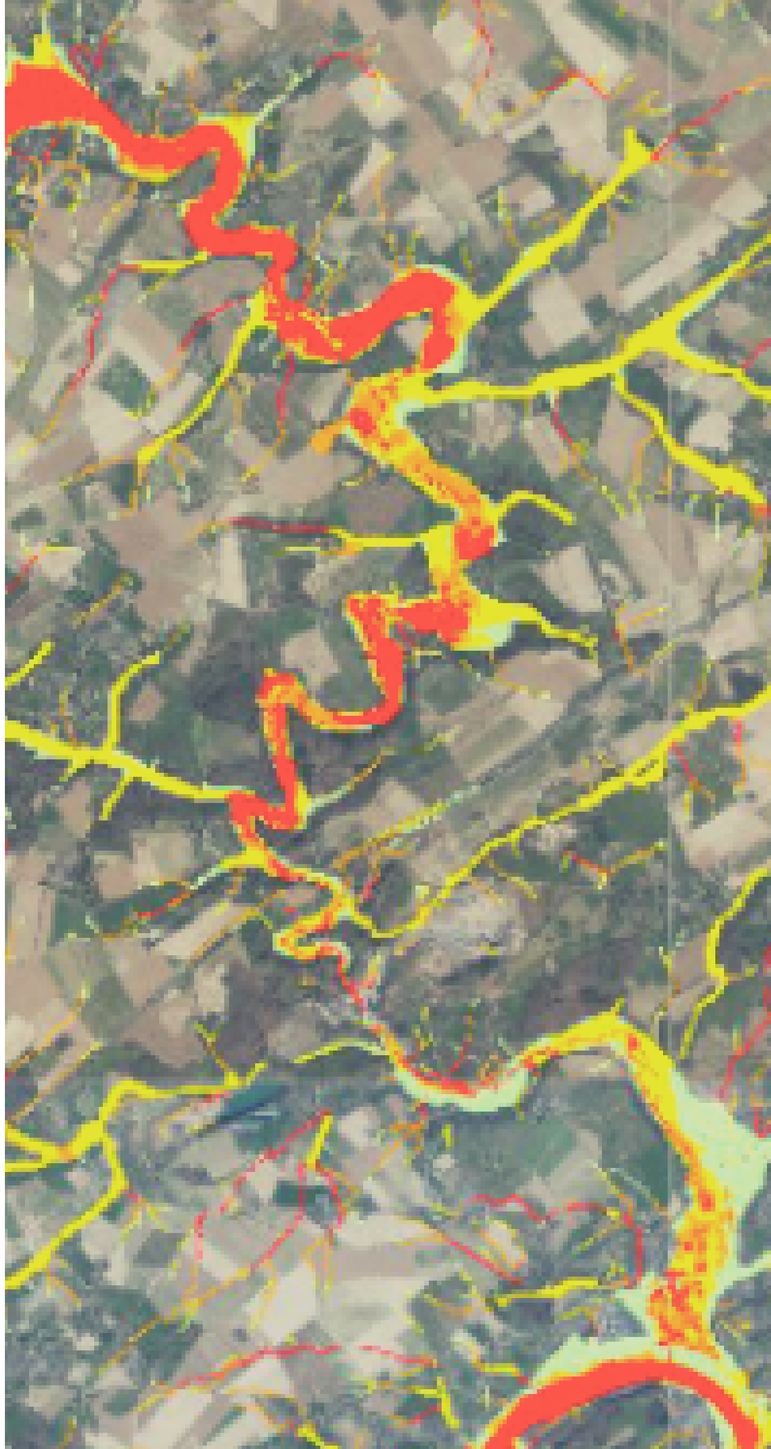
Flood Knowledge Summit (7th-8th of July 2022)



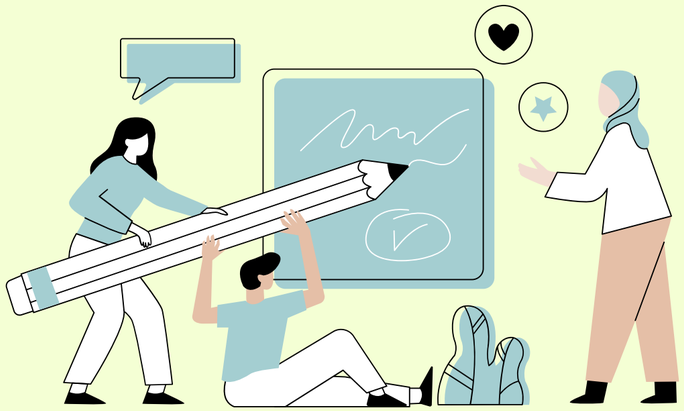
The Ahr River in Germany. 15.07.2021 (AP Photo, Daily Sabah)

Research Questions

Q1. What were the **exposure** and the multiple **vulnerabilities** of the region affected? And what do they tell us about **potential impacts** of the 2021 European Flood?

Q2. How **useful** and **accurate** is the geospatial risk information in assessing flood risks?

Methodology



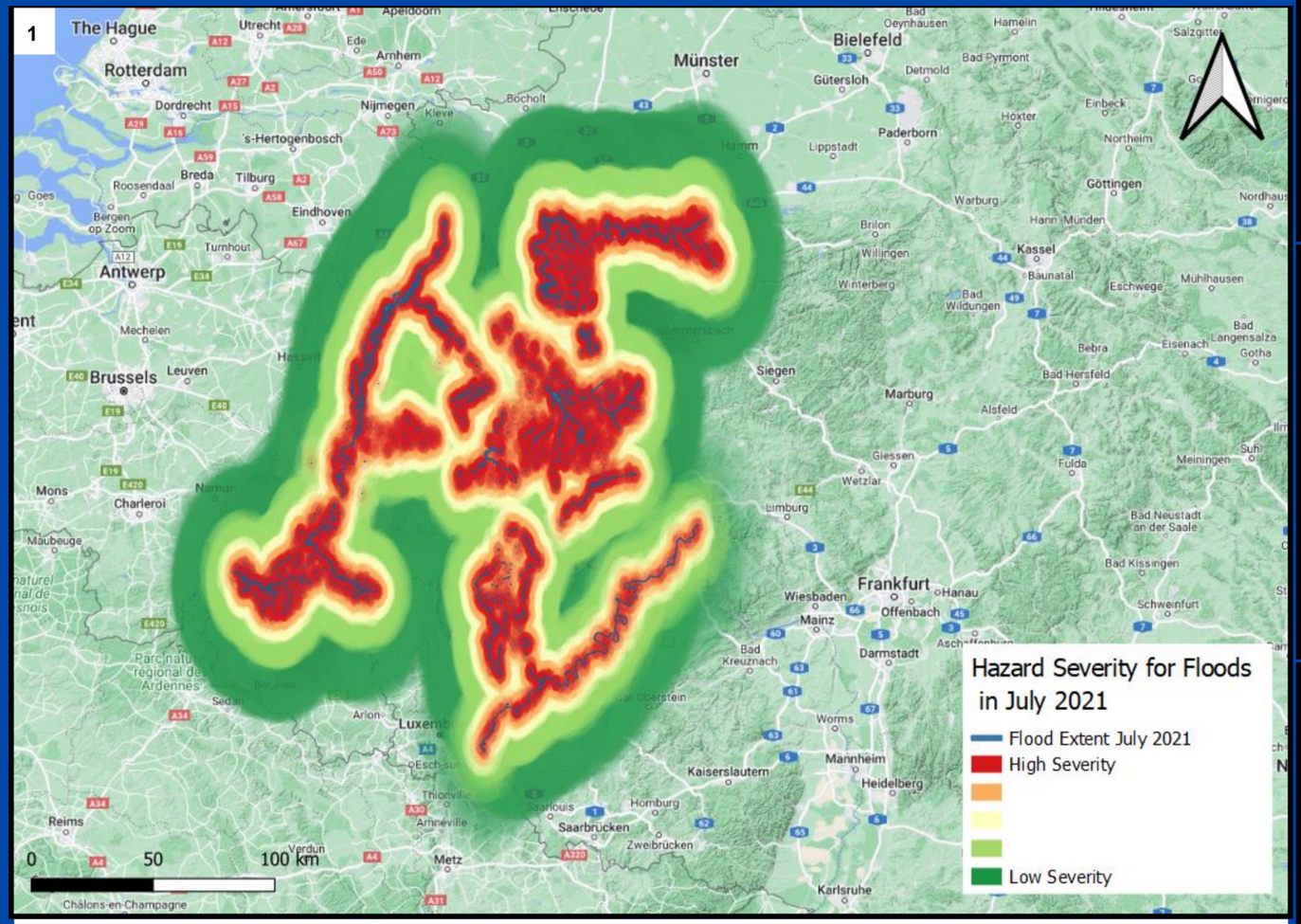
Flood Hazard Analysis – *What happened?*

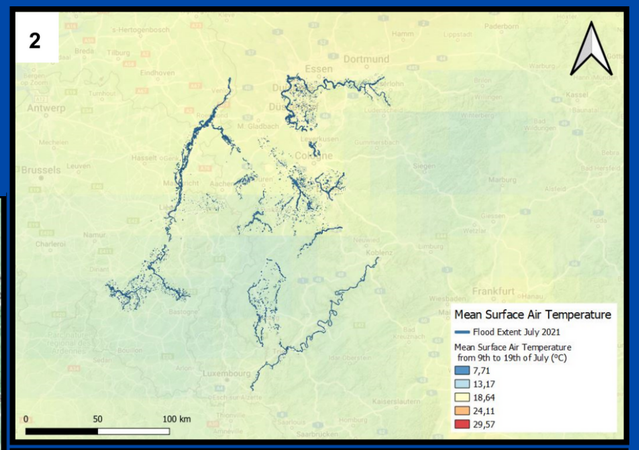
- Areas of high rainfall
- Soil moisture anomalies
- Temperature anomalies
- Flood extent
- Area of potential / indirect impact (i.e., 3km from the flood)

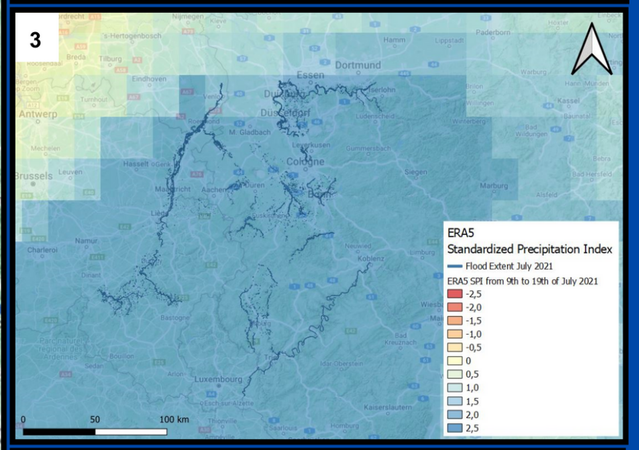
Flood Risk Assessment – *Who or what is at risk?*

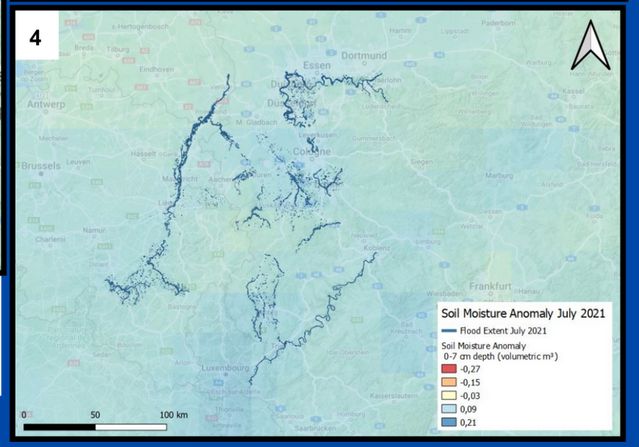
- Most affected municipalities
- Exposed land by type (e.g., urban areas, cropland, vineyards, forests…)
- Population at risk
- Infrastructure at risk (e.g., roads, railways, health sites, education facilities…)

Map #1: Flood Hazard Map (9-19th July 2021)



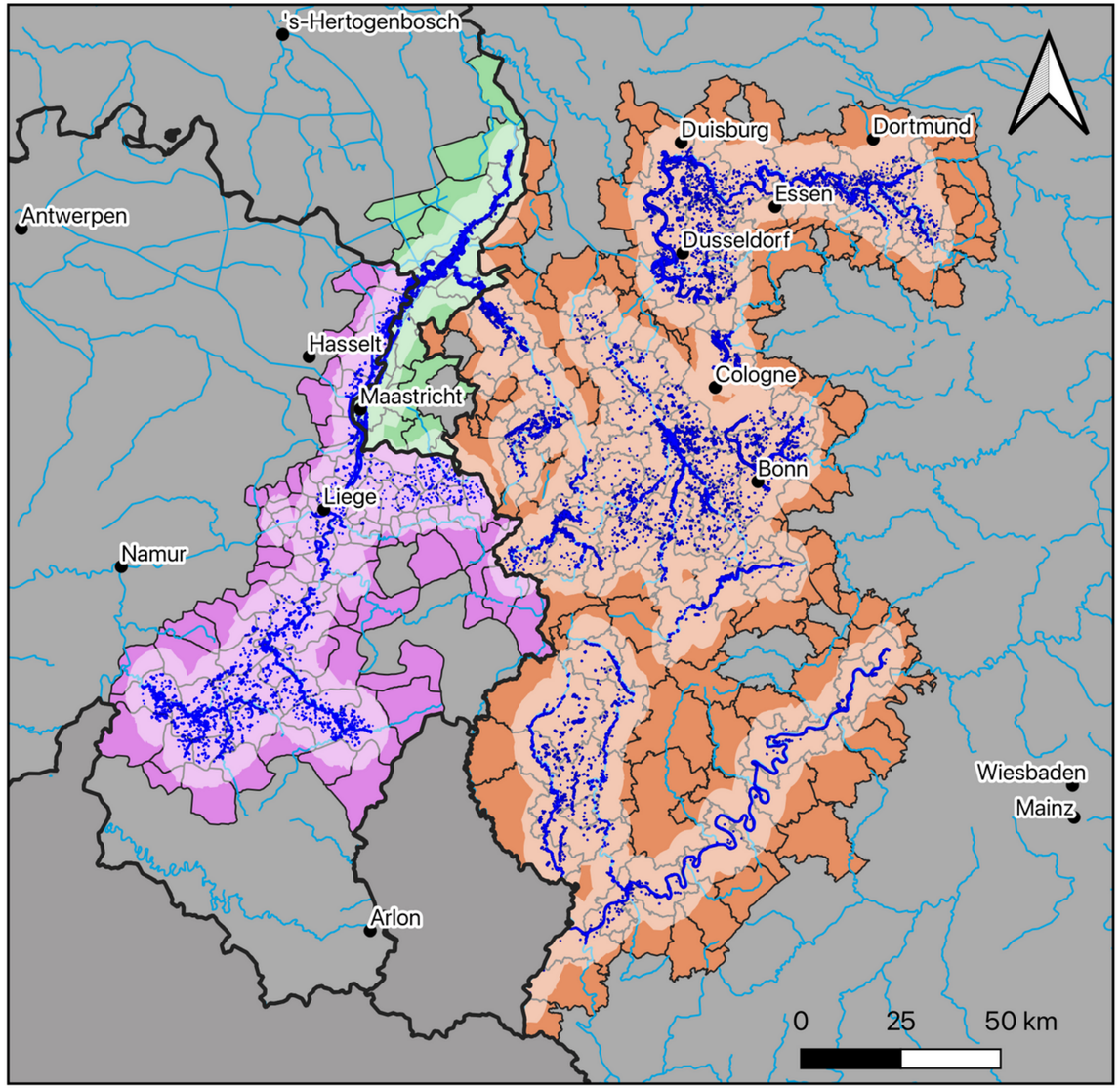






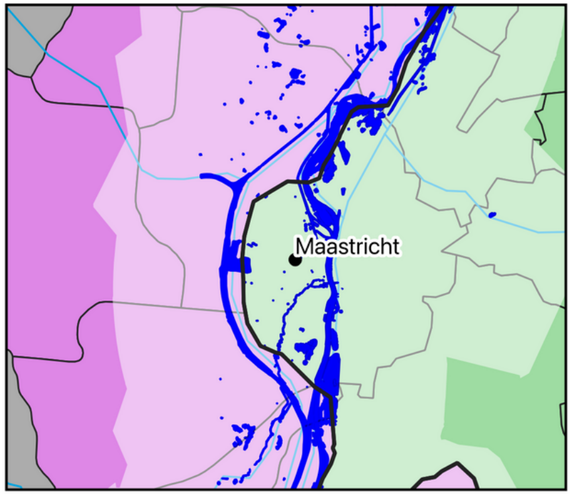
1) Hazard Severity for Floods in July 2021 – Sources: Copernicus EMS Datasets (EMSR517, EMSR518, EMSR520), Google Earth Terrain Map
2) Mean Surface Air Temperature from 9th to 19th of July 2021 – Sources: Copernicus EMS Datasets, ERA5 2m Surface Air Temperature Datasets (Climate Engine), Google Earth Terrain Map
3) ERA5 Standardized Precipitation Index from 9th to 19th of July 2021 – Sources: Copernicus EMS Datasets, ERA5 SPI Dataset (Climate Engine), Google Earth Terrain Map
4) Soil Moisture Anomaly in 0-7 cm depth for July 2021 – Sources: Copernicus EMS Datasets, ERA5 0-7 cm Volumetric Soil Moisture Datasets (Copernicus), Google Earth Terrain Map

Map #2: Flood Extent and Most Affected Municipalities



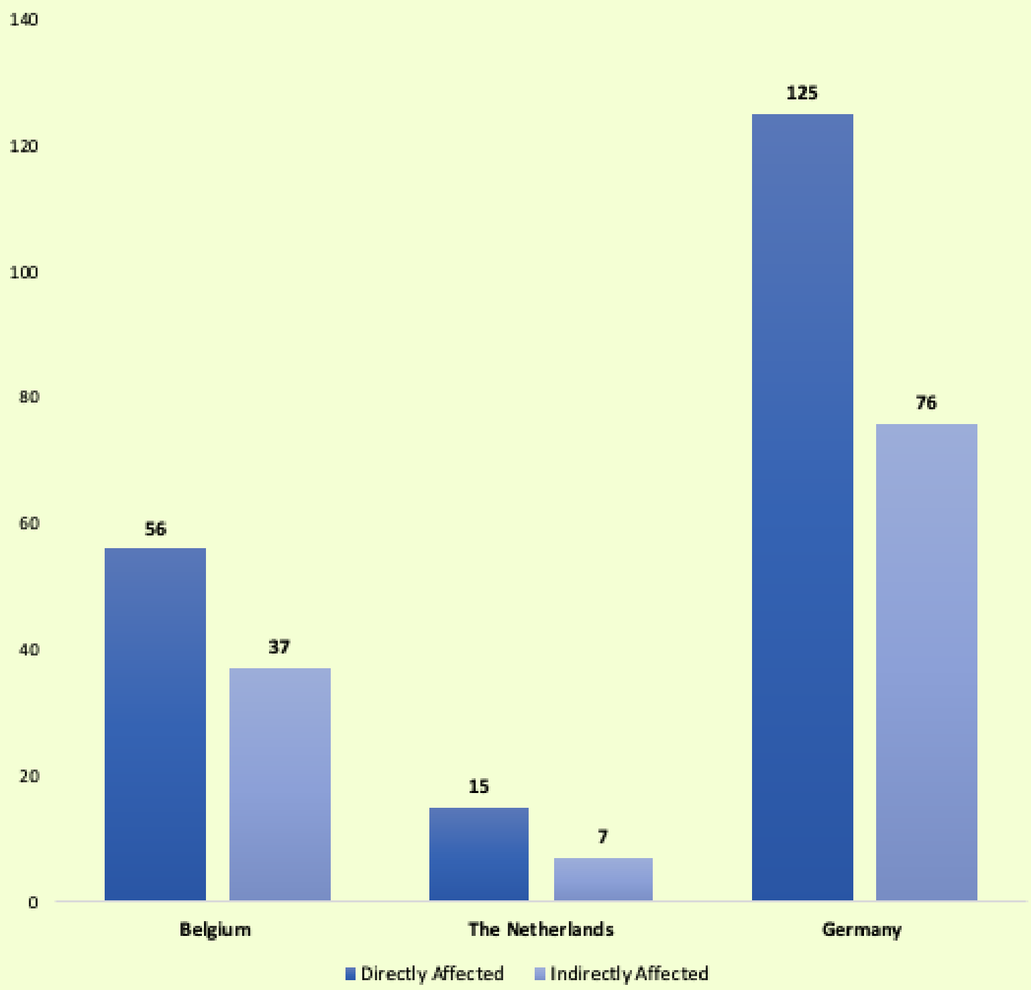
Legend

- Flood Extent as of 9th-19th of July 2022
- Area of indirect or potential flood impact
- Main Rivers
- Affected Dutch Municipalities
- Affected Belgian Municipalities
- Affected German Municipalities
- Main Cities
- Neighboring Countries



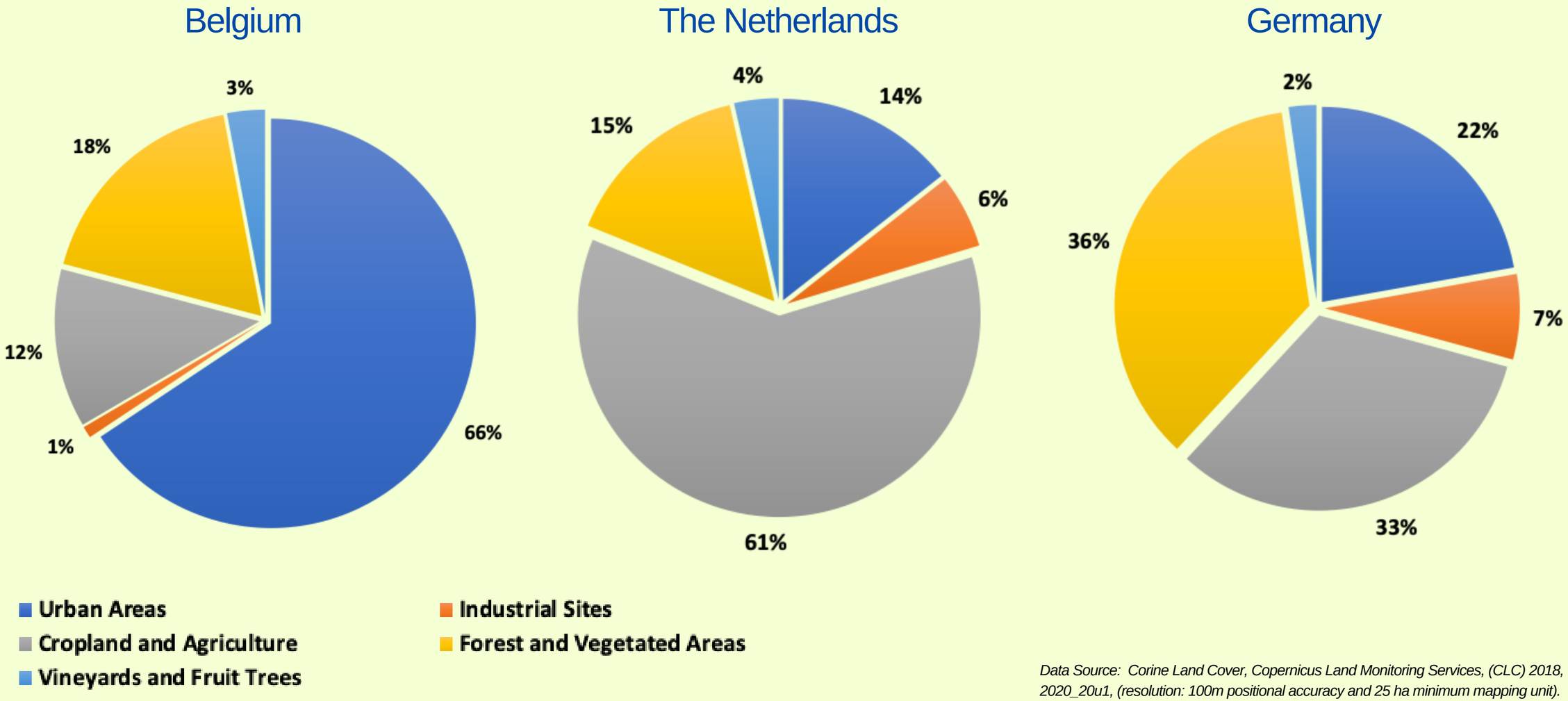
Source:
- Flood Extent and Hazard Severity: Copernicus EMS Datasets (EMSR517, EMSR518, EMSR520).
- Municipalities and international boundaries from GADM 2018-2020, version 4.0.4.
- Rivers: DIVA-GIS (Digital Chart of the World)

Quantitative Outputs - Affected Municipalties



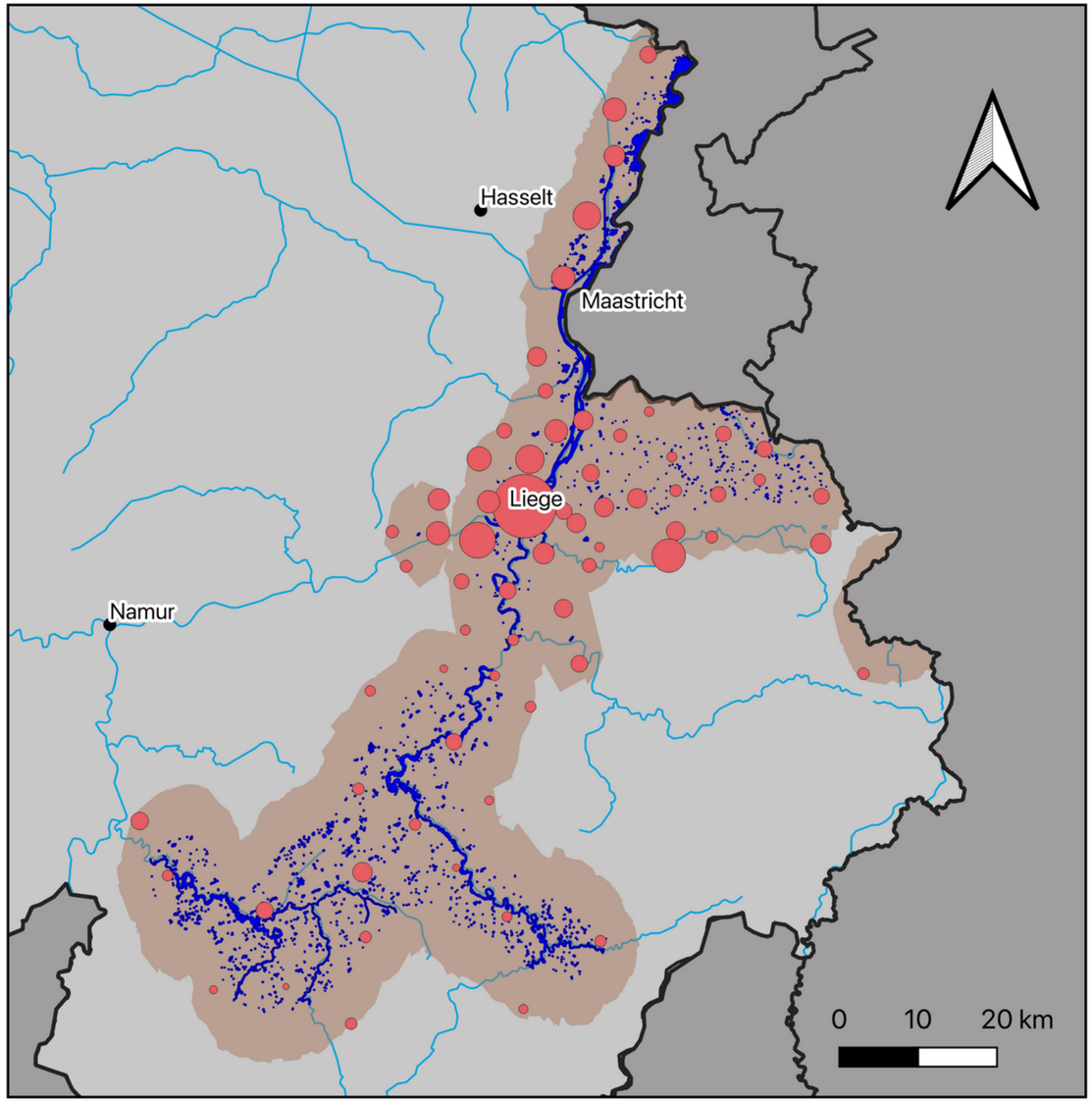
- A total of **196 municipalities** were directly affected by the flood *(dark blue)*
- A flooded area of **323 km2**
- **Germany is the most affected country** with 201 collective municipalities being directly and indirectly impacted (representing 16% of all collective municipalities)
- **15% of Belgian municipalities** were directly and indirectly impacted
- **The Netherlands is the least affected country** with 6% of municipalities affected

Exposed land by type



Data Source: Corine Land Cover, Copernicus Land Monitoring Services, (CLC) 2018, Version 2020_20u1, (resolution: 100m positional accuracy and 25 ha minimum mapping unit).

Map #3: Flood Exposure and Potential Impact on Population in South-Eastern Belgium



Legend

Flood Extent as of 9th-19th of July 2021

Belgian population at risk
(By number of people)

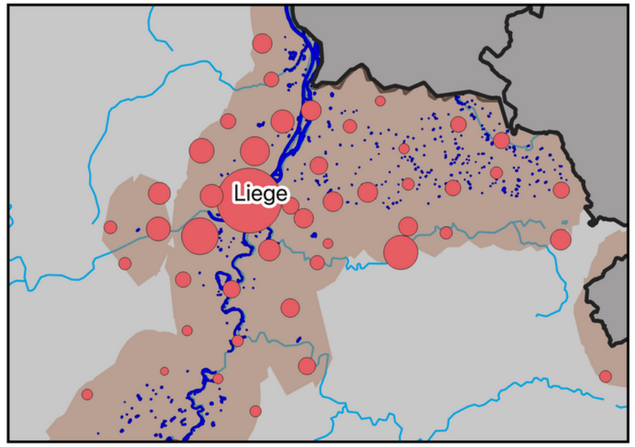
201677
200000
150000
100000
50000

Main Cities

Area of indirect or potential flood impact

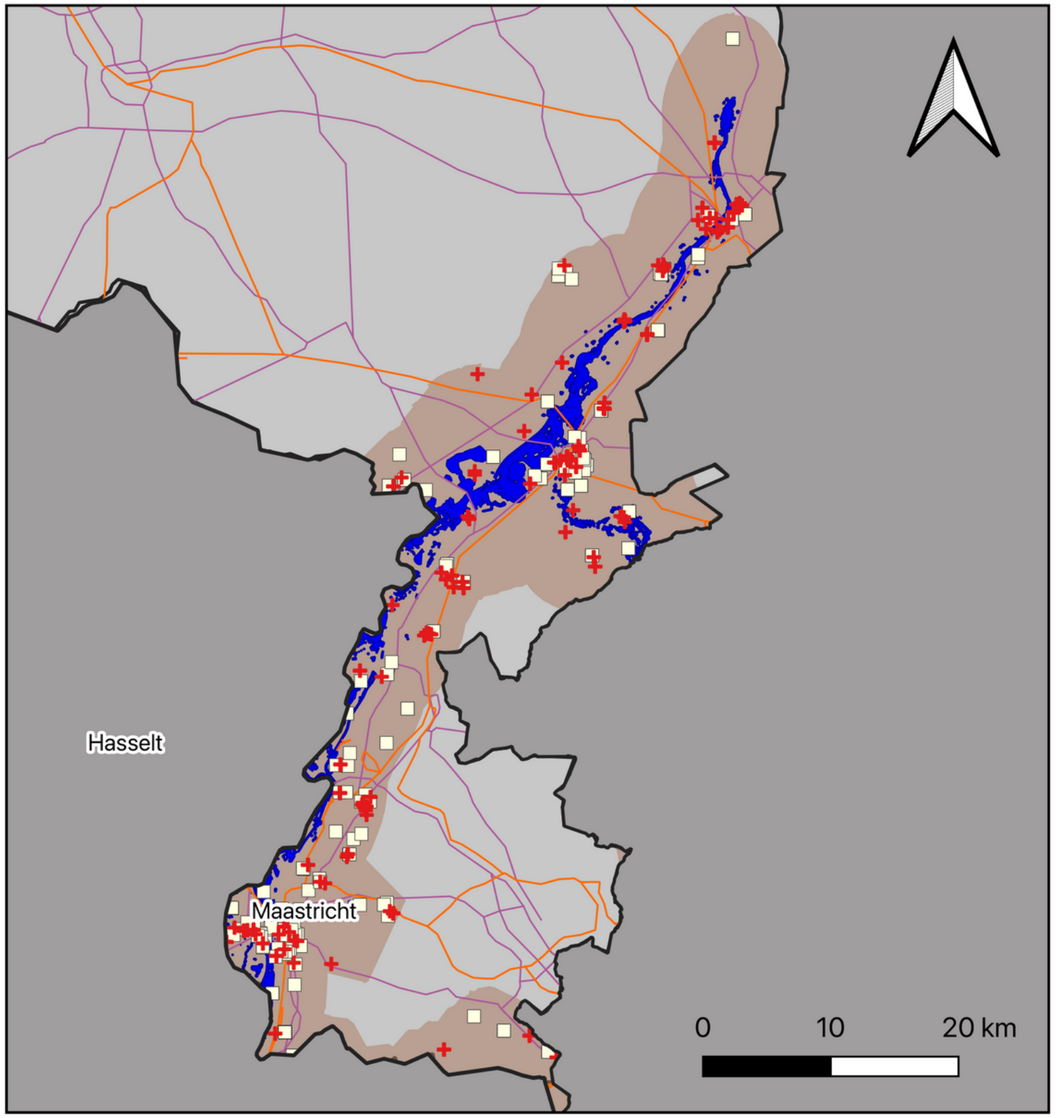
Main Rivers

Neighboring Countries



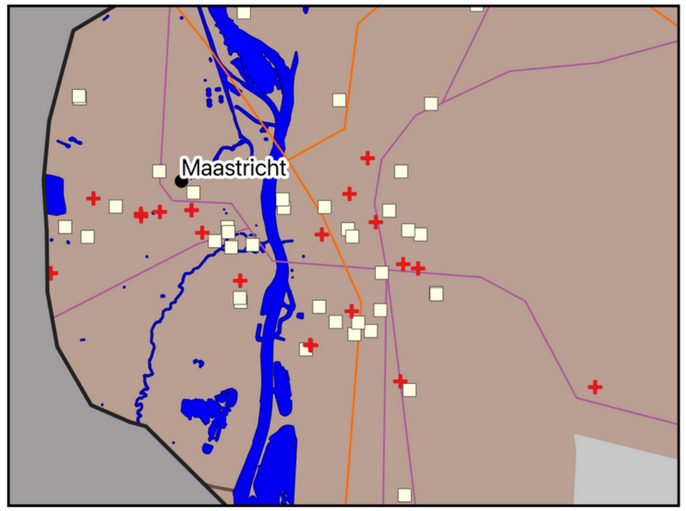
Source: Population (counts) from World Pop, 2020 version (100m resolution)

Map #4: Flood Exposure and Potential Impact on Infrastructure in Southern Netherlands



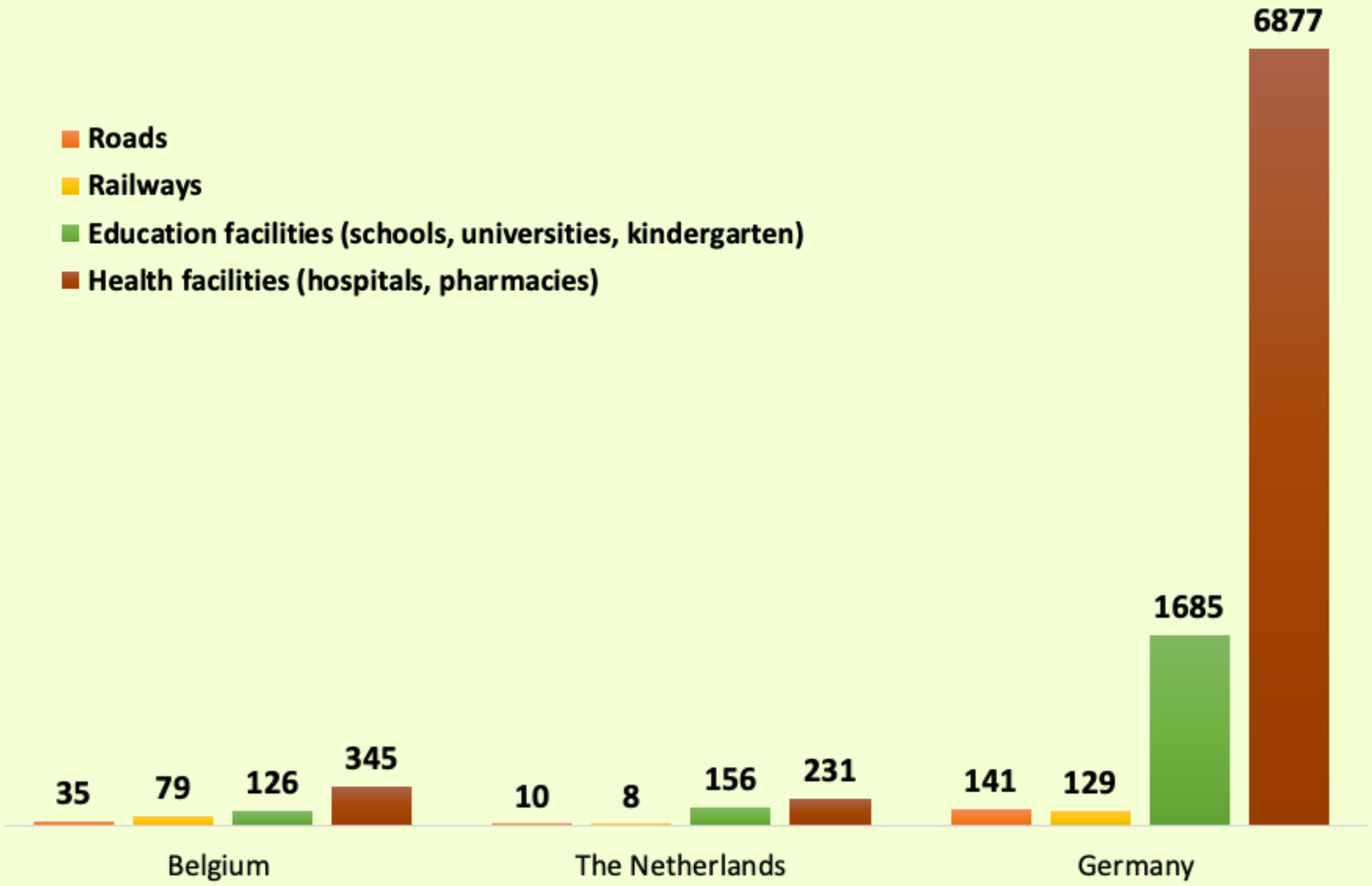
Legend

- Flood Extent as of 9th-19th of July 2021
- Area of Potential or Indirect Impact of Flooding
- Health sites at risk
- Education sites at risk
- Railways
- Roads
- Main Cities
- Neighboring Countries



Source:
- Roads & Railroads: DIVA-GIS (Digital Chart of the World)
- Education sites (schools, universities and childcare): Humanitarian OpenStreetMap Team (03/2021 - updated monthly)
- Health sites (pharmacies, hospitals): Global Health sites Mapping Project which uses OpenStreetMap (30.05.2022 - updated monthly)

Exposed infrastructure by type



- **Health facilities were the most exposed infrastructure** for the three countries
- **Germany was the most exposed country**
- More education facilities were exposed in the Netherlands than in Belgium
- In Belgium, railways were more exposed than roads

Key Learnings

The geospatial analysis is **useful in capturing the hazard and the exposure** elements in a flood risk assessment, but is **not sufficient in tackling vulnerability and impacts**

The analysis is based on a **flood extent estimation** using grid size, but possible points of improvement would be to include an **elevation model and a depth analysis**.

The **proximity factor is not sufficient** to capture the **flood severity** and draw formal conclusions on the **indirect or potential impacts** on the population and infrastructure.

Conclusion - *What's next?*

- Validate results
- Include qualitative Inputs for a greater vulnerability and impact assessment
- Map flooded areas at a more local level (e.g., Valkenburg, Bad Münstereifel...)
- Question the use and utility of geospatial tools by local authorities

Open Question.

Does risk mapping still have a role to play in flood management policies?

Data

- **Anomaly and mean data from the Surface Air Temperature** from ERA5 in 0.25° * 0.25° resolution (~24 km) contain temperatures for 9th – 19th of July 2021 – the anomaly data contain the data for July 2021 in comparison to the years 1991-2020 as their reference data
- **Anomaly Surface Air Relative Humidity** (2t-data) from ERA5 in 0.25° * 0.25° resolution (~24 km) contain relative humidity in % from July 2021 compared to the reference months in 1991-2020
- **Anomaly Volumetric Soil Moisture** (swvl1-data) from ERA5 in 0.25° * 0.25° resolution (~24 km) contain the soil moisture in 0-7 cm depth in m3
- SPI (Standardized Precipitation Index) data from ERA5 in 0.25° * 0.25° resolution (~24 km) contain the Precipitation anomaly for 9th-19th of July in comparison to the reference data from 1979-2021 (data from Climate Engine)
- The **Flood Extent** data contains all rivers and flooded area within the event from 9th- 19th of July in Belgium, the Netherlands and Germany (data from Copernicus EMS)
- **Land use data** from Corine Land Cover, Copernicus Land Monitoring Services, (CLC) 2018, Version 2020_20u1, (resolution: 100m positional accuracy and 25 ha minimum mapping unit). Classes have been reduced to 12 for visibility purposes (https://land.copernicus.eu/pan-european/corine-land-cover/clc2018?tab=metadata)
- **Roads, Railroads and Rivers** data from DIVA-GIS (Digital Chart of the World): (https://www.diva-gis.org/gdata)
- **Education sites** (schools, universities and childcare) from Humanitarian OpenStreetMap Team (03/2021 - updated monthly) (https://data.humdata.org/dataset/)
- **Health sites** (pharmacies, hospitals) from Global Health sites Mapping Project which uses OpenStreetMap (30.05.2022 - updated monthly). (https://data.humdata.org/dataset/)
- **World cities** from ESRI Data & Maps (8/05/2021 version) (https://hub.arcgis.com/datasets/esri::world-cities/about)
- **Population** (counts) from World Pop, 2020 version (100m resolution) (https://www.worldpop.org/geodata/summary?id=49977)
- **Administrative units** (municipalities) and national borders data from GADM 2018-2020, version 4.0.4 (https://gadm.org/data.html)
- **World Countries** data from GISCO - Eurostat, version 3/04/2020 (scale 1:1 million) (https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/administrative-units-statistical-units/countries)