

# **The geography of disaster risk and participatory risk management:**

## **Harnessing sensors and geospatial technology for disaster resilience**

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# Outline

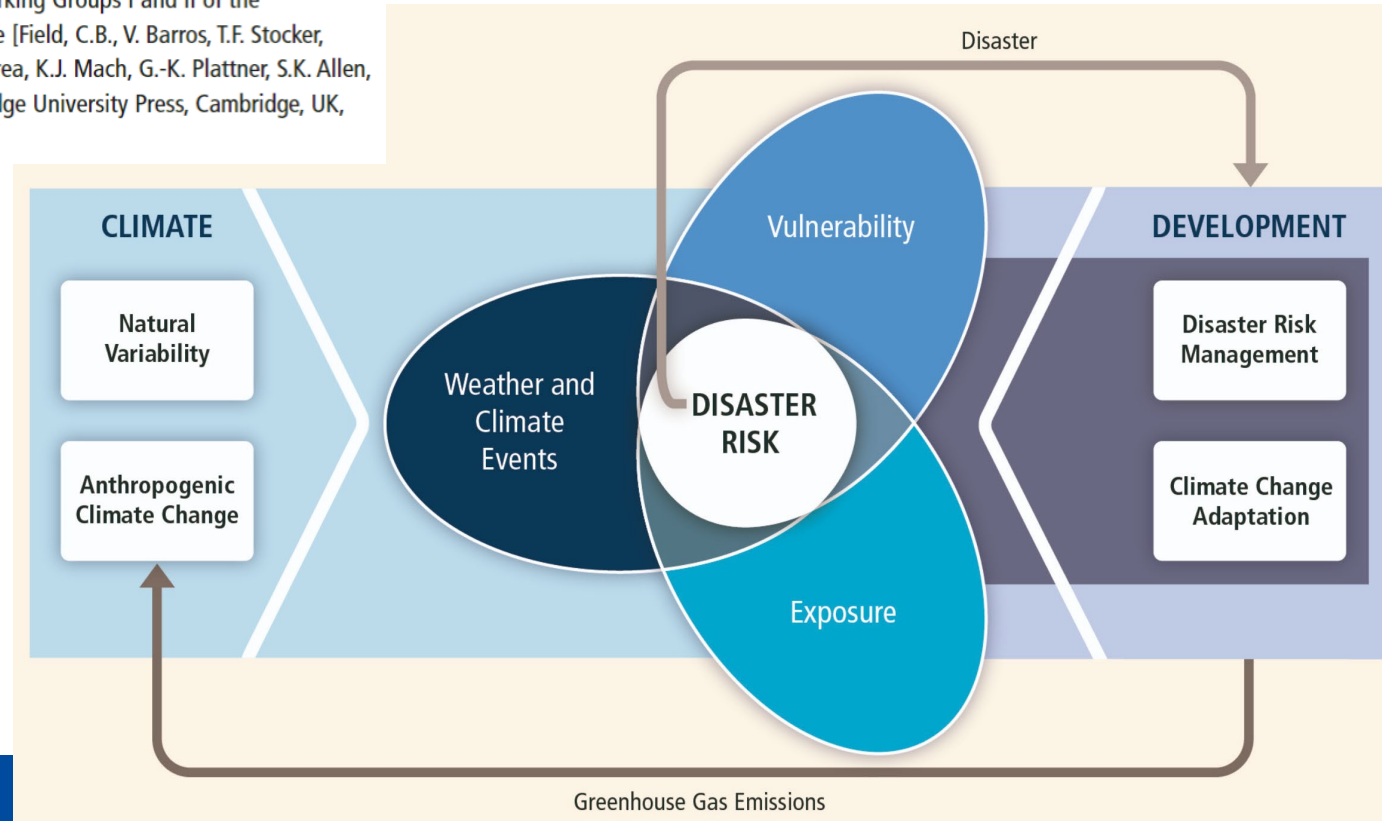
- IPCC's framework for Disaster Risk (Hazards, Exposure, Vulnerability)
- Geospatial Sensor Technologies
  - Remote Sensing
  - Automatic Sensors (e.g., Weather Stations)
  - Citizen Sensing



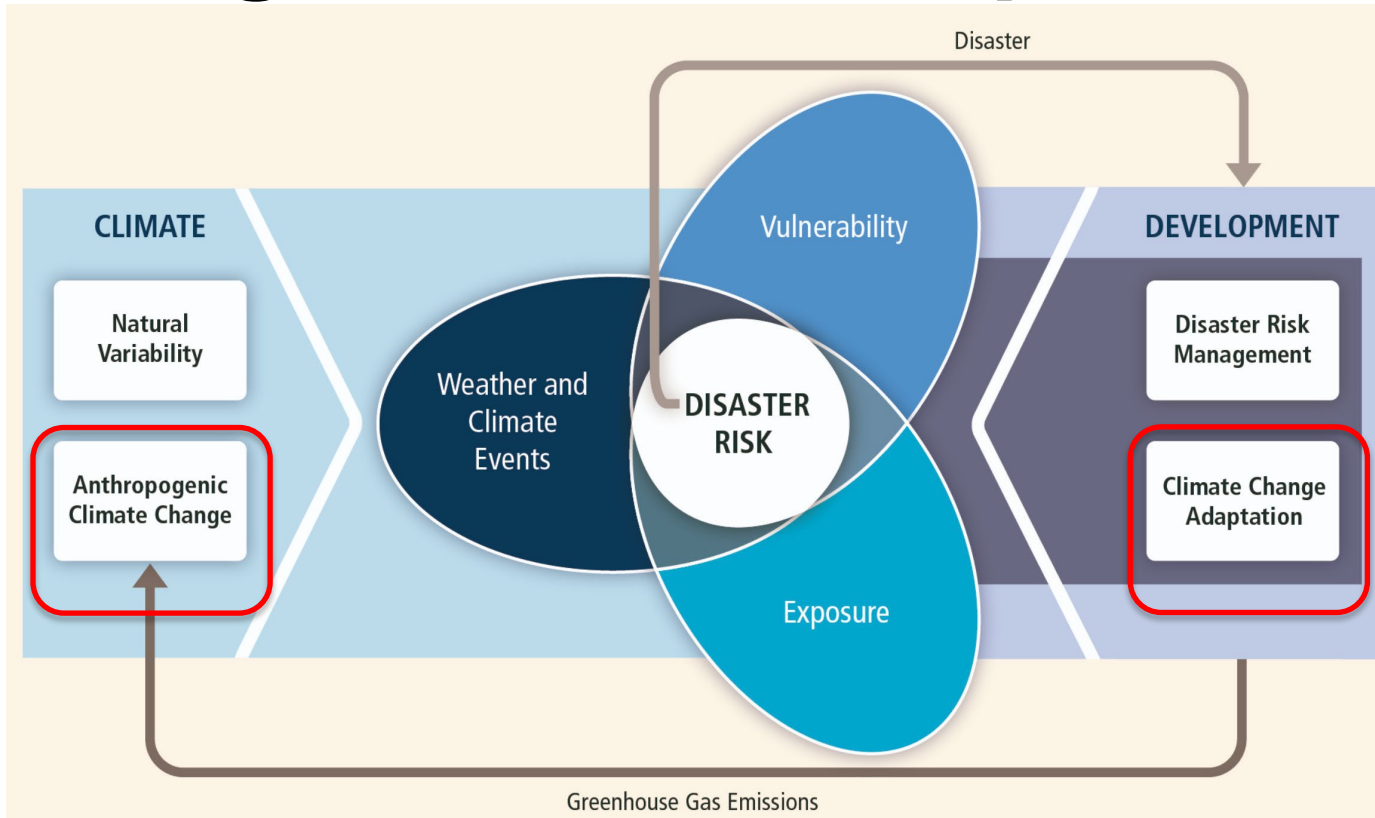
Participatory  
risk management

# IPCC's Framework for Disaster Risk

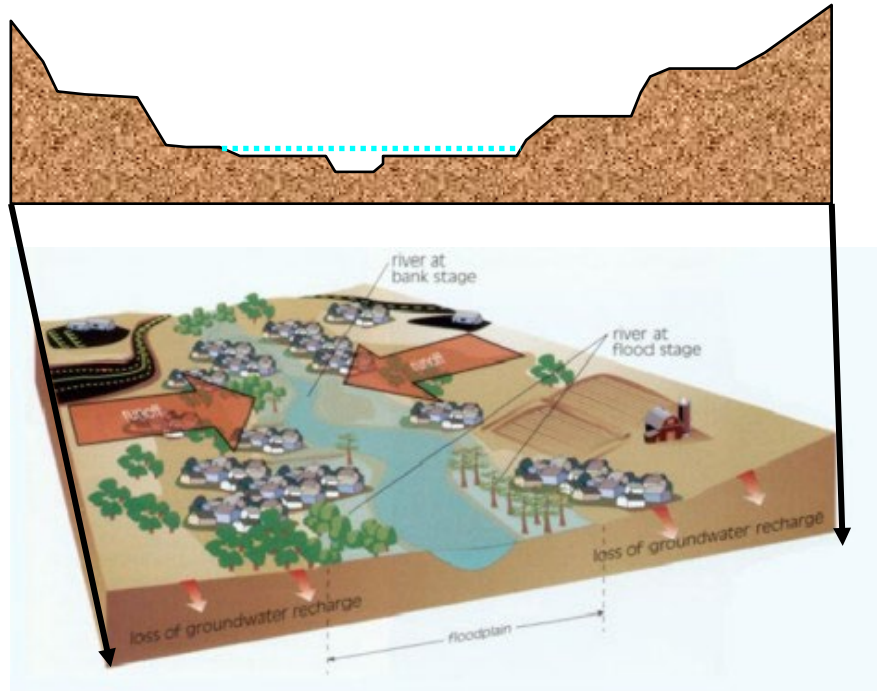
IPCC, 2012: *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp.



# Mitigation and Adaptation

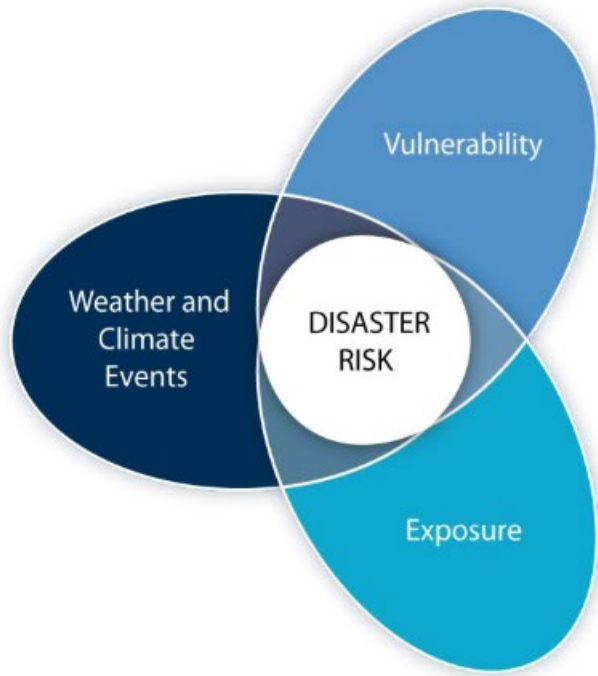


# Risk is a spatial problem: example flood



- **Hazard:**  
How much water when and where (flood zone)?
- **Exposure:**  
Which elements could be adversely affected?
- **Vulnerability:**  
What are the predisposed characteristics of the elements that are at risk?

# How can disaster risk be reduced?

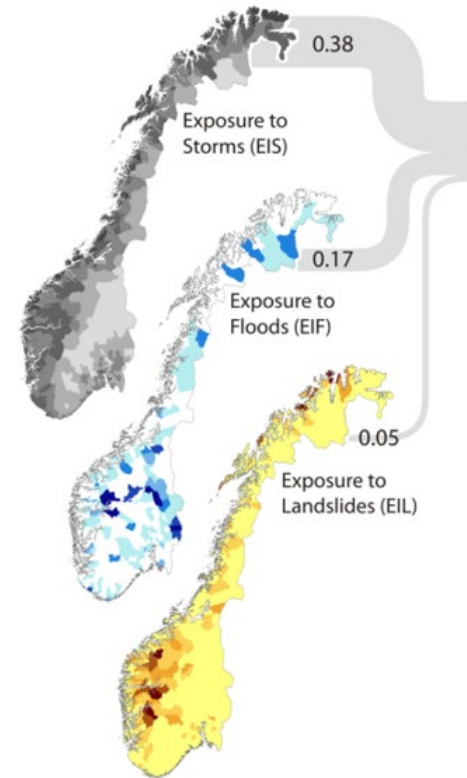
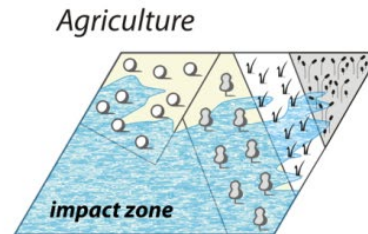
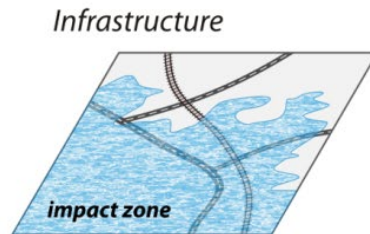
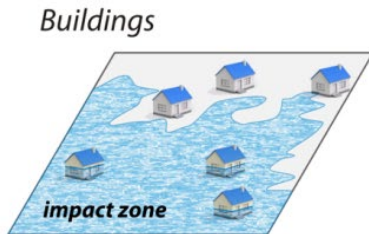


- There is a geography of
  - Hazard
  - Vulnerability
  - Exposure
- These element should be measured and mapped
- Challenging if available data is scarce

# How to measure exposure?

- Exposure can be measured by:
  - counting the numbers of buildings,
  - sum the length of roads,
  - sum the area of farmland
- that are within an impact zone, relative to the total number of buildings, ... that are within a define unit (e.g., municipality)

## Elements at risk



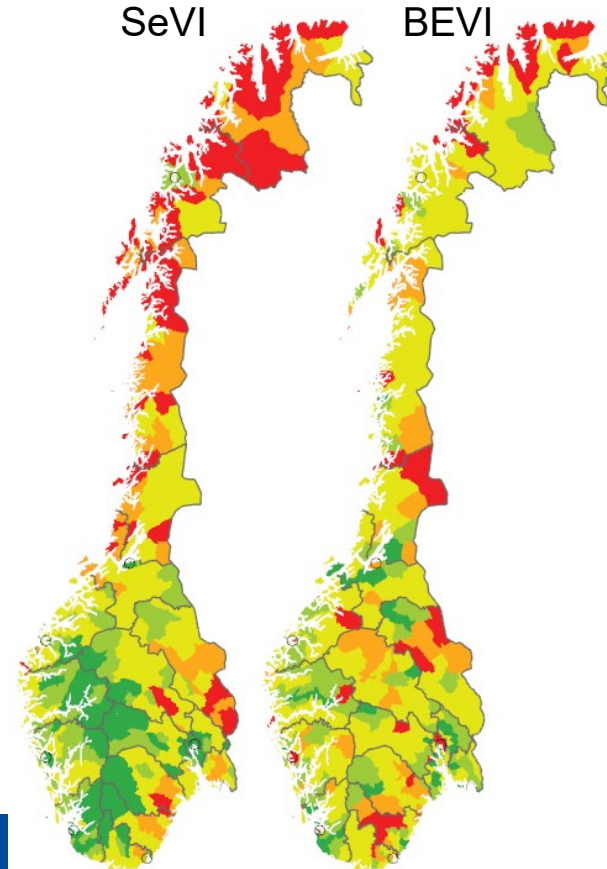
# How to measure (social) vulnerability?

Variables (examples):

- Pop. 0 – 5 (%)
- Pop. 67 + (%)
- Single parent (%)
- Immigrants (%)
- Wealth
- Income
- Higher education (%)
- Unemployment (%)
- Municipality wealth
- ...
- Population density
- Dist. to nearest hospital
- Average age sewer and water lines
- # exit routes
- ...

SeVI

BEVI





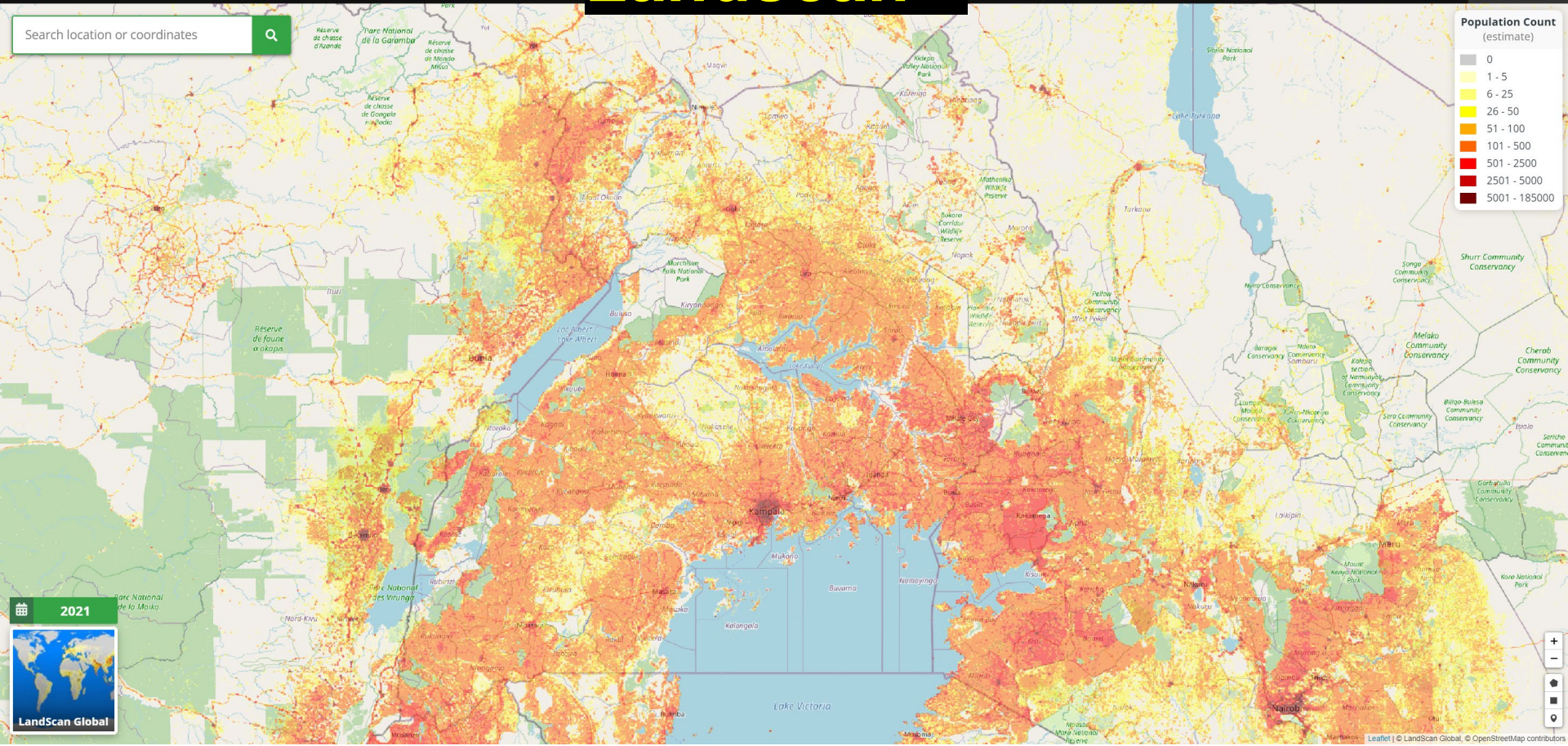
# Landscan

Search location or coordinates



**Population Count (estimate)**

- 0
- 1 - 5
- 6 - 25
- 26 - 50
- 51 - 100
- 101 - 500
- 501 - 2500
- 2501 - 5000
- 5001 - 185000



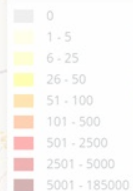
2021

LandScan Global





Search location or coordinates

Population Count  
(estimate)

- Resolution 30" by 30"
  - Do not count where people sleep but where they may likely be at any random time of the day
  - Obtained by a dasymetric technique
    - Roads
    - Night-light (NOAA)
    - ...
    - Sea, desert, ...
    - Steep slopes
    - ...
- } **Increase** the likelihood of human presence
- } **Decrease** the likelihood of human presence

2021

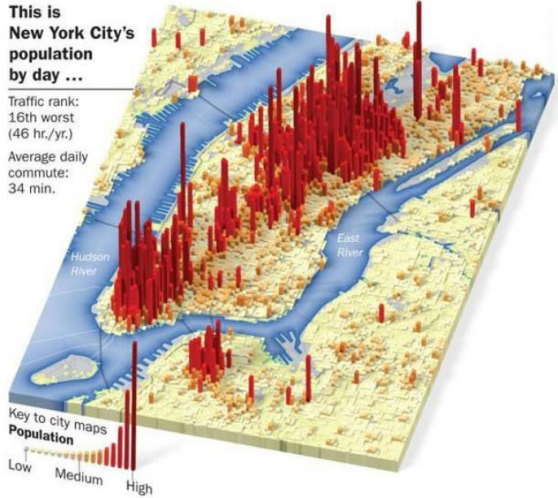


# Landscan USA

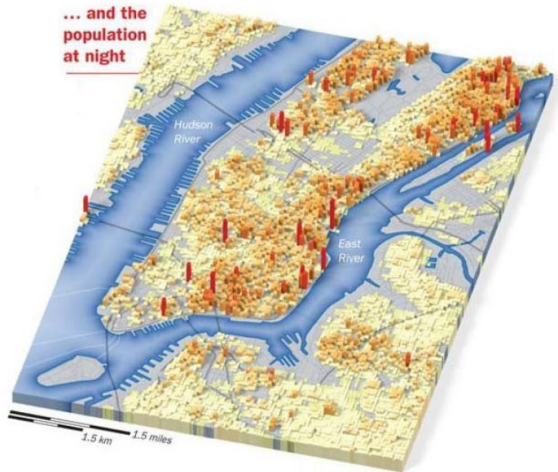
This is  
New York City's  
population  
by day ...

Traffic rank:  
16th worst  
(46 hr./yr.)

Average daily  
commute:  
34 min.



... and the  
population  
at night

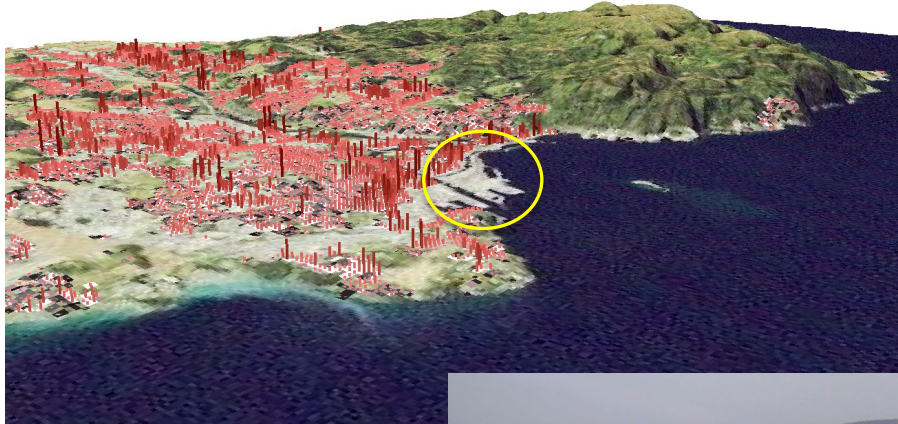


- Higher spatial resolution
- One representation for daytime
- Another representation for nighttime

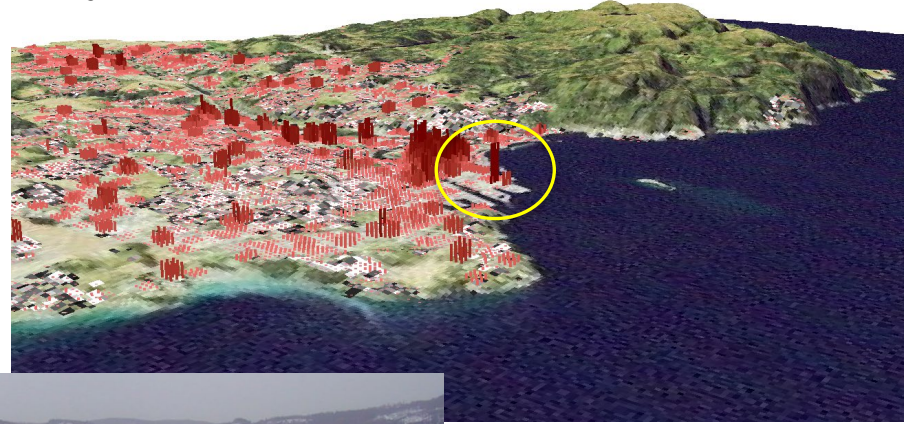


# Temporal vulnerability

Night



Day





# Where are the most exposed and vulnerable areas?

- **Exposure**

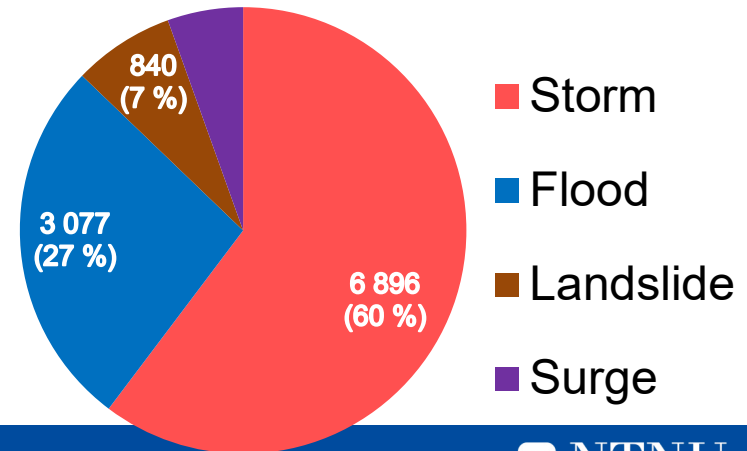
- **Vulnerability**

Integrated vulnerability assessment (Tate et al. 2010)

# How to combine indices?

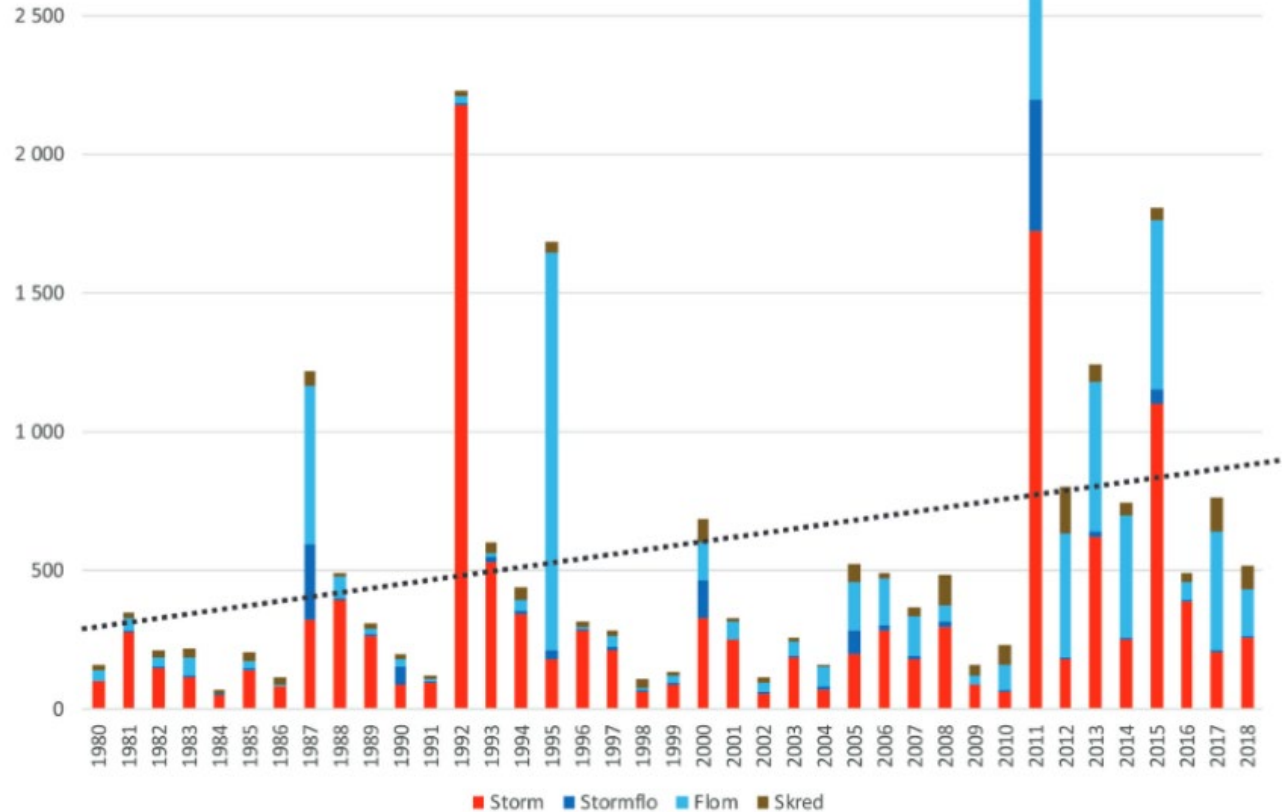
- Transform the indices to a common scale from 0 to 100
- Weight the indices on exposure based on the damage each of the hazard make (using data from the Norwegian Natural Perils Pool)

$$x' = \frac{x - \min}{\max - \min} \times 100$$



# Norwegian Natural Perils Pool

3 000 M NOK  $\approx$  300 M USD



# COP27 Result

Welcome to BBC.com <https://www.bbc.com/news/science-environment-63677466>

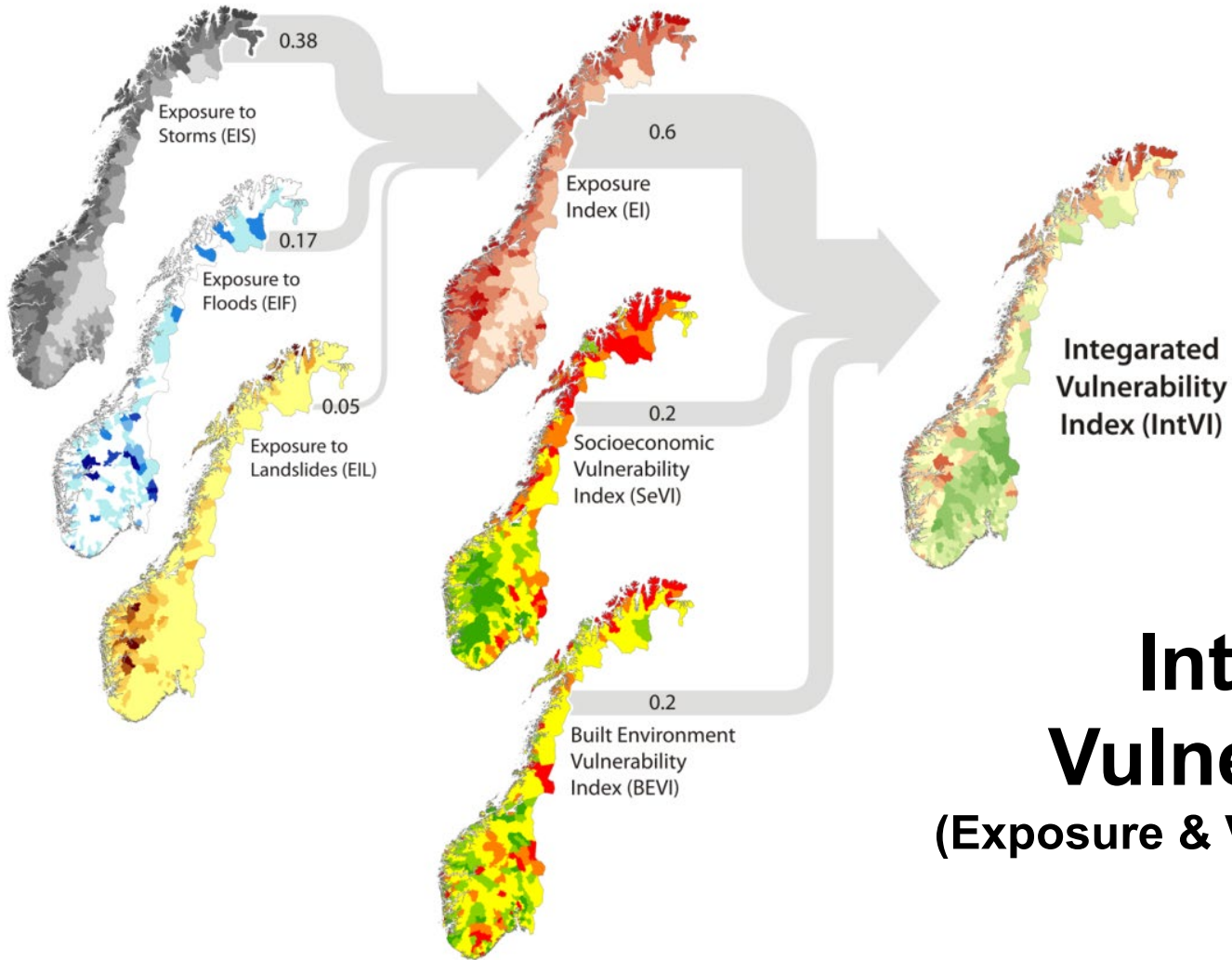


## Climate costs deal struck but no fossil fuel progress

Rich nations will pay climate damages, but the final deal does not cut fossil fuels further.

SCIENCE & ENVIRONMENT





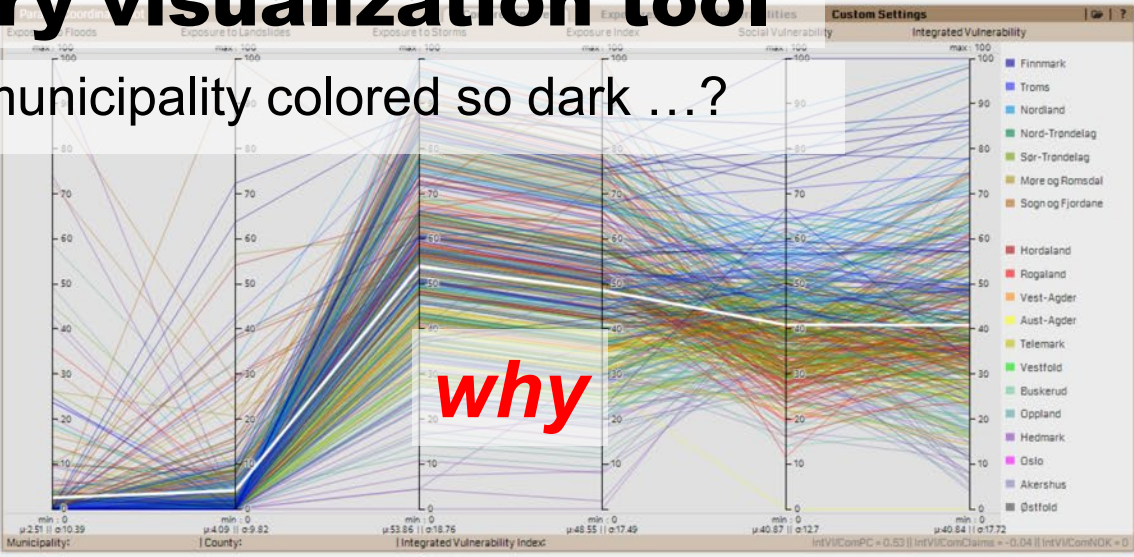
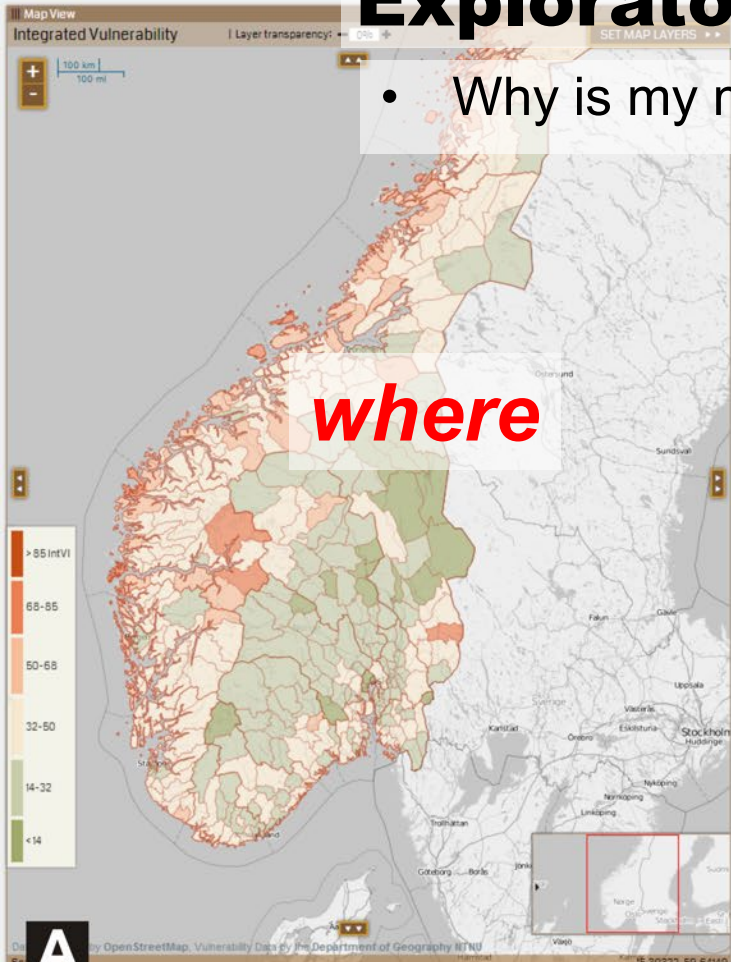
# Integrated Vulnerability (Exposure & Vulnerability)

# Exploratory visualization tool

- Why is my municipality colored so dark ...?

*where*

*why*



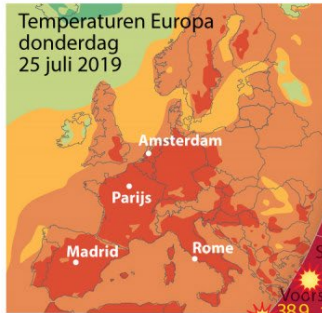
#	Municipality	County	Exp. to Floods	Exp. to Landsl.	Exp. to Storms	Exposure Index	Social Vulnerability	Integrated Vulnerabil.	FloStoPhySocInt	Integrated Vulnerabil.	PopSocEco
0	Gamvik	Finmark	0	0	84.81	75.43	84.65	88			59.81
1	Nordkapp	Finmark	0	72.31	88.27	86.88	85.37	98.03			54.61
2	Berlevåg	Finmark	0	0	83.81	74.52	82.75	96.16			83.97
3	Båtsfjord	Finmark	0	0	83.42	74.16	77.08	82.68			37.56
4	Måsøy	Finmark	0	9.78	88	79.47	100	100			58.55
5	Tana	Finmark	1.54	1.75	47.59	42.15	50.15	40.66			64.54
6	Vardo	Finmark	0	0	84.99	75.59	79.63	85.32			65.68
7	Vadsø	Finmark	0	0	50.96	44.41	48.93	41.88			44.25
8	Hammerfest	Finmark	0	38.37	60.26	57.33	56.7	57.1			39.71
9	Nesseby	Finmark	0	1.1	84.03	56.52	58	57.15			76.05
10	Kvalsund	Finmark	0	1.72	62.66	56.33	59.48	56.98			74.24
11	Lebesby	Finmark	0	13.14	73.99	67.02	78.89	77.69			61.52

# Using Citizen Sensing to Identify Heat Exposed Neighborhoods

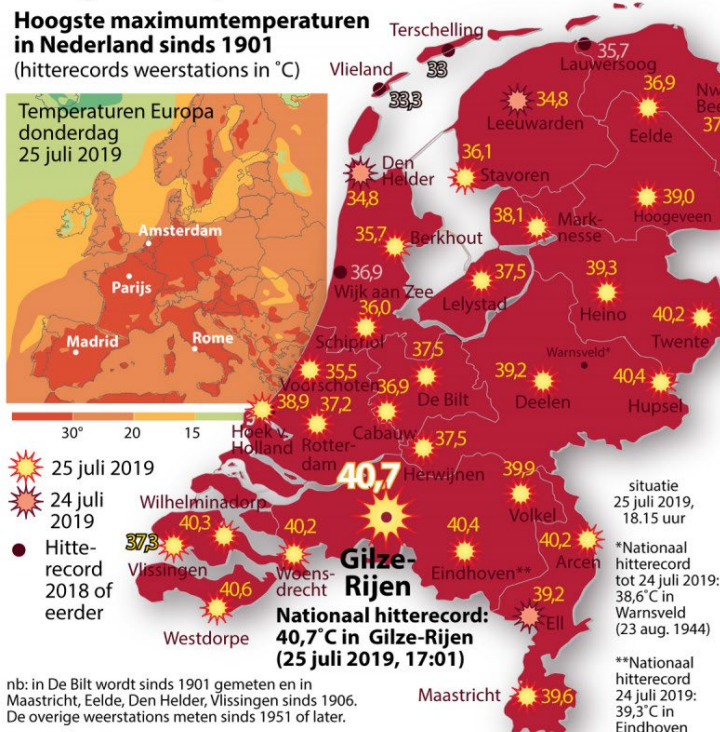
## Hittegolf Europa levert nieuw nationaal hitteste record op

### Hoogste maximumtemperaturen in Nederland sinds 1901

(hitteste records weerstations in °C)



- 25 juli 2019
- 24 juli 2019
- Hitteste record 2018 of eerder

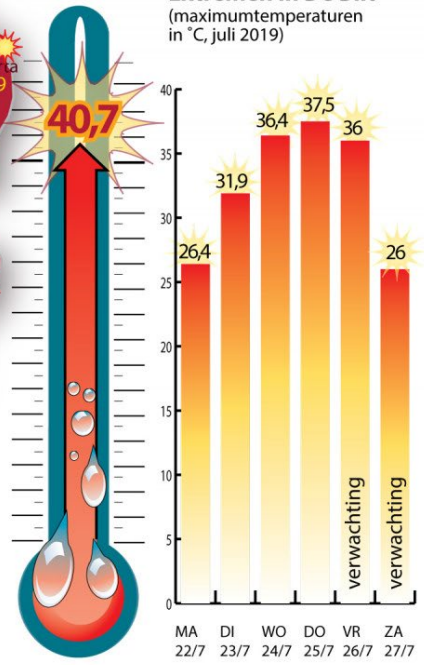


situatie 25 juli 2019, 18.15 uur  
\*Nationaal hitteste record tot 24 juli 2019: 38,6°C in Warnsveld (23 aug. 1944)  
\*\*Nationaal hitteste record 24 juli 2019: 39,3°C in Eindhoven

nb: in De Bilt wordt sinds 1901 gemeten en in Maastricht, Eelde, Den Helder, Vlissingen sinds 1906. De overige weerstations meten sinds 1951 of later.

bron: Weeronline

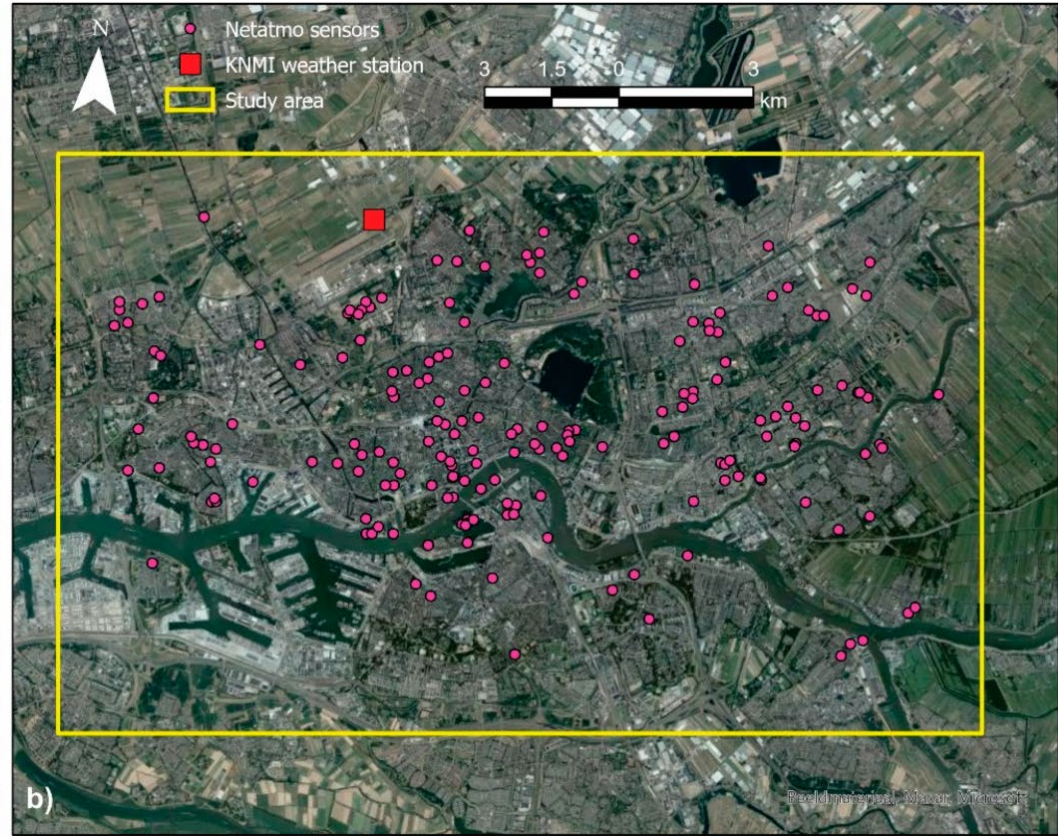
### Extremen in De Bilt (maximumtemperaturen in °C, juli 2019)

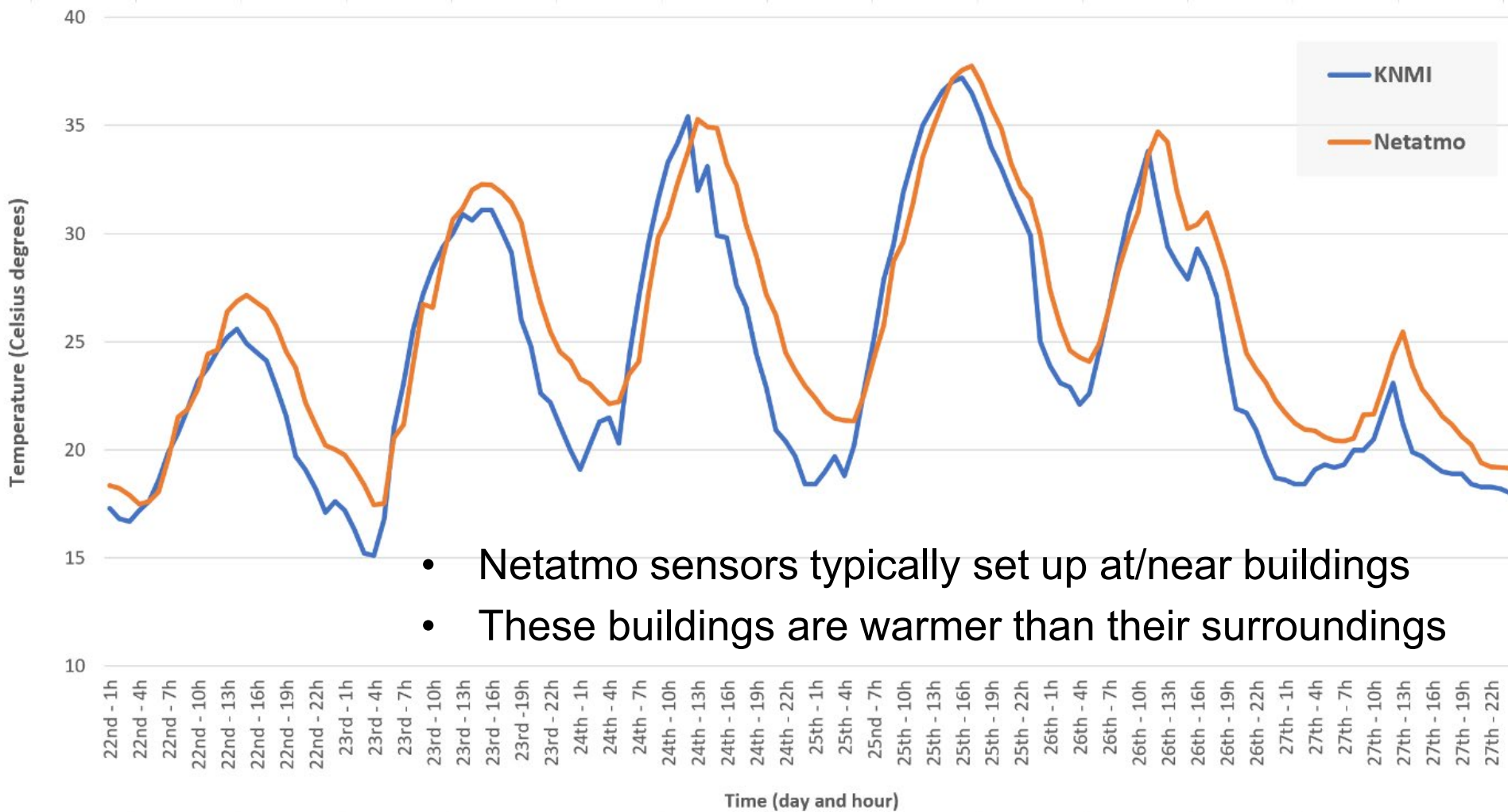


ANP



# Few official weather stations



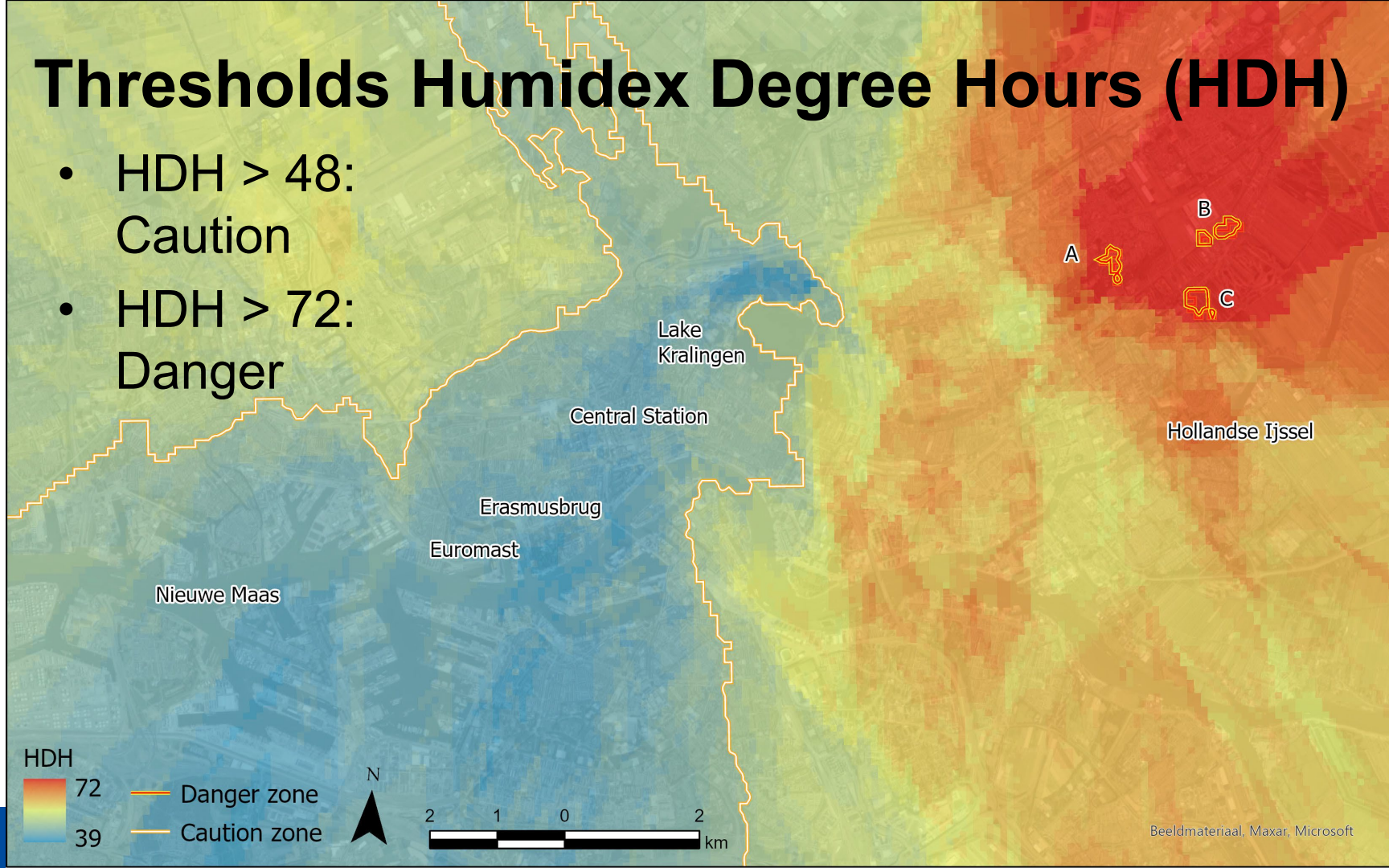


- Netatmo sensors typically set up at/near buildings
- These buildings are warmer than their surroundings



# Thresholds Humidex Degree Hours (HDH)

- HDH > 48:  
Caution
- HDH > 72:  
Danger



# Demographic data on neighborhood level

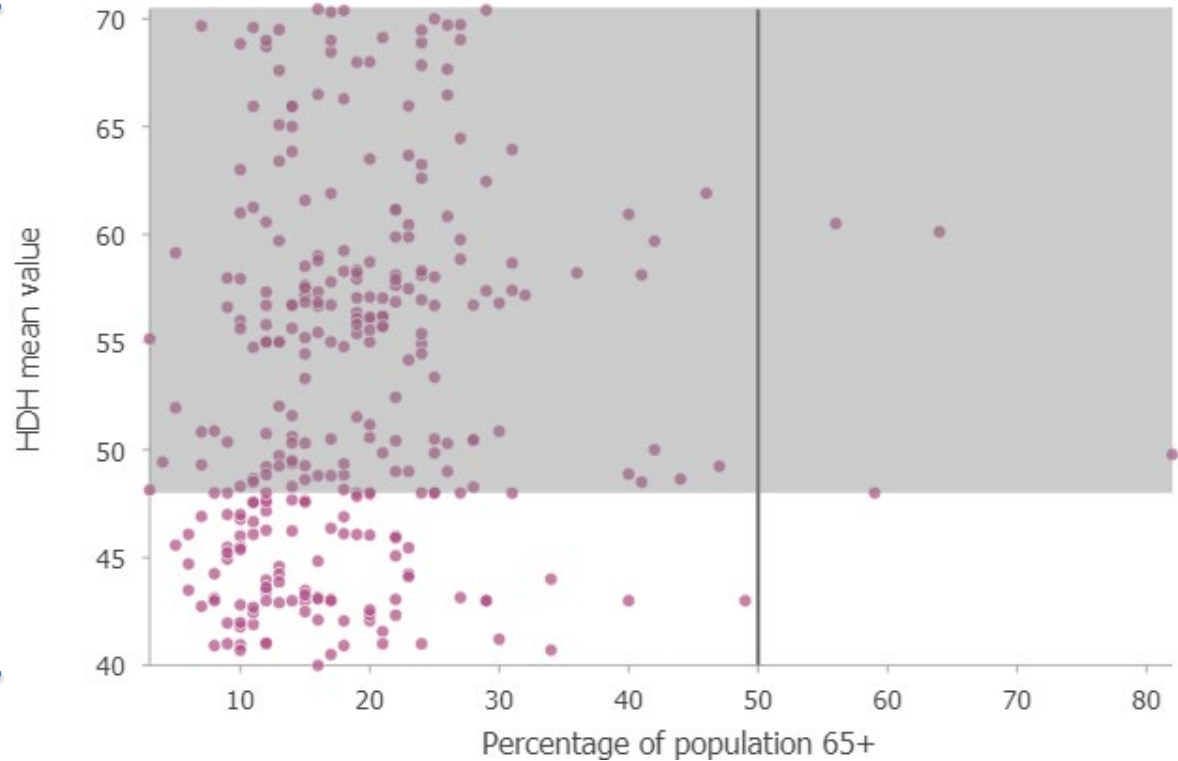


% of tot pop aged 65+

# Scatter Diagram

Exposure

- Each dot is a neighborhood

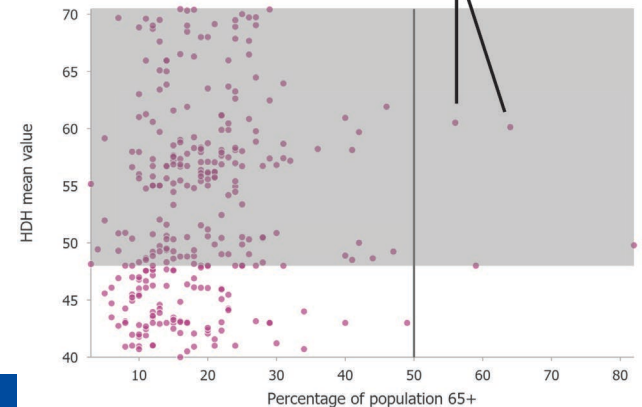
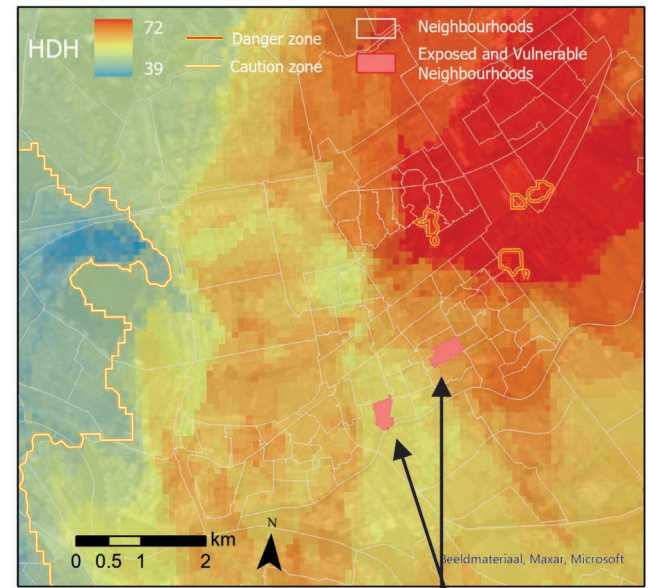


Vulnerability



# Scatter Diagram linked to a map

- Helps identify heat exposed neighbourhoods populated with vulnerable people



# Netatmo weather stations in Uganda

The image displays a screenshot of the Netatmo web interface, showing a map of East Africa with several weather stations marked by red location pins. The interface includes a search bar, navigation icons, and a temperature scale at the bottom right. The map shows major cities like Kampala, Nairobi, and Mwanza, along with geographical features like Lake Victoria and Lake Tanganyika. A red arrow points from the physical weather stations on the left to the map, and a blue arrow points from the map to the interface's bottom navigation bar.

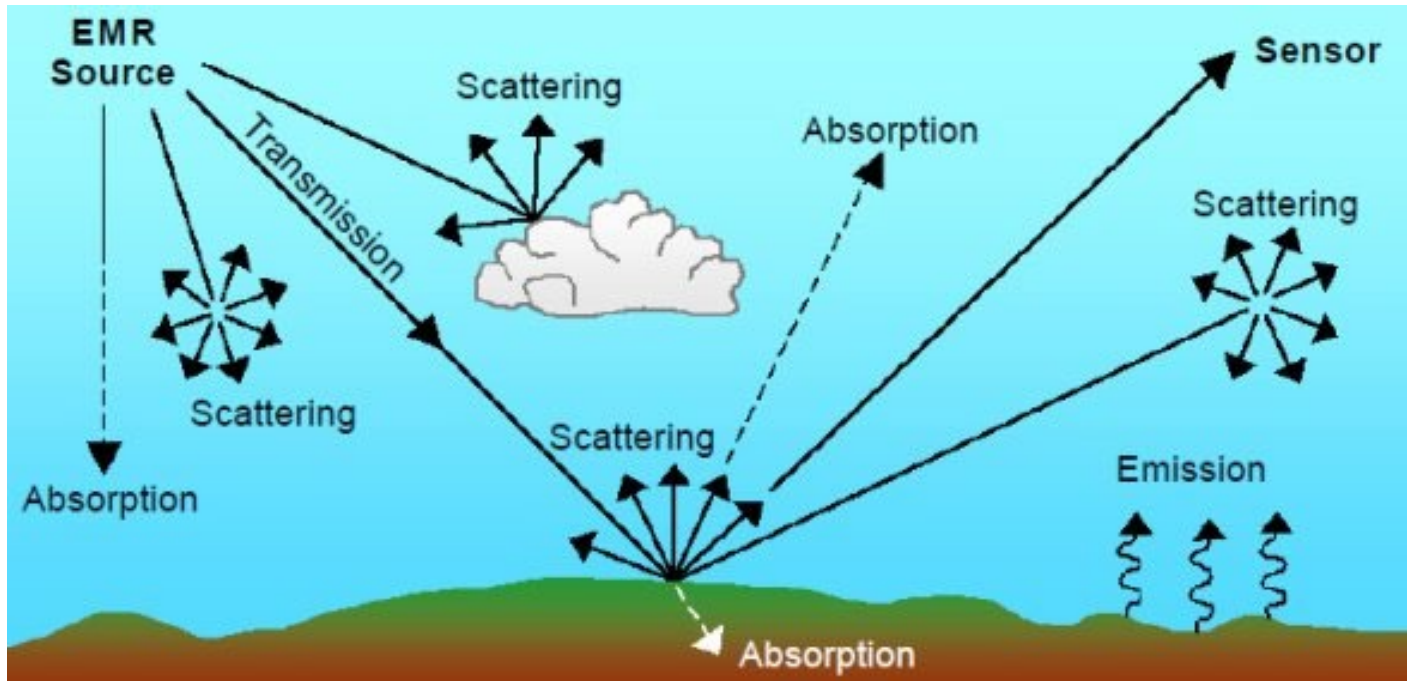
Physical weather stations shown on the left include:

- A tall, silver, cylindrical station.
- A shorter, silver, cylindrical station.
- A black, cylindrical station with a clear lens on top.
- A black, cylindrical station with a clear lens on top and a white base.

The Netatmo web interface screenshot shows:

- Search bar: Search Place
- Navigation: Favorites, Netatmo logo, Dashboard, Logout
- Map: East Africa region, with pins for stations in Uganda (Kampala), Rwanda (Kigali), Kenya (Nairobi), and Tanzania (Mwanza).
- Temperature scale: -30 to 50 °C
- Bottom navigation bar: Home, Add, Settings, etc.

# Land surface temperature from space



- Sentinel
- ASTER
- MODIS
- LANDSAT
- ...

Source: Quora

# Climate change – a health risk

## Environment and Urbanization

### Hazards and vulnerabilities among informal wetland communities in Kampala, Uganda

John Bosco Isunju<sup>1</sup>, Christopher Garimoi Orach<sup>2</sup>, and Jaco Kemp<sup>3</sup>

- (A) flooded access paths;
- (B) flood barriers made of sandbags;
- (C) flooded house; and
- (D) unprotected well prone to contamination



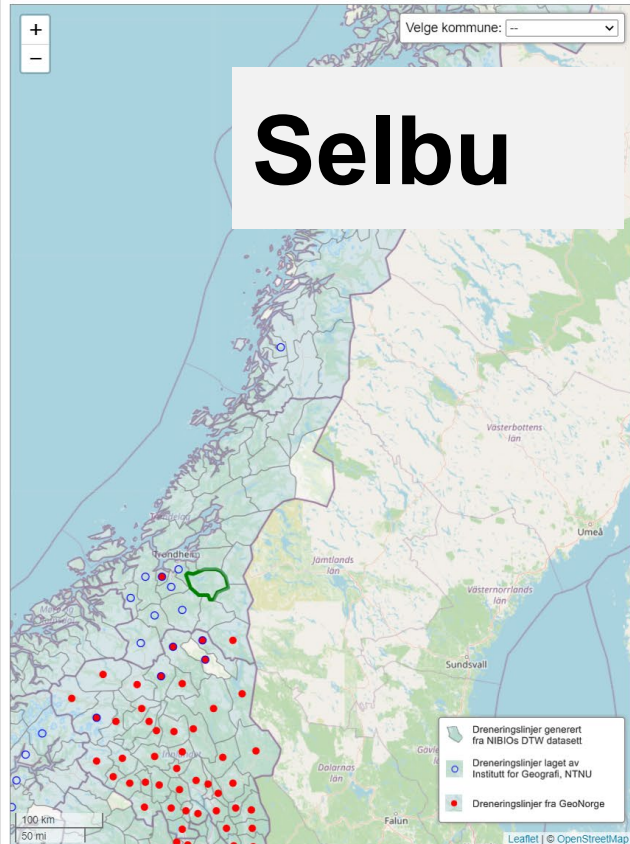


# WaterClimateRisk

- The risk of polluted ground to be «washed out» due to riverine or pluvial flooding, landslide, or storm surge



skritt 1  
VELG KOMMUNE



skritt 2  
SJEKK TILGJENGELIGE DATA

Kommune og fylke:

SLETTE VALG ✕

**Selbu** (kommunenummer: 5032)

Trendelag

Ved ekstremnedbør som resulterer i overvann kan det i Selbu være:

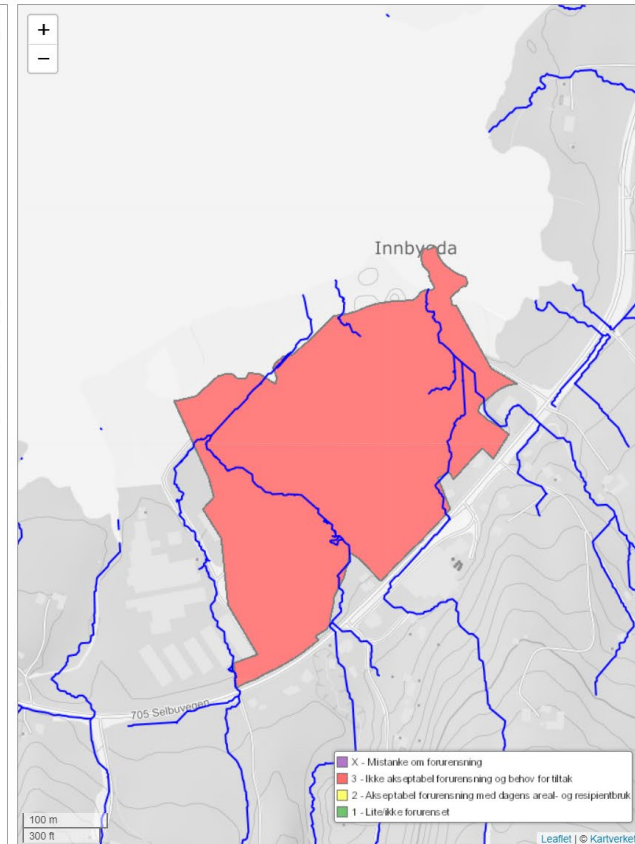
- 0 eksponerte lokaliteter der det er mistanke om forurensning
- 1 eksponerte lokaliteter med ikke akseptabel forurensning
- 1 eksponerte lokaliteter med akseptabel forurensning
- 0 eksponerte lokaliteter som er lite/ikke forurenset

Tilgjengelige data:

Tilgjengelige data	Format	
Dreneringslinjer generert fra NIBIO's DTW dataset 99.93% coverage of the municipality	Zipped ESRI shapefile in ETRS 1989 UTM Zone 33N	LAST NED ⬇
Dreneringslinjer generert fra NIBIO's DTW dataset 99.93% coverage of the municipality	WMS: <a href="https://geo.it.ntnu.no/map_waterlines/?LAYER=Dreneringslinjer_DTW_5032">https://geo.it.ntnu.no/map_waterlines/?LAYER=Dreneringslinjer_DTW_5032</a>	FORHÅNDSVISNING 🗺



skritt 3  
FORHÅNDSVISNING



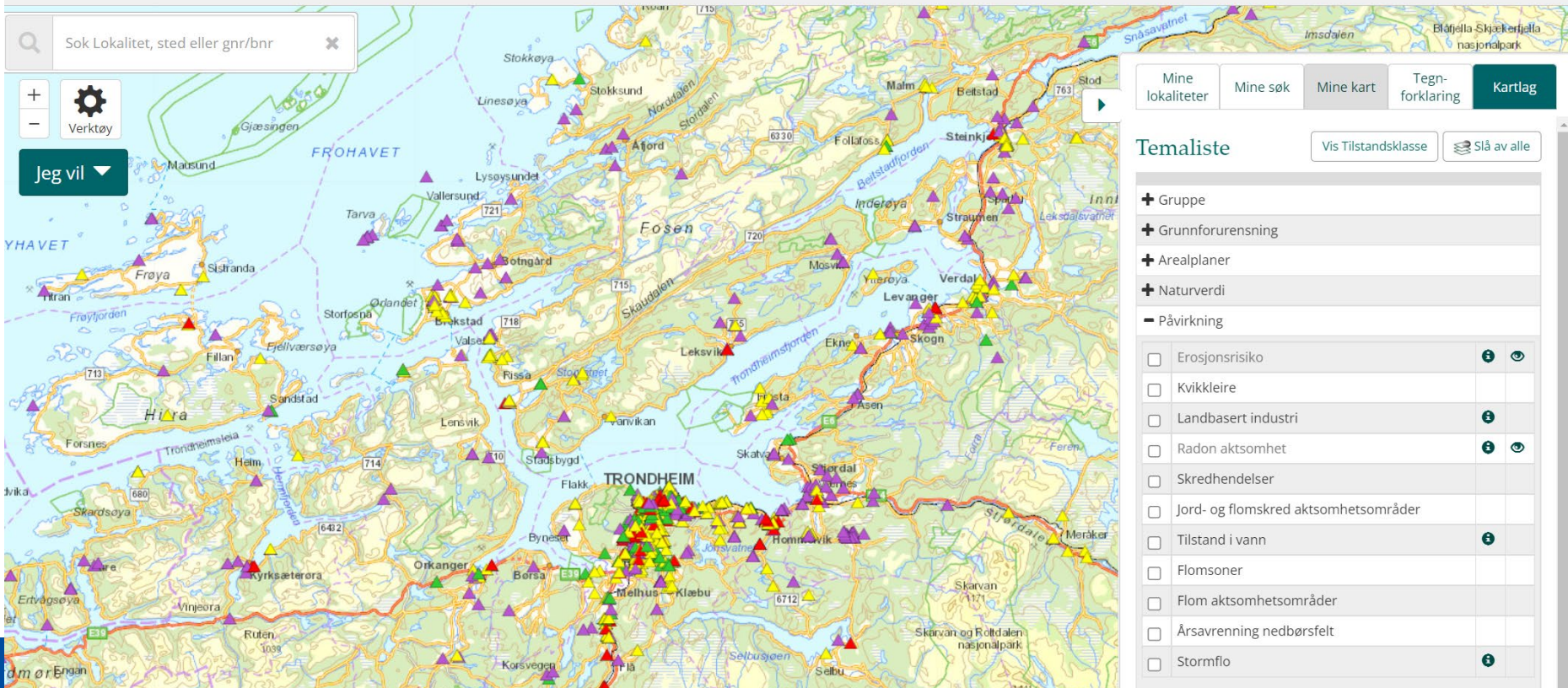


# Data viewer – Polluted Ground



Verktøy

Jeg vil ▼



- Mine lokaliteter
- Mine søk
- Mine kart
- Tegn-forklaring
- Kartlag

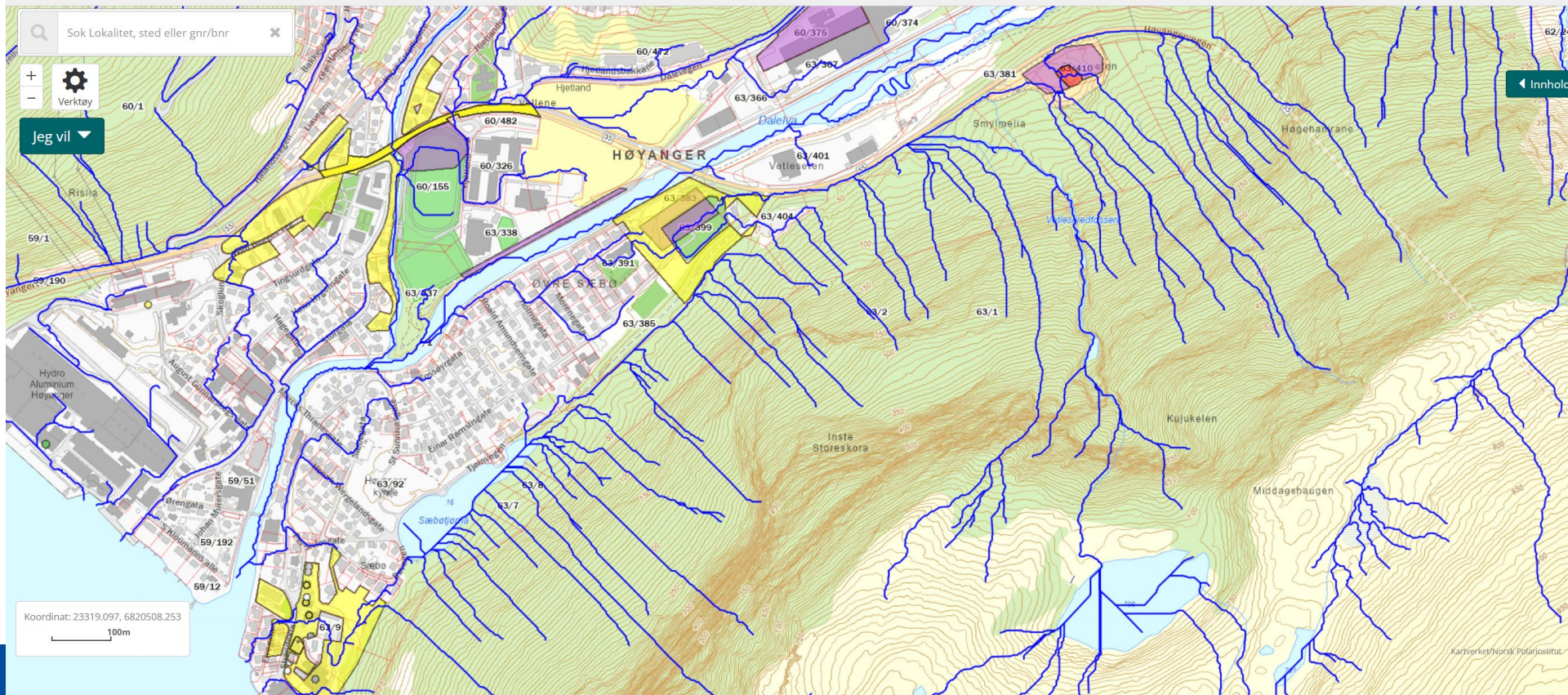
## Temaliste

Vis Tilstandsklasse  Slå av alle

- + Gruppe
- + Grunnforurensning
- + Arealplaner
- + Naturverdi
- Påvirkning
- Erosjonsrisiko
- Kvikkleire
- Landbasert industri
- Radon aktsomhet
- Skredhendelser
- Jord- og flomscred aktsomhetsområder
- Tilstand i vann
- Flomsoner
- Flom aktsomhetsområder
- Årsavrenning nedbørsfelt
- Stormflo

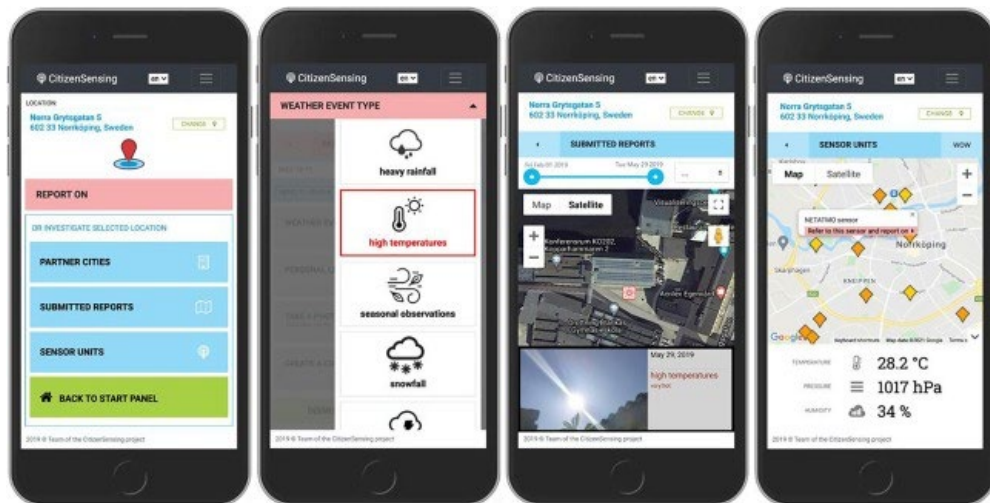
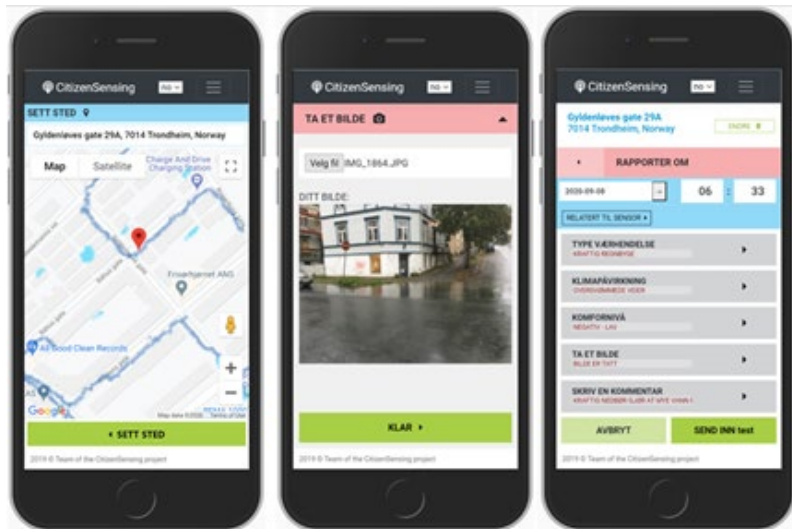


# Add topic (WMS)





# The CitizenSensing app



A

B

C

D

# Exposed buildings – Pluvial flooding

CitizenSensing no

SETT STED

Hosanger, Hosanger, Norway

Map

Mjøsvågen

567

Keyboard shortcuts Map data ©2022 Terms of Use

SETT STED

This screenshot shows the CitizenSensing app interface. The top bar includes the app name and a language dropdown set to 'no'. Below is a location search bar containing 'Hosanger, Hosanger, Norway'. A 'Map' button is visible. The main map area shows a regional view of Norway with a red location pin and a blue shaded area representing pluvial flooding. A person icon and zoom controls are on the right. The bottom bar shows 'SETT STED'.

Hosanger prestegård

Hosanger kyrke

Lusavågen

Hosanger

Mjøsvågen

Hole

Østervågen

Østhus

Østhusvegen

Keyboard shortcuts Map Data ©2022 Terms of Use

This screenshot provides a detailed view of the Hosanger area. Buildings are shown in red, and blue lines and areas indicate pluvial flooding. Two buildings are circled in yellow. The map includes labels for various locations like 'Hosanger prestegård', 'Hosanger kyrke', 'Lusavågen', 'Hosanger', 'Mjøsvågen', 'Hole', 'Østervågen', 'Østhus', and 'Østhusvegen'. The bottom bar shows 'SETT STED'.

CitizenSensing no

SETT STED

Østhusvegen 52, 5282 Lonevåg, Norway

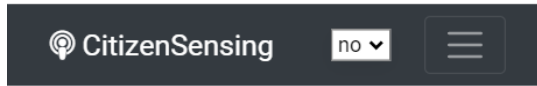
Satellite

Keyboard shortcuts Map Data ©2022 Terms of Use

SETT STED

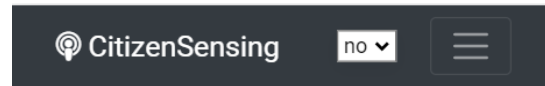
This screenshot shows a satellite view of a specific building. A red location pin is placed on the building. The surrounding area shows green fields and trees. The top bar includes the app name and language dropdown. The search bar contains 'Østhusvegen 52, 5282 Lonevåg, Norway'. A 'Satellite' button is visible. The bottom bar shows 'SETT STED'.

# Handed in reports



STED:

**Fv567 2128**  
5282 Lonevåg, Norway



STED:

**Fv567 2128**  
5282 Lonevåg, Norway

ENDRE 📍



## Takk for ditt bidrag!

Her er noen tilpasningsstrategier for bedre din beredskap og/eller for bedre kunne håndtere en krisesituasjon. Husk å:

1. Vedlikehold sluk, avløp og annet dreneringssystem for regnvann
2. Ha adskilte avløpsrør for kloakk og overvann
3. Installer regnhøsting i tønner
4. Erstatt impermeable overflater (betong og asfalt) med gresskledd vannveier
5. Kjør forsiktig
6. Vær spesielt oppmerksom langs kysten og store elver
7. Unngå å krysse oversvømmede områder

## RAPPORTER OM

ELLER UTFORSK VALGT STED

KOMMUNEPROFILER



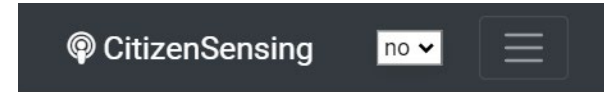
LEVERTE RAPPORTER



SENSORER



TILBAKE TIL START



**Fv567 2128**  
5282 Lonevåg, Norway

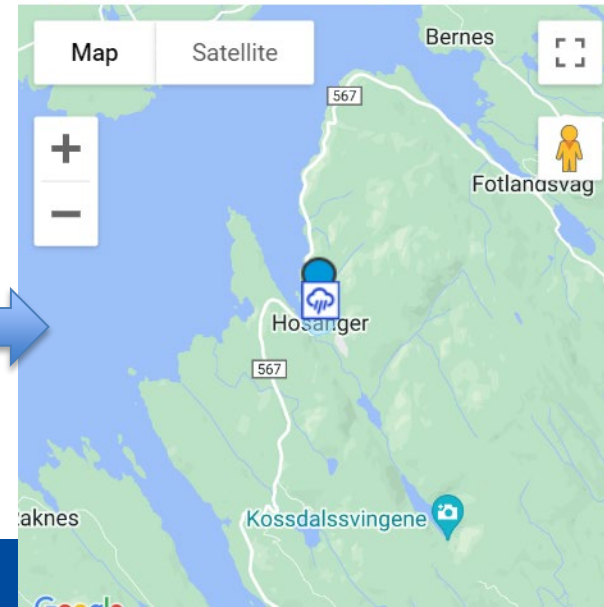
ENDRE 📍



Sun Aug 01 2021

Sun Sep 11 2022

ALL



# Concluding remarks

- CC will make it hotter, warmer, and wilder → increased hazard → increased disaster risk
- Important to know *where* the most exposed and vulnerable areas are → strategic climate change adaptation → reduce exposure and vulnerability → reduce disaster risk
- People care about their near environments → visualize cc effect for these locations → increase engagement
- Geospatial tool essential