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«Se havnivå i kart»

Norway's coastal service for visualizing sea-level rise and storm surge by maps

Workshop on sea level rise

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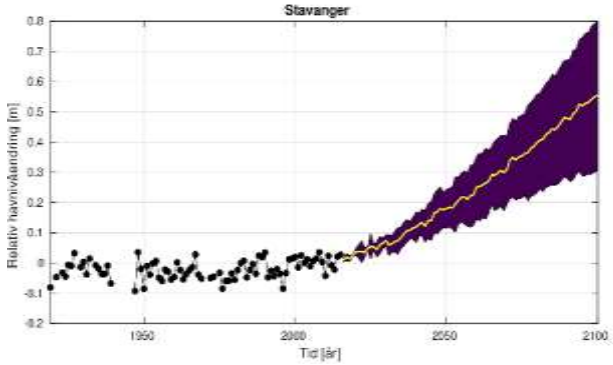
Norway is at relatively low physical vulnerability to sea-level rise, but will face some challenges

Steep topography
Bedrock resistant to erosion

Extensive recent coastal development, expensive infrastructure

Coastal cultural monuments, e.g., “Bryggen” in Bergen



The recommended sea-level increase for use in planning along the Norwegian coast ranges between 40 and 82 cm

Many homes and cabins next to the sea

Harsh weather
Photo: Jan Ivar Rødli, Promo Norge, (Kartverket.no)

Low lying industrial areas
Photo: Joakim Aleksander Mathisen (Wikipedia)

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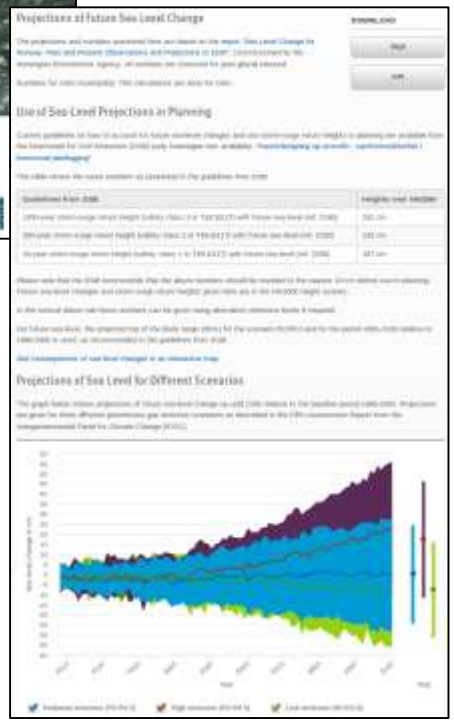
Projections for future sea-level change and return-levels for storm surge have been available since 2015



- …as text, figures, and tables
- The numbers alone do not communicate the full consequences of higher sea-level and storm surges
- The use of projections and return levels requires expert knowledge

https://kartverket.no/en/sehavniva/

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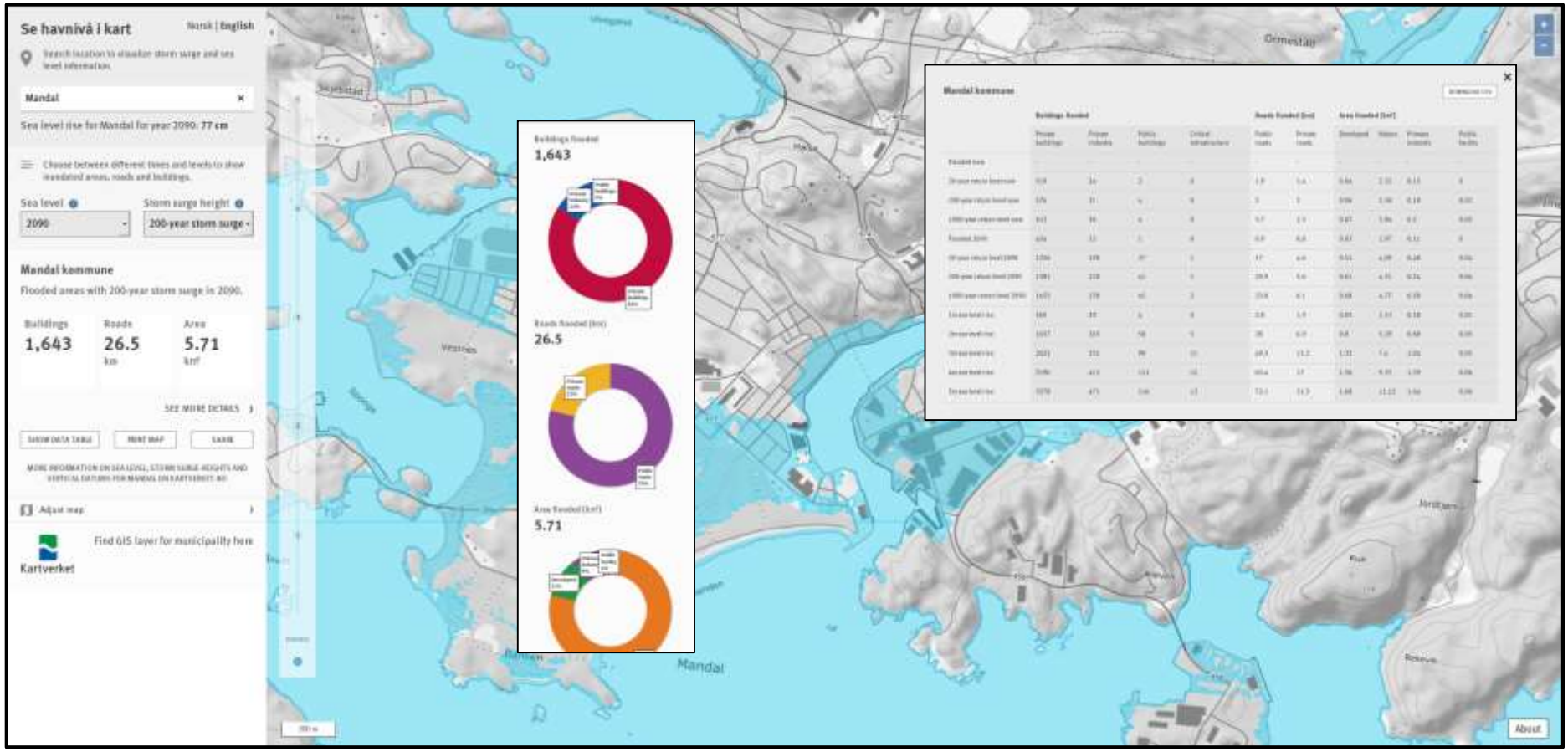
“Se havnivå i kart” is a coastal service for visualizing the consequences of sea-level rise and storm surges



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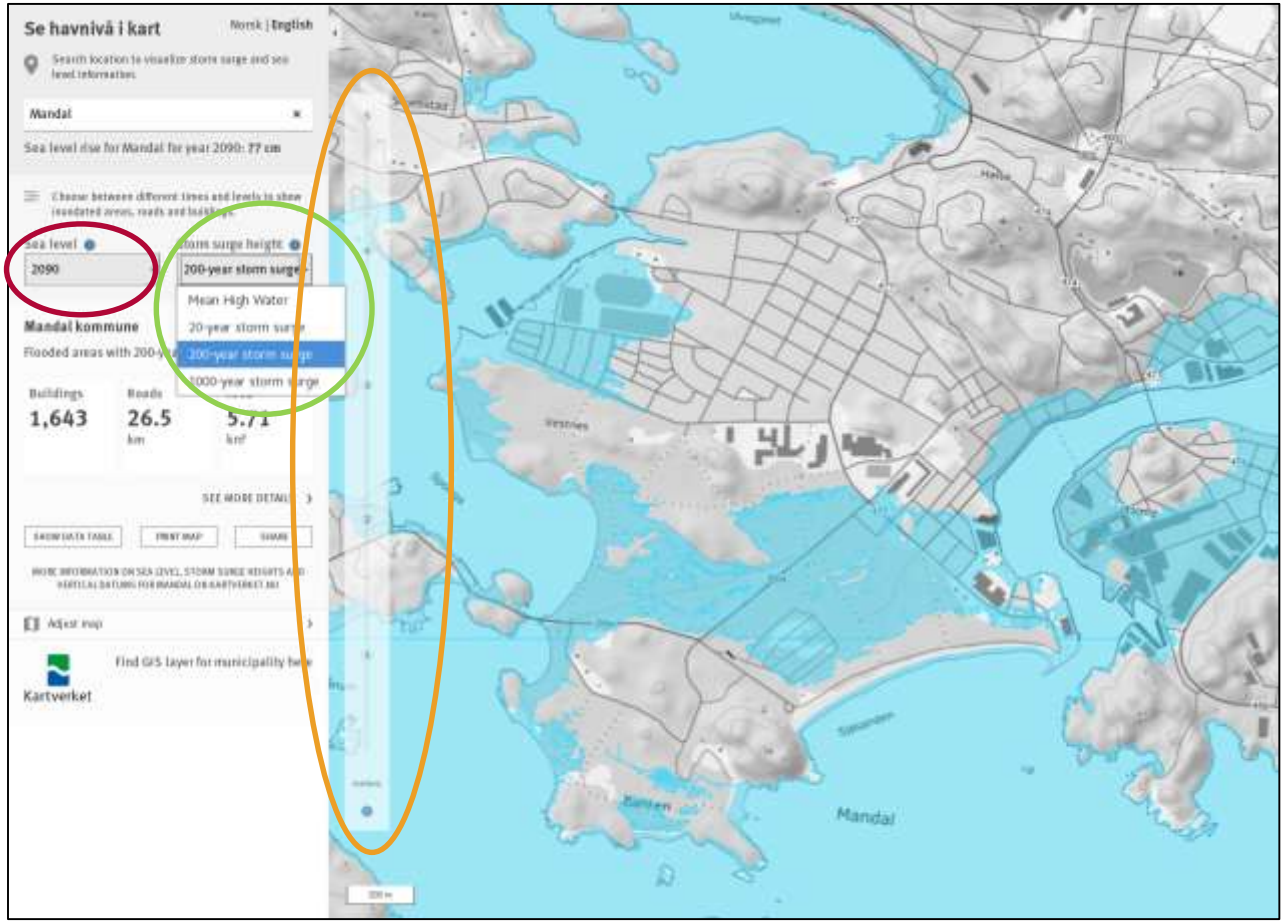
[Se havnivå i kart = View sea-level rise by maps]

“Se havnivå i kart” is made for both professional users and the public



Guidelines from the Norwegian Directorate for Civil Protection recommend that the top of the likely range of RCP8.5 is used for planning

The available storm surge heights correspond to safety classes in current buildings acts and regulations for Norway

The sea level can be set between 1 and 5 m above present Mean High Water by a slider

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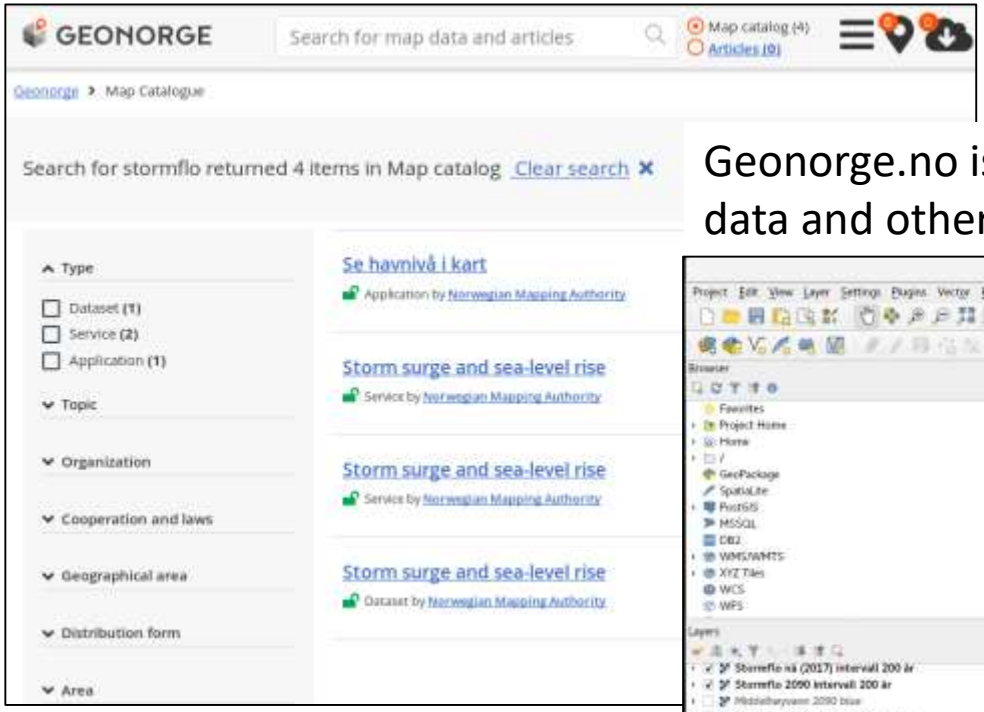
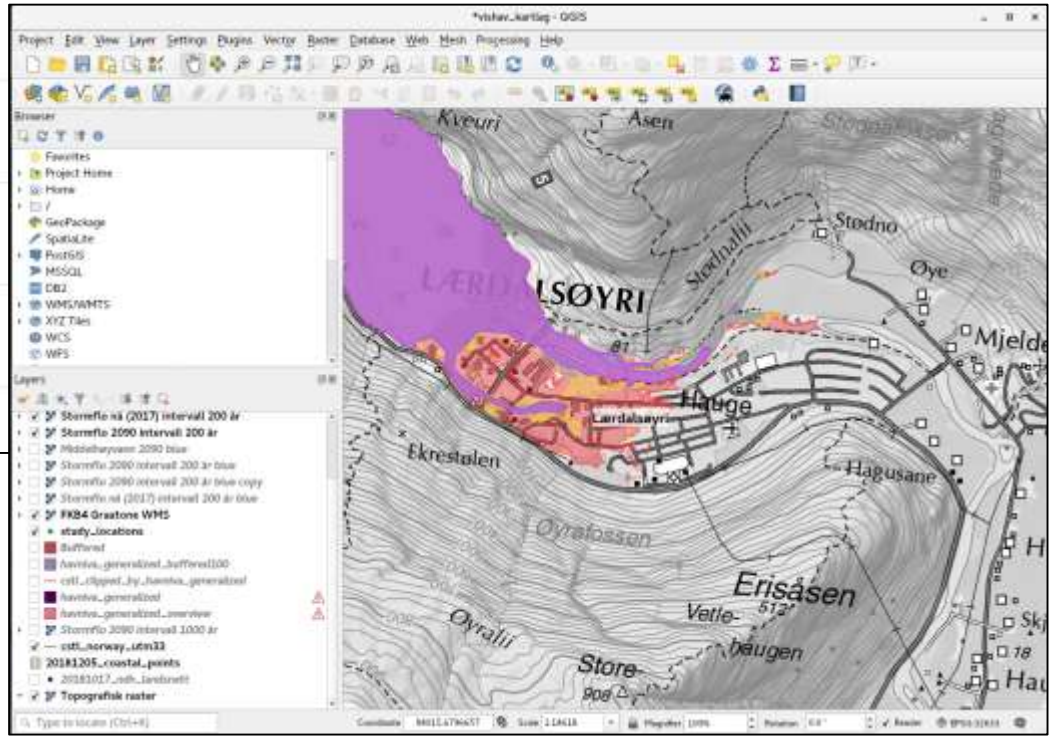
Professional users may download the inundation layers for use in custom GIS-applications



Geonorge.no is the national website for map data and other location information in Norway



"Se havnivå i kart" is primarily focused on providing information that can be used in climate adaption work

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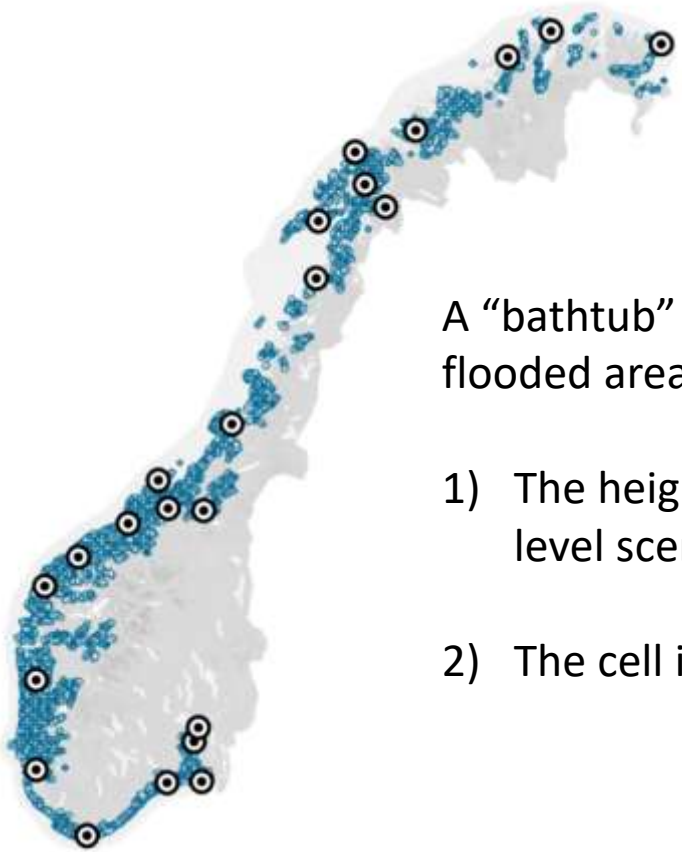
The inundation maps are made by combining sea-level projections and storm-surge heights with a 1 x 1 m DEM from LiDAR and registers of buildings, land cover, and roads



A “bathtub” approach was used for identifying flooded areas. A cell in the DEM is flooded if:

1) The height of the cell is below the given sea-level scenario or storm surge return height

2) The cell is hydrologically connected to the sea

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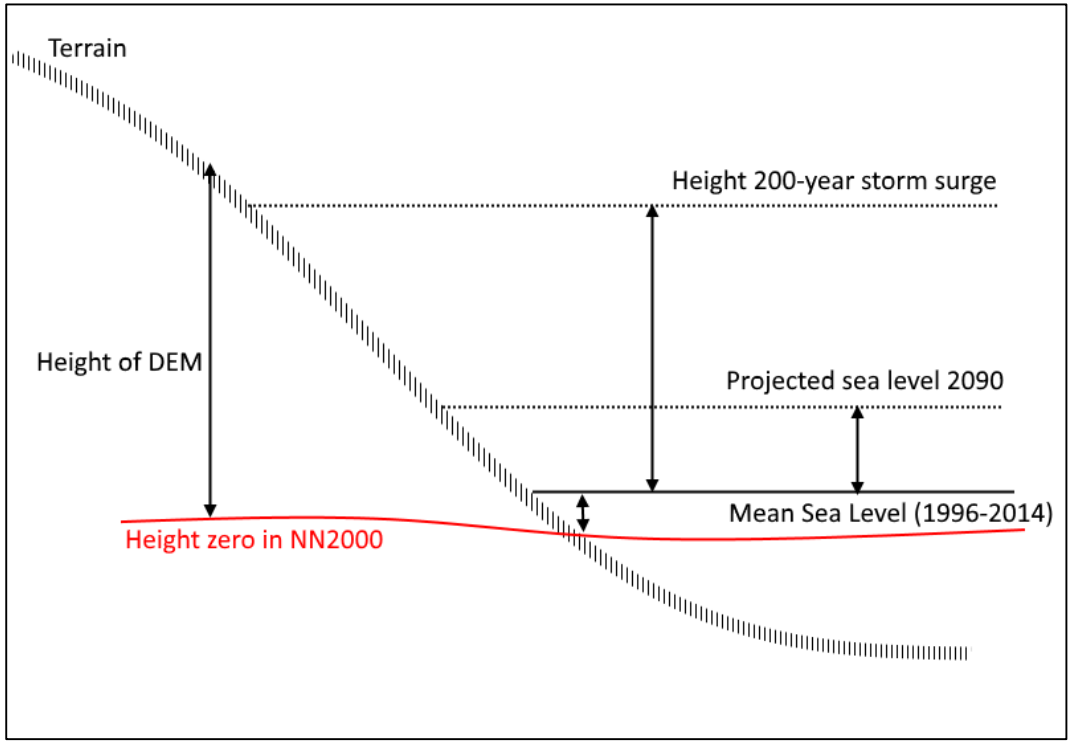
[DEM: Digital Elevation Model]

To combine elevation data, sea-level scenarios, and storm-surge heights, knowledge of transformations between different vertical reference systems is required



Sea-level projections and storm surge heights are given with respect to Mean Sea Level

The elevation data are given in NN2000 (Norway's national vertical reference system)

In general, the height of Mean Sea Level in NN2000 is accurately known only at 23 tide gauges along the Norwegian coast

Norwegian registers of buildings and roads do not include attributes that allow structures above the water surface to be removed from the statistics

[Example from Ormøya, Oslo]

MHW-bias	Buildings	Roads
Present Mean High Water	40072	180 km

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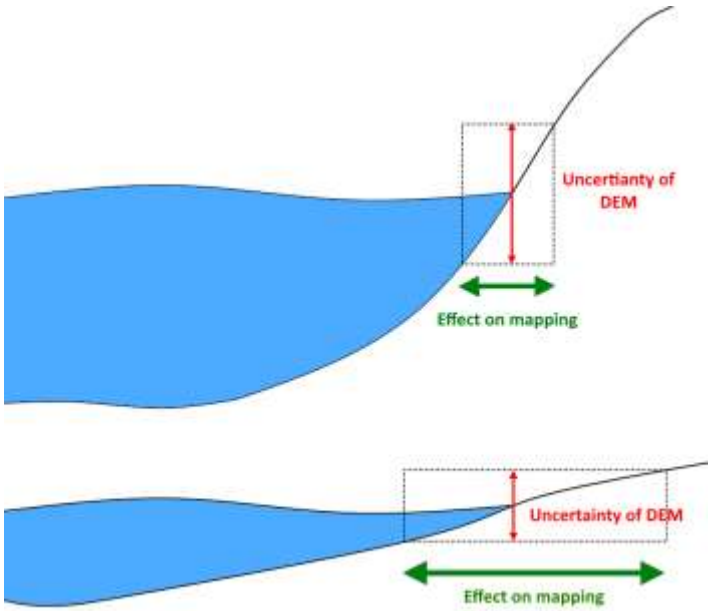
Future work should address how known uncertainties can be incorporated and visualized in our inundation maps

Contributor	Uncertainty [m]
DEM	0.26
HREF	0.01-0.10
Height of MSL in NN2000	0.02-0.10
Height of MHW in NN2000	0.02-0.10
Horizontal position of buildings	0.20-2
Horizontal position of roads and areas	2-50



The effect of the DEM-error on the mapping depends on the slope of the terrain

We believe that the effect of the sum of these mapping errors are generally smaller than the projected sea-level rise

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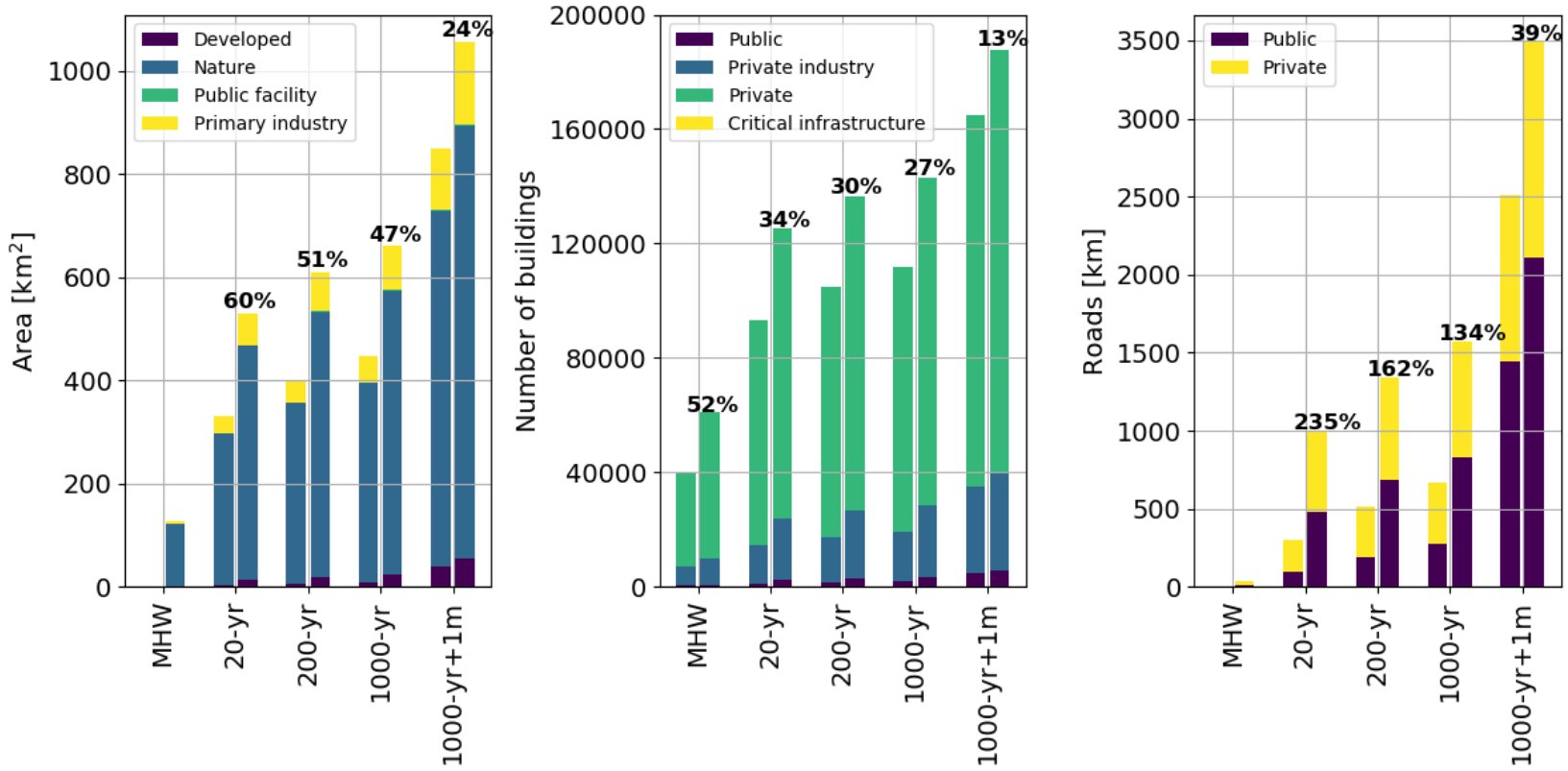
The number of buildings, roads, and areas affected by a 200-year storm surge, will increase considerably from now to 2090



Left bars: Present. Right bars: 2090

For each water level, the percentages indicate the increase from present to 2090

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To summarize: For the first time, sea level projections and storm-surge heights are combined with a high accuracy DEM and geospatial data in order to map coastal flooding in Norway

"Se havnivå i kart" is made for both professional users and the public

This is no exact mapping, local knowledge and site visits may still be appropriate

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More information…

Breili, K., Simpson, M.J.R., Klokkervold, E., and Ravndal, O.R. (2019). High accuracy coastal flood mapping for Norway using LiDAR data. Natural Hazards and Earth System Sciences Discussions. In review., doi.org/10.5194/nhess-2019-217.

Breili, K., Simpson, M.J.R, Nilsen, J.E.Ø. (2017). Observed Sea-Level Changes along the Norwegian Coast, J. Mar. Sci. Eng., 5(29), doi.org/10.3390/jmse5030029.

Simpson, M.J.R., Ravndal, O.R., Sande, H., Nilsen, J.E.Ø, Kierulf, H.P., Vestøl, O., and Steffen, H. (2017). Projected 21st century sea-level changes, extreme sea levels, and sea level allowances for Norway. J. Mar. Sci. Eng., 5(36), doi.org/20.3390/jmse5040046.

Simpson, M.J.R., Nilsen, J.E.Ø., Ravndal, O.R., Breili, K., Sande, H., Kierulf, H.P., Steffen, H., Jansen, E., Carson, M., and Vestøl, O. (2015). Sea Level Change for Norway: Past and Present Observations and Projections to 2100. Tech. rep., Norwegian Centre for Climate Services, report 1/2015. ISSN: 2387-3027. Oslo, Norway.