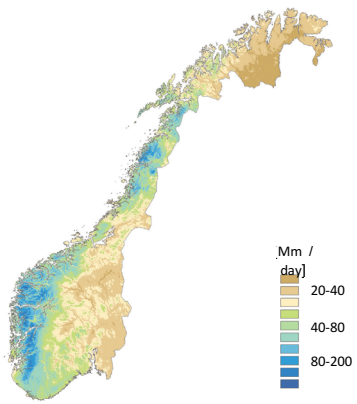
Resilient Energy, Energetic City

Adaptive strategies for coastal regions in transition

Jie Wang / 4578546 / Urbanism / D-i Studio


North Sea

1. **Climtate change** is happening





1.Melting glaciers
2.Less snow in winter
3.Rainstorm
4.Urban flood

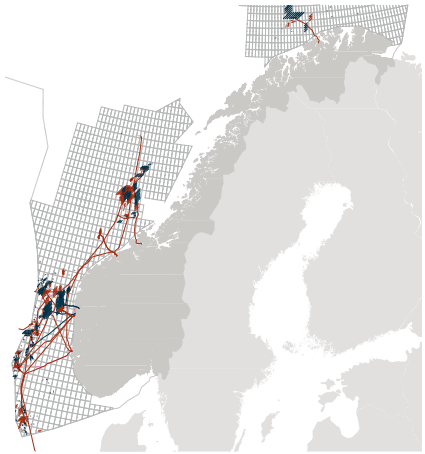
Source: Hanssen-Bauer, I., Drange, H., Førland, E. J., Roald, L. A., Børsheim, K. Y., Hisdal, H., ... & Sundby, S. (2009). Klima i Norge 2100. Bakgrunnsmateriale til NOU Klimatilpassing., Norsk klimasenter, Oslo, Norway.

2. **Energy transition** is required

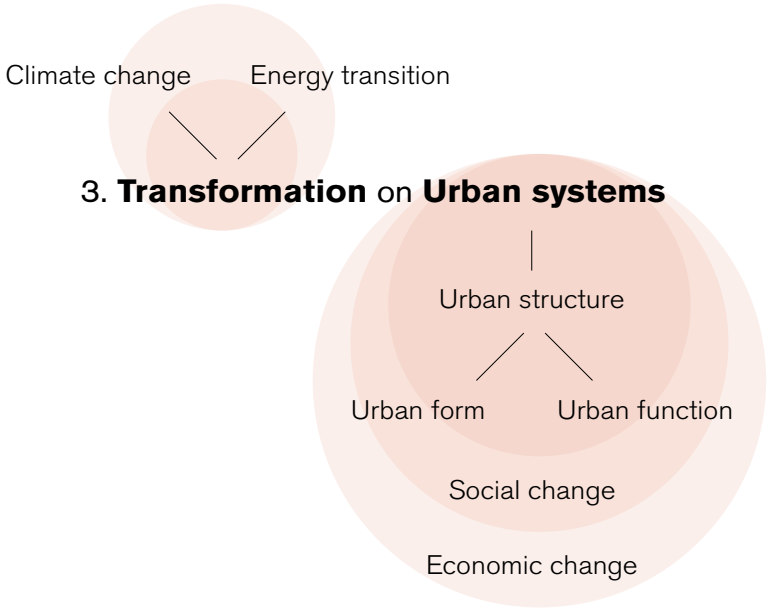
Final goal

-->2050

- Climate neutral
- keep the increased temperature under 1.5 degree



Source: by Norway Group 4 members


Climate change
Energy transition
3. **Transformation** on **Urban systems**
Urban structure
Urban form
Urban function
Social change
Economic change

Problem statement

Oil & gas assets

Tropical cyclones and hurricanes can damage assets and reduce production rates

Oil & gas pipelines

Thawing permafrost, floods and landslides can affect the asset itself, pipeline flow and associated revenue

Transmission and distribution

Strong winds and ice-storms can damage above ground T&D lines and affect associated revenue streams

Renewables

Strong winds, storms but also increased cloud conditions can result in equipment damage, erratic output and lost revenue.

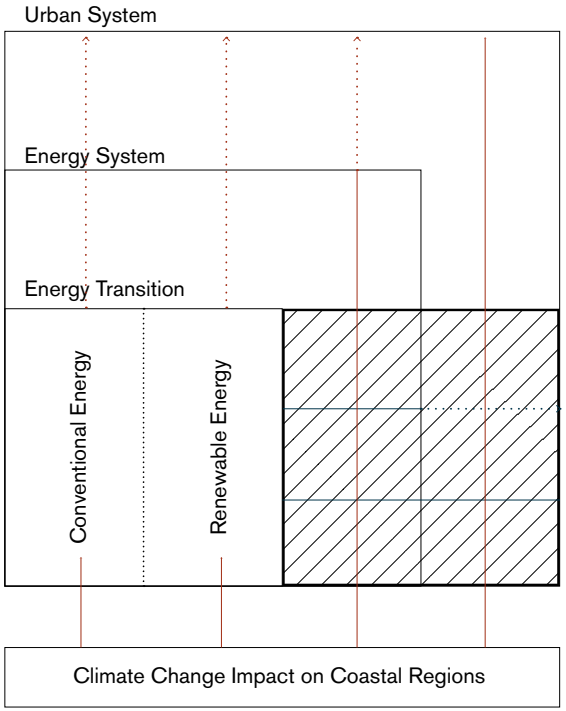
Thermal electricity generation

Floods, storms and cyclones can damage equipment and restrict generation. Rising air and water temperatures affect thermal efficiency, with impacts on cost and revenue.

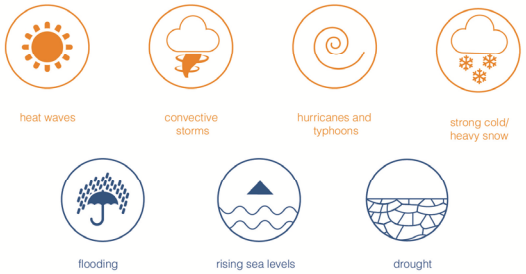
Hydropower

Hydropower plants are highly vulnerable to changes in the hydrologic cycle, including water stress, drought, floods, cyclones and higher temperatures. Equipment can be damaged and output reduced.

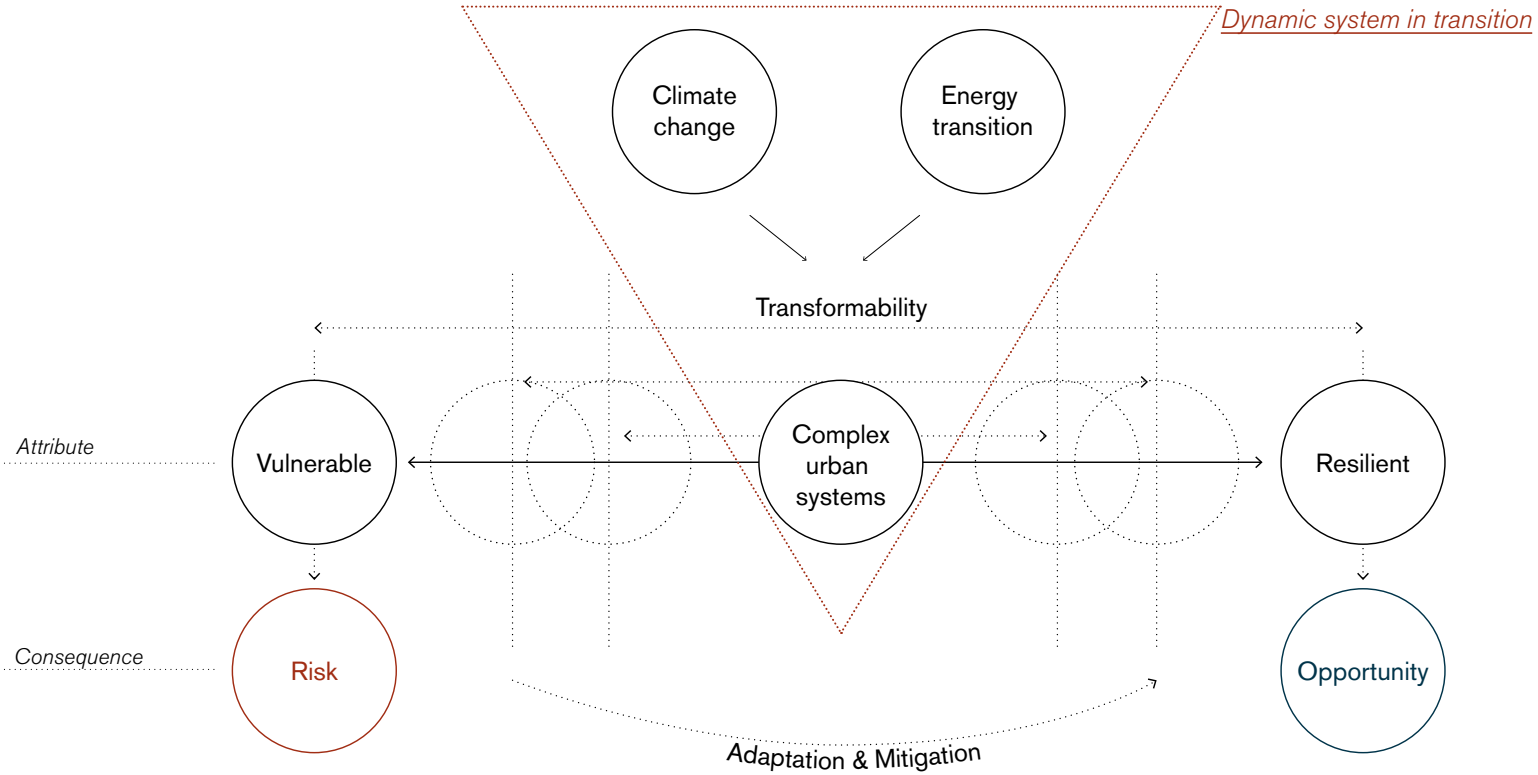
Source: 2015 Wolrd Energy Concil, Marsh and McLennan Companies, Swiss Re Corporate Solutions



Source: by author



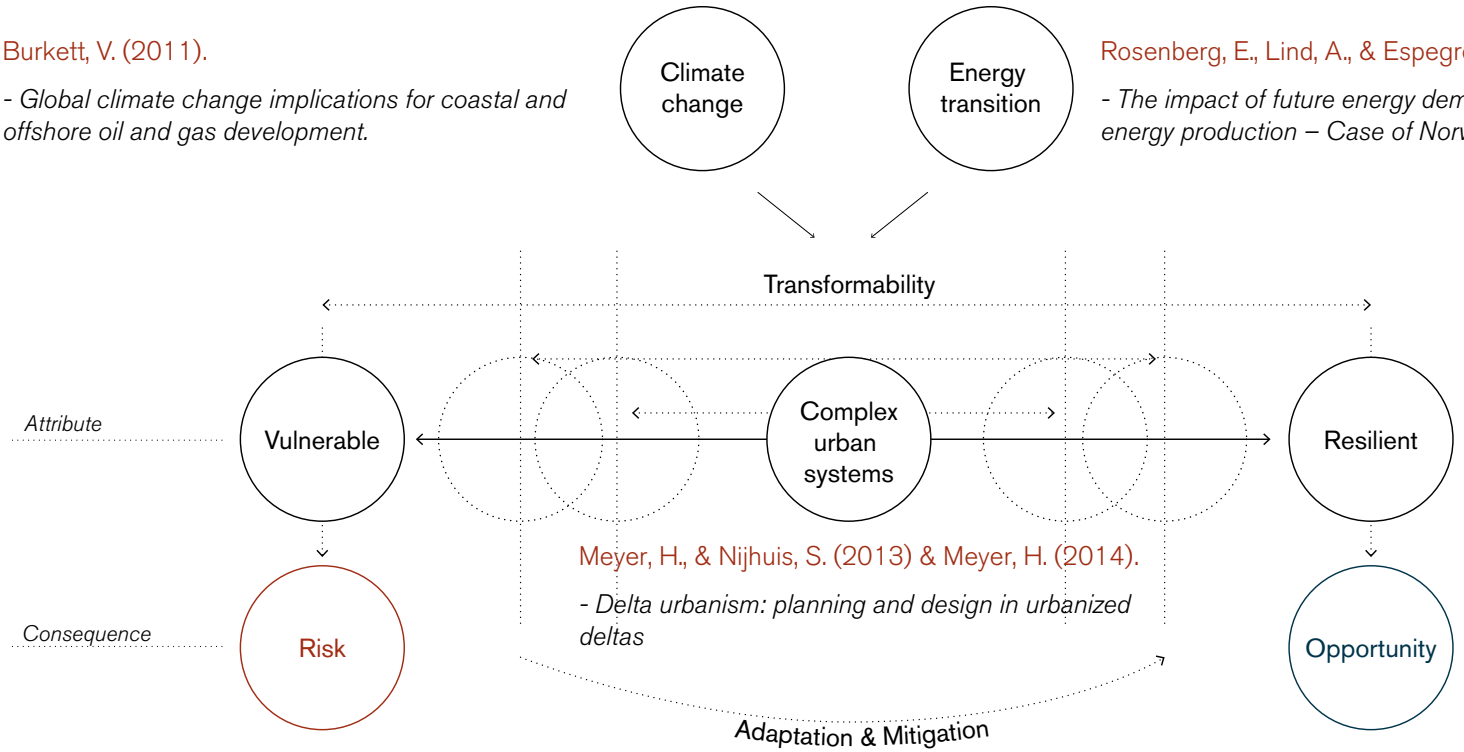
Theoretical analysis



Theoretical analysis

Burkett, V. (2011).

- Global climate change implications for coastal and offshore oil and gas development.



Rosenberg, E., Lind, A., & Espegren, K. A. (2013)

- The impact of future energy demand on renewable energy production – Case of Norway

Meyer, H., & Nijhuis, S. (2013) & Meyer, H. (2014).

- Delta urbanism: planning and design in urbanized deltas

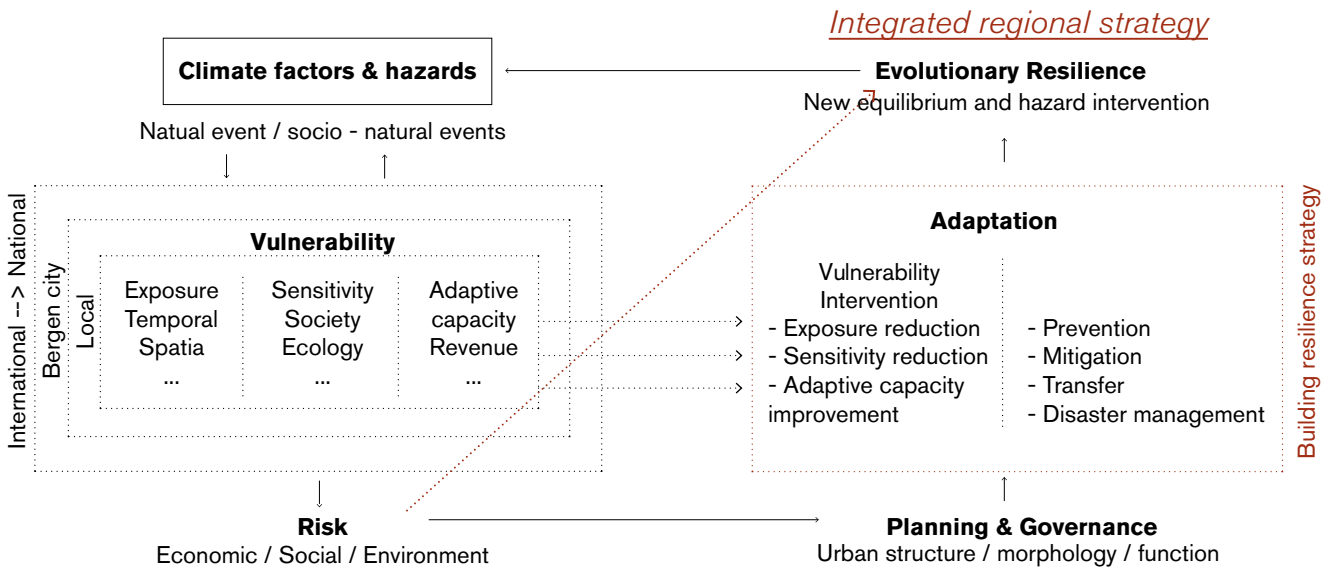
Füssel, H.-M., & Klein, R. J. T. (2006)

- Climate Change Vulnerability Assessments: An Evolution of Conceptual Thinking

Davoudi S.,Zaucha, J., and Brooks, E (2016)

- Evolutionary Resilience and Complex Lagoon Systems

Analytical framwork



Energy system

- *Oil & gas system*
- *Hydropower system*
- *Power networks*
- *Electricity capacity*
- *Electricity demand*

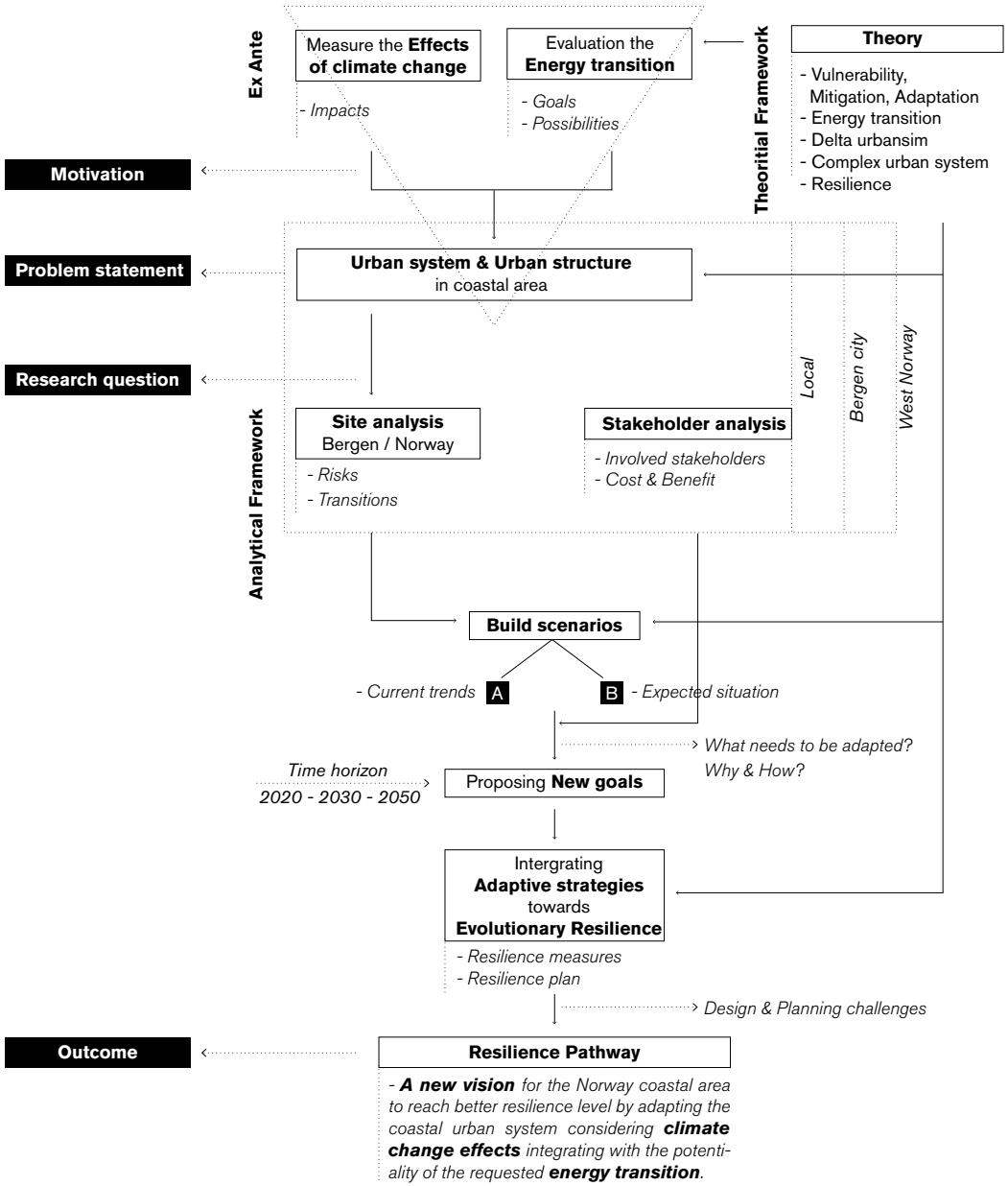
Urban structure

- *Center structure*
- *Population*
  (density, age, income. education)
- *Living and working*
- *Community*
- *Road traffic*
- *Green structure*
- *Water system*
- *Ecosystem*

Research question

Which integrated resilience strategies can be applied in the coastal regions of Norway assessing the climate change impact within the process of energy transition goals?

Methodology chart



Resilience goal

+ <1.5 C

>80% renewals

To be a cliamte proof and climate neutral district
in the process of urban economic and social development in 2050.

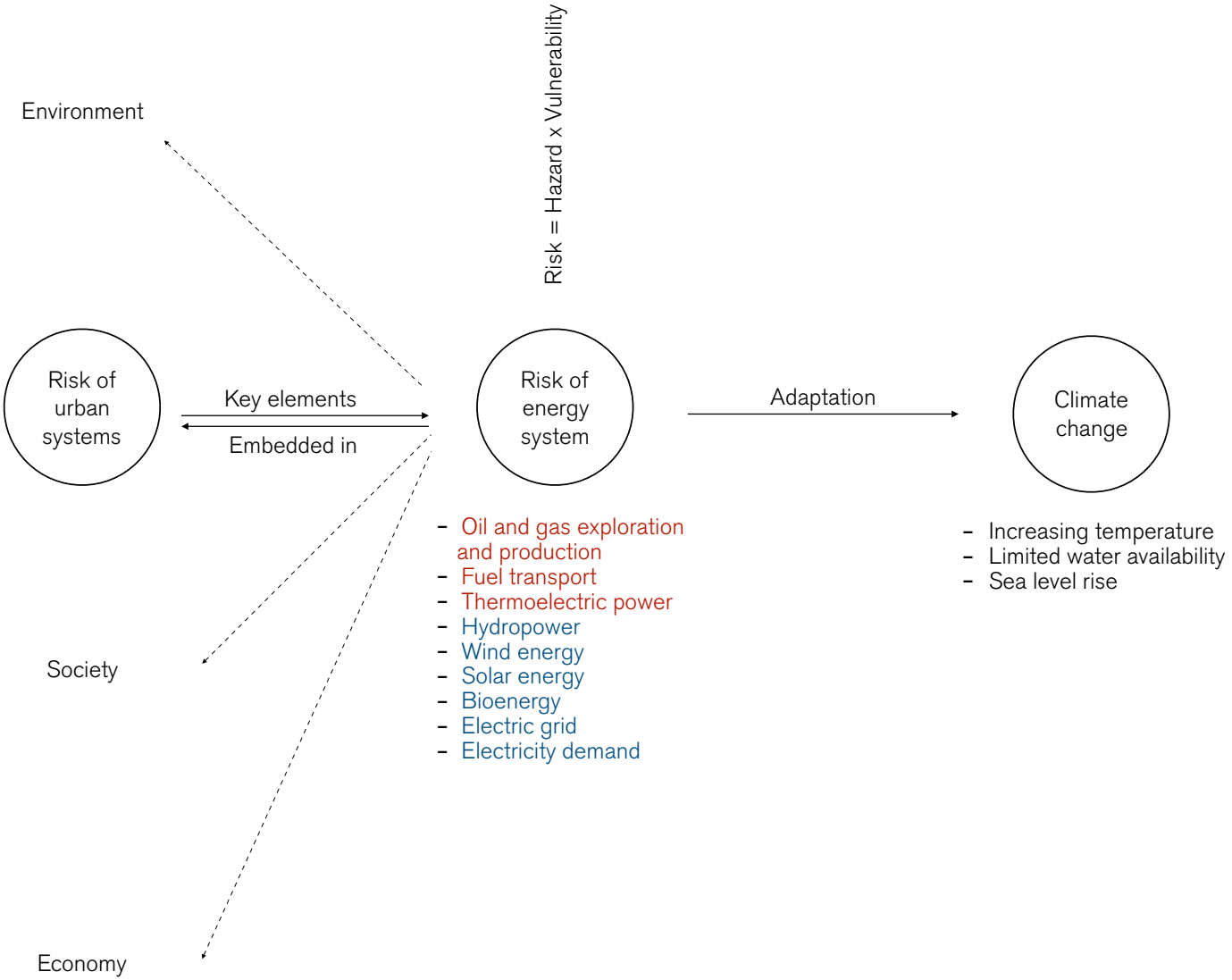
2nd largest, national center for education, tourism, finance

Hypothesis

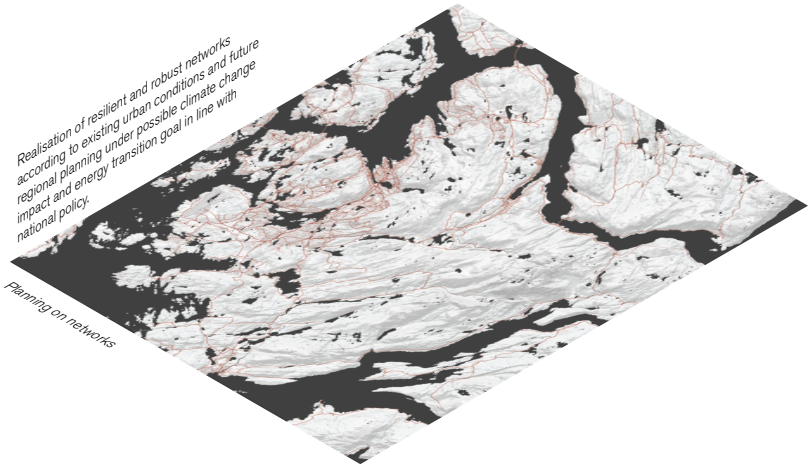
Risk of urban systems

↓

Opportunity?



Approach - Evolutionary Strategy



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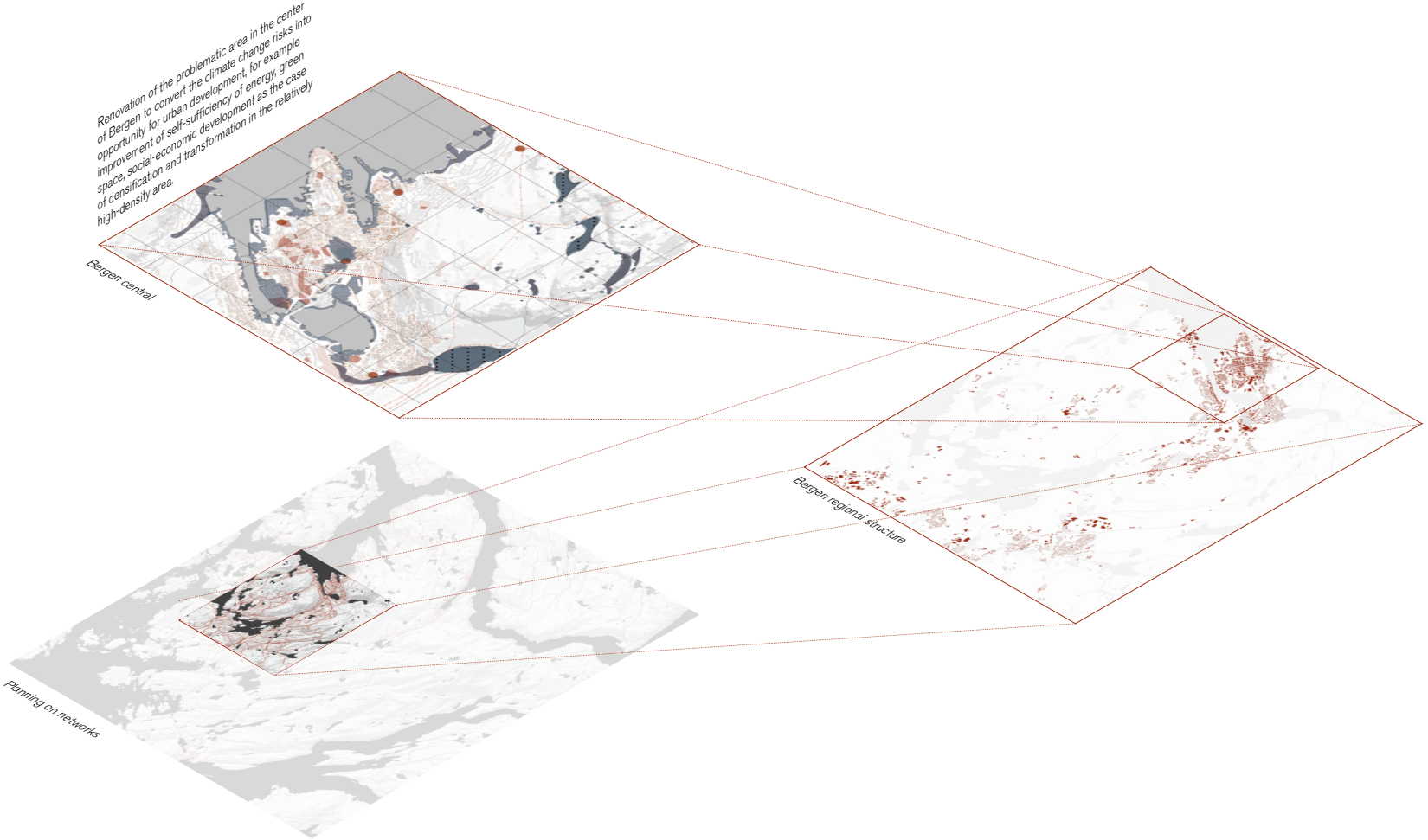

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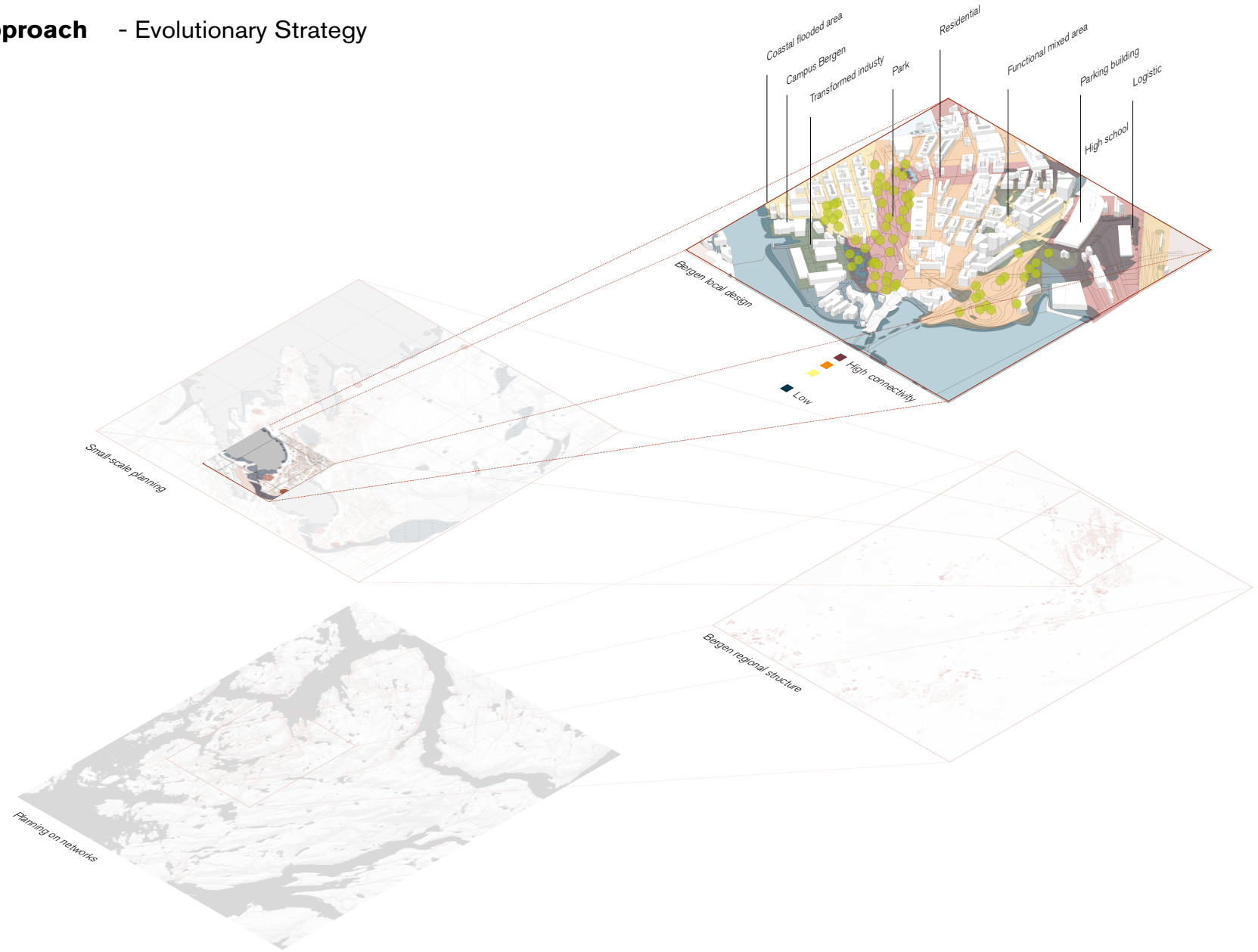

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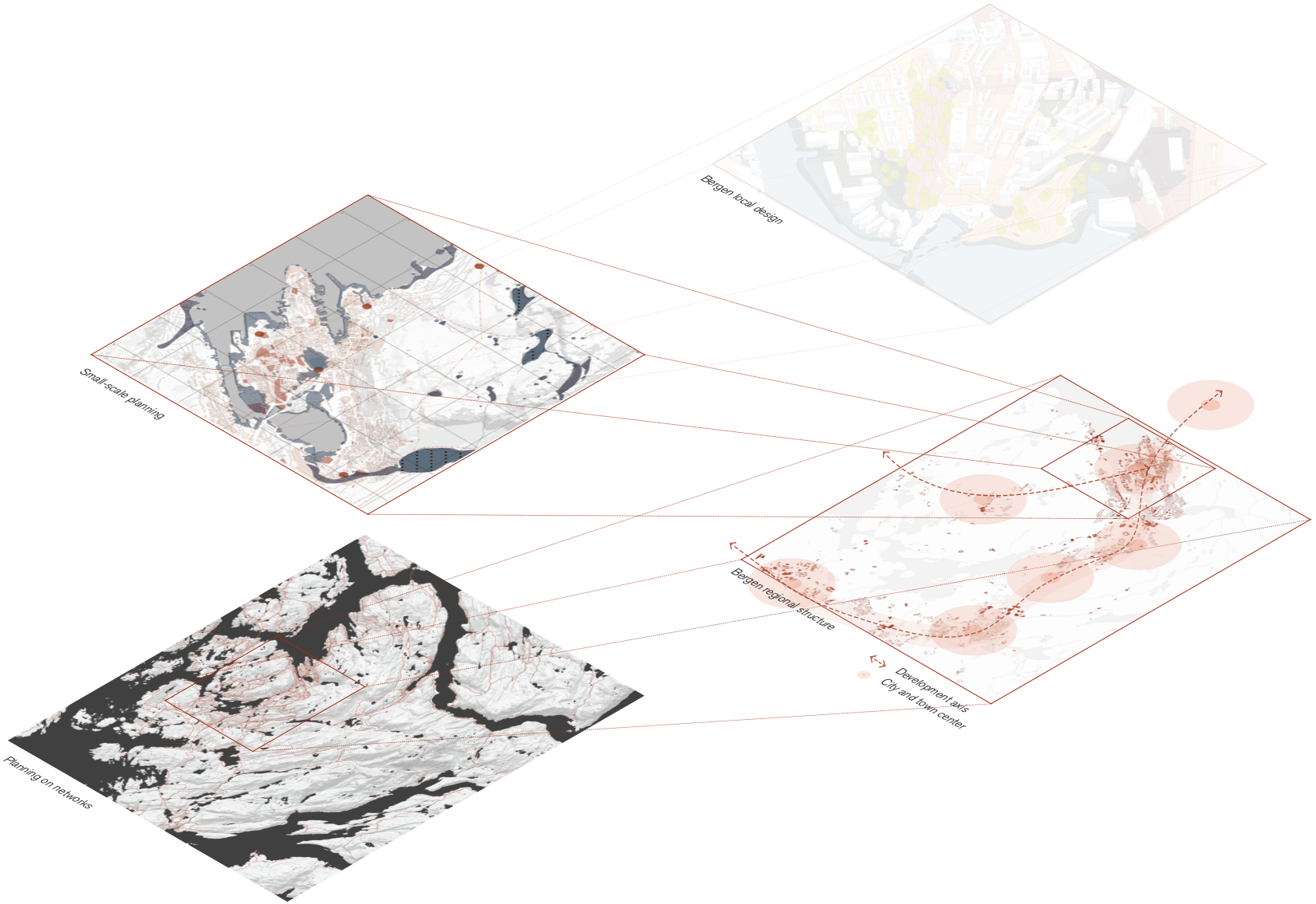
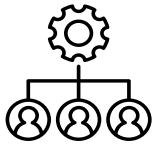
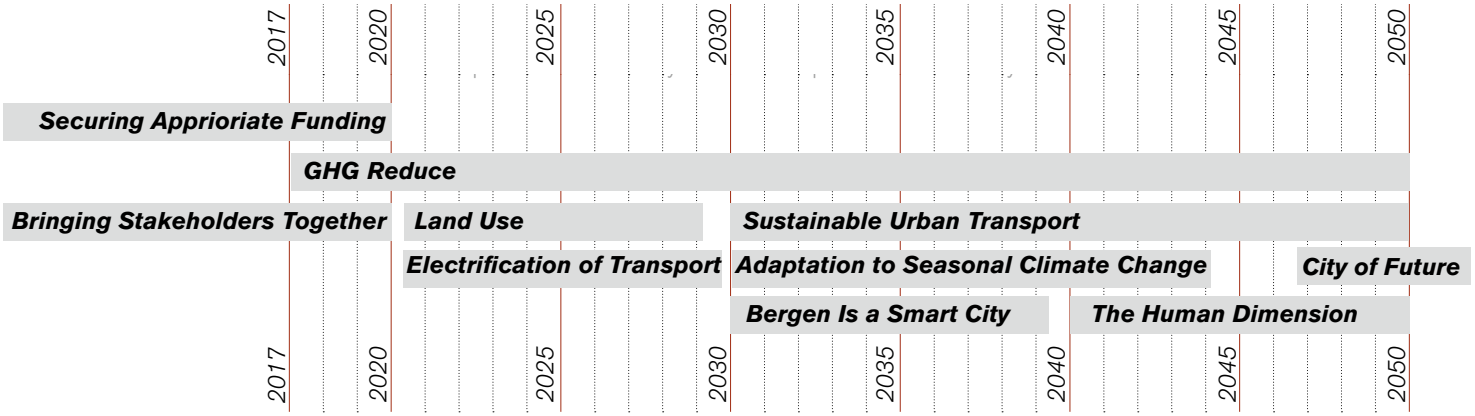


Approach - Evolutionary Change

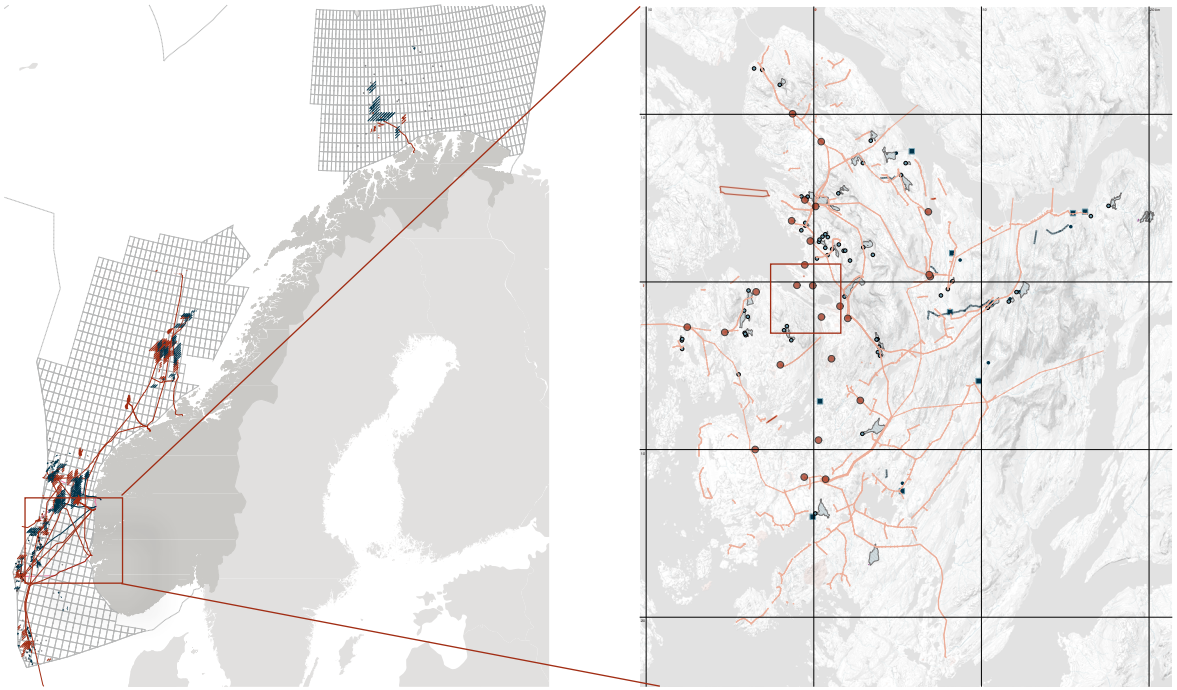


- Phases
- Operations
- Actors



Overall vision

large scale

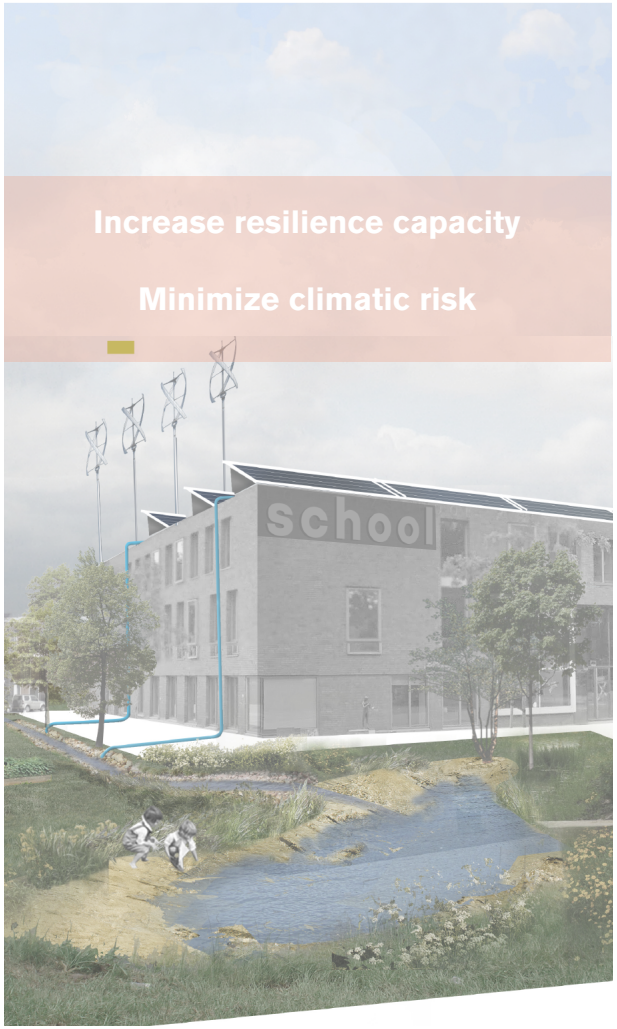


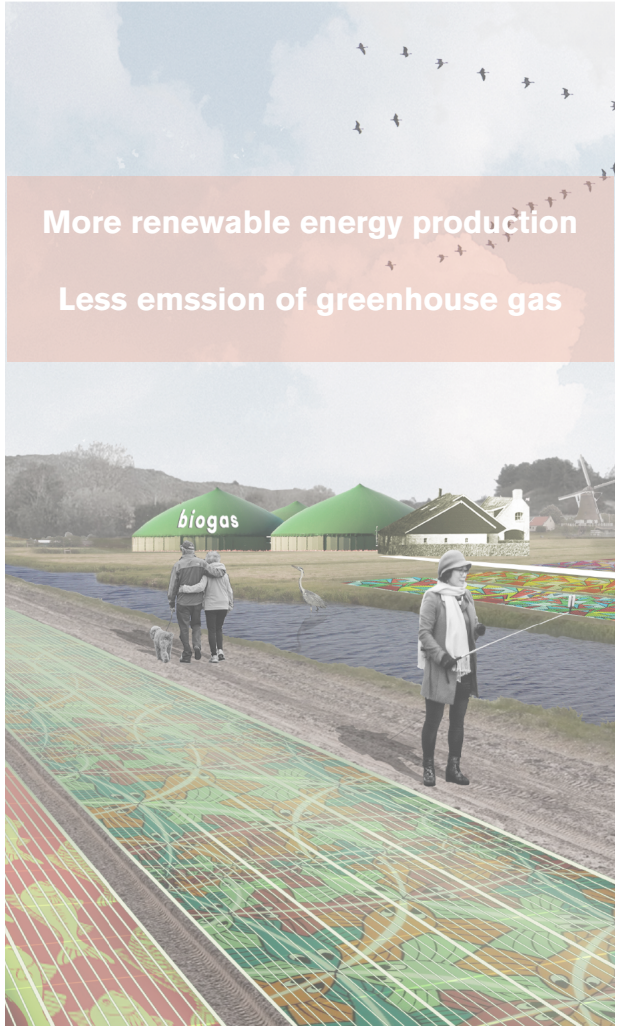
- Climate proof
- Green battery

- Climate proof
- Fossil free
- National center

Overall vision

small scale

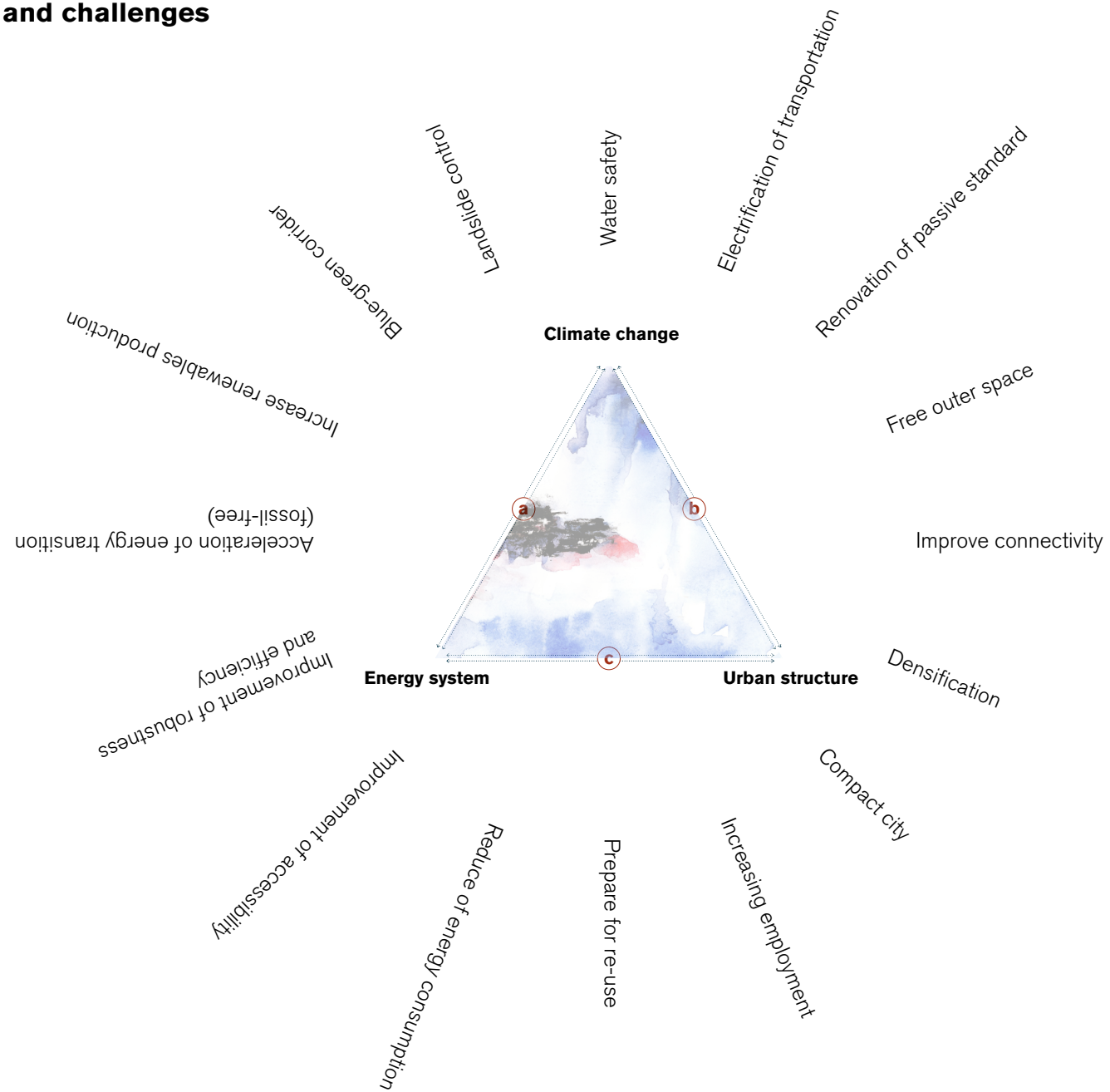




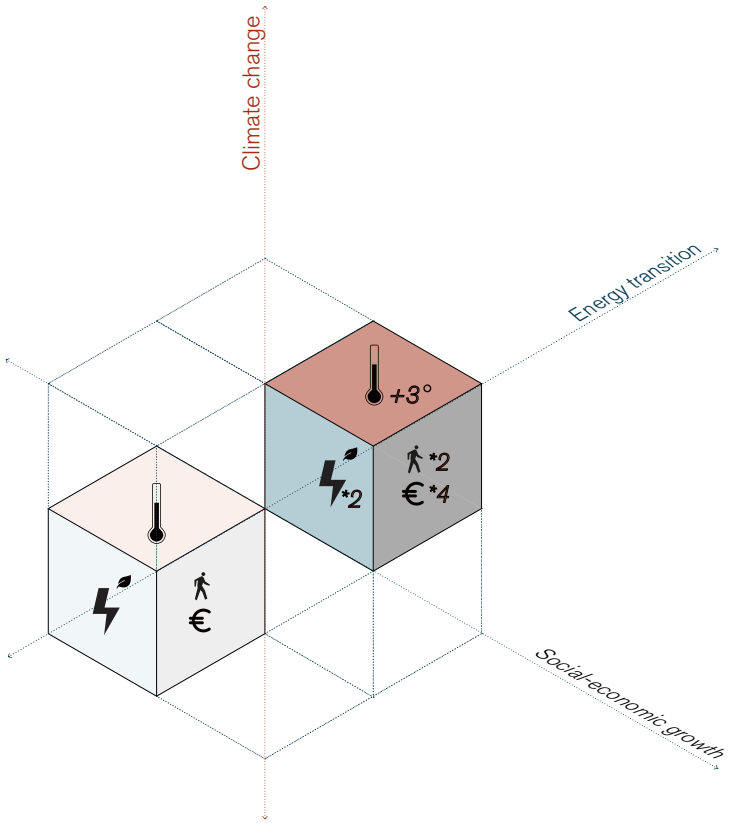


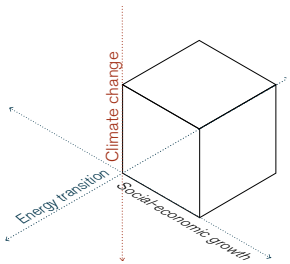
Source: Posad

Proposal and challenges



Building exploratory scenarios

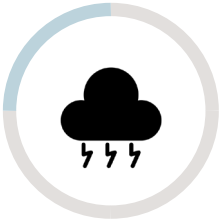




	Scenario Mild	Expected	Scenario Drastic
Climate change	+1.3°	+1.5°	+3.3°
Share of renewals production *(nation)*	75%	80%	85%
Social growth *(nation)*	6000 000		7900 000
(Bergen)	310000	348000	420000

Resilience components

1. **Climate** consensus



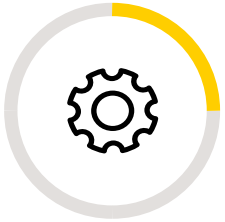
2. **Vulnerability** assessment



3. **Resilience** initiatives



4. **Implementation** roadmap



1. Climate consensus

- Temperature rise
1.5 degrees increased last 15 years

- Extreme precipitation
will increase 28% in 5 years

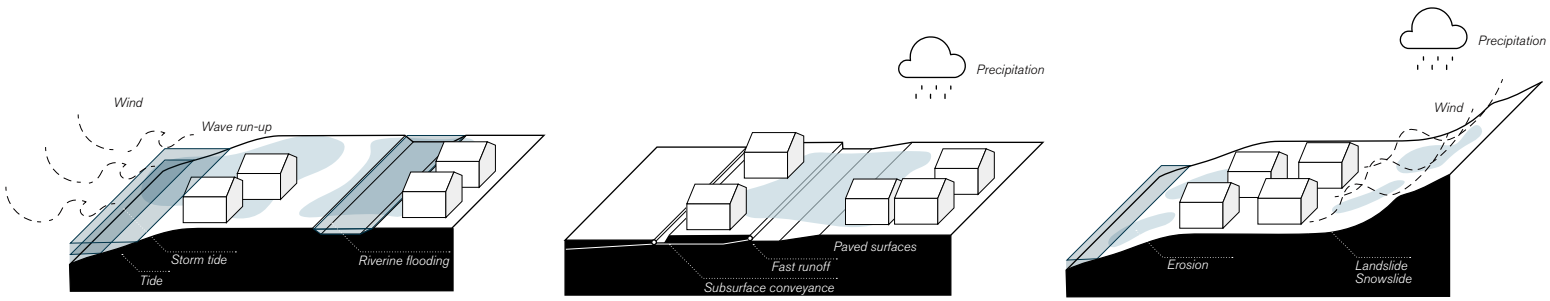
- Sea level rise
will increase 1 meter in 100 years

- Coastal storms
will be wilder in 100 years

- Melting snow
shorter snow season

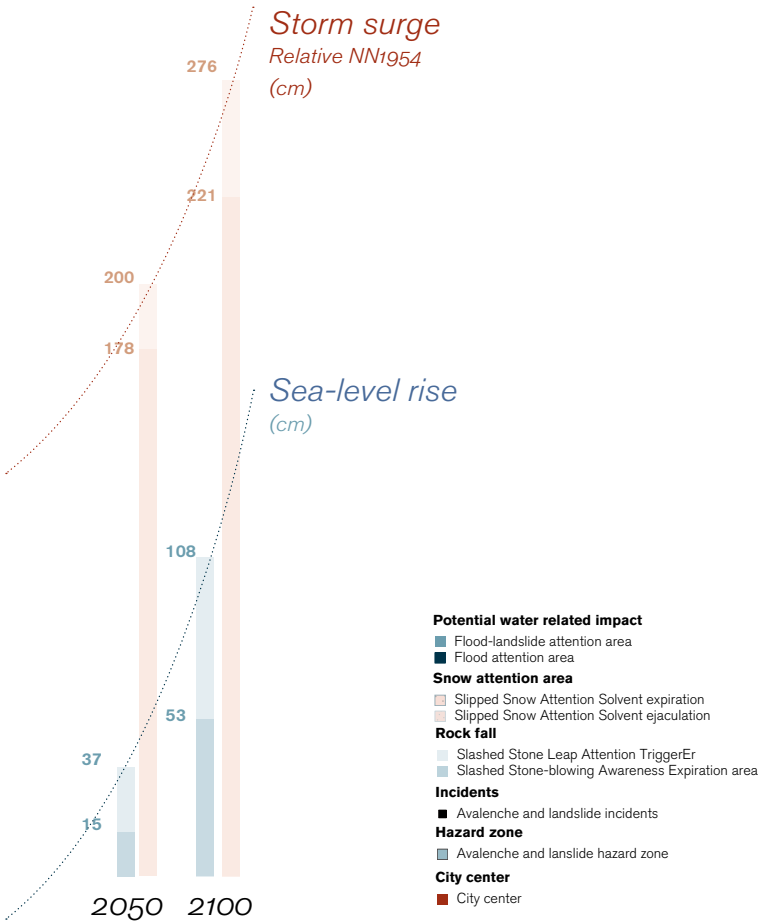
- Stormwater flooding
more often surface flooding

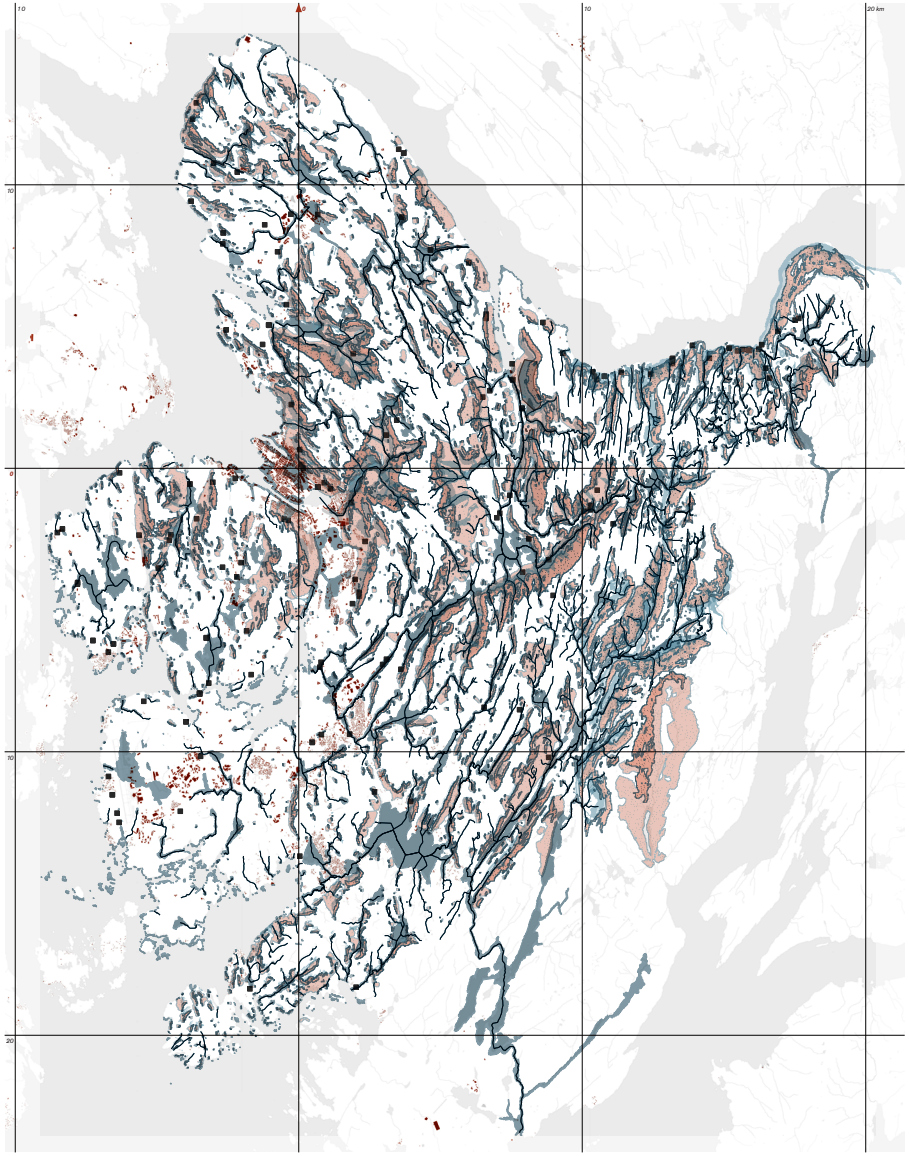
- Landslide/Snowslide
more likely to happen



1. Climate consensus

- *Coastal flooding*
- *Pluvial flooding*
- *Landslide and snowslide*





2. Vulnerability assessment

Risks impact

- Exposure population

- Exposure infrastructure

66%

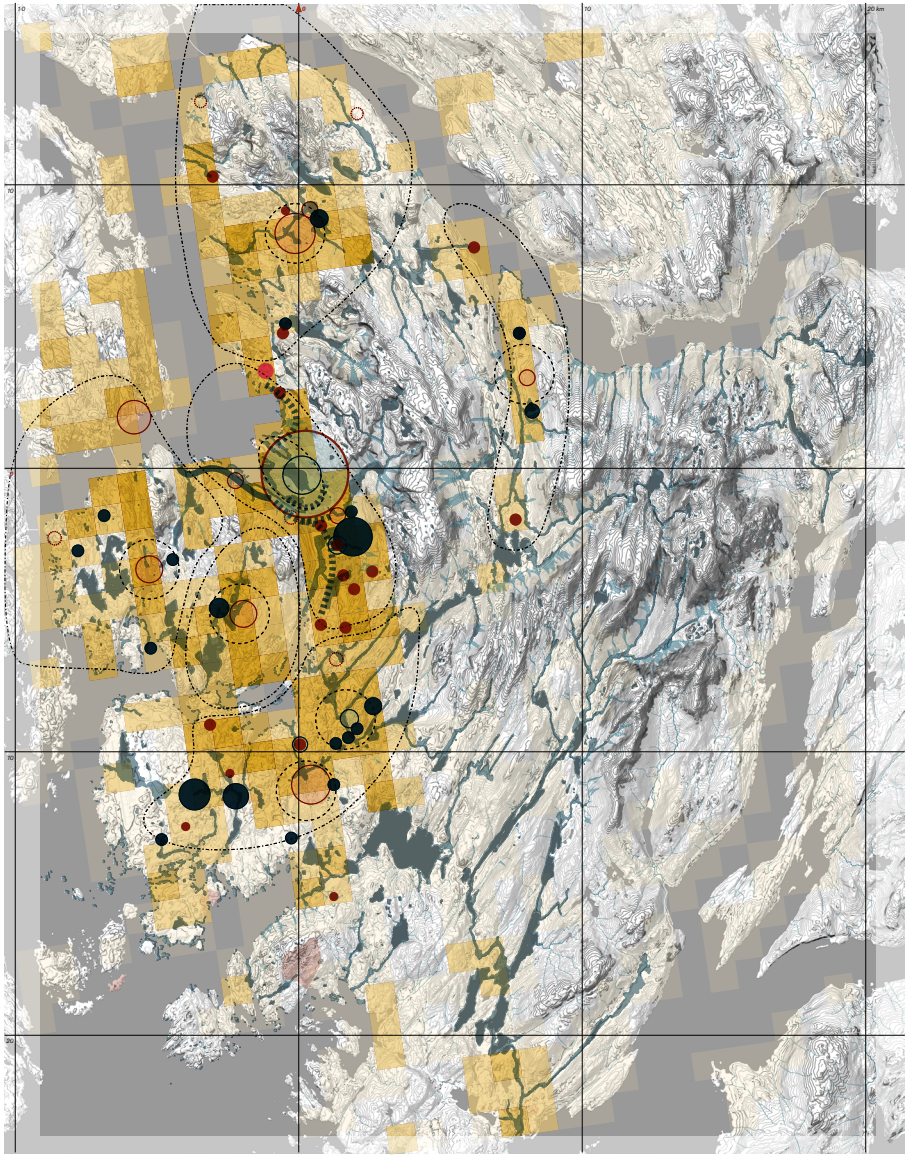
2.37m

Construction: Industrial, commercial, residential, recreational buildings, boathouses, historic buildings

Facilities: Docks, fish farms, float bridge

Infrastructure: Roads, squares, line systems

Nature: Wildland, wetlands



3. Resilience initiatives

- **Resilience initiatives**
  - **Principle**
  - **Process**
  - **Layers**

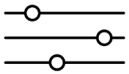
3. Resilience initiatives { **Principle** / **Process** / **Layers**



Work in layers for independently effective solutions



Support multiple benefits with each activities



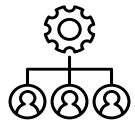
Develop adaptive and flexible strategies



Minimise impact on energy consumption and natural resources



Define a responsive urban form



Incorporate local involvment in design and decision-making

3. Resilience initiatives

- Principle
- **Process**
- Layers



Build a prepared and SAFE community



Accelerate access to reliable and clean ENERGY



Adapt to the SEASONAL change under CLIMATE



Promote shared economy and culture to advance city DEVELOPMENT

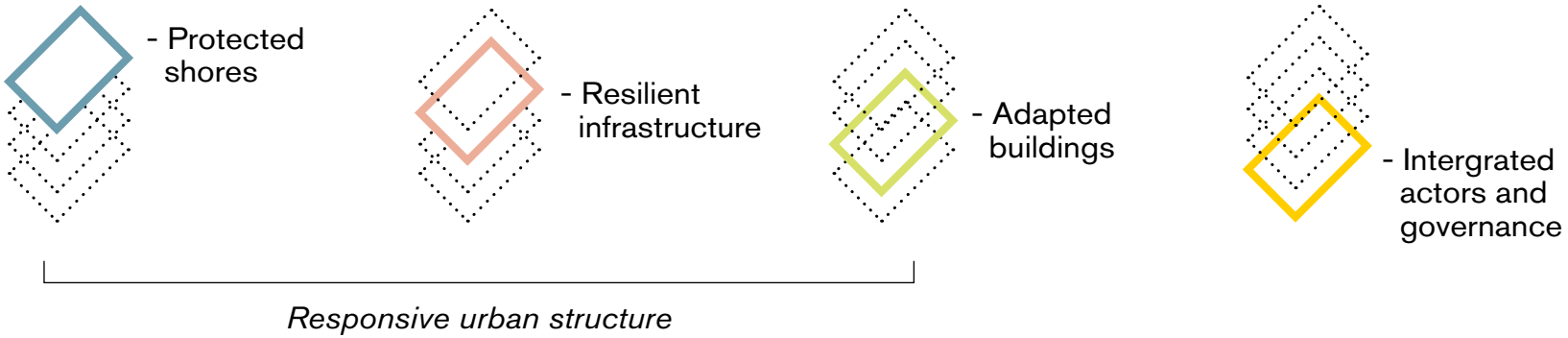


Excel at working together within URBAN GOVERNANCE to better serve the community



Build regional EVOLUTIONARY RESILIENCE SYSTEM

3. Resilience initiatives { **Principle** / **Process** / **Layers**

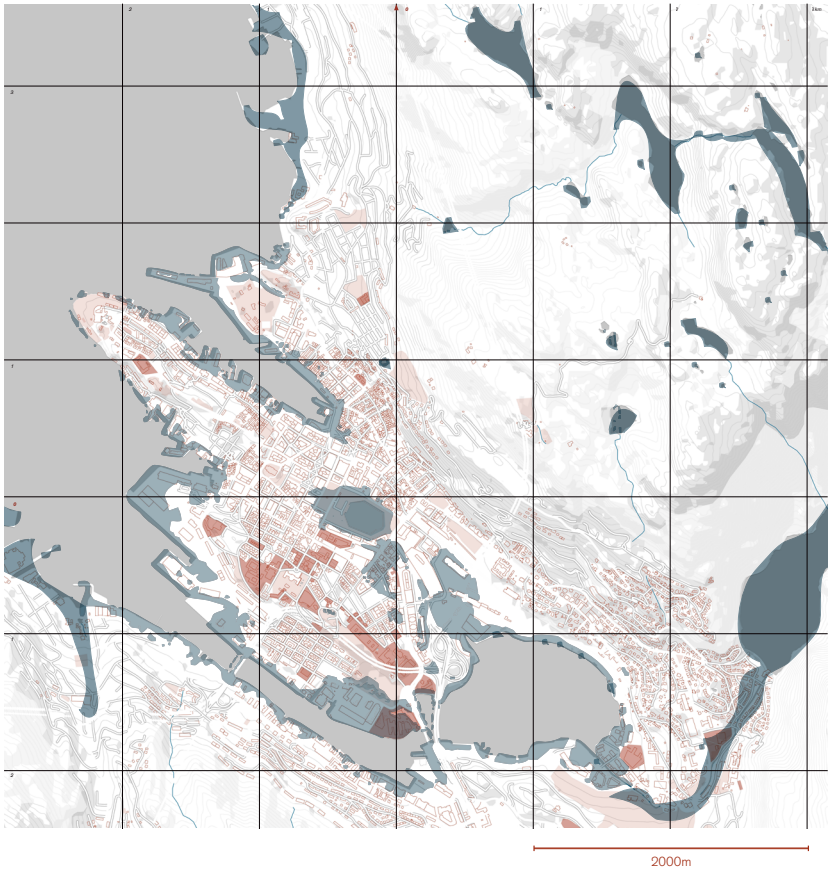


3. Resilience initiatives layers

- Protected shores

1) District flood defenses

2) Harbor-wide protection



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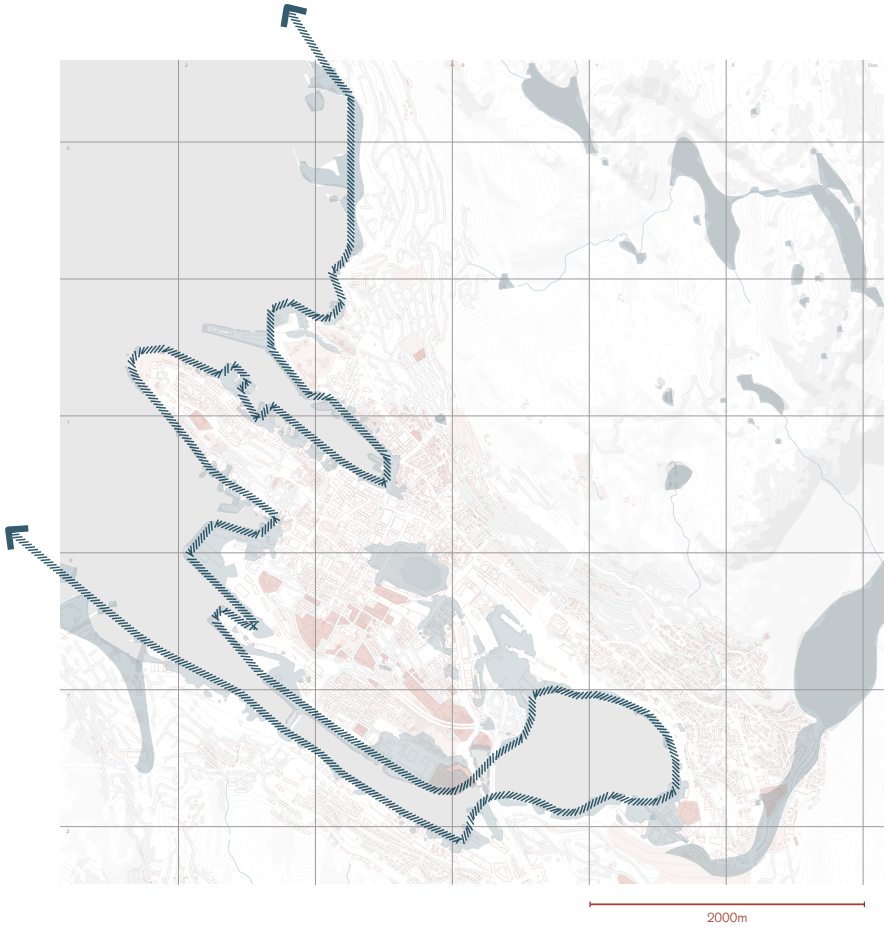

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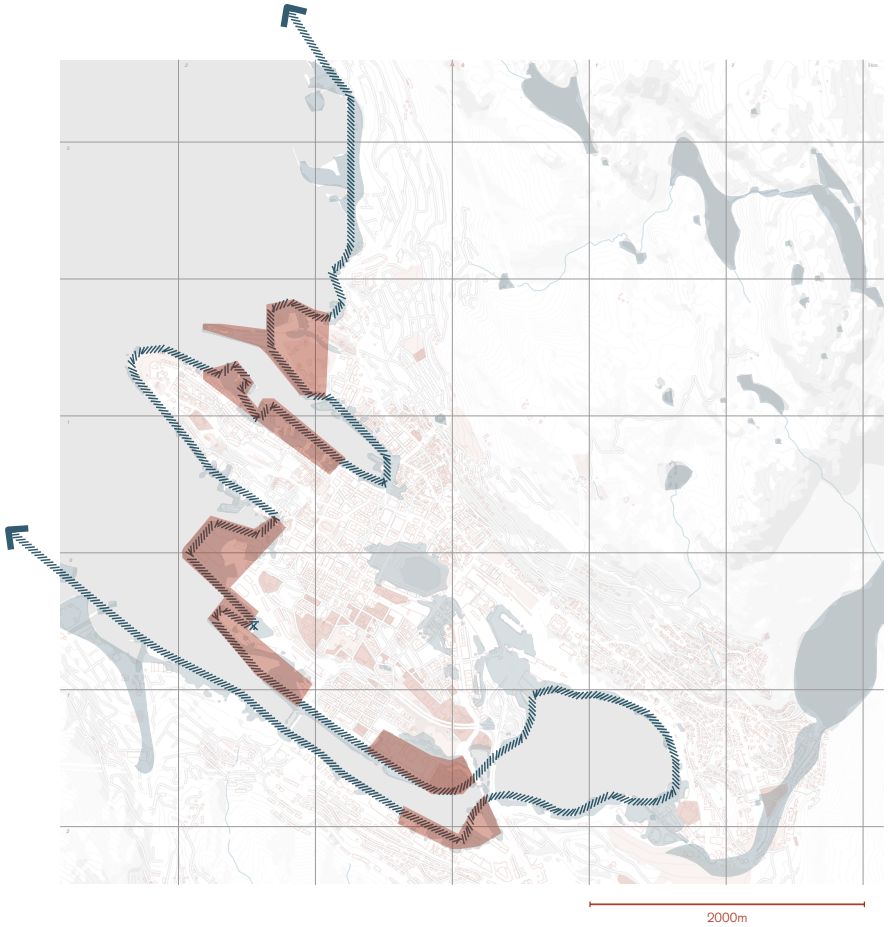


3. Resilience initiatives layers

- Resilient infrastructures

1) Common planning, agendas and design standards

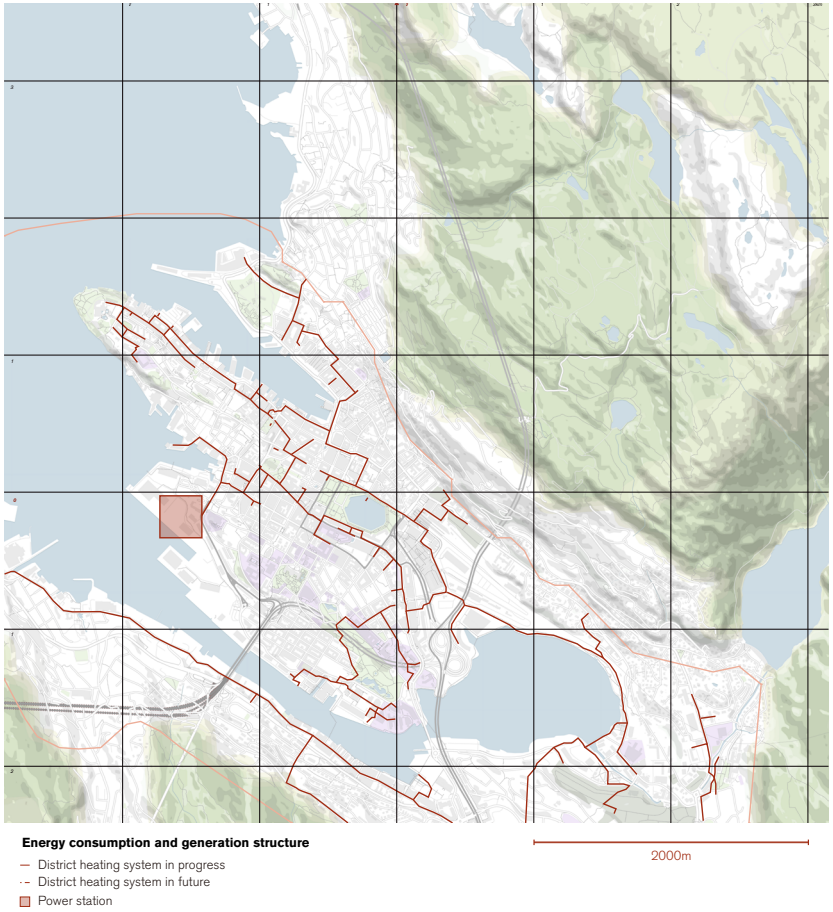
2) Green infrastructure protection & expansion

3) Energy system redundancy and renewal

4) Adaptation of existing infrastructure systems

- Water and sewer

- Transportation



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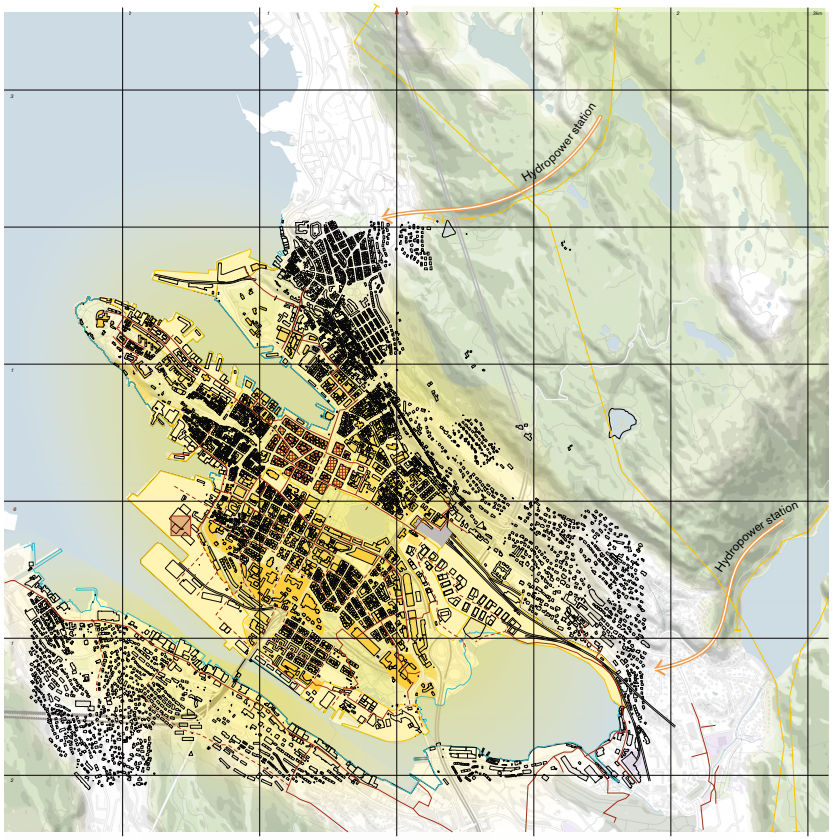


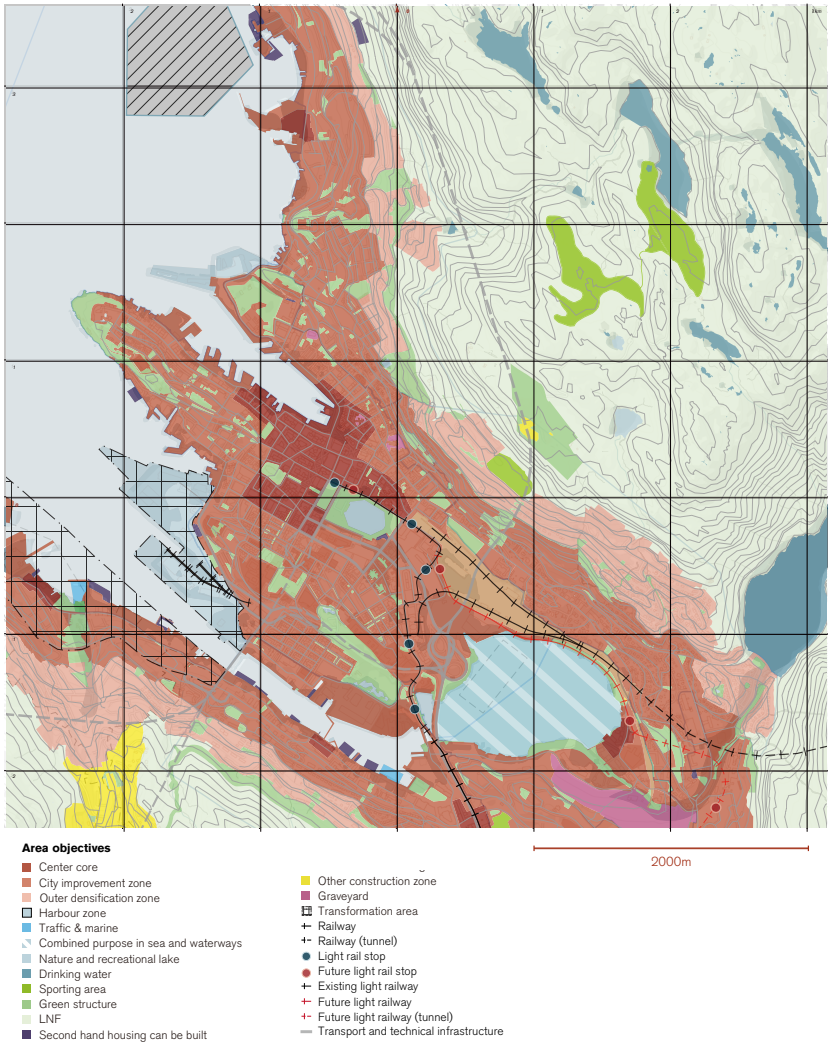
3. Resilience initiatives layers

- Adapted buildings

1) Support for building retrofits

2) Standards for new buildings

3) Risk insurance reform



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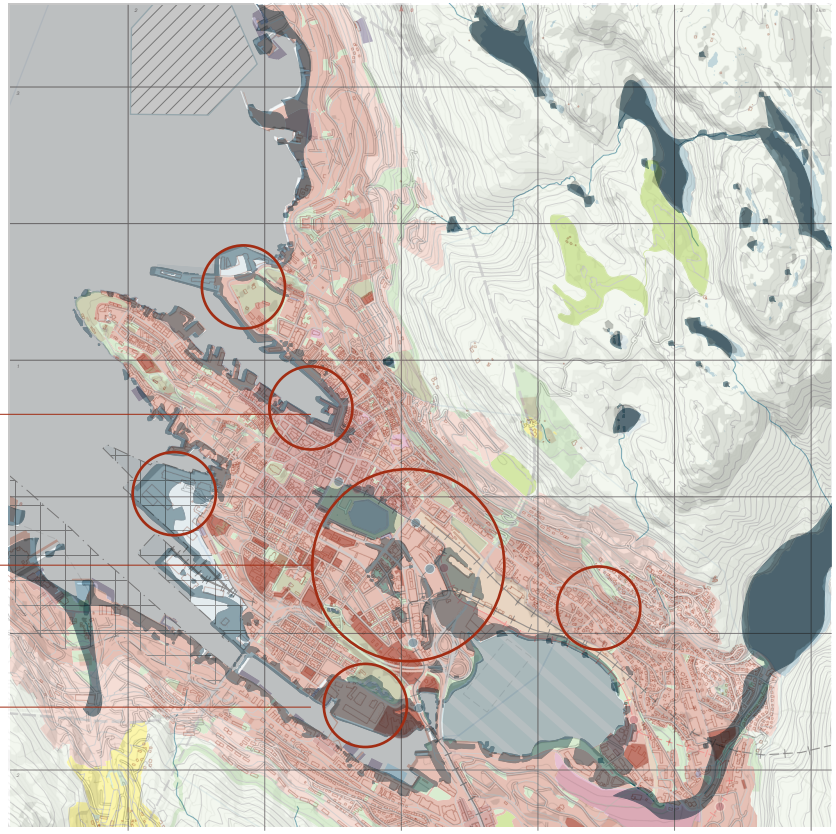
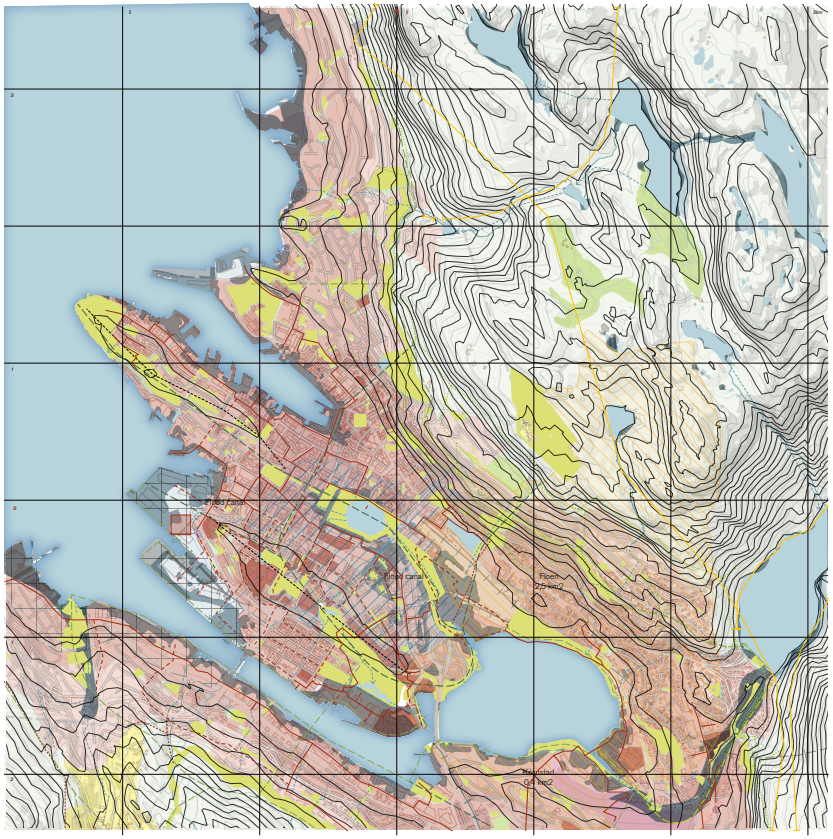


3. Resilience initiatives layers

- Responsive urban structure



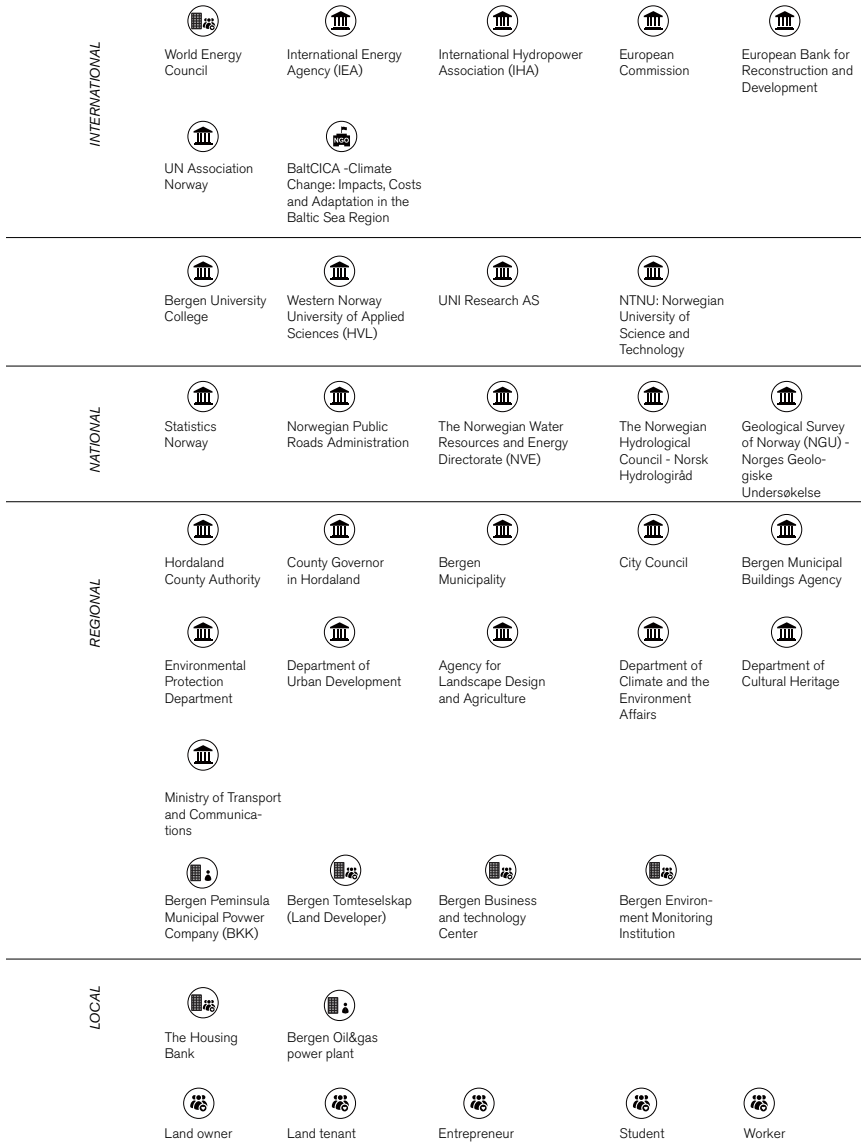
Responsive urban structure



4. Intergrated actors, agendas and governance

1) *Climate projection consensus*
2) *Engagement of at-risk stakeholders*
3) *Preparedness planning and agendas for vulnerablility*
4) *Small businesses and institution support*
5) *Economic development through resilienc*





Bergen local scale

as a case study



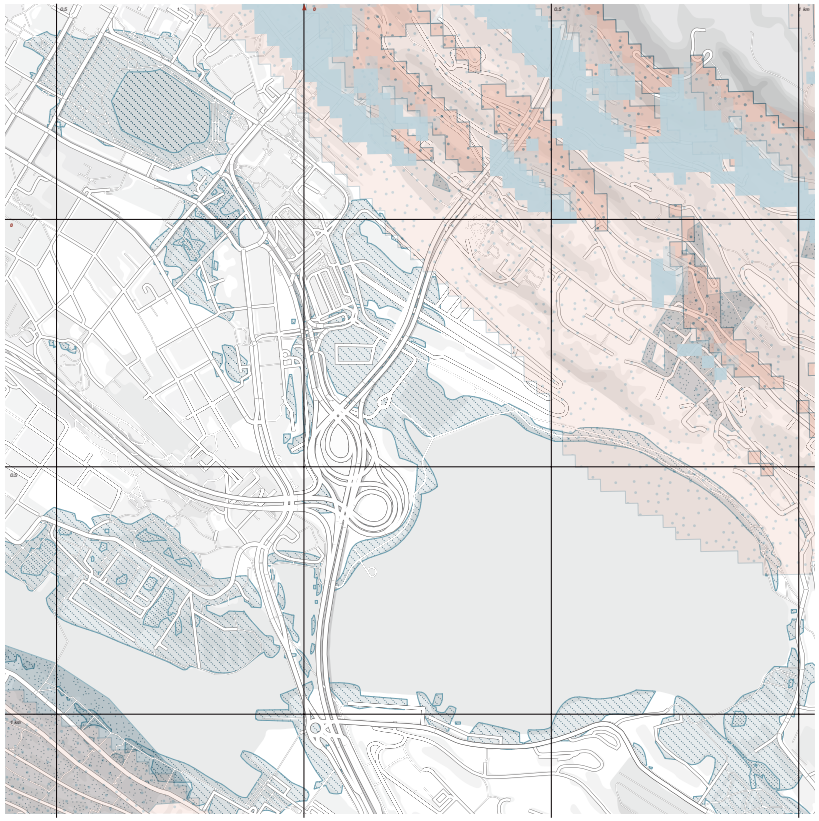


Source: RAMBOLL

1. Climate consensus

- Pluvial flooding

- Coastal flooding



- Landslide and snowslide

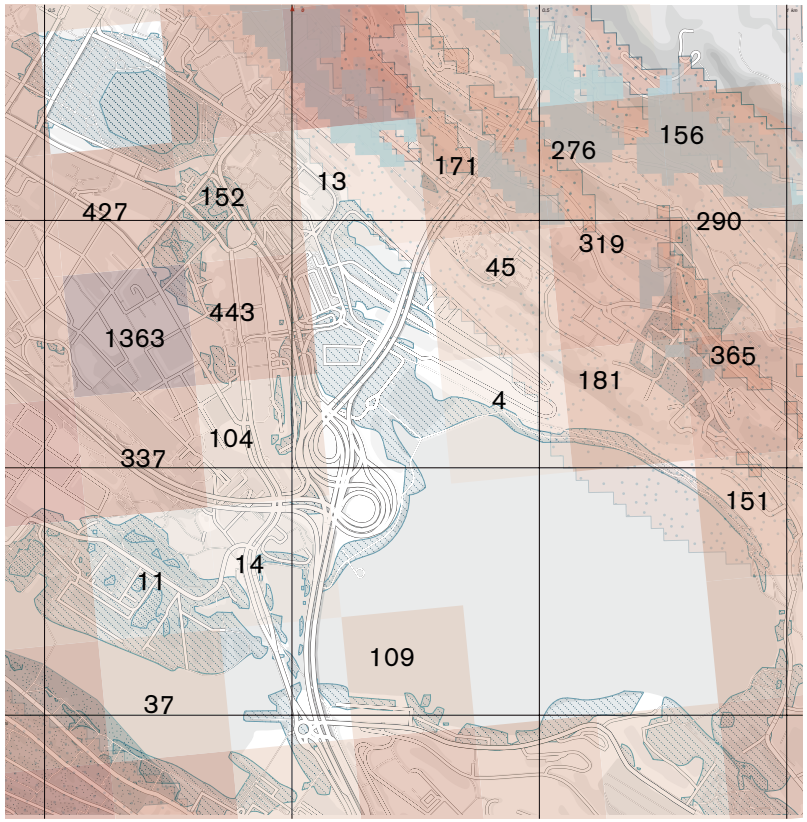
Potential coastal flood, snow slide and landslide

- Flooded area
- Potential landslide hazzard
- Slipped snow attention solvent expiration area
- Slipped snow attention solvent ejaculation area
- Slashed stone leap attention trigger area
- Slashed stone-blowing awareness expiration area

2. Vulnerability assessment

Risks impact

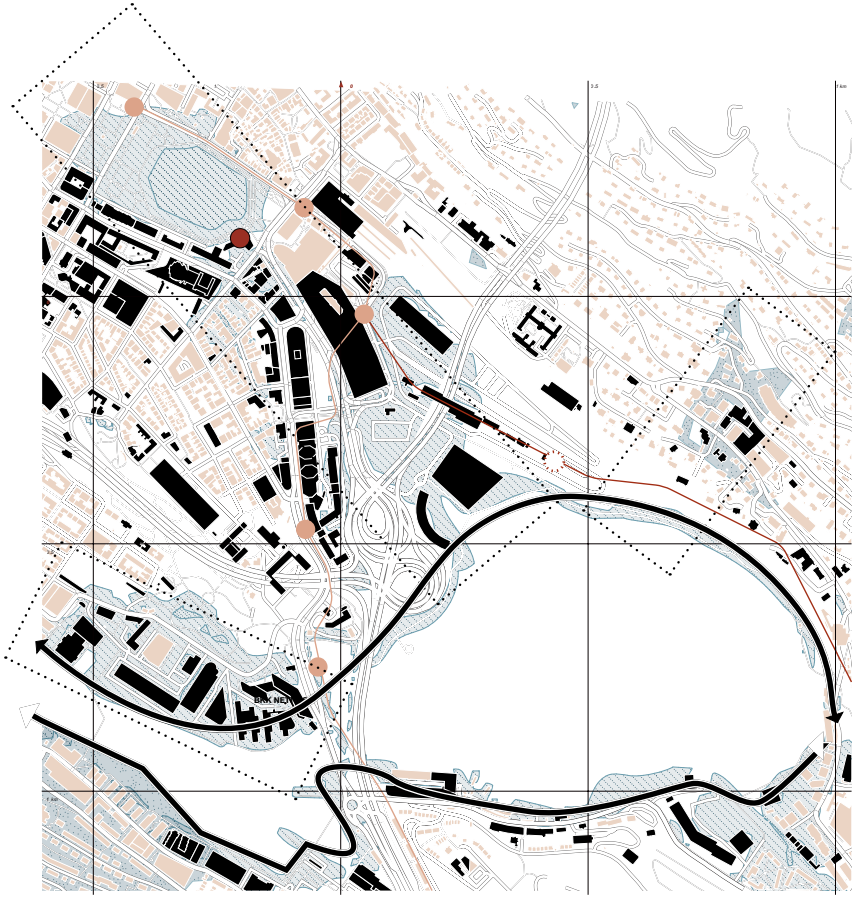
- Exposure population



Population (250m grid)

- 1-31 inhabitants (<500 per km2)
- 32-124 inhabitants (500-2000 per km2)
- 125-312 inhabitants (2000-5000 per km2)
- 313-624 inhabitants (5000-10000 per km2)
- 625-1249 inhabitants (10000-20000 per km2)
- 1250 or more residents (> 20000 per km2)

- Exposure infrastructure



Potential influence on urban structure

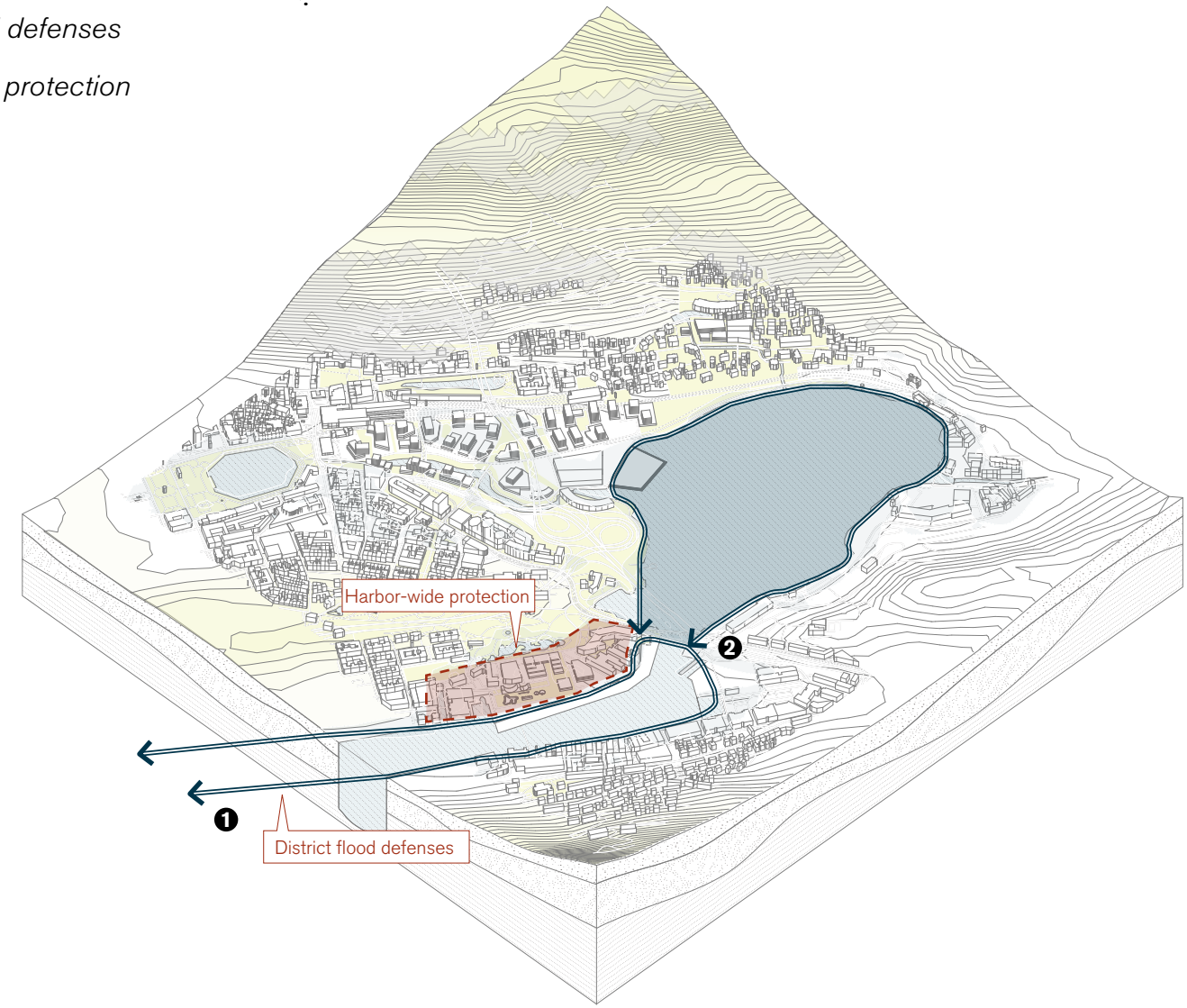
- Power transformer station
- Dwellings
- Other funtion buildings
- Existing light rail station
- Existing light railway
- Future light rail station
- Future light railway

3. Resilience initiatives layers

- Protected shores

1) District flood defenses

2) Harbor-wide protection

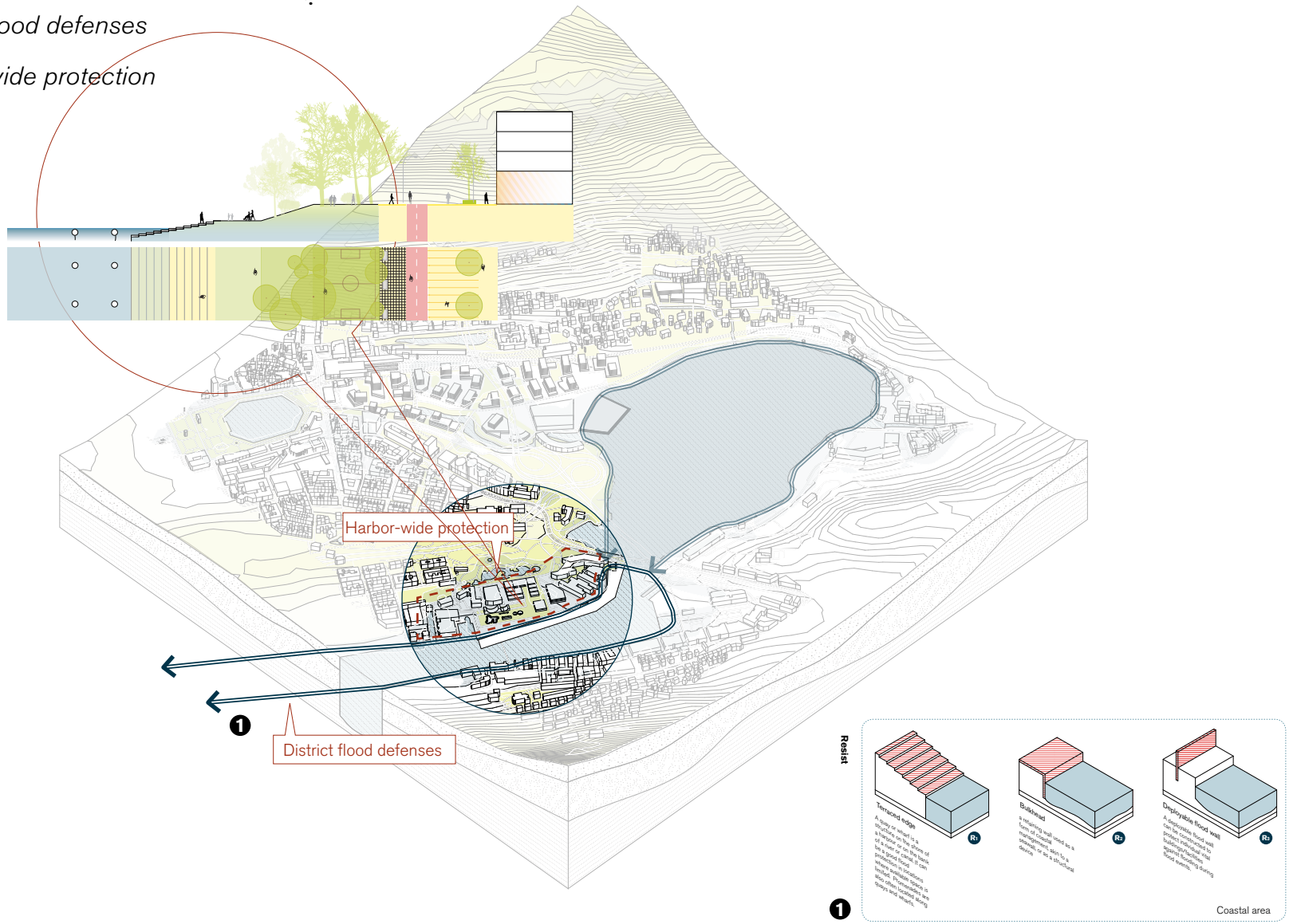


3. Resilience initiatives layers

- Protected shores

1) District flood defenses

2) Harbor-wide protection

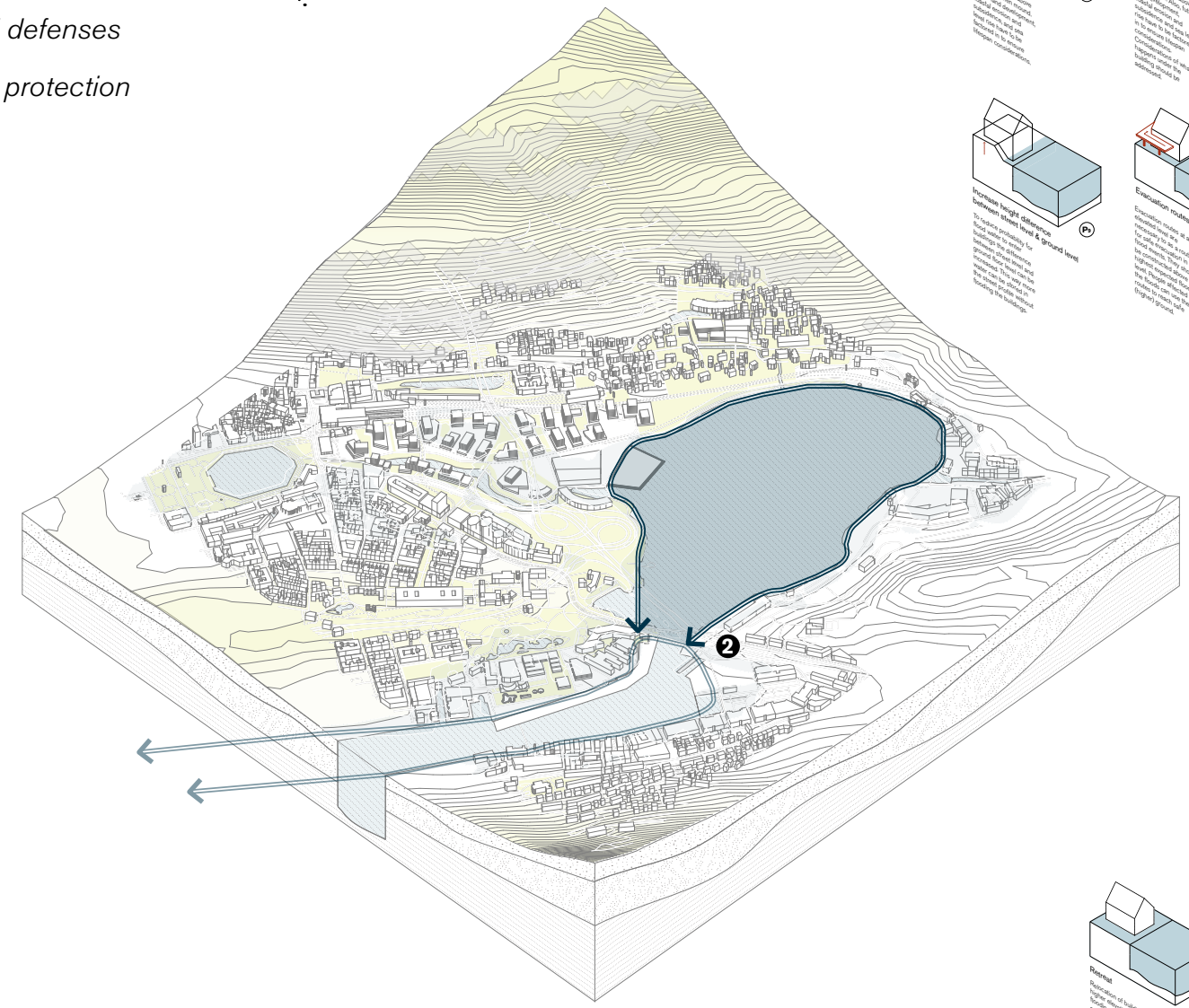


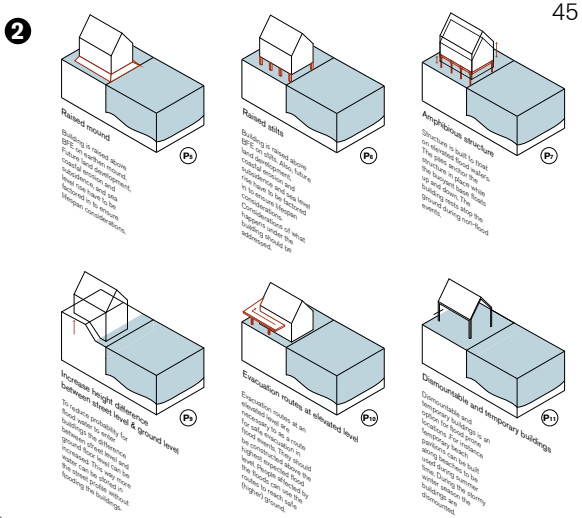
3. Resilience initiatives layers

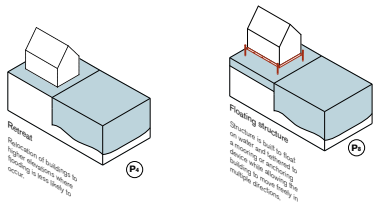
- Protected shores

1) District flood defenses

2) Harbor-wide protection



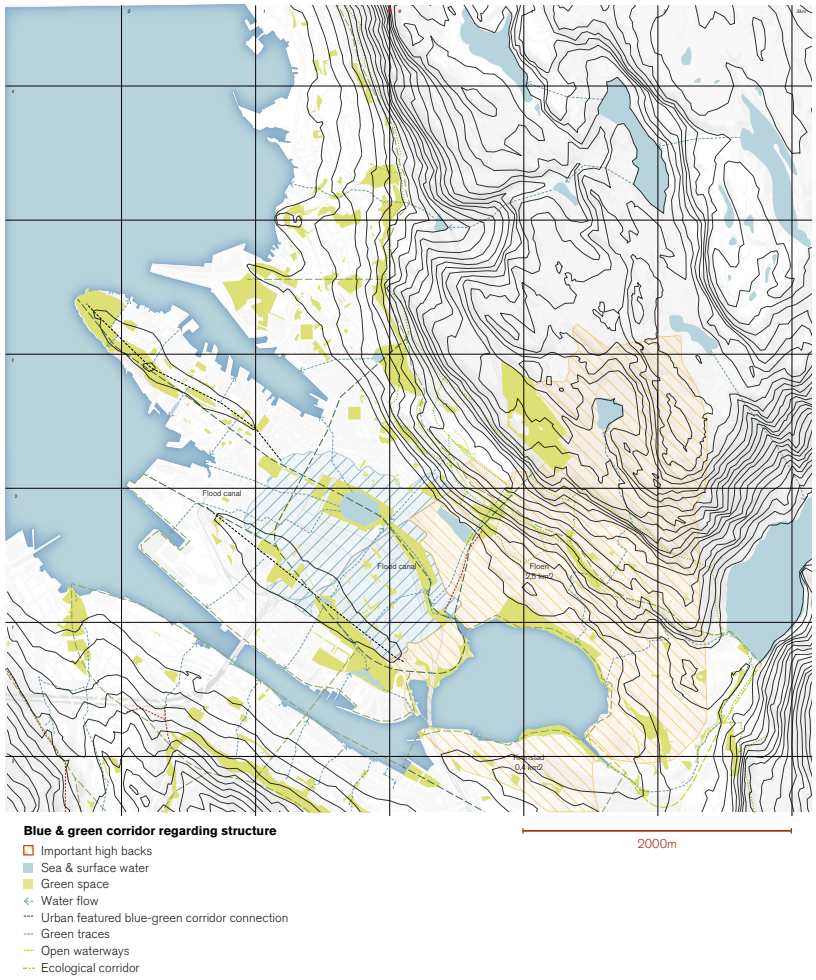




3. Resilience initiatives layers

- Resilient infrastructures

1) Common planning, agendas and design standards



3. Resilience initiatives layers

- Resilient infrastructures

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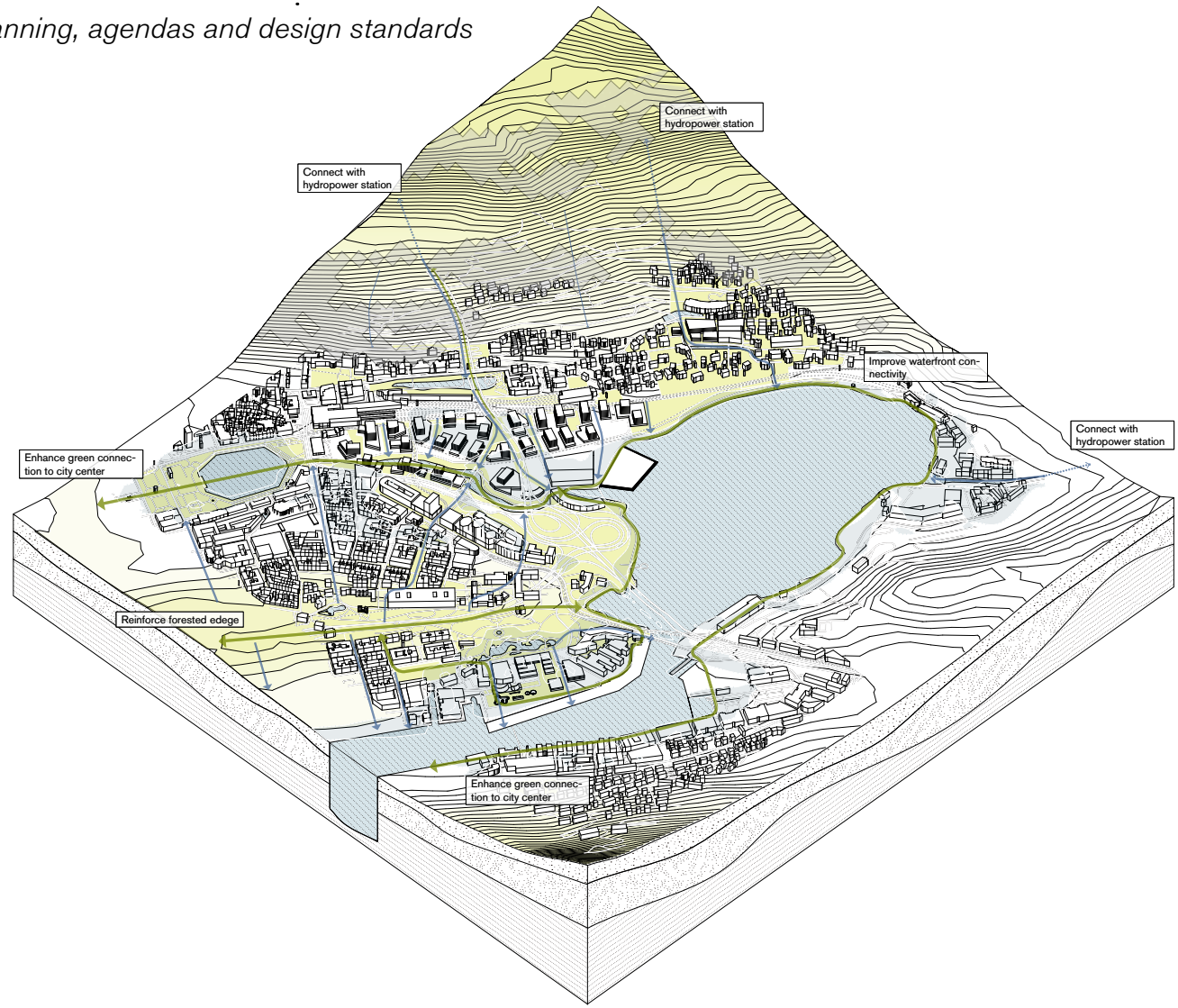

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- Resilient infrastructures

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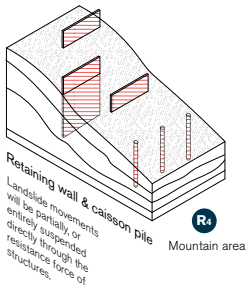
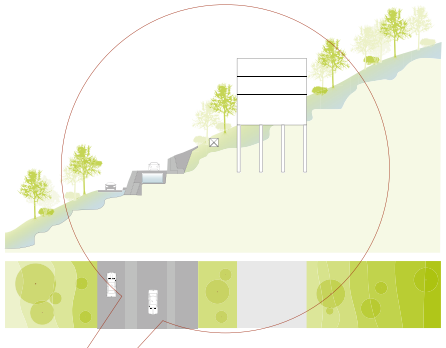
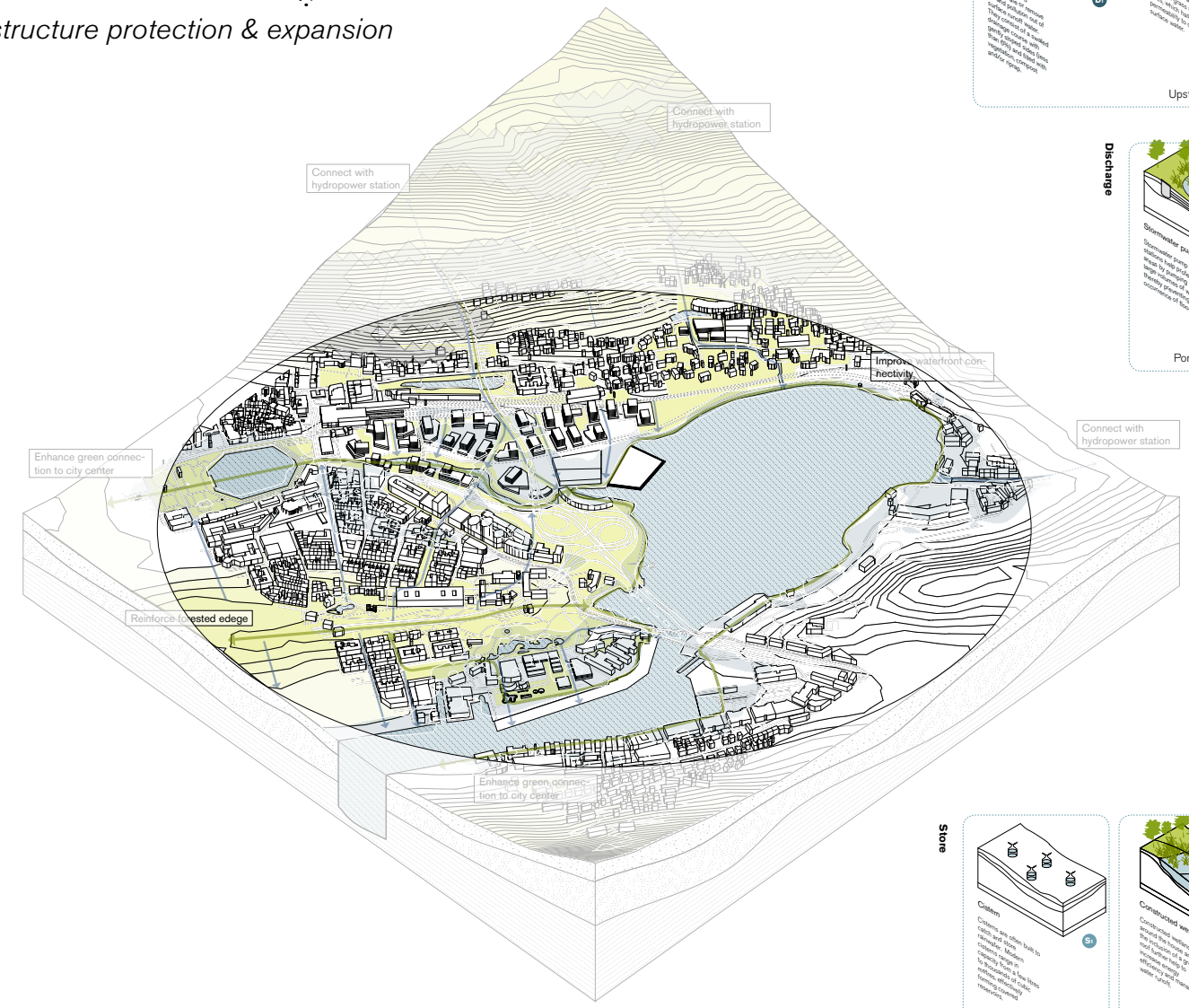


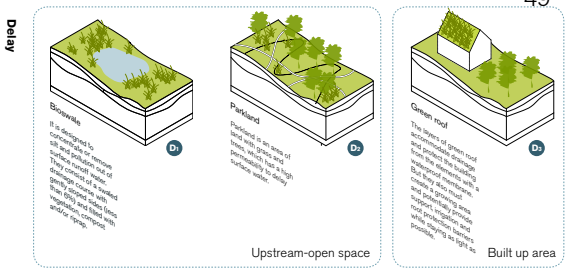


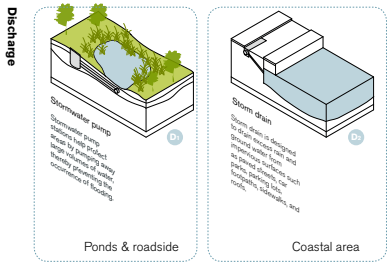
3. Resilience initiatives layers

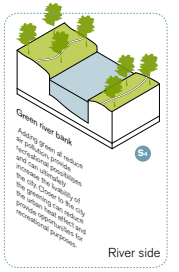
- Resilient infrastructures

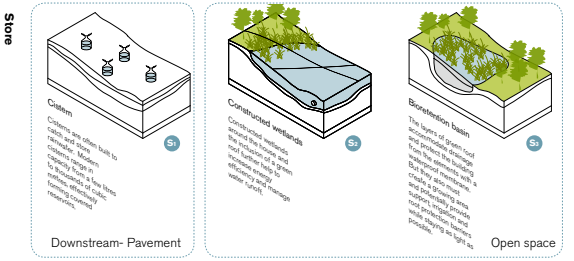
2) Green infrastructure protection & expansion











3. Resilience initiatives layers

- Resilient infrastructures

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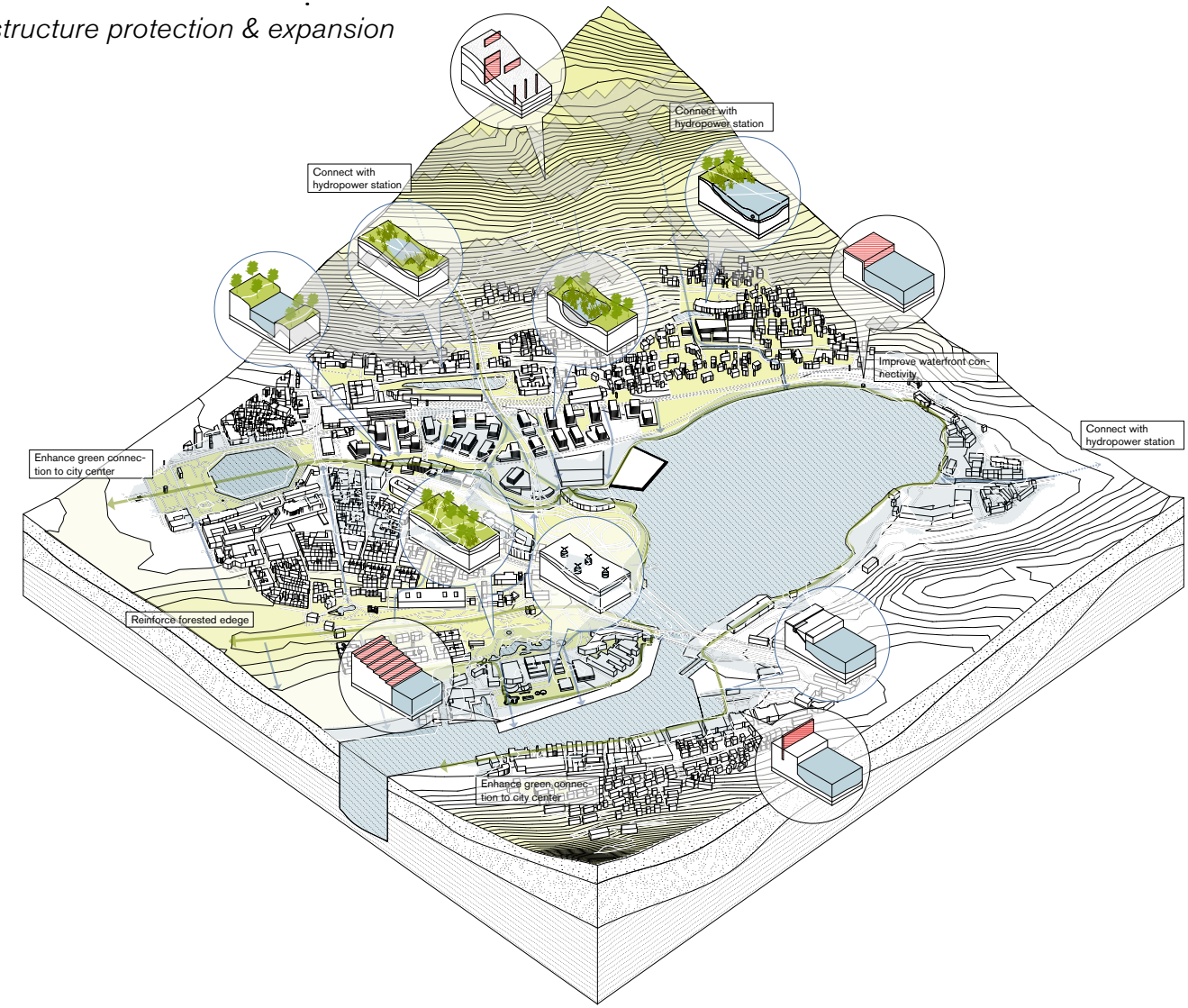
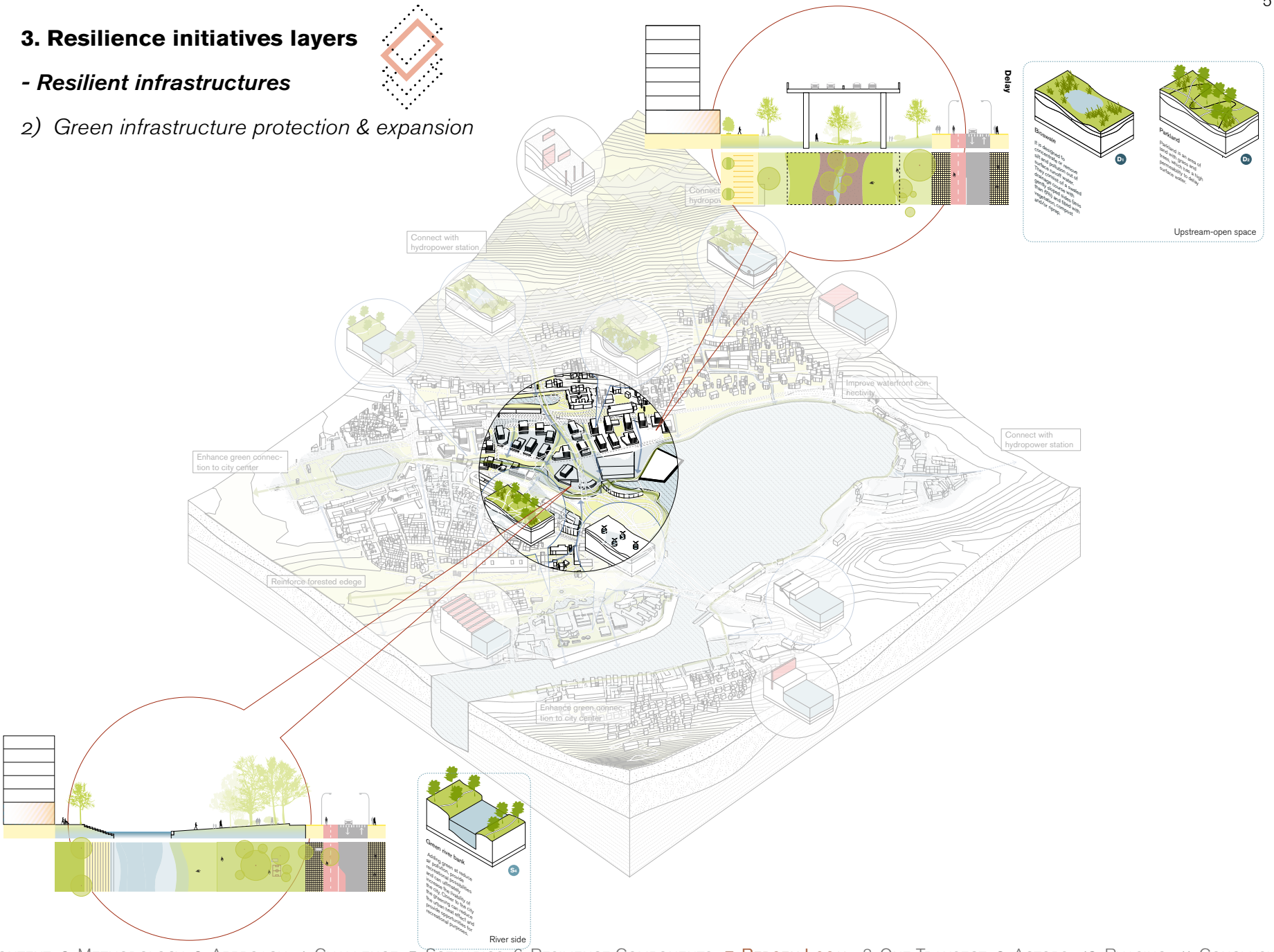


3. Resilience initiatives layers

- Resilient infrastructures

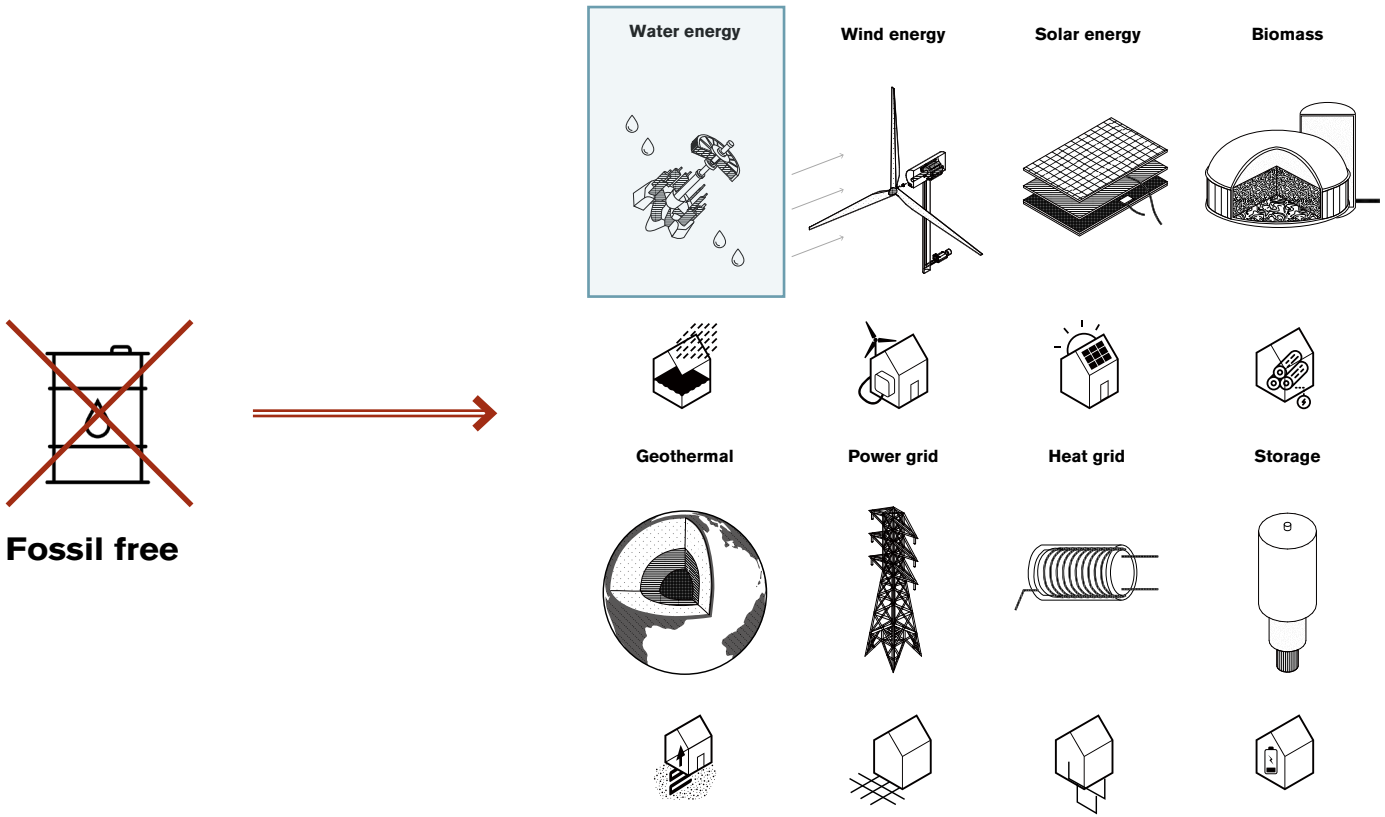
2) Green infrastructure protection & expansion



3. Resilience initiatives layers

- Resilient infrastructures

3) Energy system redundancy and renewal



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- Resilient infrastructures

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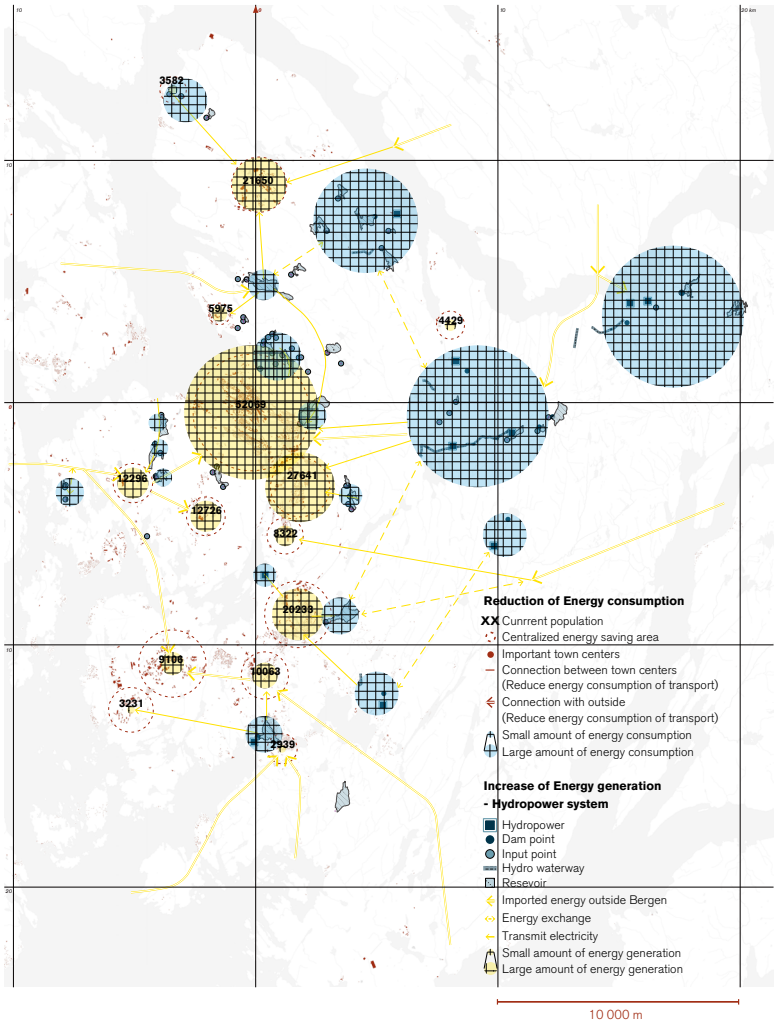

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- Resilient infrastructures

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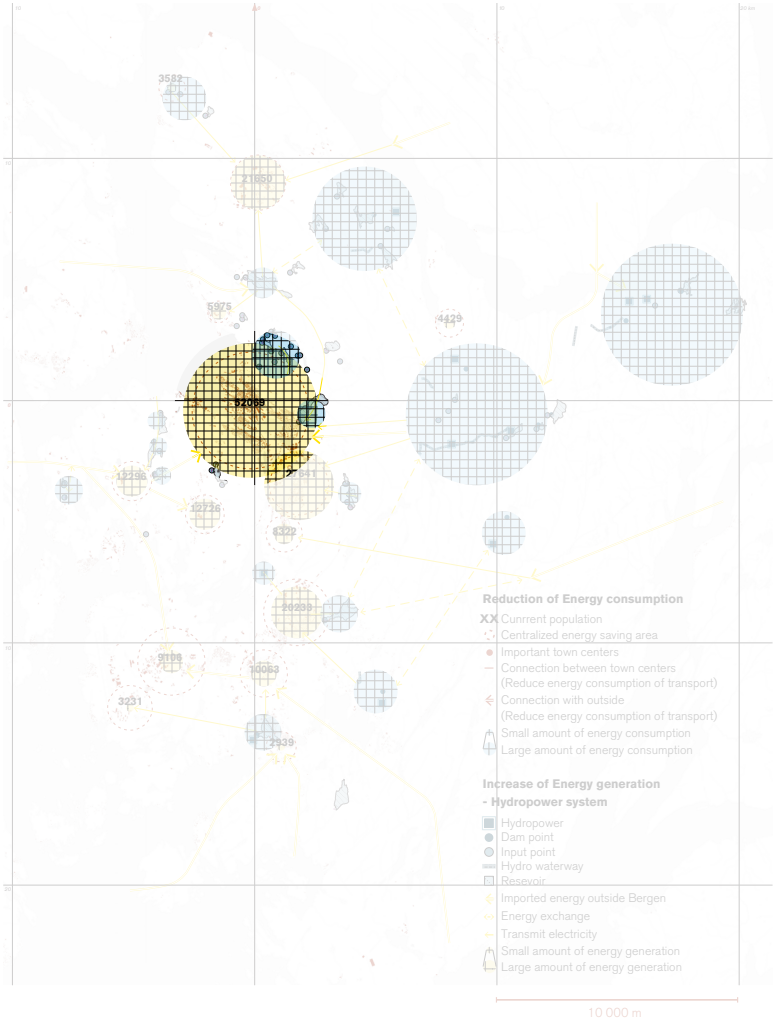

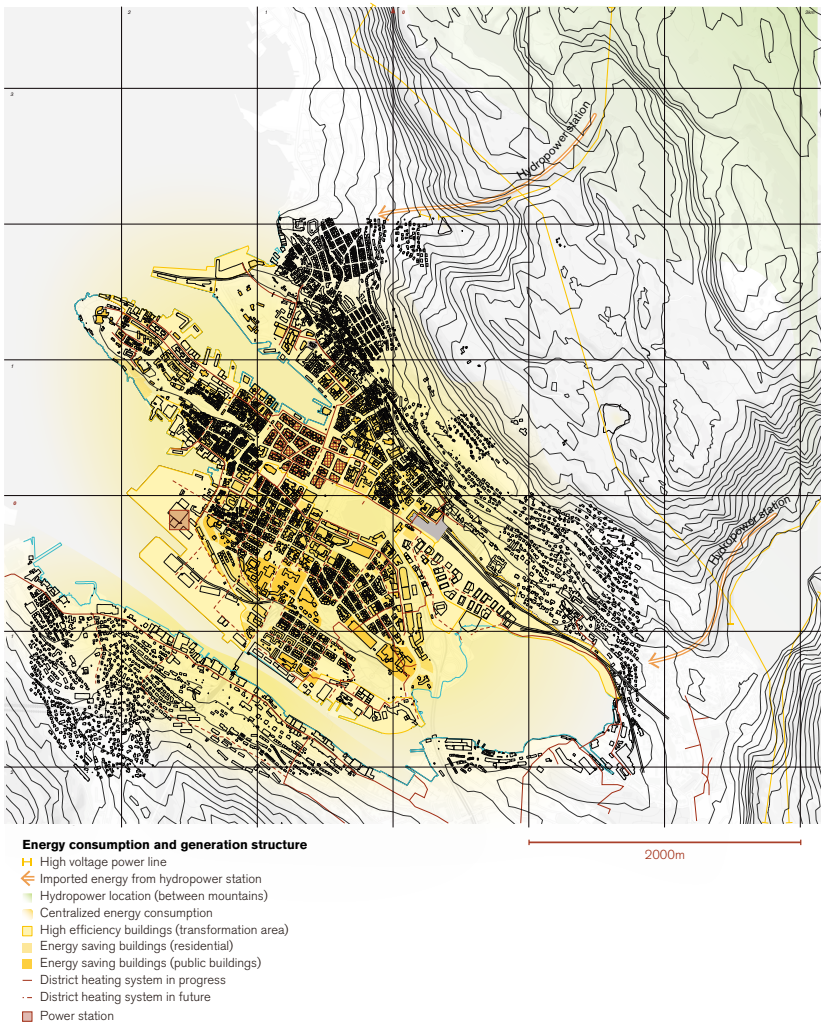

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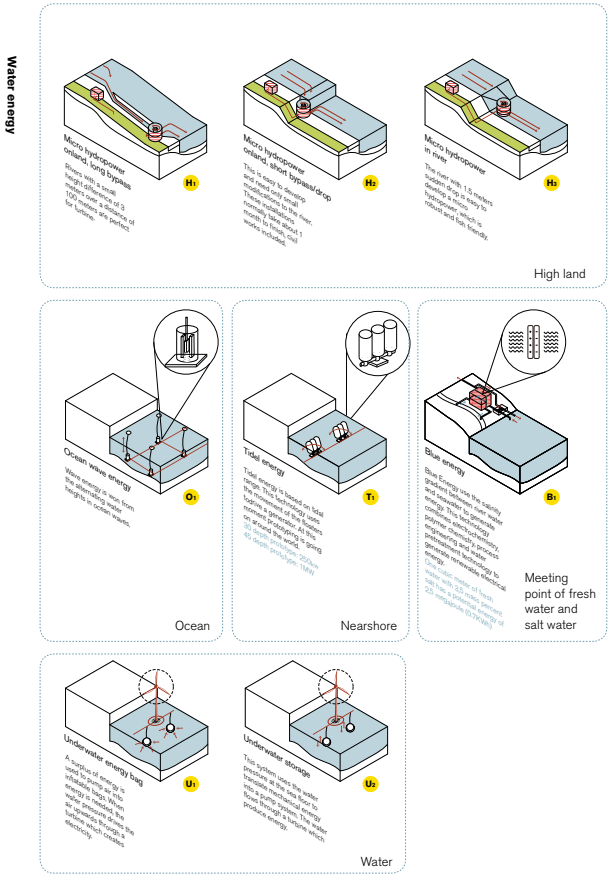

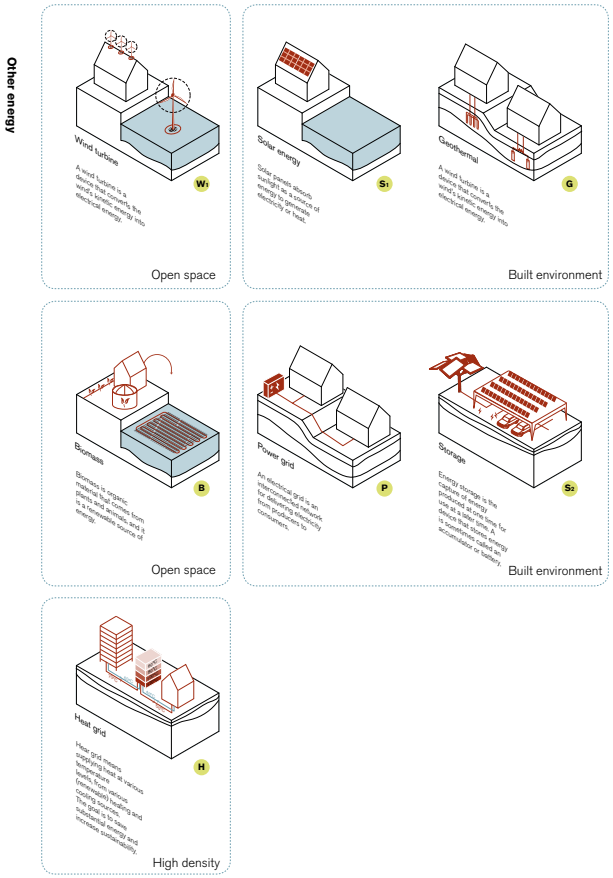

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- Resilient infrastructures

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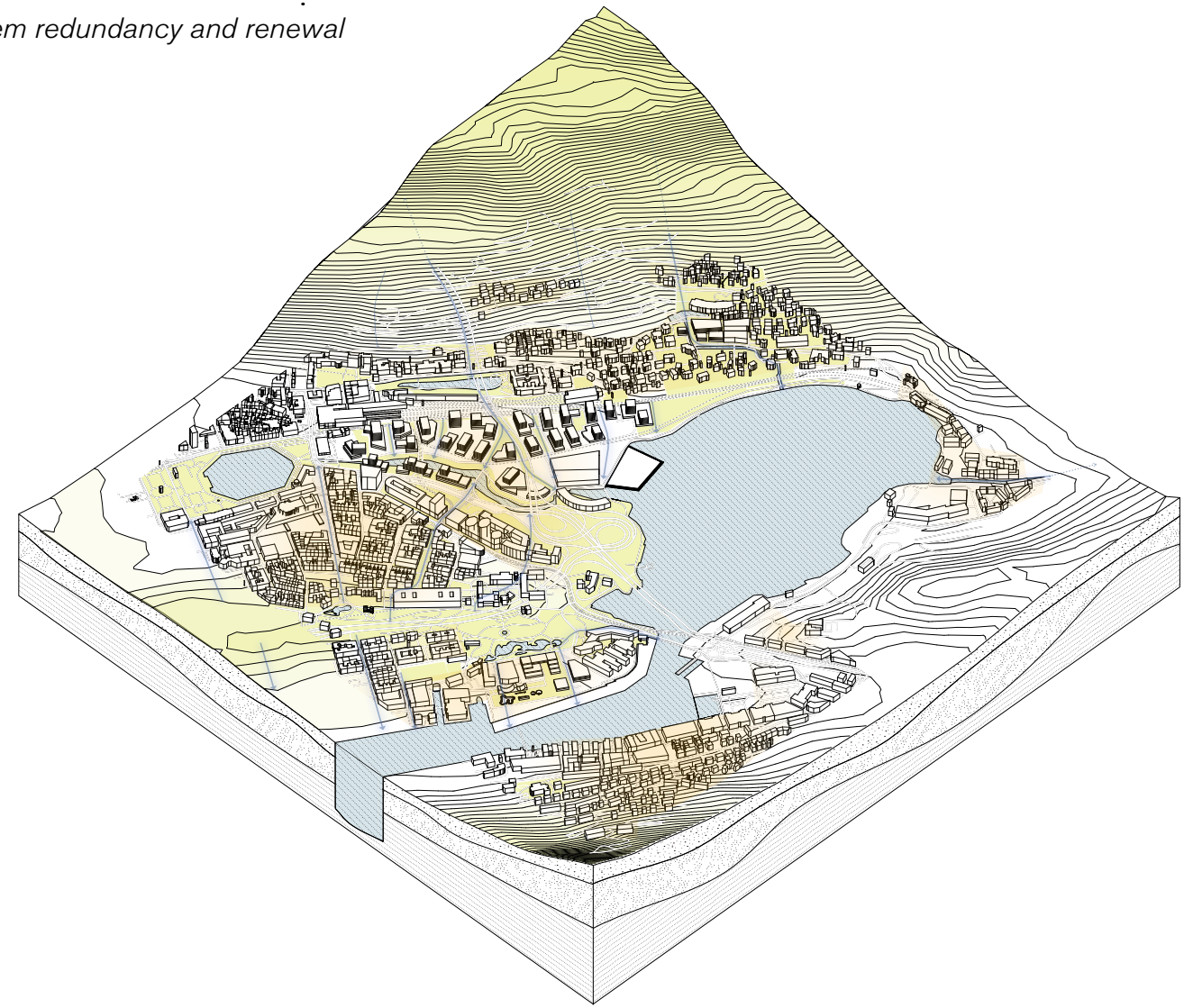

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- Resilient infrastructures

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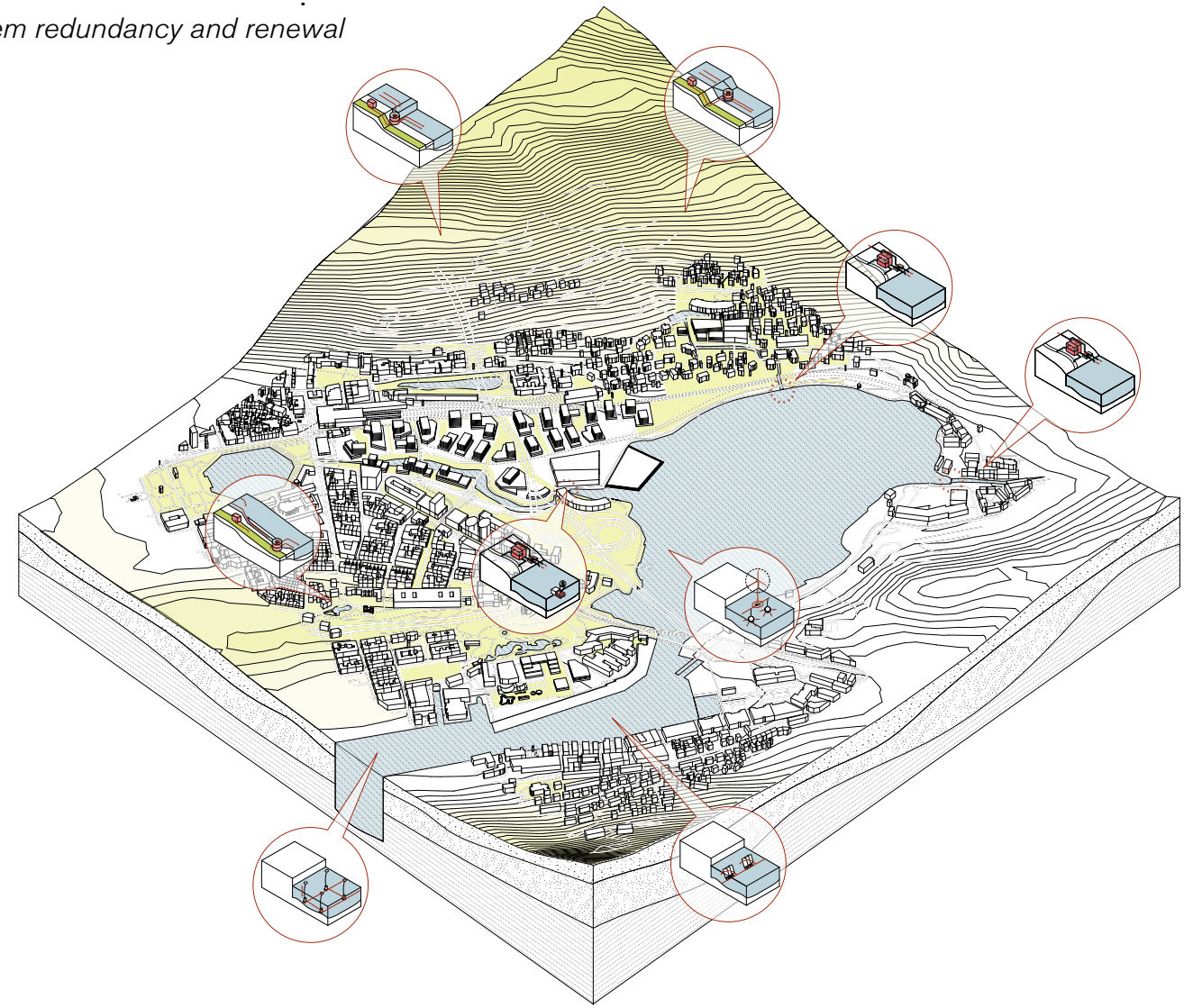

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- Resilient infrastructures

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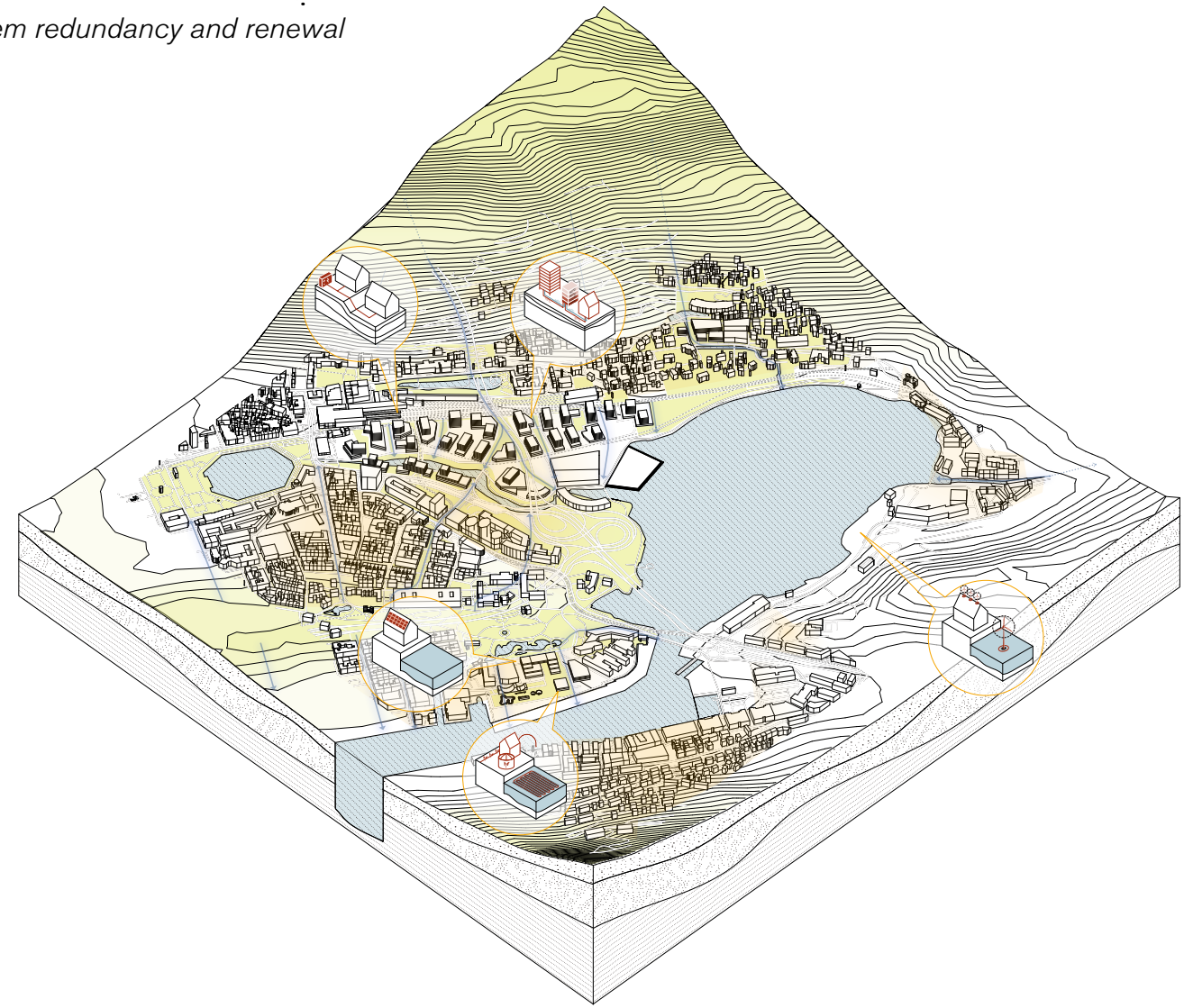

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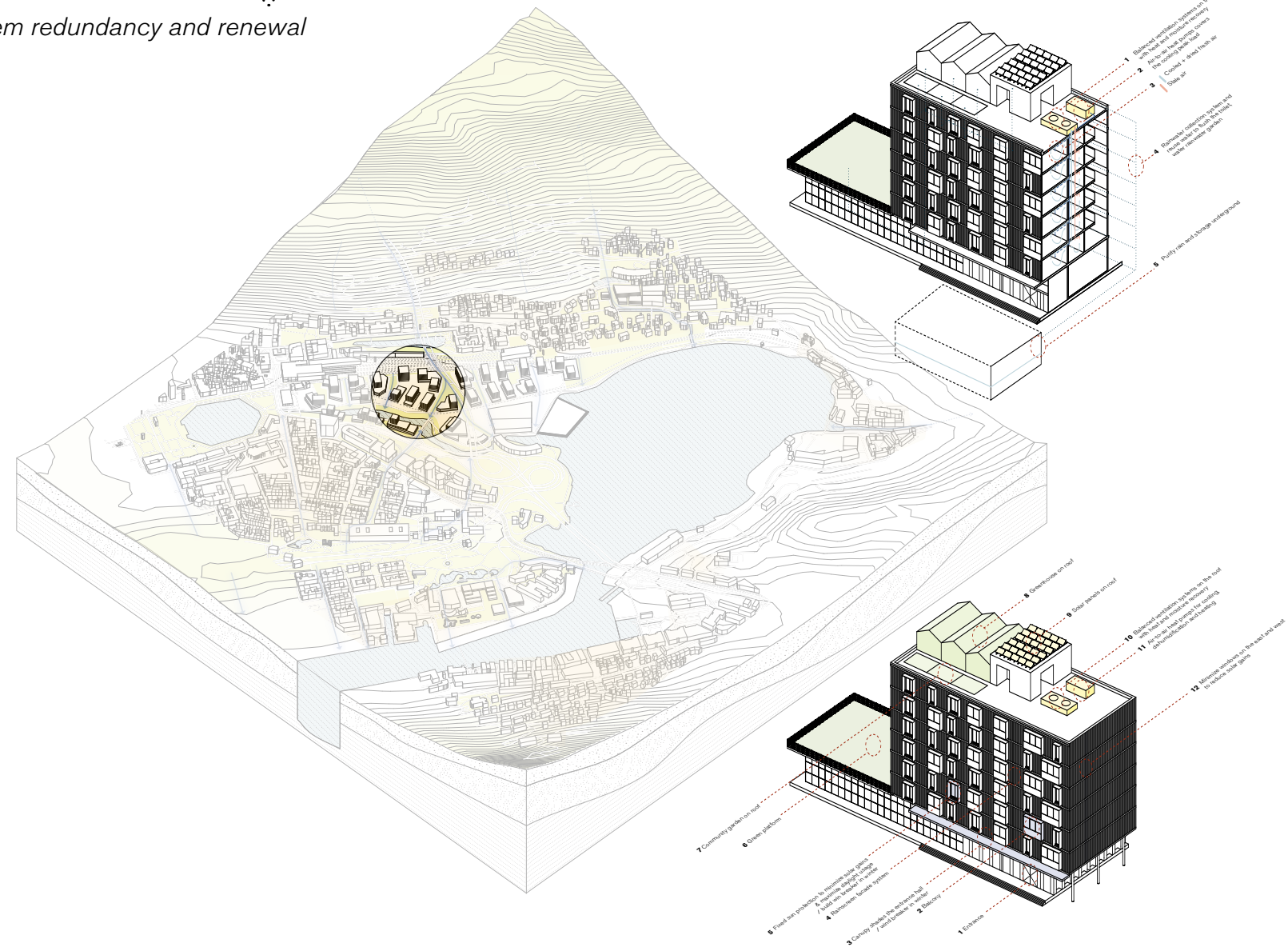

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- Resilient infrastructures

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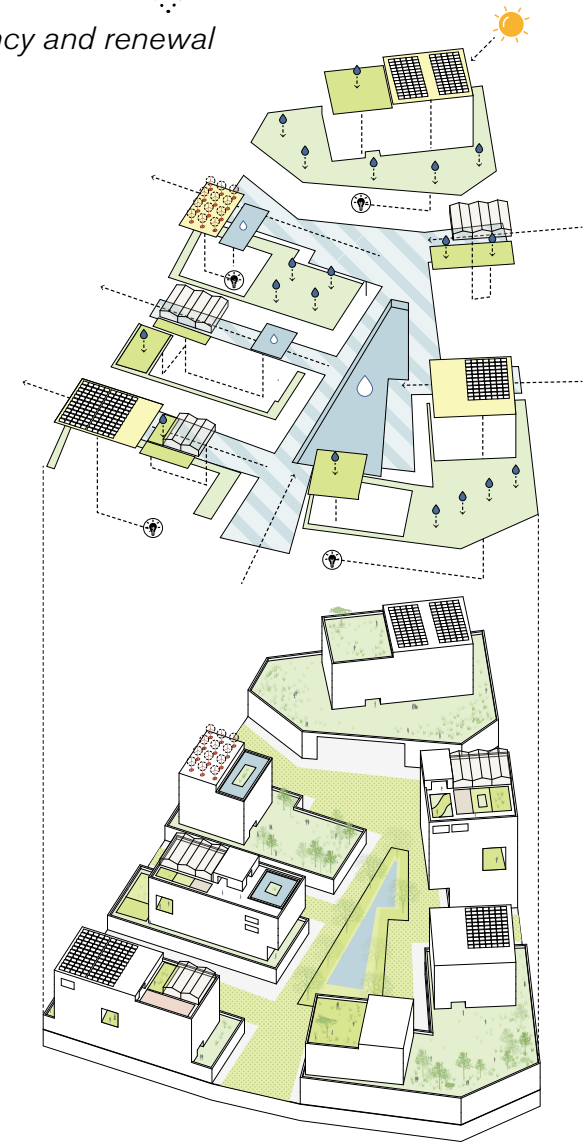
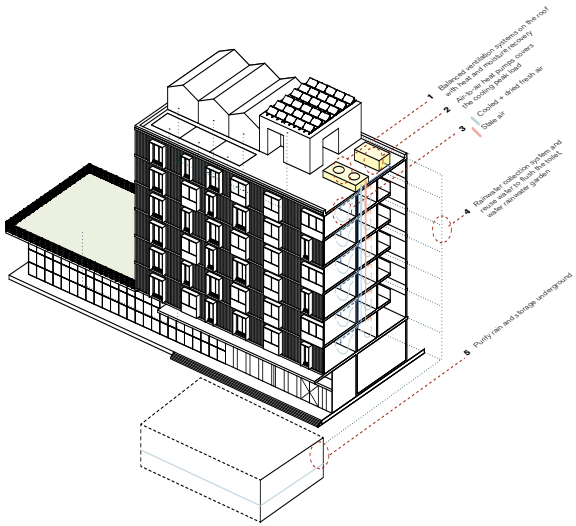
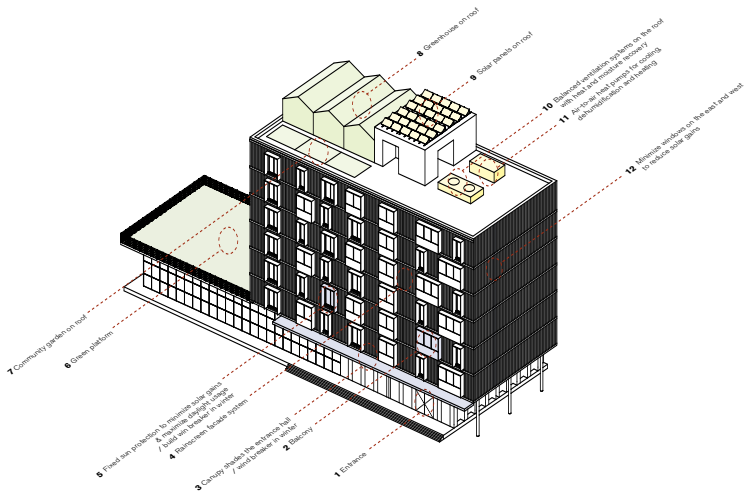






3. Resilience initiatives layers

- *Resilient infrastructures*

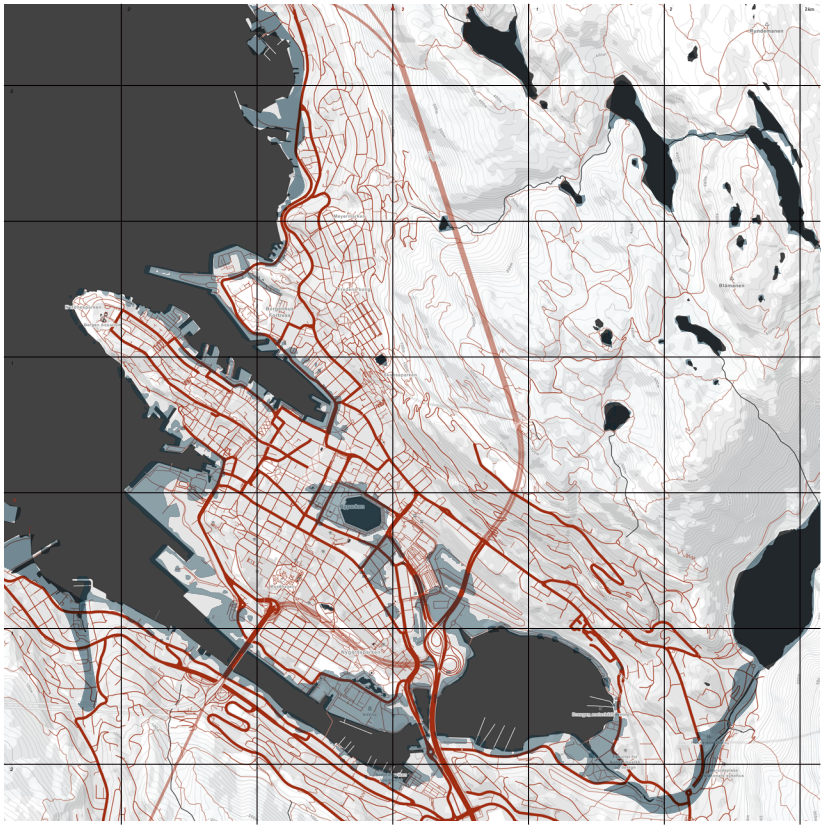
4) Adaptation of existing infrastructure systems

- *New blue-green structure*
- *New water management*
- *New energy system*

↓

- *Adaption of existing Transportation system*
- *Adaption of communication system*

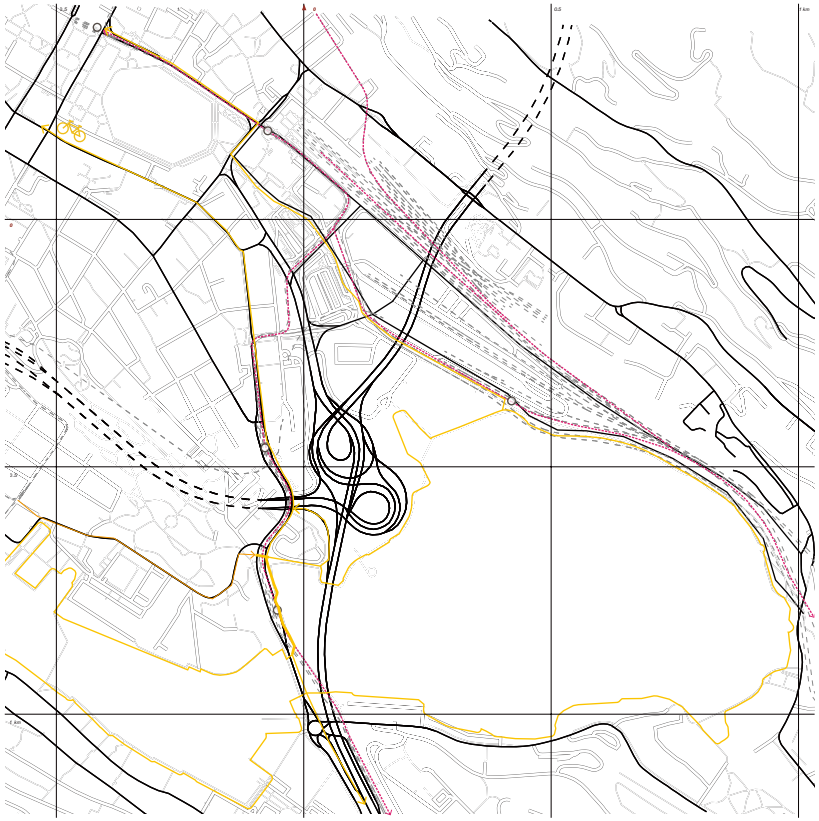
....



Energy consumption and generation structure

- High voltage power line
- Imported energy from hydropower station
- Hydropower location (between mountains)
- Centralized energy consumption
- High efficiency buildings (transformation area)
- Energy saving buildings (residential)
- Energy saving buildings (public buildings)
- District heating system in progress
- District heating system in future
- Power station

2000m



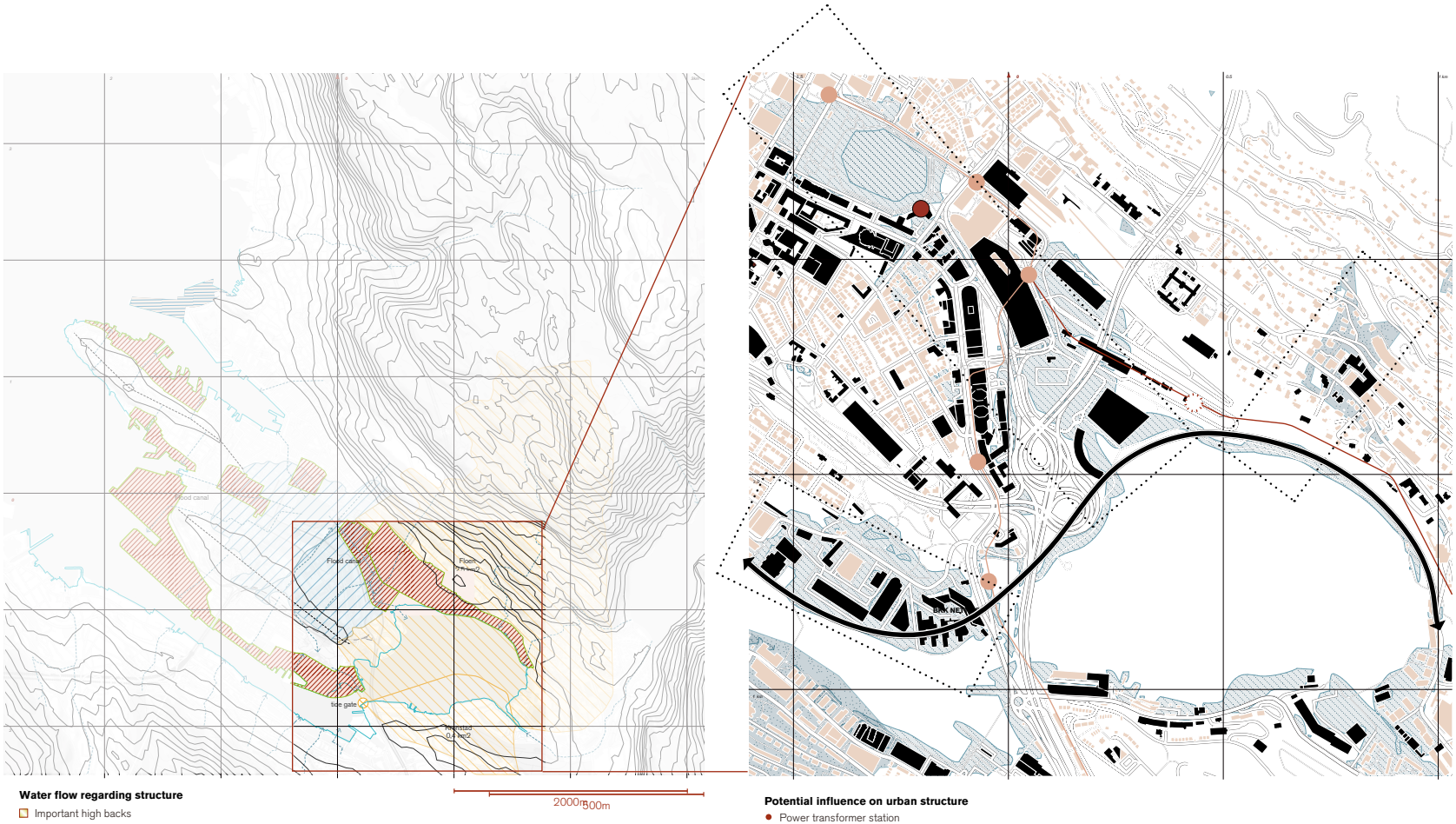
Current infrastrcture system

- Existing railway
- Existing light rail station
- Existing light railway
- Future light rail station
- Future light railway
- Existing high way
- Existing high way (tunnel)

3. Resilience initiatives layers

- Adapted buildings

1) Support for building retrofits



3. Resilience initiatives layers

- Adapted buildings

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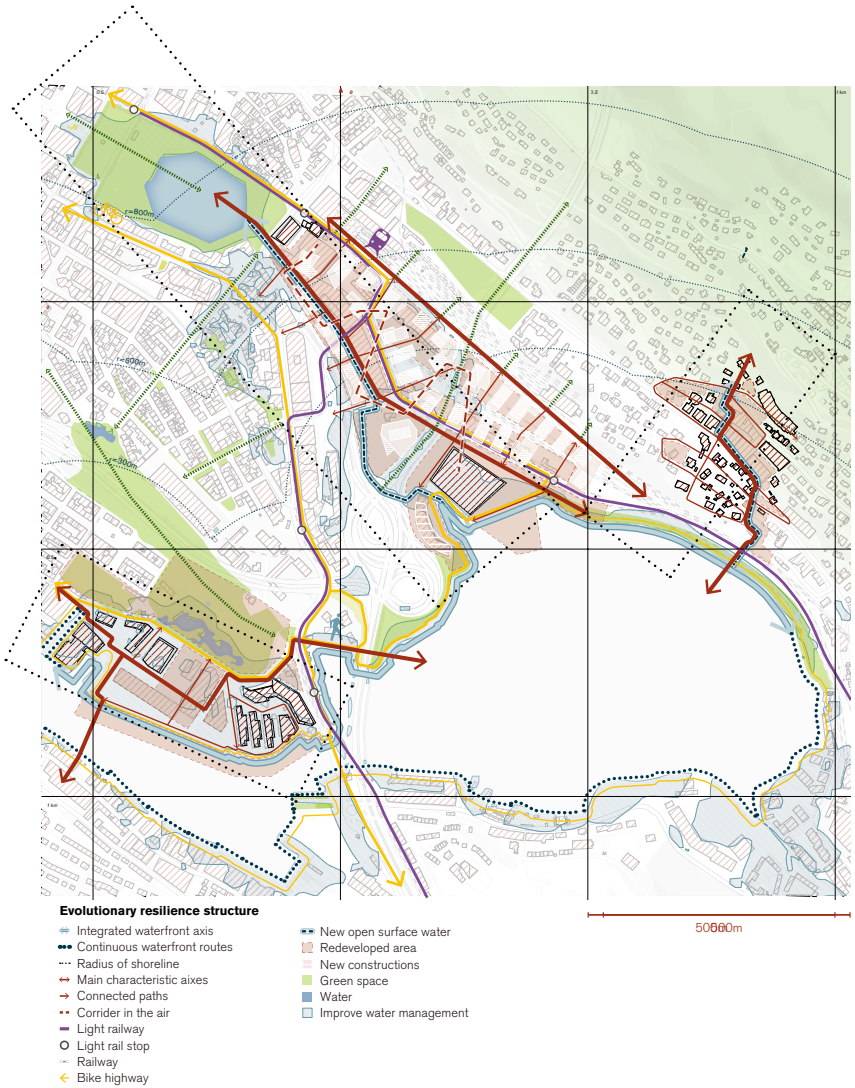
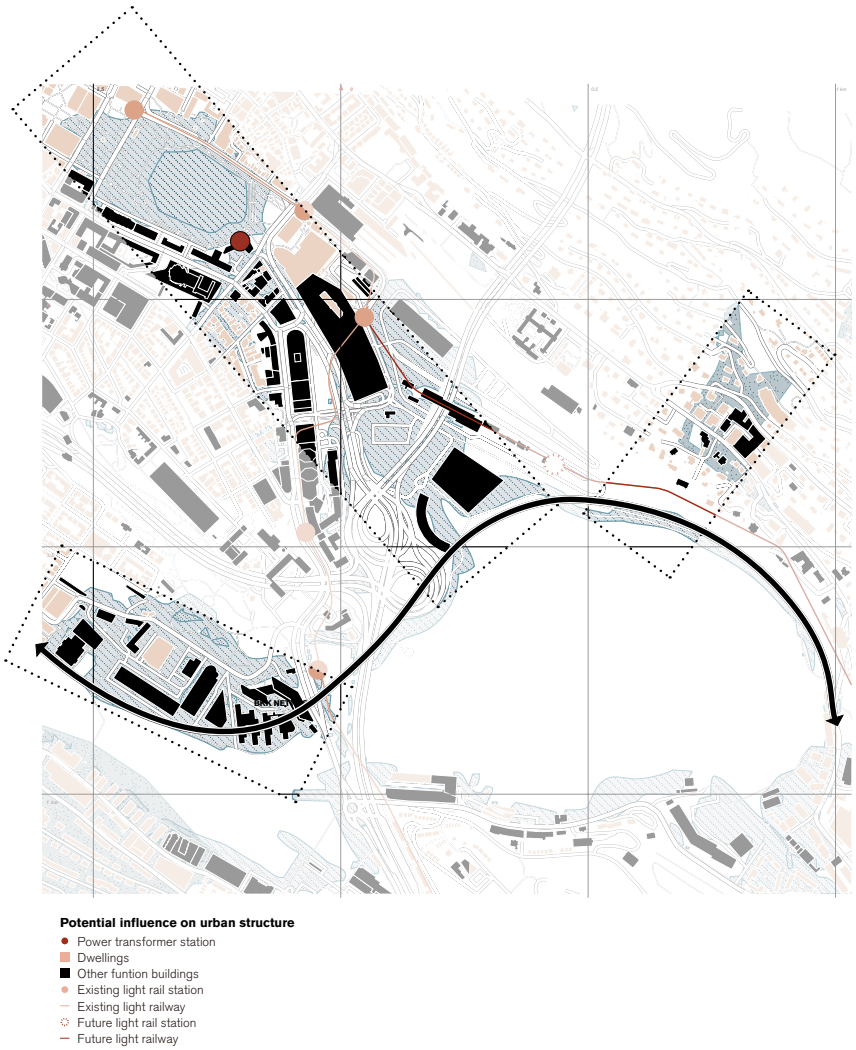




New responsive urban form

evolutionary resilience structure

1. Sport + Education + Energy

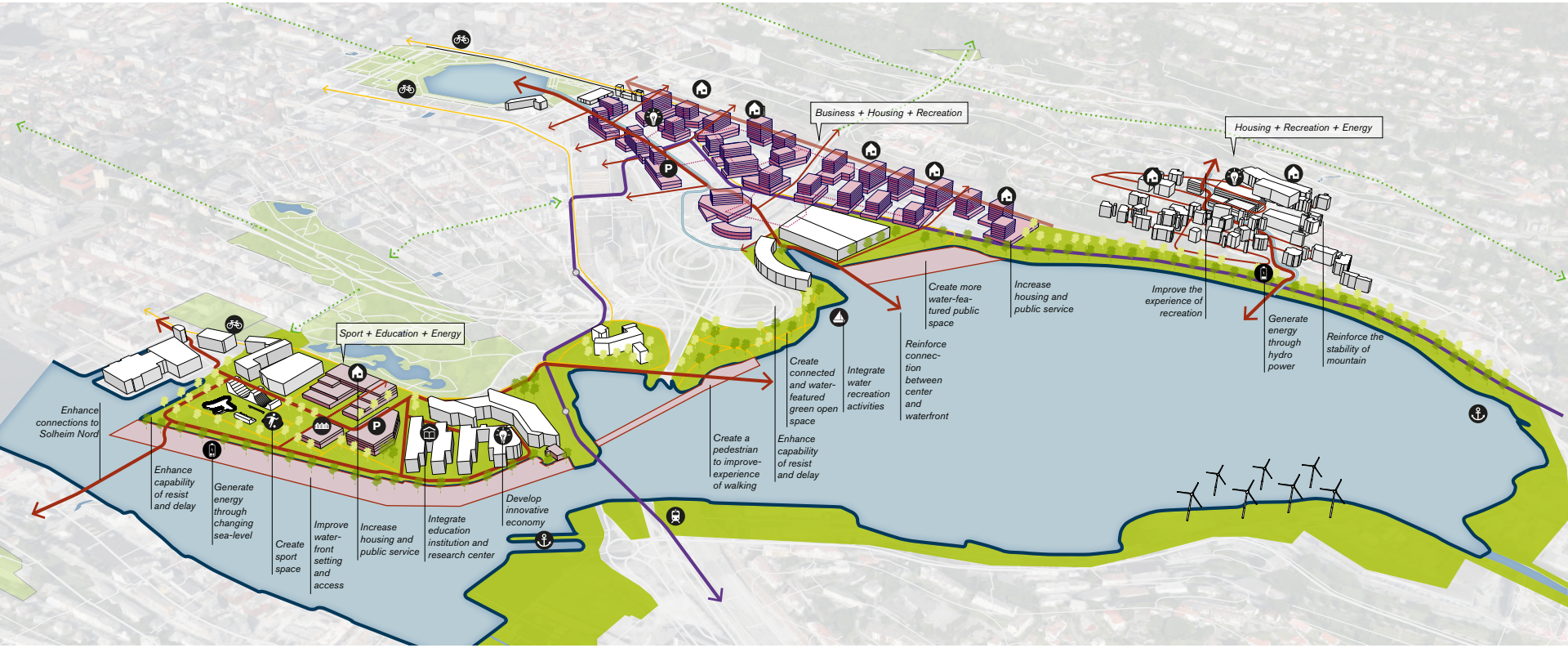
This area centralized some research centers, high schools and universities. Thus, the aim is to intensify the national centre for higher education while minimize the possiblity of flood risk and extreme precipitation. To take full advantage of the open green space, multi-functional service is considerded, for example combine the skate park, green space and water storage underground. Meanwhile, the location is sensitive to the changing sea-level. But this can be also used to generate more energy from water.

2. Business + Housing + Recreation

Due to the rapid development, this area is quit chaotic and aggregated a lot of large-scale public transportation station, parking garage and logistics center. Thus, the transformation of this axis is to activate the region between center and Store Lungegårdsvann with more business, housing and recreation and building characteristic landmarks. Reconnect the Lille Lungegårdsvannet and Store Lungegårdsvann to better discharge extreme precipiation and decrease flood risks. Meanwhile, using the meeting point of fresh water and sea water to generate more energy.

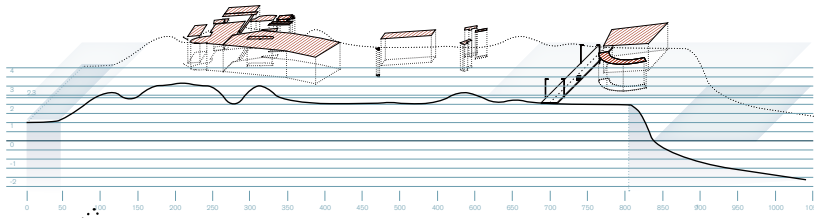
3. Housing + Recreation + Energy

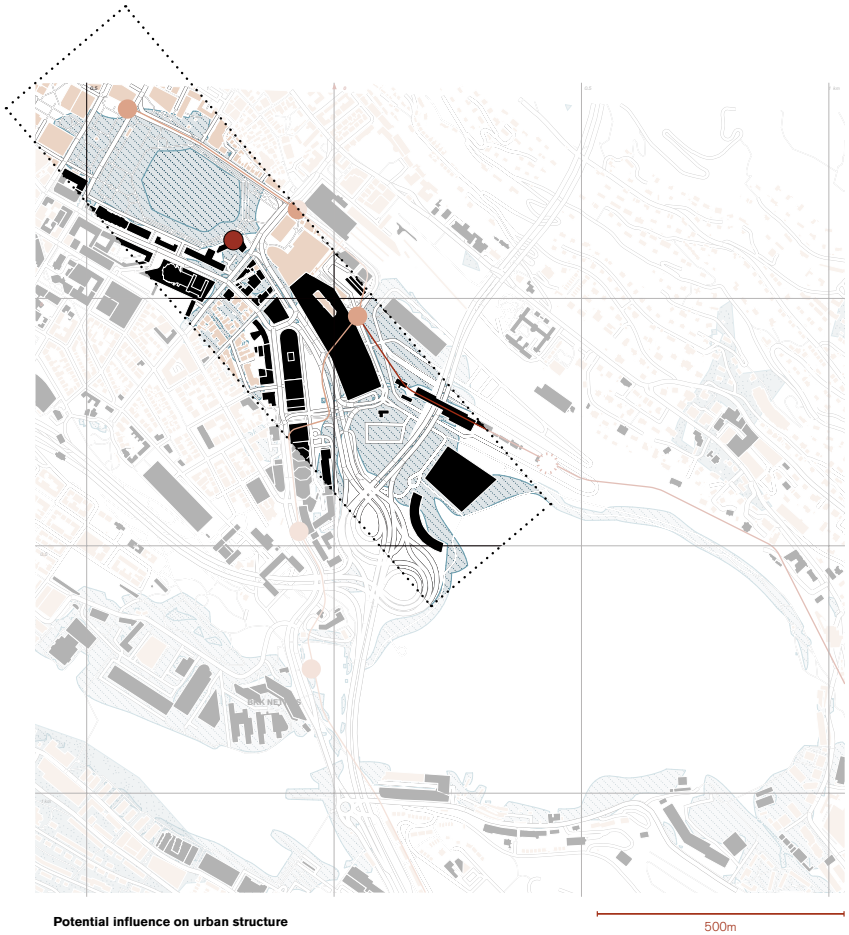
Mountains can be seen as the most distinctive features of Bergen, but it will also increase the possibility of landslide and snowslide in extreme weather, especially in winter. So this axis aims to strengthen the protection measures and utilize the adavantage of altitude difference and more precipitation to generate more energy through hydropower. Also, amphsis is put on the ecological connection, recreation and housing development.



Responsive urban form

- One transect







Potential influence on urban structure

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- Dwellings
- Other funtion buildings
- Existing light rail station
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- Future light rail station
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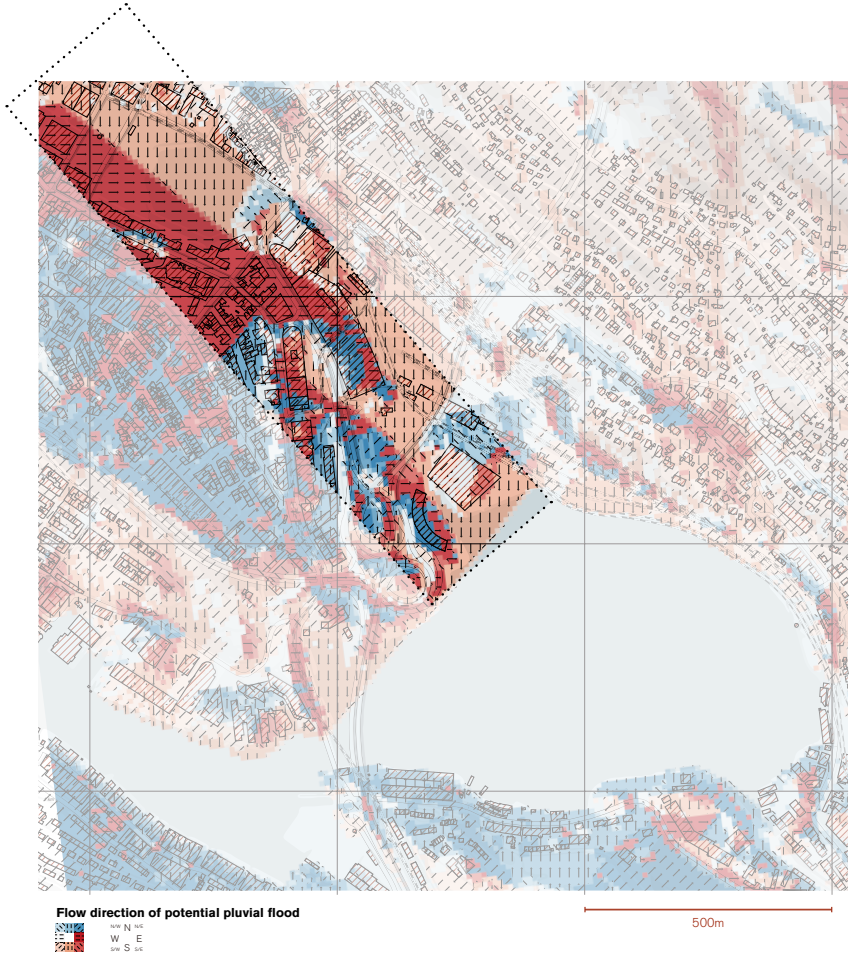
Responsive urban form

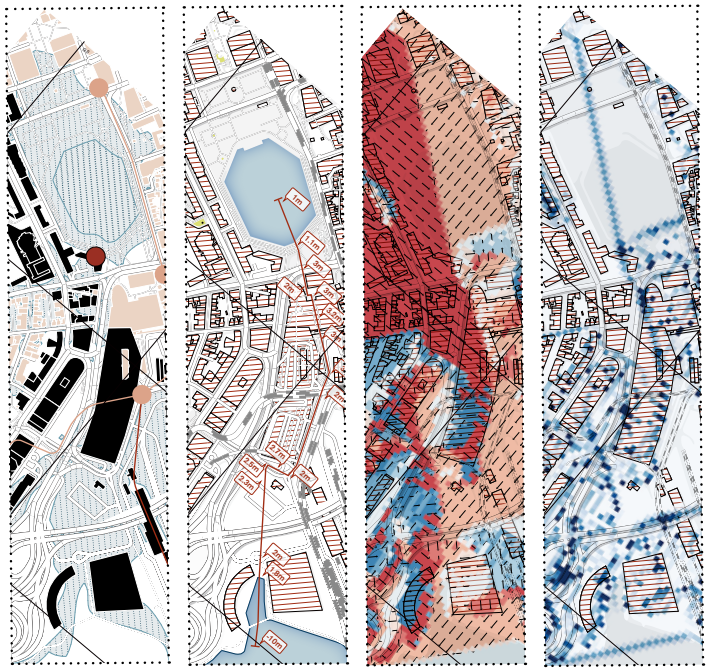
- One transect





Responsive urban form

- One transect

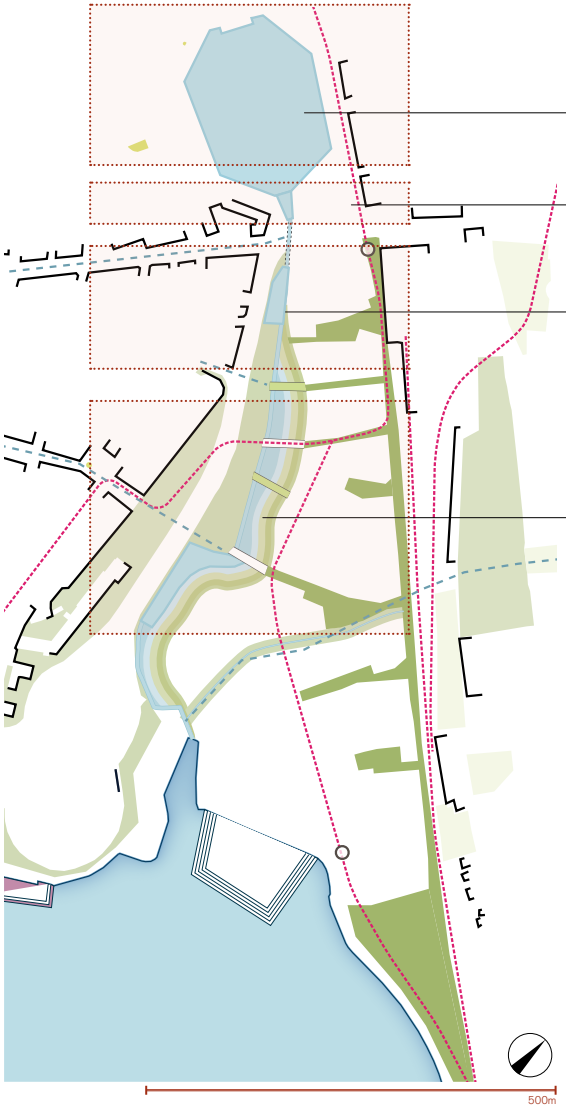


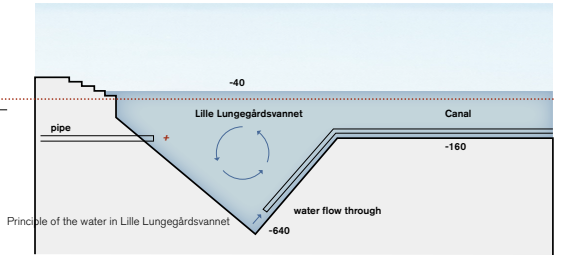


Responsive urban form

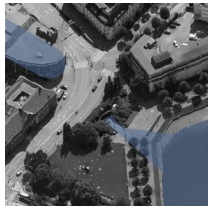
- One transect

1) New blue-green structure

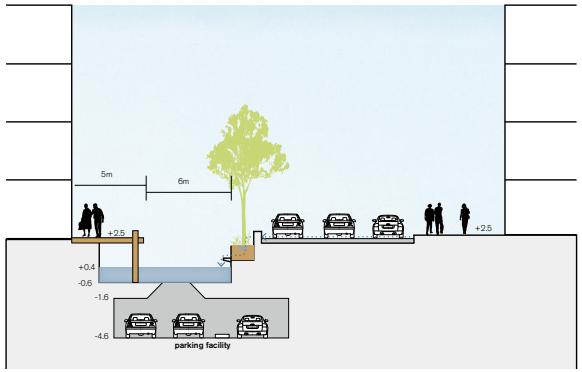




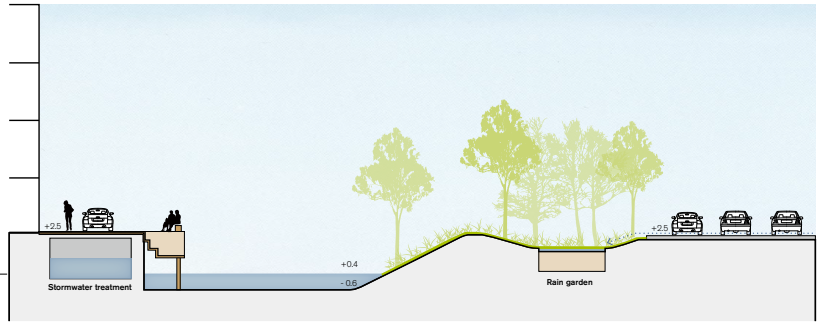
Principle of the water in Lille Lungegårdsvannet



Pedestrian walkway can be "reused" as a channel.



Principle of canal and underground parking facility between Lille Lungegårdsvannet and Store Lungegårdsvann.



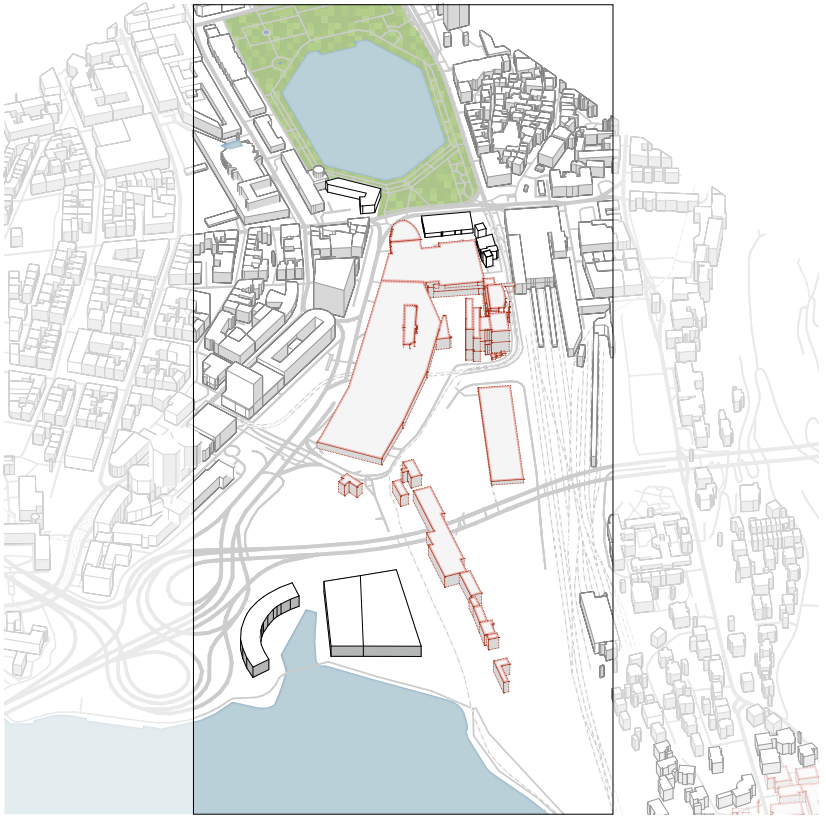
Principle of water management along canal.

Responsive urban form

- One transect

2) Mobility improvement

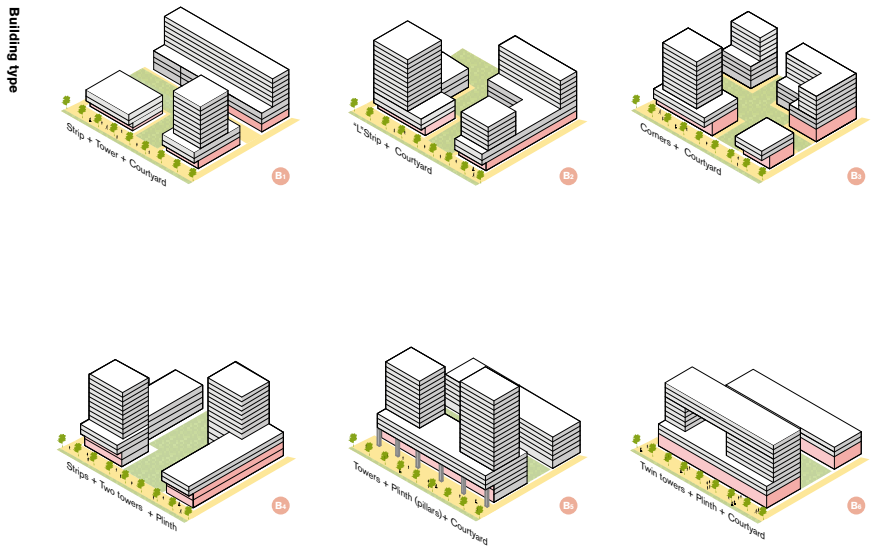




Responsive urban form

- One transect

3) Adapted buildings

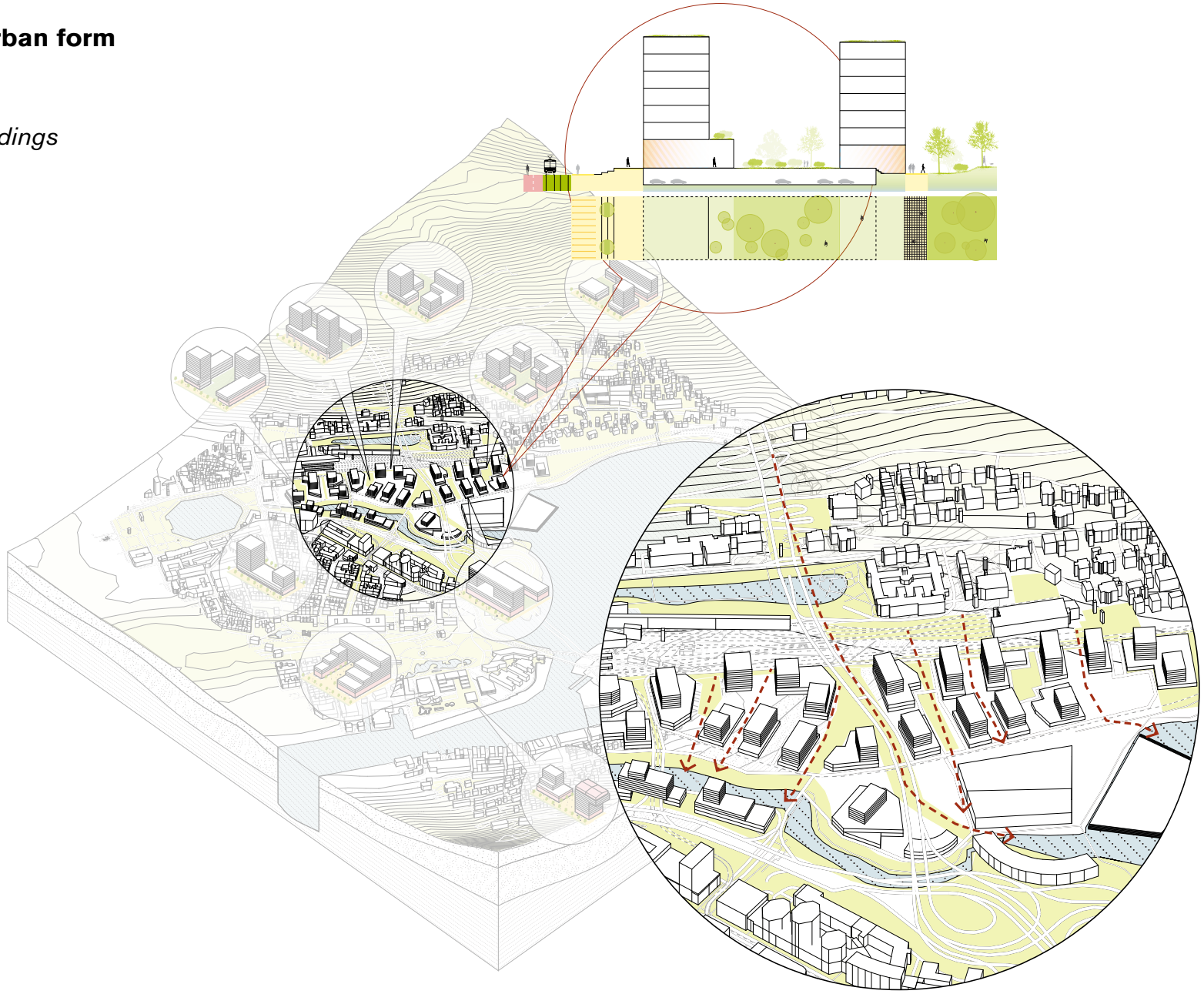




Responsive urban form

- One transect

3) Adapted buildings

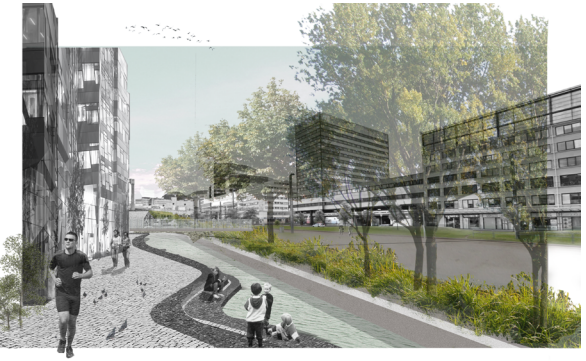


Responsive urban form

- One transect

3) Adapted buildings

❶





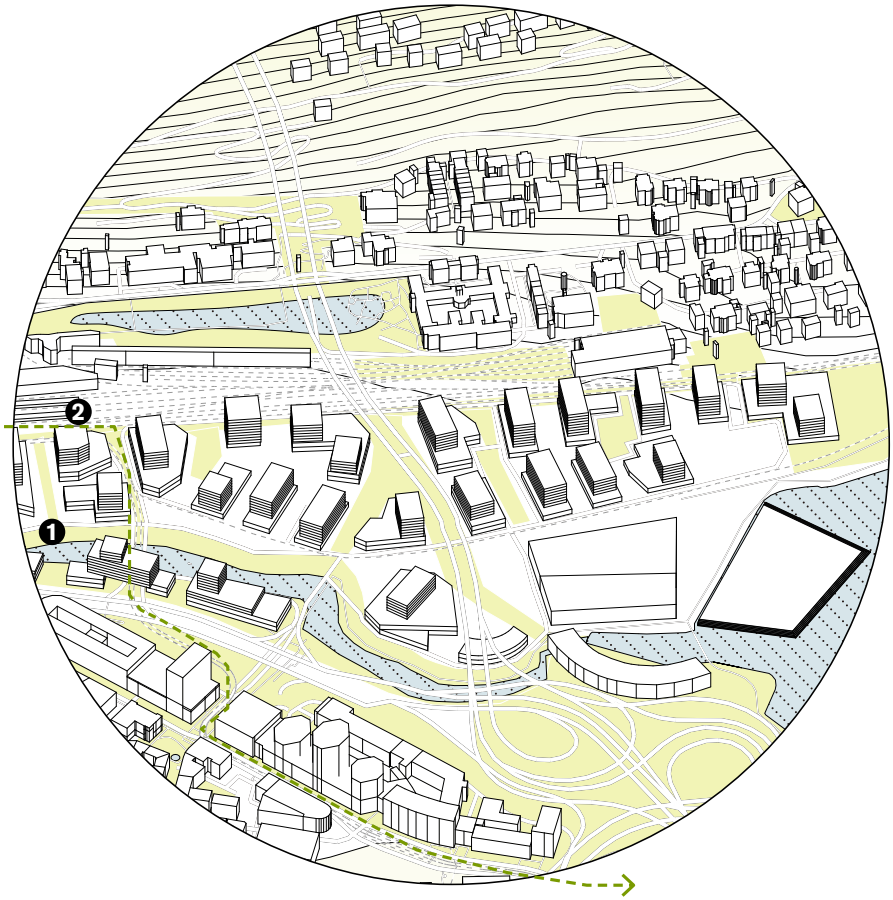
The water connects Lille Lungegårdsvannet the canal, which provides a quiet and comfortable atmosphere.

❷



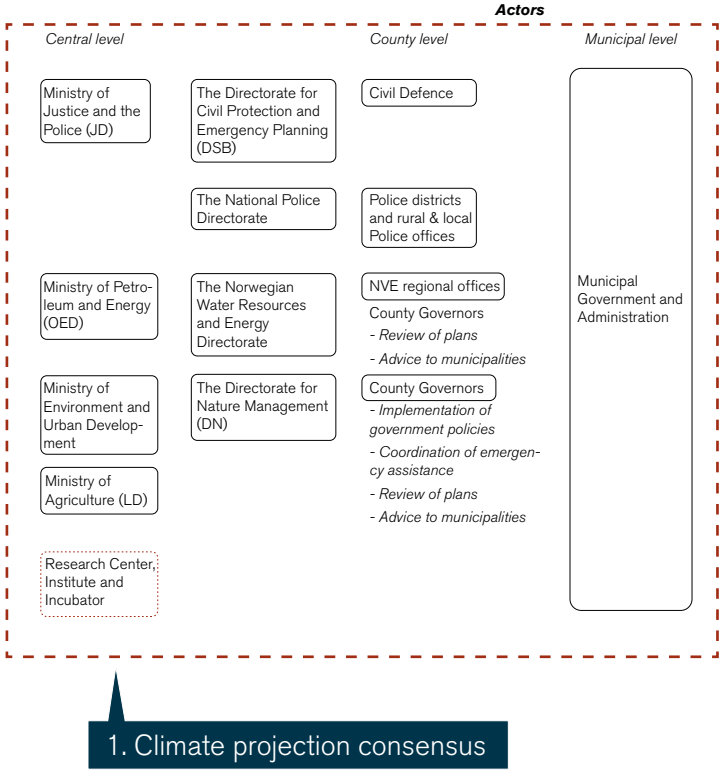


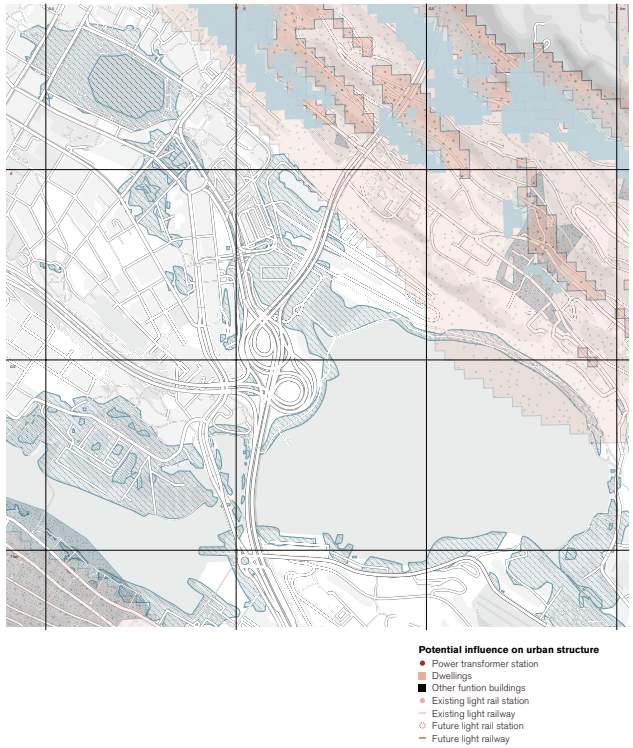
New light rail way on the green connects the built environment and green open space.



4. Intergrated actors, agendas and governance

1) Climate projection consensus





4. Intergrated actors, agendas and governance

2) Engagement of at-risk stakeholders

Actors

Central level

- Ministry of Justice and the Police (JD)
- Ministry of Petroleum and Energy (OED)
- Ministry of Environment and Urban Development
- Ministry of Agriculture (LD)
- Research Center, Institute and Incubator

- The Directorate for Civil Protection and Emergency Planning (DSB)
- The National Police Directorate
- The Norwegian Water Resources and Energy Directorate
- The Directorate for Nature Management (DN)

County level

- Civil Defence
- Police districts and rural & local Police offices
- NVE regional offices
- County Governors
  - *Review of plans*
  - *Advice to municipalities*
- County Governors
  - *Implementation of government policies*
  - *Coordination of emergency assistance*
  - *Review of plans*
  - *Advice to municipalities*

Municipal level

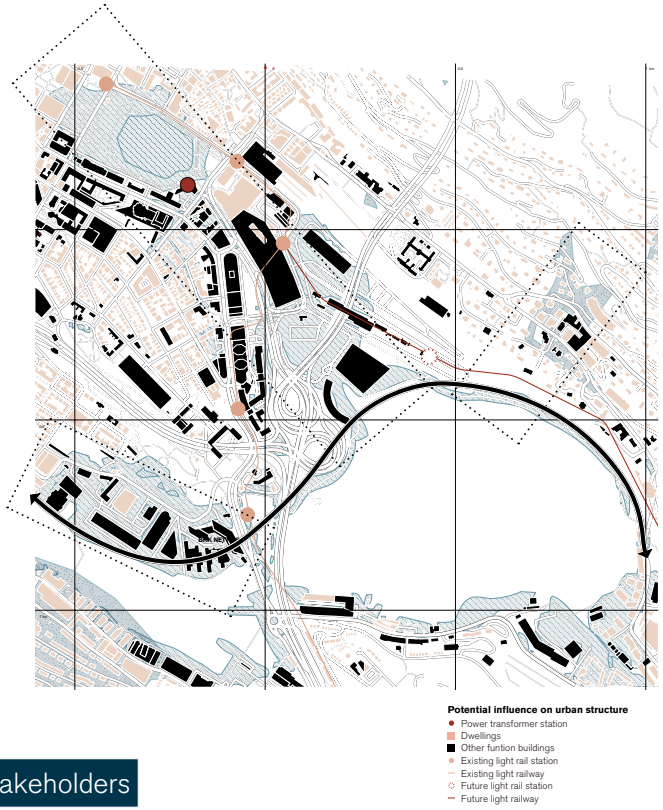
- Municipal Government and Administration

Interest groups

- Private investors, companies
- Land owners
- NGOs (environment, energy, recreation)
- General public

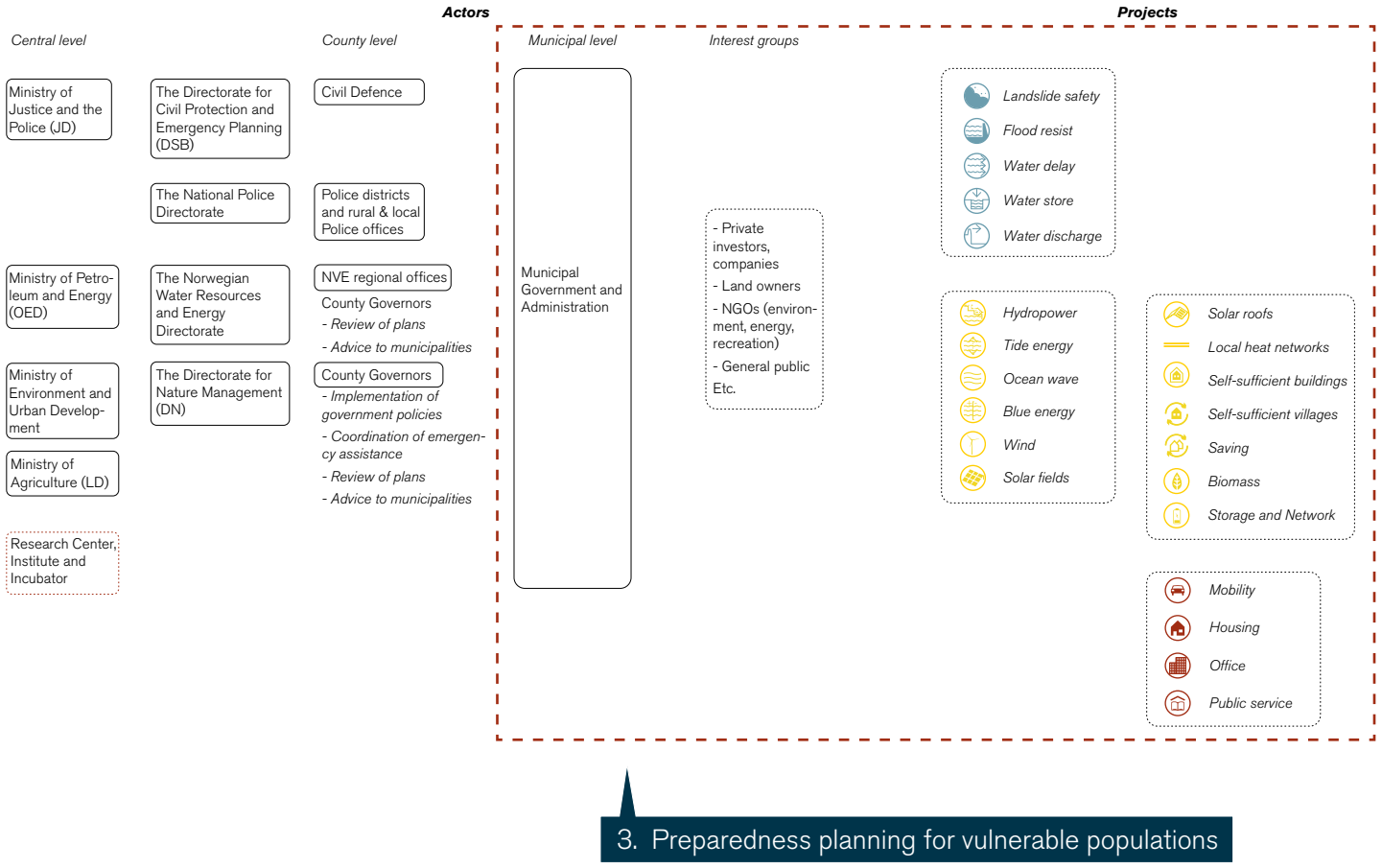
Etc.

2. Engagement of at-risk stakeholders



4. Intergrated actors, agendas and governance

3) Preparedness planning and agendas for vulnerablility



4. Intergrated actors, agendas and governance

4) Small businesses and institution support



Funds

- EU funds
- Europe Energy Efficiency Fund (EEEF)
- Government Pension Fund of Norway
- European Structured & Investment Funds (ESI funds)
- Nordic Development Fund (NDF)
- The Norwegian National Fund for Natural Damage Assistance

Actors

Central level

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Interest groups

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- General public

Etc.

Projects

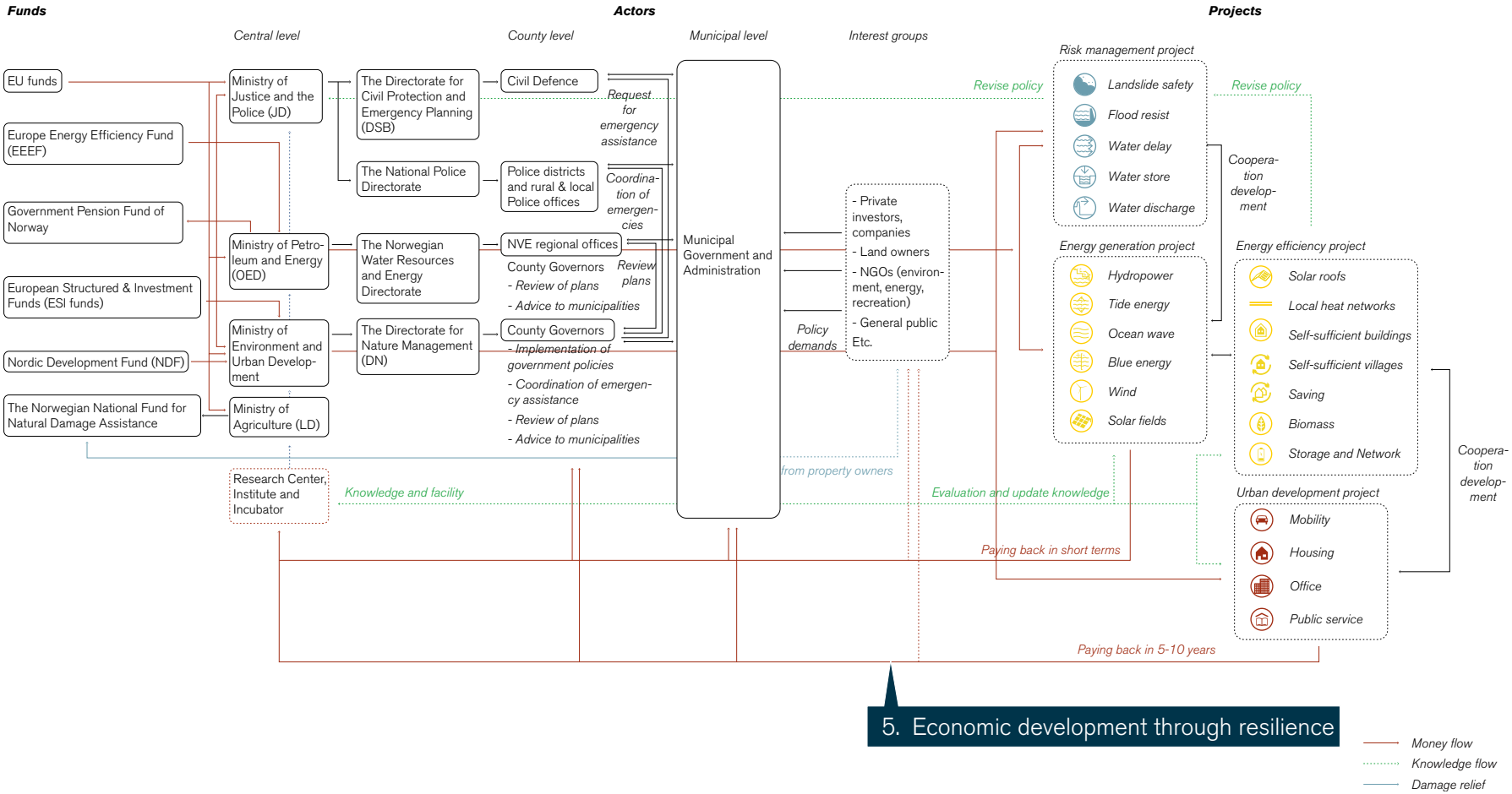
- *Landslide safety*
- *Flood resist*
- *Water delay*
- *Water store*
- *Water discharge*
- *Hydropower*
- *Tide energy*
- *Ocean wave*
- *Blue energy*
- *Wind*
- *Solar fields*
- *Solar roofs*
- *Local heat networks*
- *Self-sufficient buildings*
- *Self-sufficient villages*
- *Saving*
- *Biomass*
- *Storage and Network*
- *Mobility*
- *Housing*
- *Office*
- *Public service*

4. Institution support

4. Small businesses support

4. Intergrated actors, agendas and governance

5) Economic development through resilienc



5. Implementation phase



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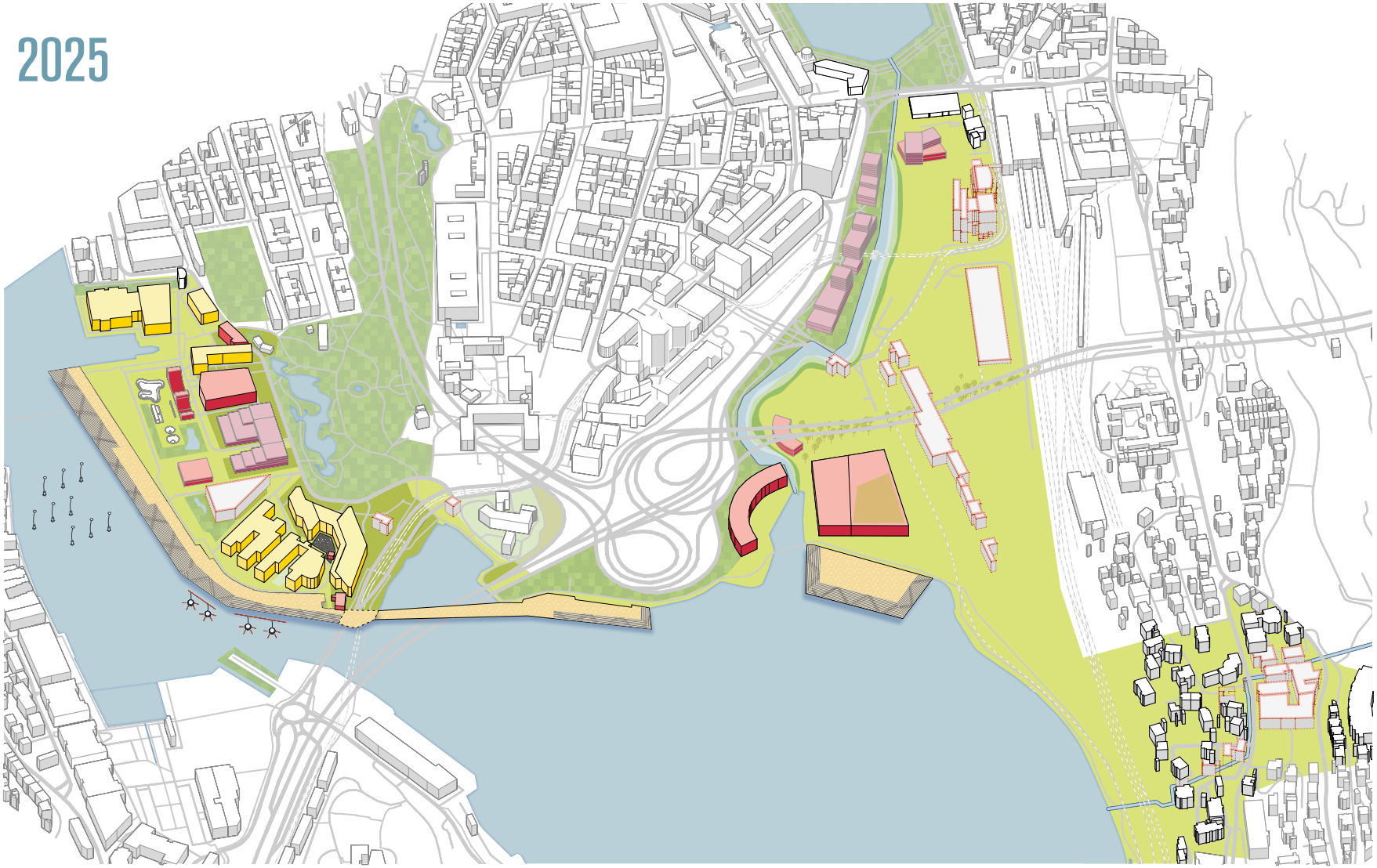
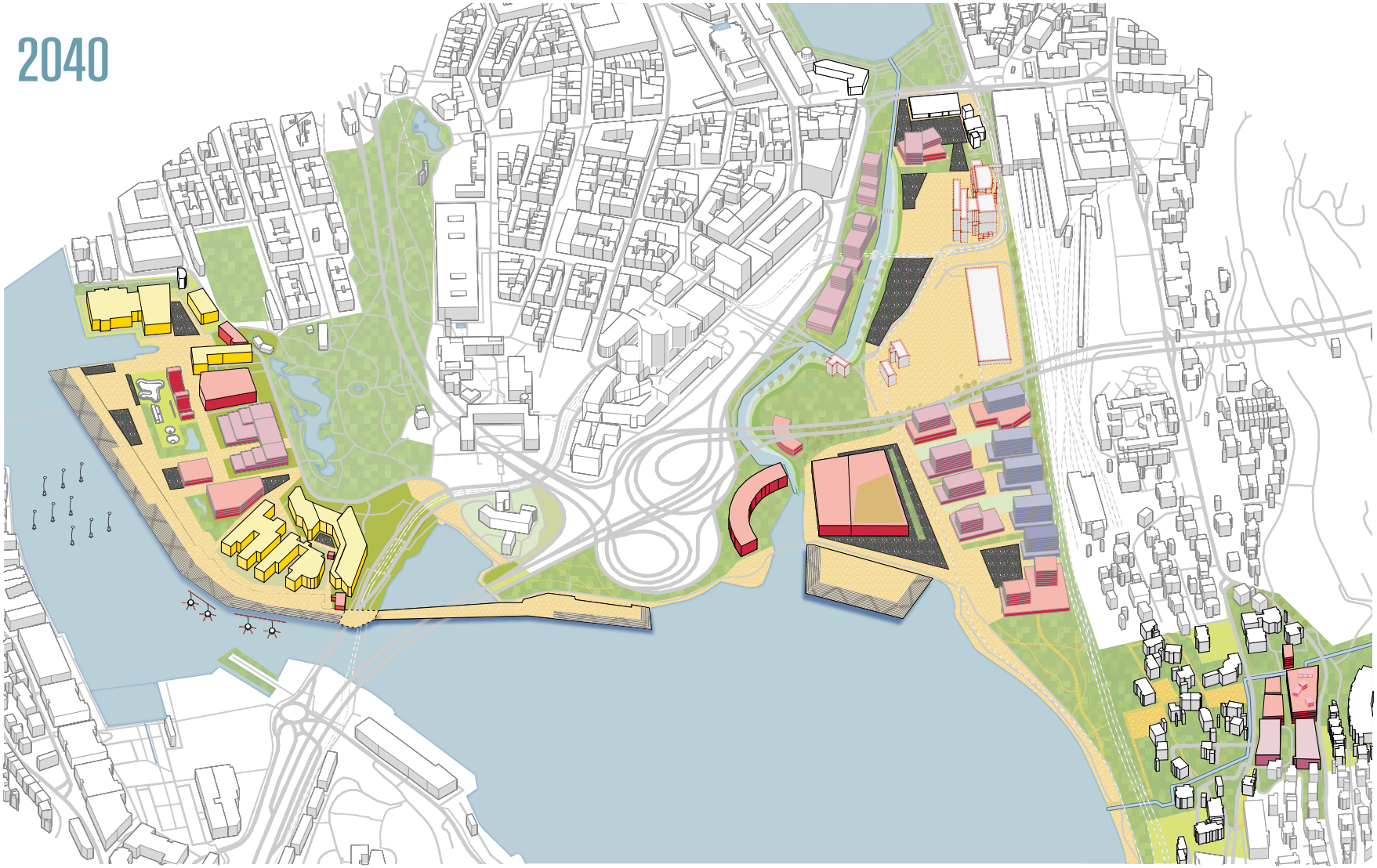


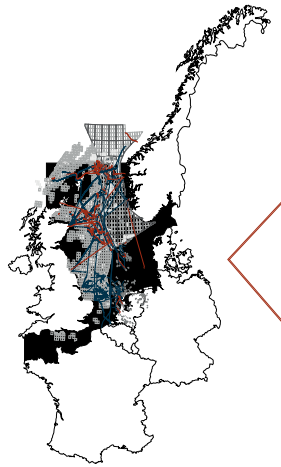
5. Implementation phase



5. Implementation phase



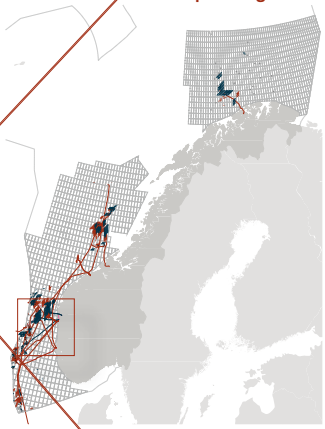
Conclusion & reflection



Important cities in the North Sea Region

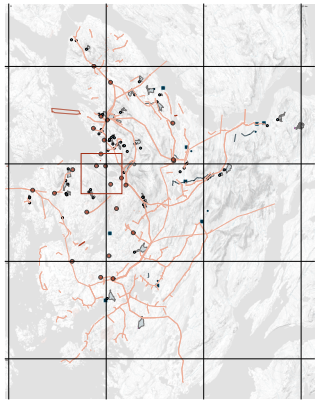
Source: Delta intervention Studio

Upscaling



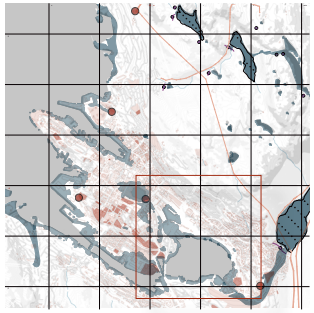
Oil & gas field in Norway

Source: Group 4



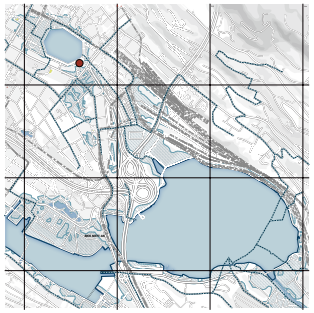
Energy system in Bergen

Source: Authour



Flooded projection of Bergen Center

Source: Authour



Flooded projection of Part of Bergen Center

Source: Authour

Motivation

- *Climate change* effects
- *Energy transition* requirement
- affected *Urban systems* and people as victims

Research (extensive) → **Research** → **Research by design** → **Design**

Ex ante	Question	Analysis	Result of analysis	Exploring opportunities	Result of exploration	Final result
- theory framework - climate change - energy transition - urban system *(Norway)*	- problem statement - reseach question	- policy - network - ocupation - nature *(Bergen)*	- environment context - potential risks & influence - spatial restrictions & chance	- future scenario - phasing	- spatial principles - promising interventions - preferred development	- structure planning - urban design & vision - spatial rules and inspiration - advise on policy

Integrated strategy towards evolutionary resilience

adapting the urban systems to climate change integrating with the potentiality of the requested energy transition

Thanks.