Sustainability Index *for* Climate wise construction

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Joensuu City _ Application: ArcMap 10.8.1

About SBTCP

Sustainable Building Technologies- Community of Practices

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- Karelia UAS, Joensuu, Finland
- Jade UAS, Jade, Germany
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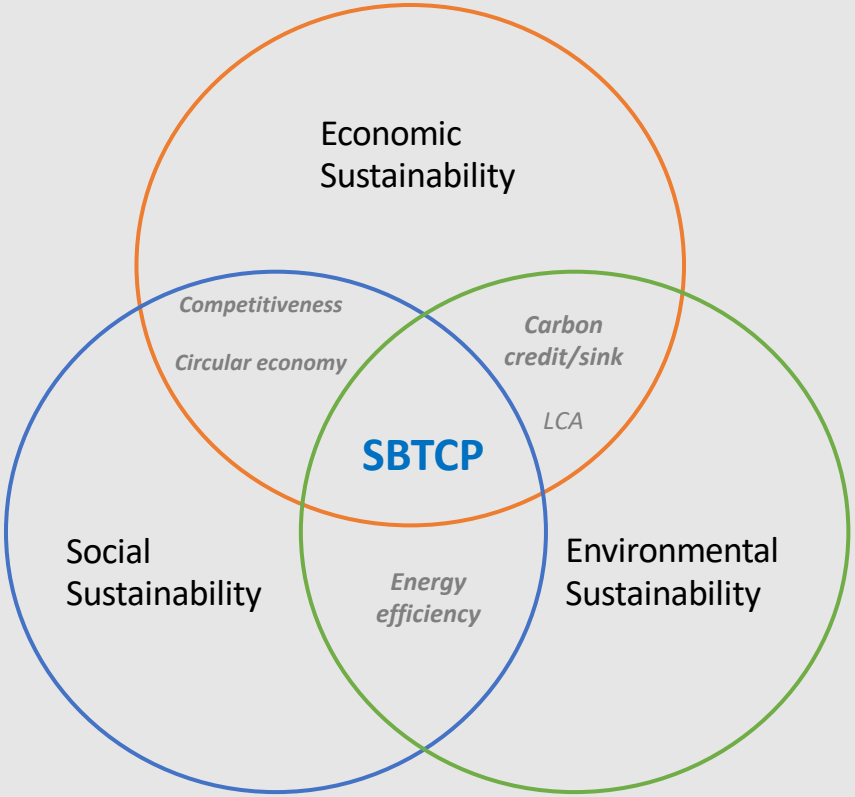
Three Piers of Sustainability

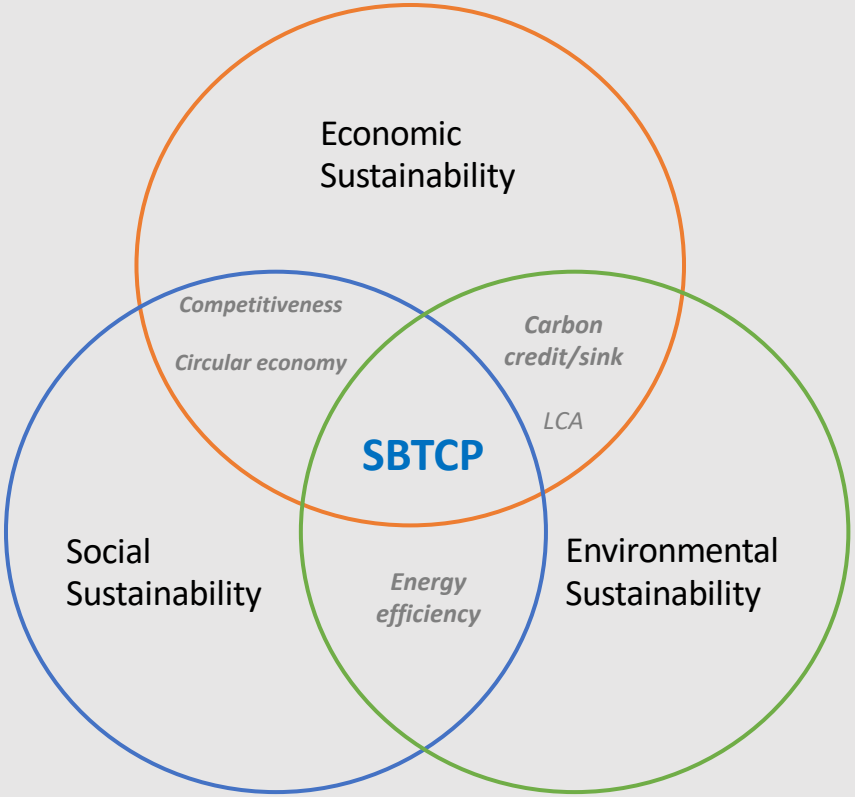


WP1 Research HUB_ Karelia UAS

1. Bringing Wood Back to Cities

- **Spatial Modelling for Climate Wise Construction**: An Urban Morphology-Energy Consumption Nexus Based Framework
- **Materiality and Urban Micro-climate**: Impact of Building Envelope Material on Urban Micro-Climate
- Investigation of long-term **Indoor Air Quality** in wooden wall structures
- **Sustainability Index development** from the summary of earlier results

Three Piers of Sustainability



2. Competitiveness of wood construction

- Key elements of **competitiveness of wood construction**
- Competitiveness analysis by **TALO 2000 categories**
- **Potential of competitiveness development** in construction industry
- **Holistic analysis of the competitiveness** of wood construction

Question is…

How to develop a systematic and quantitative decision support system to optimize energy and material usage in building and city scale?

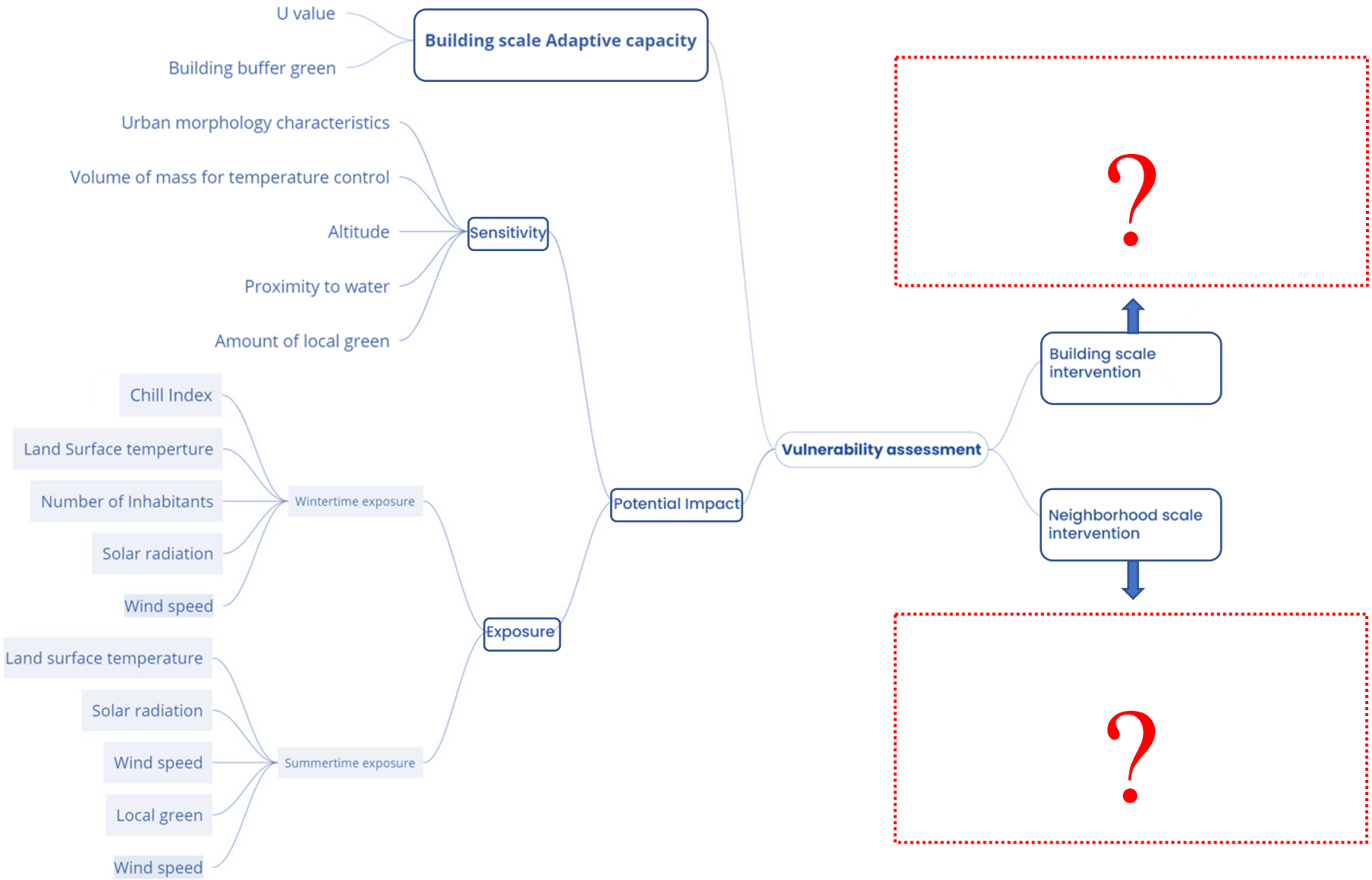
INTRODUCTION

Sustainability Index *for* Climate wise construction

- "The construction sector is not on track to decarbonize by 2050" *(United Nations Environment Program's 2022 report)*
- 73.2% of the global GHG Emissions is caused due to energy usage, Building sector holds 17.5% of the share *(Climate watch, World Resources Institute, 2020)*
- Buildings are responsible for 50% of extracted materials & 33% of waste and water use *(Tokede et al., 2022;European Commission (2011))*
- The recent agreement by the European commission establishes an EU energy efficiency target of 11.7% for 2030 *(European Commission (2023))*

1. Promote heating and cooling plans large municipalities having populations above 45,000.
2. Revised definition of efficient district heating and cooling
3. EU countries' obligation to renovate each year at least 3% of the total floor area of buildings owned by the energy efficiency target now also covers the regional and local levels

MATERIALS AND METHODS



Extreme Weather Vulnerability Index (EWVI) for Energy Consumption

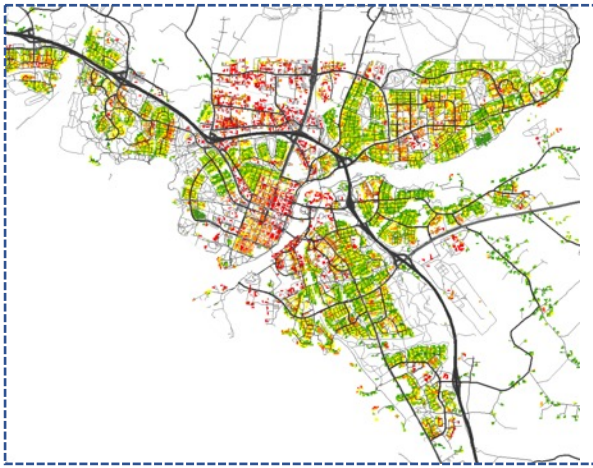
Assessment equation by the Intergovernmental Panel on Climate Change (IPCC)

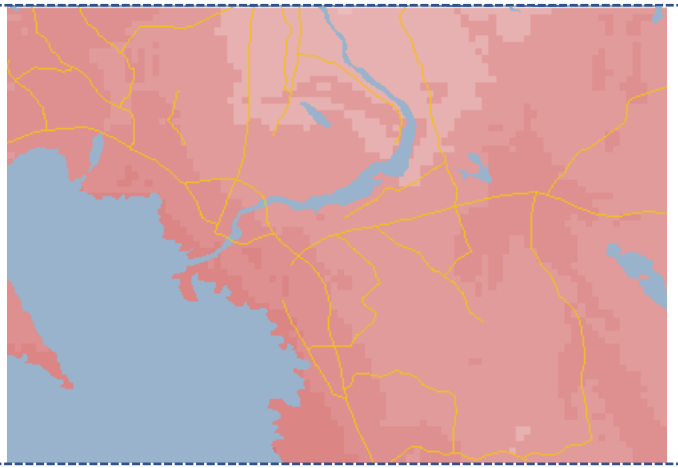
Vulnerability= Potential Impact x (1- Adaptive Capacity)

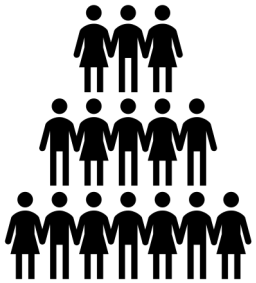
$$\text{EWVI, } \boldsymbol{I_{SC}} = \boxed{\textit{Exposure}, \boldsymbol{I_E}} \times \text{Sensitivity}, \boldsymbol{I_S}\ (1 - \textit{Adaptive capacity}, \boldsymbol{I_{AC}})$$

Exposure: Magnitude and duration of the climate-related stress

External Parameters (Summer + Winter)







Land Surface Temperature	Solar Radiation + Air temperature + Wind Speed	Occupants Number

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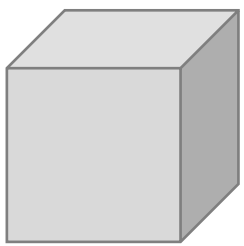
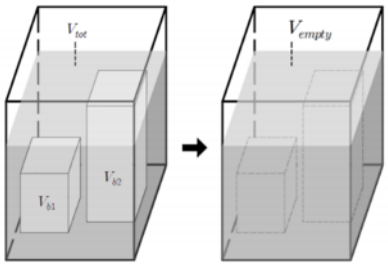
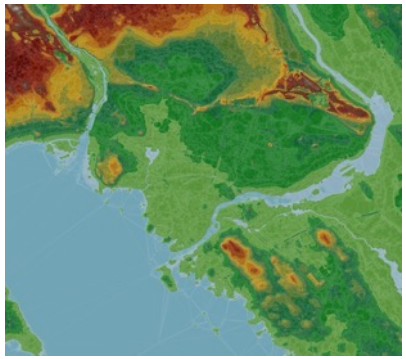
Sensitivity: The degree to which the system is likely to get affected

Internal Urban Morphological Qualities- Sensitivity







Mass Volume to Heat/cool

Porosity

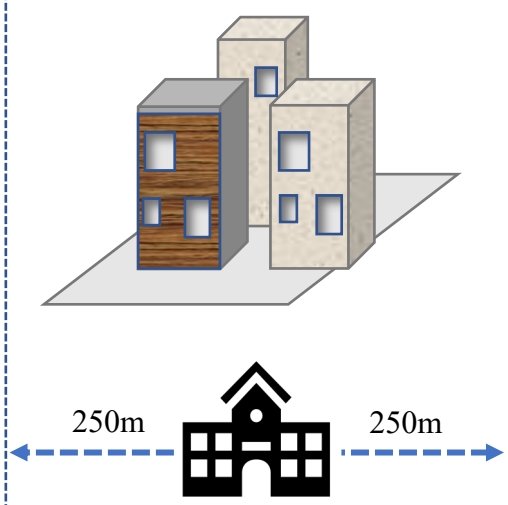
Proximity to green + Waterbody

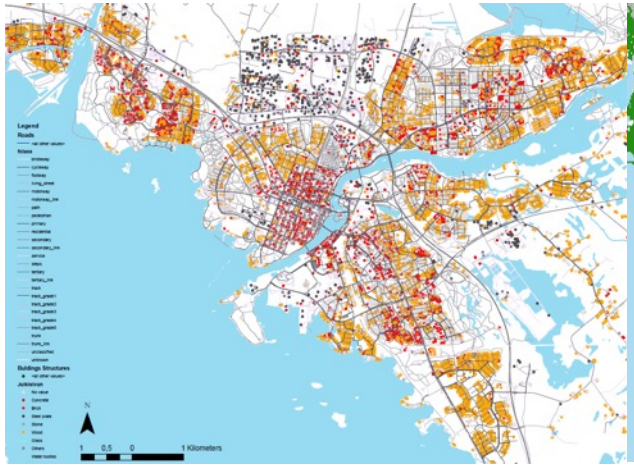
Extreme Weather Vulnerability Index (EWVI) for Energy Consumption

$$\text{EWVI},\ \boldsymbol{I_{SC}} = Exposure, \boldsymbol{I_E} \times \text{Sensitivity}, \boldsymbol{I_S}\ (1 - Adaptive\ capacity, \boldsymbol{I_{AC}})$$

Adaptive capacity: The system's ability to withstand or recover from extreme events/damage

Adaptive Capacity





Building based data- U value

Normalized constructed carbon sink volume within 250m buffer

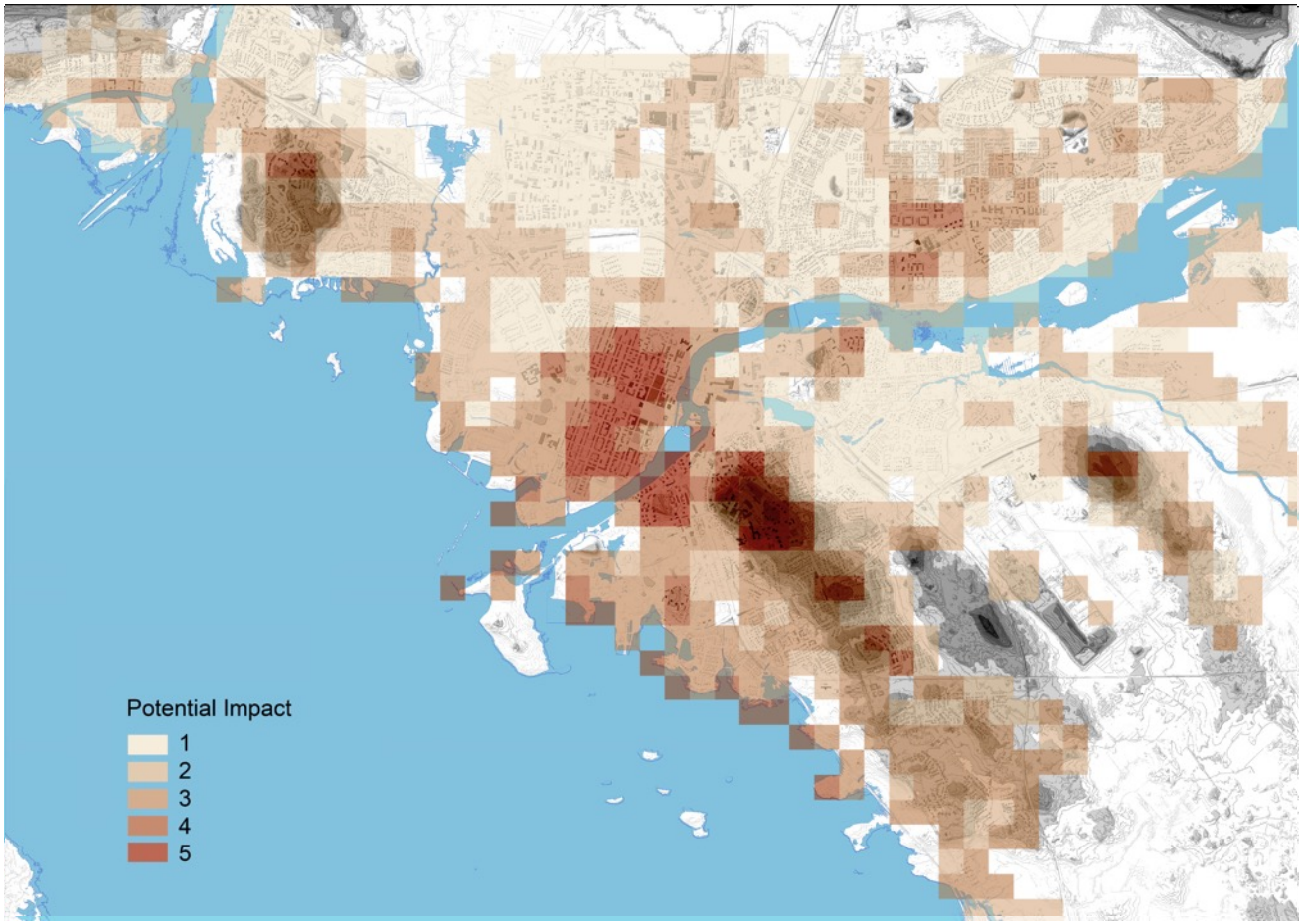
Normalized Vegetation Index (NDVI) value- 250m

Extreme Weather Vulnerability Assessment in the City of Joensuu

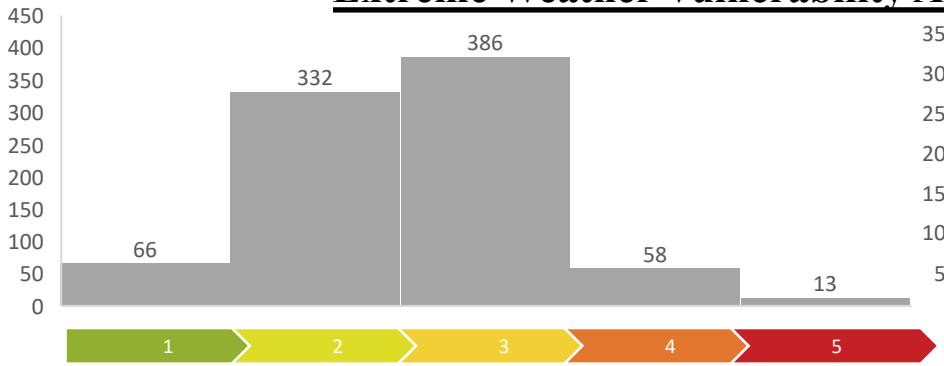
$$\textbf{\textit{Wintertime Potential Impact}},\quad PI_{winter} = Exposure, I_E \times \text{Sensitivity}, I_S$$

$$\textbf{\textit{Summertime Potential Impact}},\quad PI_{summer} = Exposure, I_E \times \text{Sensitivity}, I_S$$

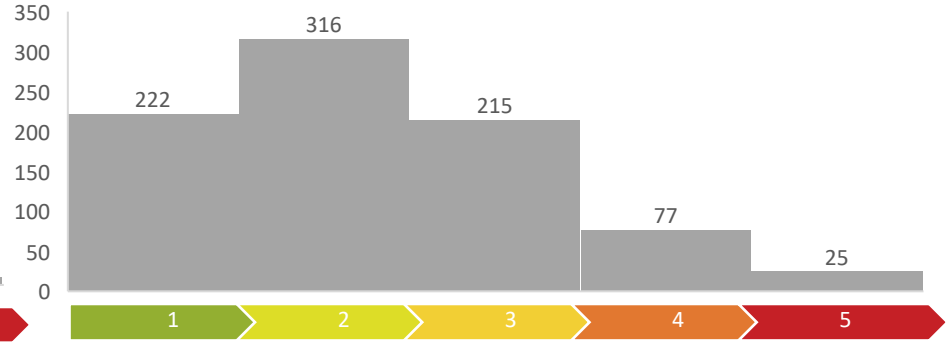
$$\textbf{\textit{Total Potential Impact}},\quad PI_{Total} = 0.75 \text{ x } PI_{winter} + 0.25 \text{ x } PI_{summer}$$



Extreme Weather Vulnerability Assessment in the City of Joensuu



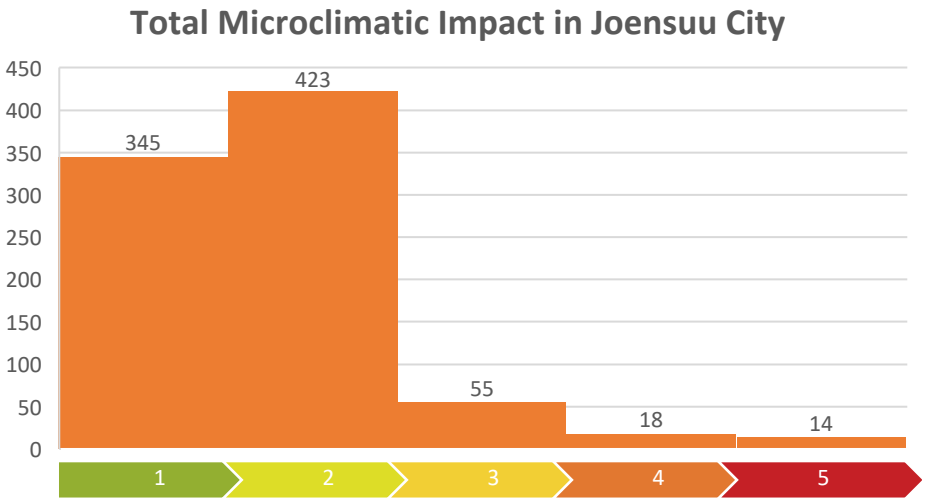
Neighborhoods exposed to **winter impact**
Low = 46.5%
Average = 45.1%
High = 8.3%



Neighborhoods exposed to **summer impact**
Low = 62.9%
Average = 25.1%
High = 11.9%

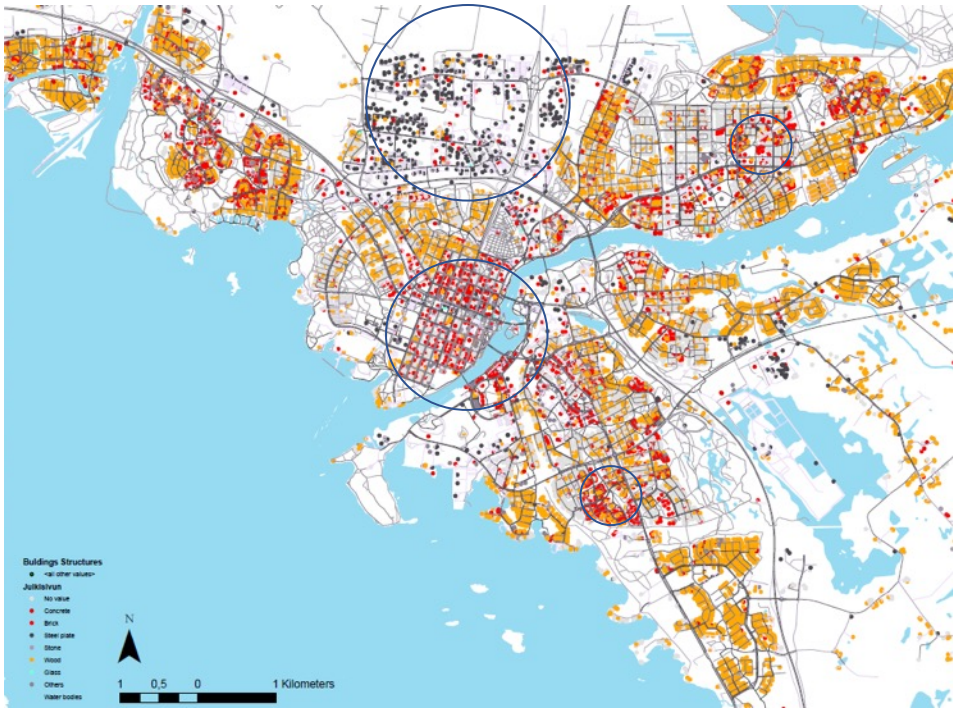
Overall impact in different neighbourhoods in the City of Joensuu

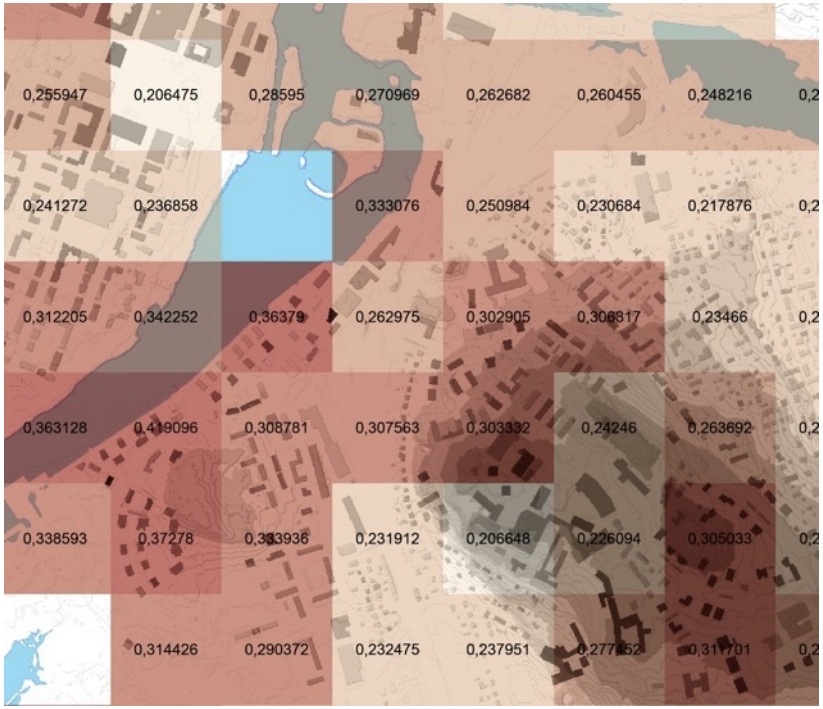
Low = 89.8%
Average = 0.06%
High = 0.037%



Variability of microclimatic impact within the same City

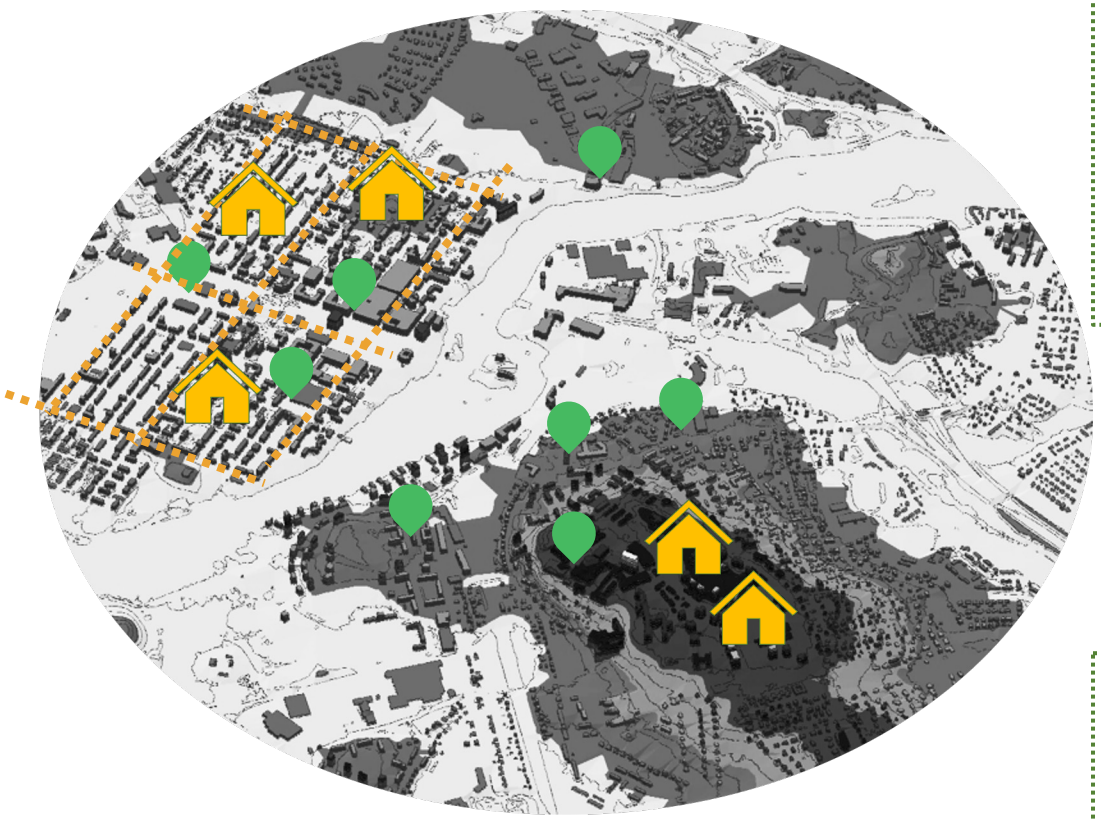
Building Specific Assessment





Building ID	PI	U value	Normalized U value	Building specific Vulnerability *V= PI (1- AC)*
A	0.36	0.64	0	**0.36**
B	0.36	0.19	0,957447	**0.015**
C	0.36	0.17	1	**0**
D	0.36	0.25	0,829787	**0.06**

INTERVENTIONS



- U value adjustments
- Increasing carbon storage/constructed Carbon in buildings (e.g., usage of wood)
- Solar panel installation
- Facade greening
- User-orientated instruction

Building level intervention

Neighborhood level intervention

- Neighborhood greening zones for cooling
- Solar panel grids for heating
- Low carbon infrastructure
- Reduced road density

Thank you

Karelia