

Thermodynamic Adaptation

A Pattern Language Atlas

COLOFON

A Pattern Language Atlas

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ABOUT THE ATLAS

The pattern language atlas “Thermodynamic Adaptation” is part of the master’s graduation project: “Thermodynamics of Public Space, Designing comfortable and social public space adaptive to seasonal temperature extremes in Vilnius, Lithuania”

Delft, Netherlands

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01

The Pattern Language

The Subject of the Pattern Language

The Design of the Patterns

The Transformation of the Patterns

The Adaptation Framework

The Subject of the Pattern Language

Why Urban Adaptation to Temperature Extremes?

Urban adaptation to both temperature extremes is crucial, due to climate change intensifying heatwaves and making cold spells unpredictable. Urban settings particularly face high vulnerability, due to rapid urbanisation leading to dense populations, while the urban form, land-use patterns and anthropogenic heat generation amplify one or the other temperature extreme. This shift in the urban climate will strongly impact the both the energy demand of buildings and, as examined in this thesis, the comfort of people (Palme & Salvati, 2021). These extremes also pose serious risks to public health, especially for groups of people that have lower acclimatisation capabilities to these climate effects (Seltenrich, 2015).

While climate change mitigation is important to reduce greenhouse gas emissions to decrease the implications of climate change, this effort cannot prevent the current increasing climate effects. Thus, the adaptation patterns developed within this Pattern Atlas emphasise the necessity to rethink the current public spaces, that provide social cohesion, recreation and well-being for urban inhabitants, to ensure they remain comfortable and usable throughout the year.

For whom is this Atlas?

While the Atlas and its patterns can be used as a communication tool between designers, planners, developers and residents to explain, discuss and co-design together with various stakeholders (Rooij & Van Dorst, 2020), the main aim of this Atlas is to bridge the gap between research and design, providing designers with a pattern set to explore and design adaptive public spaces for various urban morphologies.

The intended audience for this graduation thesis outcome is municipalities and design studios working on adapting urban environments to temperature extremes. This atlas could be used as an interdisciplinary tool that guides urban greening implementation, transport infrastructure planning and urban renovation and redevelopment plans all together through the lens of temperature adaptation. This tool could allow the

departments to priorities and distribute adaptation strategies, such as reducing Exposure, safeguarding Sensitivity and increasing Adaptive Capacity, in different neighbourhoods, while reducing vulnerability to temperature extremes throughout the whole city.

Future studies can be undertaken to develop a more non-designer friendly pattern set to extend the usability for different stakeholders, including public participation to future temperature adaptation strategies.

What does the Atlas Include?

In order to identify interventions to adapt public spaces to extreme cold and heat, a study was carried out to list and understand potential design solutions. Through literature review, possible solutions were extracted fitting the goals derived from analysis of Exposure, Sensitivity and Adaptive Capacity. As multiple solutions were found addressing the Focus, Urgency and Approach Adaptation Goal categories, a system of cataloguing them in relation to their corresponding challenges and spaces was needed. Pattern language emerged as a structural method to map potential design interventions and their potential units of application. This method provided a categorised set of strategies and technologies proven to be effective to manage urban temperature extremes, which could be used to analyse the current public space adaptation capabilities and to further adapt the problematic spaces.

Christopher Alexander's Pattern Language approach was chosen to represent the possible design solutions for its ability to analyse and catalogue complexity. As stated by Salingaros (2008) pattern language emerges for two distinct goals: one being to understand and, if required, to change a complex system, the other being to create a design tool, with which something functional and spatially coherent can be built. To tackle the challenges of urban climate, both of these ambitions are required to deconstruct the system into understandable parts and then be able to implement changes to it.

The Design of the Patterns

Designing the Pattern Cards

The design of the pattern as a card was inspired by previous studies working with pattern language (Bechmann, 2023; Croxford et al., 2020; de Meijer, 2024). The two card sides emphasise different application of the pattern, with the card face face-side, including the sketch, title and the main statement, allowing designers and non-designers alike to discuss the possibility and implication of the pattern, as it states a simplified design component open to interpretations. The back side defines the pattern with empirical justifications and expresses spatial implications of its implementation, which can be used to precisely design and plan adaptive spaces. The exemplary project or literature cites, where the empirical justification has been taken from. Each pattern is linked to specific adaptation goals derived from the previous chapter on Urban Climate Analysis. The patterns' primary adaptation purpose is indicated within the top-left square, in which it states the number and the category of either Exposure Reduction (E), Social Well-being (S) or Coping Networks (C). These three categories are respectively linked to Focus, Urgency and Approach Adaptation Goal groups. However, the patterns were identified to also influence other goals, which were marked in the top-right position, indicating each specific Adaptation Goal, with triangles representing Focus, hexagons – Urgency, and circles representing Approaches.

This approach differs from a standard toolset, as it also focuses on the relationships and categories between the patterns, highlighting synergies and conflicts between them. The relationships between patterns were observed by comparing if the two patterns provided benefits when applied together, they solved the same issue, they hindered each other or whether one pattern was required to apply the other, creating links that emphasised their complementary, alternative, conflicting or embedded patterns. The relationship between patterns were noted individually, through logic reasoning and site analysis, when patterns were selected that were the most successful in improving the sites and interacted with one another. These relationships are indicated below each pattern card.

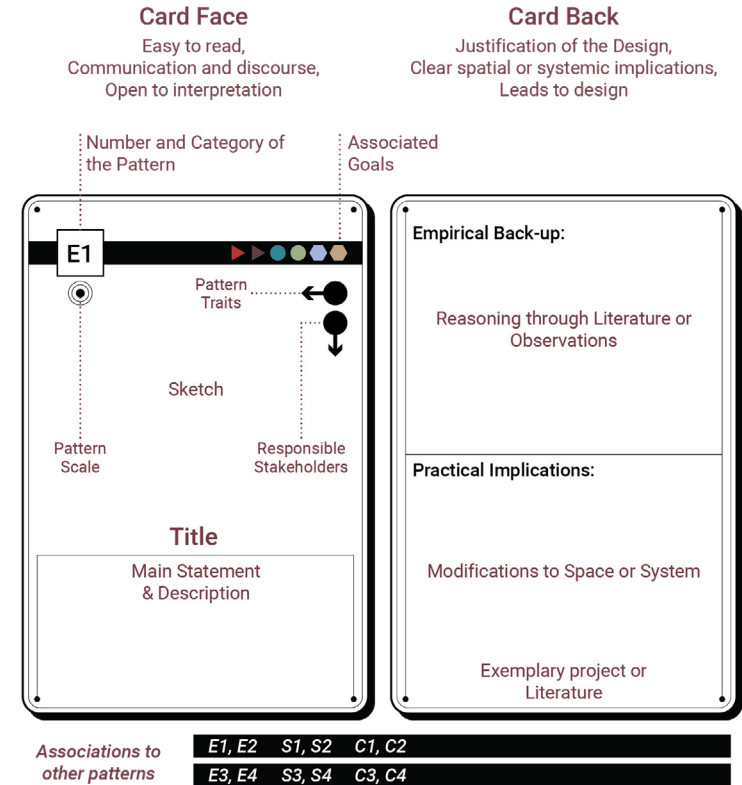


Figure 01. Explanation of the Pattern Card Structure

Pattern Card Properties

The patterns are also arranged into three main properties marked as circle diagrams below the pattern's number and goals. These properties relate to the pattern scale, implementing Stakeholders and category specific traits. Urban climate scales are used to illustrate pattern impact extent, various stakeholder diagrams specify, which groups is responsible to ensure the pattern is implemented and maintained. Exposure Reduction (E) traits list, which climate factors the design influences, Social Well-being (S) traits explain the social spaces arrangement, and lastly, Coping Network (C) traits describe the adaptation type.

Climate-Sensitive Considerations		Exposure Reduction Factors					
		Sun Light	Wind	Humidity	Rain	Snow/Ice	Dark
Climate Extreme	Heatwave	Reduce ☀️	Increase 🌬️	Increase 💧	Store ☔️		
	Cold Spell	Increase ☀️	Reduce 🌬️			Store/Remove ❄️	Address 🏠

Social Well-being & Coping Network Pattern Traits			
Space Arrangement (Social Well-being)	Indoor Space 🏠	Outdoor Space 🌳	Threshold Space 🚧
Adaptation Type (Coping Networks)	Policy Implementation 📄	Behaviour Change 🚶	Environment Transformation 🏡

Urban Temperature Adaptation Dimension	Urban Planning & Design Scales					
	Point	Building	Street Canyon	Block	District	City
Urban Climate Scale	Micro 🎯	Micro 🎯	Local 🎯	Local 🎯	Meso 🎯	Meso 🎯

Stakeholders Responsible for Pattern Implementation					
Stakeholders	Local Residents 👤	NGO's 🗳️	Private Sector 🏢	Public Services ⚙️	Municipality 🏛️

Figure 02. Possible Pattern Traits to Categorise Complexity

The Transformation of the Patterns

The Always Expanding Atlas Set

While the adaptation goals are established and could be expanded to include alternative approaches or other sensitive groups, such as people with pre-existing health conditions or impoverished people, in future studies, the collection of Exposure Reduction (E), Social Well-being (S) and Coping Networks (C) solution patterns acts as an undefined set, which is changing and increasing with each iteration and implementation.

When developing these patterns, 9 possible creation or transformation options were identified to further increase the Pattern atlas set, illustrated in the Possible transformations of Patterns diagram. Three creation options to directly answer a specified adaptation goal, deriving the answer from literature, observations or precedent studies, were the most recurring. The specificity of a pattern was the most difficult task, as the patterns could be merged if they were too vague, split if they were too definitive, or cloned if similar alternatives could be used.

Urban climate scales were also informative, as design solutions could be upscaled or downscaled depending on the required development or the gained effect. The differentiating scales also allowed previously conflicting patterns, such as Channelling Wind (E7) and Green Windbreaks (E17), to operate together, as one design creates ventilation corridors through street canyon on a local scale, while the other creates small microclimates sheltered from wind throughout the canyon.

The most successful pattern transformation was produced by merging multiple relevant patterns, linking Exposure Reduction (E), Social Well-being (S) and Coping Networks (C) pattern categories. These new patterns are more site specific and act as development guides for a particular city or neighbourhood type.

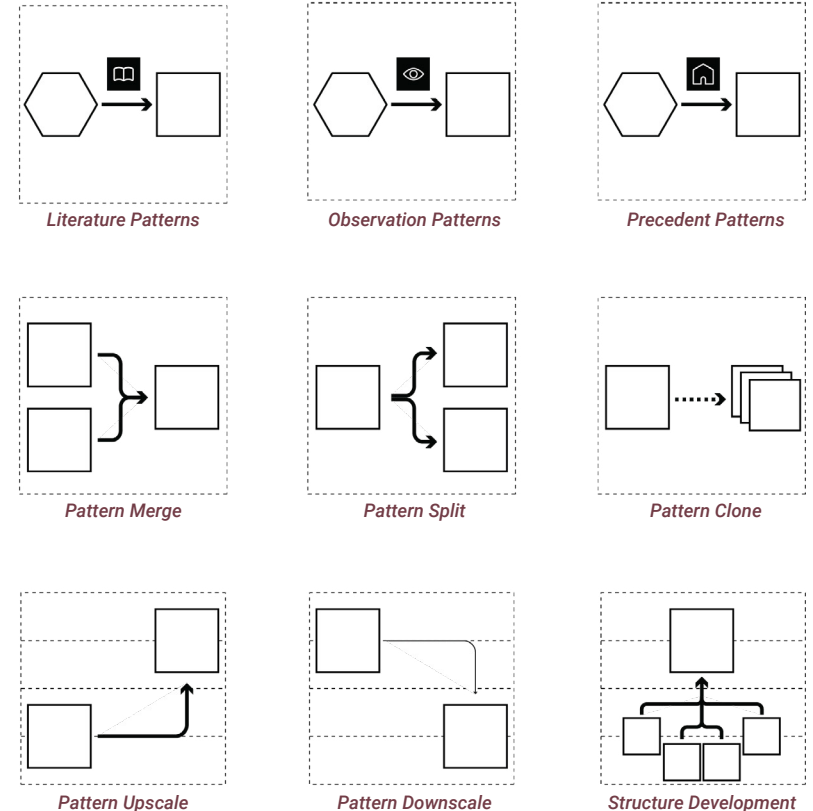


Figure 03. Possible transformations of Patterns

The Adaptation Framework

How do you use this Atlas?

A large set of design patterns focused on one specific problem can lead to a comprehensive design that tackles the problem from different scales and points of view or can bring out a discourse on the prioritisation of one solution over others to optimise the possible outcome. However, when tackling multiple problems, as in this case, working on adapting to opposite temperature extremes, the large set of solutions can become overwhelming or contradicting. To overcome this challenge, the created patterns are linked to specific Adaptation Goals, which prioritise one Focus, Urgency or Approach Goal over the other. In this sense, the large set is reduced to patterns that only focus on the chosen problem, which later on can be extended with additional patterns that solve issues, which will emerge in the future.

The Pattern Language as a design method is applied in 4 steps:

- 1. The initial urban analysis provides specific goals related to temperature Focus (triangle), sensitive group Urgency (hexagon) and possible adaptation Approaches (circle). These Adaptation Goals can be considered as the area's adaptation brief, which selects specific solution patterns linked to these goals.**
- 2. The area's site analysis allows the designer to situate these goals to potential spaces for adaptation and select the most applicable solution patterns based on existing structure analysis and thermal comfort findings, narrowing down the list.**
- 3. The chosen patterns are implemented or merged to create a new, integrated, site-specific pattern, which adapts the current environment to a specific temperature extreme considering a sensitive group of people that are residing in the area.**
- 4. Lastly, if a new pattern is developed, it is included into the Pattern Atlas to be implemented in other contexts.**

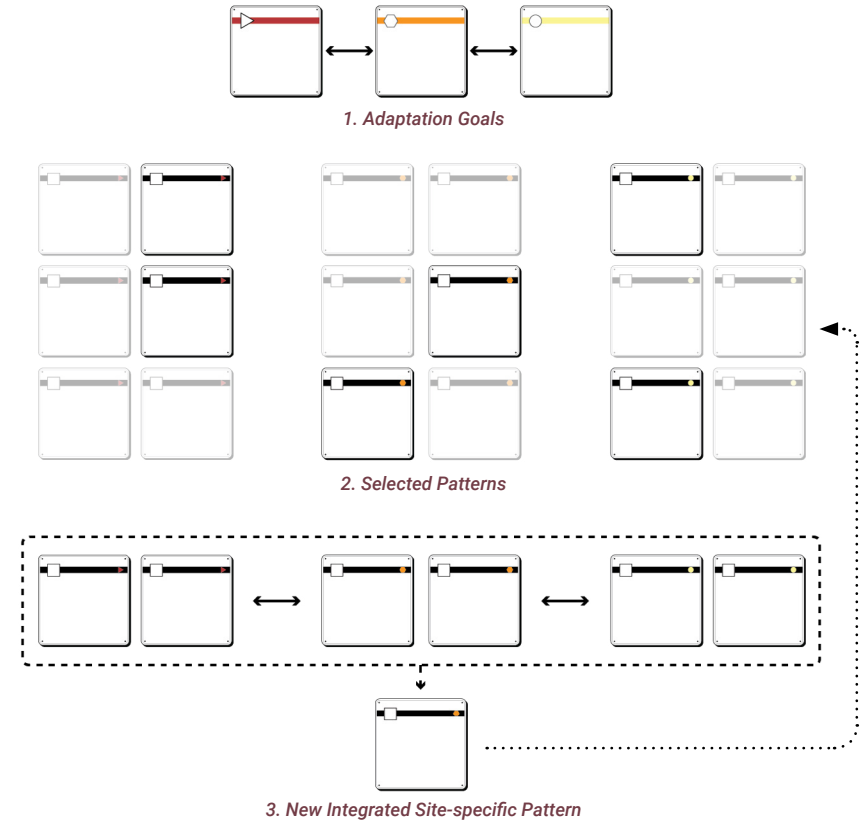


Figure 04. The Pattern Language Design Framework

02

Adaptation Goals

Focus Adaptation Goals

Urgency Adaptation Goals

Approach Adaptation Goals

Adaptation Goals

Focus Adaptation Goals

Temperature exposure analysis revealed that some urban environments are more prone to trap and store heat, while others quickly dissipate it. Because of this, the adaptation process needs to focus on either one temperature extreme before the other or areas that required a dual approach. Therefore, three Focus Adaptation Goals were created: Cool in Density, Covered in Cold Plains, and Seasonal Spaces for areas exposed to extreme heat, cold, and both, respectively. Exposure Reduction patterns were created in continuity to these Focus goals to help urban environments mitigate extreme temperatures.



Urgency Adaptation Goals

Analysis of temperature sensitivity indicators revealed age group distributions with some neighbourhood populated with larger percentages of elderly, while other have larger proportions of children. While adaptation is important for both demographics, the types of spaces these neighbourhoods should adapt and improve differ, creating specific urgencies for one group or the other. In response to this, three Urgency Adaptation Goals were created according to population distribution: Safe Children, Risk-Free Elderly, and Resilient Communities for areas with high proportions of children, elderly citizens, and both demographics, respectively. Social Well-being patterns address these Urgency Adaptation Goals by emphasising the user-selected spaces that provide social and physical benefits for sensitive demographics.



Approach Adaptation Goals


In order to see how Adaptive Capacity can be realised spatially, Approach Adaptation Goals were created based literature on accessibility and climate shelters. Community Refuge, Comfort Trails, Shelter-in-Place, and Sanctuary Routes are offered as four possible approaches to shelter populations ranging from bottom-up outdoor shelters for low-risk temperature extremes to district public indoor shelters for extremely hazardous temperatures. While the previous meso-scale analysis suggested possible Approach Goals to increase adaptive capacity, local adaptation planning should consider the possibility to incorporate all four approaches to create a comprehensive coping network. The Coping Networks patterns address these Approach Goals by improving urban accessibility and people's mobility with the aim of increasing Adaptive Capacity.



While the initial Focus, Urgency and Approach Goal selection allows to simplify the designing process of spaces, long term future adaptation requires to incorporate all the mentioned goals.

The Focus

F1



Cool in Density

Cooling strategies within the public realm lowers health risks and increases comfort during heatwaves or hot periods in dense and compact environments.

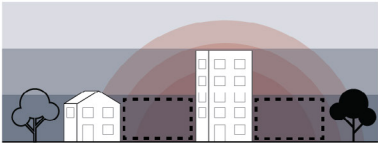
Explanation:

Dense and compact urban environments absorb and retain heat, amplifying the urban heat island (UHI) effect. This problem arises due to the heat-absorbing materials like asphalt and concrete, limited vegetation, and restricted airflow caused by closely situated buildings. As a result, urban spaces can become overheating zones, particularly during heatwaves, leading to increased health risks such as heat exhaustion and dehydration, especially for sensitive populations. To ensure outdoor comfort, encourage social activities, physical exercise and economic activity, these compact urban environments have to primarily focus on reducing exposure to heat.

Aligned patterns are marked with the associated symbol:



F2



Seasonal Spaces

Community areas that incorporate activities and sites, which can endure both temperature extremes, extend the usage of these public spaces year-round.

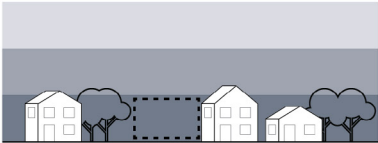
Explanation:

Mid-density and open-dense urban environments face a dual challenge, as their structures fail to provide sufficient protection against either temperature extreme, making public spaces uncomfortable and underutilised throughout the year. During heatwaves, these areas often contain high paved surfaces and few shaded spaces, leading to heat retention, while in winter, the lack of dense building formations or protective landscape elements expose residents to wind, freezing temperatures, and icy surfaces. For these reasons, these spaces require a holistic climate-adaptive design approach to ensure that the local communities are not left without functional or welcoming urban environments.

Aligned patterns are marked with the associated symbol:



F3




Covered in Cold Plains

Sheltered Public spaces protect people from inhospitable and unsafe freezing temperatures and cold waves, especially in low-density, open environments.

Explanation:

Low-density, open environments exhibit public spaces exposed to harsh winter conditions, making them inhospitable and unsafe during freezing temperatures and cold waves. With fewer buildings, less heat-absorbing materials and structures to block wind, open squares, wide streets, and sparsely planted parks, lack the thermal buffering effect that denser environments provide, leading to rapid heat loss and uncomfortable conditions, increasing the risk of frostbite or hypothermia. As a result, this decreases the use of these spaces, contributing to isolation for populations reliant on public spaces. Strategic interventions that prioritise reducing cold exposure, can help maintain safety and usability of common spaces.

Aligned patterns are marked with the associated symbol:



The Urgency

U1




Safe Children

Seasonally adapted youth spaces allow younger residents to safely engage, play and grow together, despite any temperature risks.

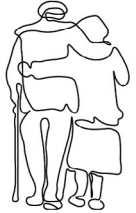
Explanation:

Younger children are more sensitive to temperature extremes than grown adults, as their bodies are not fully developed to efficiently regulate heat and acclimatise to cold. While there are cultural differences, today this demographic usually spends their time socialising and playing around their homes, as parents do not allow to roam unsupervised. This creates an urgency for residential areas that have a large children population to seasonally adapt the surrounding spaces to allow children to safely play, interact and learn through actively engaging with their environment.

Aligned patterns are marked with the associated symbol:



U2




Risk-Free Elderly

Sheltered meeting spaces provide an opportunity for residents, that do not have adequate adaptation possibilities and are more susceptible, such as elderly, to adapt to temperature extremes.


Explanation:

Older people are sensitive to temperature extremes due to age-related health conditions. Pensioners typically have less adaptive capacity for their reduced mobility and limited resources. Many elderly individuals rely on nearby public spaces for exercise, social interaction and daily routines, although these areas often lack temperature adaptations that ensure comfort and safety. Adapting public spaces with temperature responsive design can promote active aging and ensure social cohesion for spaces that have older populations.

Aligned patterns are marked with the associated symbol.



U3



Resilient Communities

Climate-adaptive communal places with a balance range of functions provide joined social spaces for people of different backgrounds and ages.

Explanation:

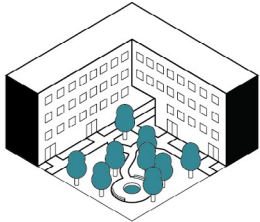
Public spaces that are designed for both children and the elderly must address diverse needs while ensuring safety and comfort throughout the year. Children require open, engaging environments that support active play, while older adults need accessible and comfortable areas for rest and socialisation. Both demographics prioritise safety due to them being highly sensitive to temperature extremes. To ensure that these groups are not excluded from public spaces, requires adapting their surroundings to seasonal temperature extremes and bridging socialising activities to encourage intergenerational social cohesion.

Aligned patterns are marked with the associated symbol.



The Approach

A1




Community Refuge

Community participation and regular upkeep ensure that local outdoor temperature shelters, situated within blocks, are functional to protect the neighbouring population.

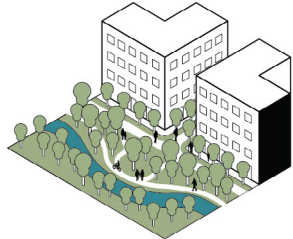
Explanation:

Community participation and regular upkeep are essential to ensuring that local sheltered spaces remain functional and accessible for those in need. For urban environments that do not have public services or are low-income, bottom-up collective neighbourhood spaces can act as primary adaptation spaces for lower risk hazards. For these areas to be transformed to better adapt to temperature extremes, engaging residents through active involvement fosters responsibility to help and maintain these communal spaces safe.

Aligned patterns are marked with the associated symbol:



A2




Comfort Trails

Ecological corridors that connect urban areas to large natural spaces offer protection, rest and comfort along the way.

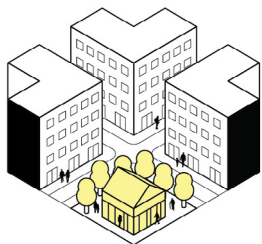
Explanation:

Ecological corridors and large natural spaces offer safe, comfortable and accessible paths that protect people from temperature extremes. These green connections provide shade, windbreaks and sheltered rest areas, creating thermal refuges during both heatwaves and cold spells. By maximising solar exposure in winter and offering cooling canopies in summer, they ensure year-round comfort and encourage active mobility and well-being. Together with reducing urban heat islands effect, these corridors support biodiversity and habitat continuity. Connection with nature ensures inclusive and equitable spaces for nearby communities.

Aligned patterns are marked with the associated symbol:



A3



Shelter-in-Place

Adapting nearby indoor public services as shelters from temperature extremes creates accessible and prepared refuges, that are equally managed.

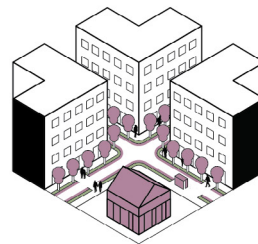
Explanation:

Adapting public services as shelters from temperature extremes ensures that vital community spaces, such as libraries, parks, schools, community centres or transit hubs, can function as climate-prepared refuges for local residents and visitors alike. These spaces can provide relief during extreme heat, while also serving as warm shelters. Adapting existing public buildings is a more efficient, sustainable, and equitable strategy by directing resources towards infrastructure improvement. Although, to address current spatial inequalities in some areas, expansion of well-managed shelter network enhances climate resilience, ensuring no community is left behind.

Aligned patterns are marked with the associated symbol:



A4



Sanctuary Routes

Shielded and dedicated paths or movement corridors effectively connect neighbourhoods to indoor district shelters that provide refuge from temperature extremes.

Explanation:

Safe, shielded and dedicated movement corridors are essential for connecting neighbourhoods to indoor district climate shelters, ensuring all residents can access refuge from extreme heat and cold. Without well-designed protected pathways, during high temperatures these spaces can put people at higher health risks, while in cold conditions, people can be disconnected and isolated from their intended destinations. Accessible design, clear movement paths and integration with public transport further enhance connectivity and limits exposure to extreme temperatures.

Aligned patterns are marked with the associated symbol:



03

Solution Patterns

Exposure Reduction Patterns


Social Well-being Patterns


Coping Networks Patterns


Exposure Reduction Patterns


E1


▶▶▶
▶▶▶

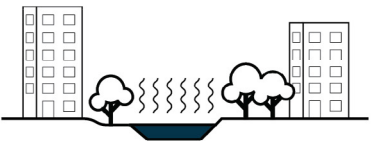












Nearby Regulating Water

Public spaces connected to natural water features provide residents with spaces that mitigate both extreme temperatures.

Empirical Back-up:
Studies have measured that even small urban rivers significantly cool down ambient air temperature over the watercourse of around 2°C during consecutive hot days. Cooling extents are dependent on urban form and surrounding materials. For extreme cold situations, open river plains allow larger amount of solar radiation and higher reflectivity, although significant impacts have yet to be measured.


Practical Implications:
Urban development should prioritise **planning around river and waterbodies**, as these spaces experience reduced heat exposure. To maximise cooling, ensure the watercourses **have space for highly vegetated banks**. To spread the cool air into the city, **open up the streets to the river** and **design public spaces next to the water**.


(Hathway & Sharples, 2012)


Complementary	E7; S2, S3
Alternative	C19; E2, E9
Conflicting	E4, E8
Embedded	C7


E2


▶▶▶
▶▶▶














Staying on the Edge

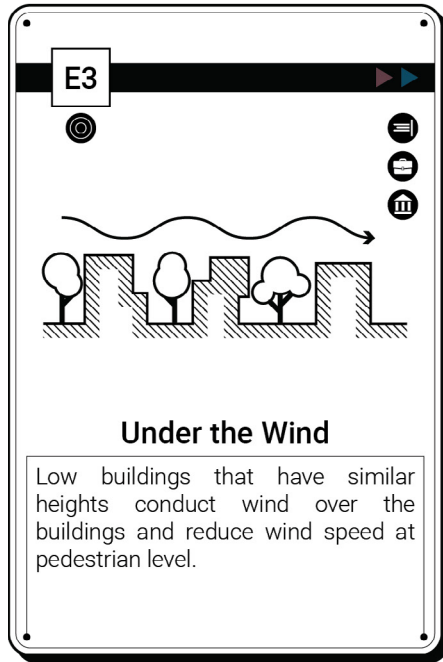
Developing near natural areas while preserving their integrity ensures easy access to high quality green spaces, promoting well-being and ensuring thermal comfort.

Empirical Back-up:
Forests reduce heat through shading and evapotranspiration, lowering temperatures by up to 1.5°C. Field studies have shown that larger green spaces provide higher temperature reduction, with the effects extending over a 350m distance from the green space boundary.

Practical Implications:
Urban expansions or densification should **prioritise development around large urban forests**, while integrating connectivity to these areas. Zoning laws should define a **forest boundary**, promoting a transitional green space to **limit human intrusion** and ensure local **ecological preservation**.

(Aram et al, 2019).

Complementary	C1, C17; S2, S3, S5
Alternative	E1, E5, E23, E26
Conflicting	-
Embedded	C7; E15



Empirical Back-up:

Literature on winter settlement design suggests that low buildings with similar heights conduct wind over the buildings and vegetation, while the air movement at pedestrian levels are reduced and less turbulent. Areas that avoid buildings, which are more than twice taller than their surroundings can reduce wind intensity up to 50%.

Practical Implications:

Plan neighbourhoods, where adjacent block or building height limits are consistent, allowing a gradual variation of one story to create an even skyline. For dense environments maintain building heights of 3-5 stories, with exceptions for mixed-use block, where heights could be increased to 4-6 stories. For open areas consider the current vegetation and the tree heights for building design.

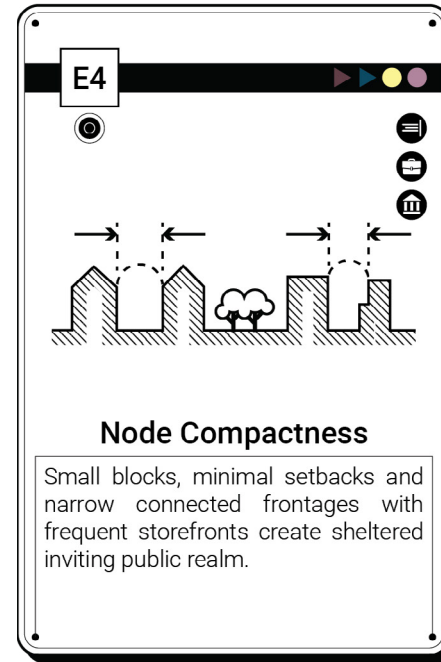
(Chapman et al., 2018;
DIALOG & City of Beaumont, 2022)

Complementary E17, E18, E19, E20, E24

Alternative C6; E4, E8, E25

Conflicting E7

Embedded C18



Empirical Back-up:

Local hubs require comfortable microclimatic conditions to be successful. Smaller blocks enhance walkability and create diverse spaces with varying thermal comforts allowing the district to have shelters from high heat and intense cold. Small compact shops and amenities reduce distances between destinations, which minimise prolonged exposure.

Practical Implications:

Design core centres with small perimeter blocks, around 50–100 meters in length, to enhance connectivity and provide additional sheltered pedestrian routes. Encourage active frontages with frequent entrances and shopfronts to foster vibrant spaces. Minimise front setbacks to 0–3 meters, creating enclosed street canyons that buffer against wind, where street orientation and canyon design does not amplify wind corridors.

(DIALOG & City of Beaumont, 2022)

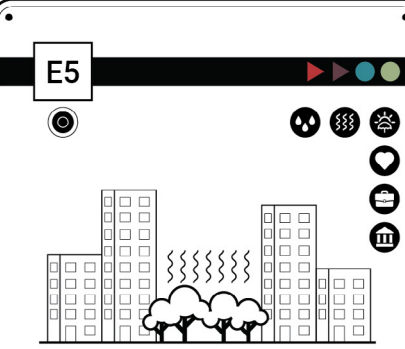
Complementary C11, C14, C17; E16; S9, S10, S12, S13

Alternative C1, C6; E3, E8, E25

Conflicting E1, E5, E6, E9, E11

Embedded C18

E5



Filling Cold Pockets

Integrated cold pockets within public spaces provide essential heat relief through evaporation.

Empirical Back-up:

Studies have measured that pocket parks, small layout densely vegetated areas, improved thermal environment during heat extremes not limited to the area itself, but extending up to 100m. from the park boundary. Additionally, these spaces showed high potential in promoting mental and physical well-being.

Practical Implications:

Design dense compact urban environments to include strategically placed cold pockets every 200m. in high activity areas, providing opportunities for heat relief. Place these spaces on the edge of ventilation corridors to allow wind patterns to extend the cooling effect further. Incorporate seating and social functions to encourage use of these microclimates throughout the day.

(Balai Kerishnan & Maruthaveeran, 2021;
Ma et al., 2022)

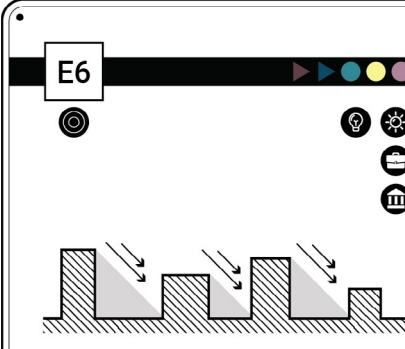
Complementary C17; E7, E17, E25; S1, S2, S5

Alternative E2, E9, E10, E23

Conflicting E4, E8

Embedded C7; E15

E6



Solstice Urban Grid

Urban environments with greater building spacing and optimised orientation to maximise winter solar gains provide warmth to outdoor spaces adjacent to buildings

Empirical Back-up:

Studies have shown that winter solar access can increase outdoor temperatures in sheltered spaces. Wide street canyons ensure solar infiltration, improving thermal comfort and reducing seasonal energy use. While this is difficult to achieve in compact urban cores, this can be implemented within a spacious urban fabric.

Practical Implications:

Orient main streets to follow either **Northeast to Southwest or Northwest to Southeast directions**. Residential streets oriented East-west should be designed with a **H/W ratio of 0.25**. Use **deciduous trees and low constructions** to trap heat without creating large shadows. Design **south facing facades and stepped building layouts** that do not cast shadows on other buildings.

(Chapman et al., 2018)

Complementary C6, C10, C14; E11, E13, E22; S1, S4, S12

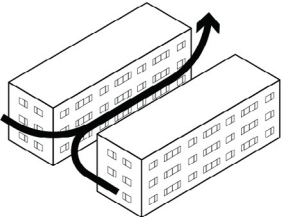
Alternative -

Conflicting E4, E8, E16, E20, E21

Embedded C18

E7
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Channelling Wind

Street canyons and open spaces oriented parallel to prevailing wind patterns and connected with local cold air conservation areas allow cool air to inflow into the city and alleviate high heat stress.

Empirical Back-up:
To reduce high urban temperatures during heatwaves, it is essential to have cold wind flows from cold air producing areas, such as forests, water bodies or rural landscapes. By integrating corridors inside the city, that follows prevailing winds, a constant air circulation can be obtained. Street canyons, with limited obstruction, work well as wind corridors, as due to the Venturi effect, wind speed is increased.

Practical Implications:
Plan **primary roads, linear parks and green corridors to be aligned with prevailing winds.** Connect these corridors to **local cold air producing spaces.** Incorporate **green blue spaces along the corridors** to enhance their cooling effects. Design **continuous street canyons** with straight road lines.

(Hsieh & Huang, 2016;
Son et al., 2022)

Complementary E1, E5, E9, E10; S10, S11, S12

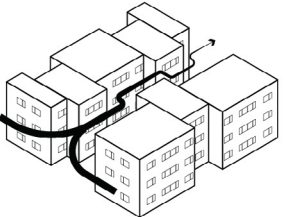
Alternative -

Conflicting C6; E3, E8, E17, E18, E25

Embedded C18

E8
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Broken Canyon

Perpendicular urban corridors to prevailing winds and fragmented street canyons reduce wind speed and limit cold air inflowing into pedestrian areas.

Empirical Back-up:
Winter city design literature emphasise that wind is one of the most important and well-studied climatic factors when it comes to cold. Prevailing winter winds effects not only thermal comfort but can have dire health consequences. It is essential to interrupt wind flows in high pedestrian environments during cold spells, to create calmer and warmer outdoor spaces.

Practical Implications:
Design **offset intersection, curved streets and chaotic street canyons** with elements, such as canopies and balconies, for streets **parallel to prevailing cold breezes.** Provide **small, scattered wind-protected environments** for key public spaces, situating them in **courtyards, urban pockets and coniferous covered spaces.**

(Pressman, 1988)

Complementary C1, C2, C15; E17, E18; S6, S7, S8

Alternative E3, E4, E19, E20, E25

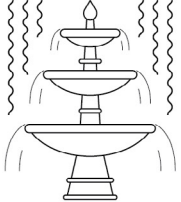
Conflicting E1, E5, E6, E7, E9, E10, E26

Embedded C18

E9

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Running Water

Integrating fountains and water spraying features in public spaces helps reduce heat exposure, enhancing thermal comfort and urban resilience.

Empirical Back-up:
Studies have shown that spray cooling water evaporation reduces air temperatures, during heatwaves, in microclimate conditions and local scales. By utilising open spaces, wind corridors and prevailing winds, the cooling effect of evaporated water can be spread further, increasing its adaptability.

Practical Implications:
Design fountains or water spraying systems in **open areas, intersections or high wind street canyons.** Water attracts people, **design spaces around water features** by including social spaces, such as seating, meeting spaces or other amenities. Design these water features to **have a function during cold periods,** such as public art or skating rings.

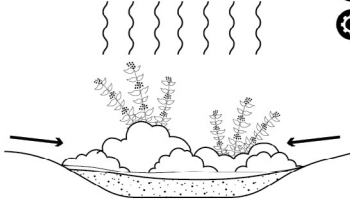
(Gehl, 2010; Wai et al., 2021)

Complementary	E7, E20;	S9
Alternative	E1, E5, E10	
Conflicting	C6;	E4, E8, E17, E18
Embedded	C7	

E10

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Rain Garden

Lower lying vegetation areas collect and manage water runoff, while also cooling down the surrounding temperature.

Empirical Back-up:
Studies demonstrate that diverse and layered vegetation gardens that collect and store water significantly regulate the microclimate during heat extremes, by water vapor emitted through evapotranspiration. These effects are most impactful during the evening and night, when solar radiation is limited.

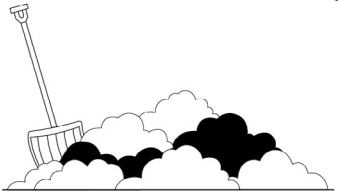
Practical Implications:
Design rain **gardens in high flood areas** **situating them lower within the space.** To optimise their effects **place them nearby active public spaces or valuable social zones.** Ensure these **gardens are shaded** during peak hours to maintain water in the soil and limit drought.

(Wang et al., 2024)

Complementary	E7, E11, E12, E15, E17, E25;	S1
Alternative	E5, E9, E23	
Conflicting	E8	
Embedded	-	

E11
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Snow Box

Smaller snow storage areas with solar access and adequate draining, allow to safely store and naturally melt down snow.

Empirical Back-up:
Snow is a climate feature that increases risks of injury and limits mobility as well as making the environment brighter by reflecting as much as 85% of solar radiation. This requires integrating design opportunities with storage and removal strategies. Design guidelines argue that distributed snow storage areas more efficiently in melting snow, while single locations provide a topography change that can be utilised to block wind and provide new activities.

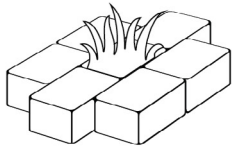
Practical Implications:
Incorporate extensive snow storage areas exposed to sunlight, into street design to safeguard mobility. Ensure that pavement level is either higher or blocked off to limit snow accumulation. Design drainage systems for storage areas that allows infiltration of water and slush.

(Chapman et al., 2018; Pressman, 1988)

Complementary	C3, C12, C15; E6, E10, E12, E14, E24; S3, S6, S7, S8
Alternative	E13
Conflicting	E4, E16
Embedded	-

E12
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Porous Path

Permeable surfaces reduce heat exposure by allowing natural soil processes to occur and limiting the amount of low-albedo material.

Empirical Back-up:
Permeable surfaces allow water to drain through the structure, reducing the surfaces temperature and increases the ability to evaporate. Some investigations have illustrated that permeable pavements can mitigate surface temperatures up to 9°C, compared to ordinary pavements, reducing the surfaces influence on the UHI effect.





Practical Implications:
Incorporate permeable surfaces to movement space and service spaces, such as slow vehicular streets, parking areas and alternative walking paths, as these surfaces do not prioritise accessibility for people with mobility issues. These surfaces can be used as sidewalk extensions and transitions between paved and unpaved.

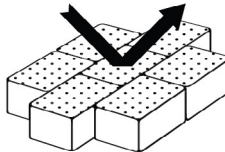
(Liu et al., 2018)

Complementary	C3, C8; E10, E11, E15, E17, E24; S1, S5, S7
Alternative	E13, E23
Conflicting	C14, E14; S3
Embedded	-

E13

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Reflective Path

Light surfaces possess higher albedo reducing heat absorption and increases the brightness of the space.

Empirical Back-up:
Lightly coloured, bright surfaces poses high albedo, reflecting a high fraction of solar radiation. By limiting the absorption of heat by the surface, simulations have shown a decrease of 10°C in surface temperatures and 2°C of ambient air temperature at the height of 2m. Although areas with a low Sky View Factor require consideration, as reflective surfaces in deep street canyons can transfer the radiation from surface to façade.





Practical Implications:
Design cool, reflective surfaces in all open spaces and on the North side of buildings. Reduce these surfaces, situated nearby buildings, on the Southern side, as the reflected solar radiation transfers the problem to the building.

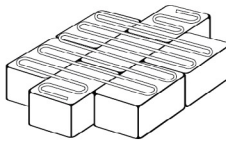
(Freire et al., 2021;
Sen & Khazanovich, 2021)

Complementary	E6, E14, E22, E24; S4, S10
Alternative	E11, E12, E15, E16, E21, E23
Conflicting	-
Embedded	-

E14

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Radiant Path

Heated sidewalks with adequate drainage remove snow and ice coverage, ensuring safe movement and less fall injuries during cold periods.

Empirical Back-up:
Heated pavements incorporate technical systems that radiate heat to melt snow and ice from the surface. This ensures lower maintenance and quicker responses, while also reducing the need to use salt for ice clearance. Clear paths provide safe movement during cold periods.

Practical Implications:
Implement heated sidewalks in dangerous sections, such as nearby stairs, street crossings or high incline paths. For large scale implementations, examine possible residual heat usage or incorporation with district heating, placing heating pipes under pedestrian paths.

(Safdie, 2024)

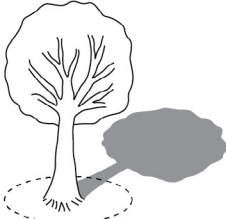
Complementary	C14, C16, E11, E13, E17, E18, E24, E25, S4, S6, S7, S11, S12, S13, S14
Alternative	C3, C6, C12; E16, E20
Conflicting	E12
Embedded	-

E15

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Green Shades

Strategically placed deciduous trees, pergolas and green canopies enhance thermal comfort by shading in summer and letting light through in winter.

Empirical Back-up:
Deciduous trees and vegetation considerably reduce urban heat island effects in summer by evapotranspiration cooling and blocking solar radiation through shading during midday and evening times to limit direct solar exposure and manage residual heat. In winter, deciduous trees allow solar short-wave radiation to pass, supporting passive heating and daylight access.

Practical Implications:
Design social spaces **North of mature deciduous trees**, while **leaving the surface area unpaved** around the tree as large as the **crown's projection**. If there are no mature trees, **plant them to the South and West of valued meeting spaces**. **A larger cluster provides** more benefits than individual trees.

(Oke, 1987)

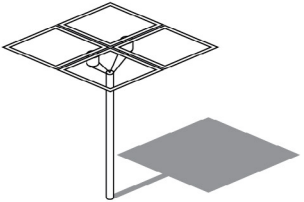
Complementary	C2, C15; E10, E12, E17, E24, E25; S2, S5, S7, S10
Alternative	C6; E13, E16, E20, E23
Conflicting	-
Embedded	-

E16

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Structural Shades

Strategically placed adjustable shading structures enhance thermal comfort by effectively blocking strong solar radiation during heatwaves.

Empirical Back-up:
Researchers have been examining how man-made structures can optimise shading structure by utilising biomimicry and smart shading devices. Adjustable shading structures, such as hanging fabric or movable panels, allow to increase shading during extremes, while removing them during cold periods.

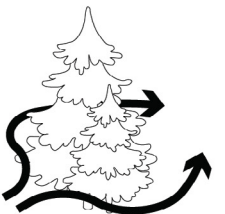
Practical Implications:
Install adjustable **shading elements in high activity areas with limited vegetation capabilities**. Position these structures on **Southern and Western sides** to provide shade during peak solar hours. Prioritize **materials that are lightweight and durable**. Ensure **artistic and heritage sensitive designs** as well as **additional functions**, such as **PV panels** to generate energy. Integrate mechanisms that **allow manual or automated adjustment**.

(Borrego, 2024)

Complementary	E4, E18, E19, E24, E25; S4, S11, S12, S13
Alternative	C4, C6; E13, E14, E15, E20, E23
Conflicting	E6, E11
Embedded	-

E17

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Green Windbreaks

Coniferous trees used as windbreaks filter and reduce the wind without stopping it entirely, while also providing shade.

Empirical Back-up:
 Winter design guidelines suggest that coniferous trees, for their dense foliage and evergreen nature, provide a strong wind buffer, with better protection from airborne pollution than deciduous trees. Additionally, coniferous trees retain colour throughout the year, providing health benefits for people.

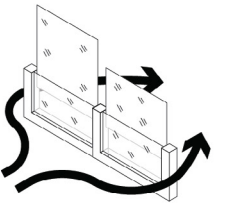
Practical Implications:
 Place coniferous trees **around high activity spots in dense clusters** to minimise cold wind breeze from the North. Due to their pyramid shape, these trees not only block wind but line of sight as well. **Use these trees as privacy barriers between resident spaces and public corridors, although do not hide active plinths and storefronts** from the public.

(Chapman et al., 2018;
City of Edmonton, 2017)

Complementary	C2, C3, E3, E5, E8, E10, E12, E14, E15, E19, E25, S1, S6, S10, S11
Alternative	C6; E18, E24
Conflicting	E7, E9
Embedded	-

E18

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Wind Shields

Well-orientated transparent structures minimise wind exposure, while maximising sunlight gains during cold periods.

Empirical Back-up:
 Transparent glass panels provide an alternative to reduce wind speed in outdoor spaces while allowing to retain high visibility. Observations on commercial streets illustrate how these elements can provide thermally comfortable seating environments near cafes and restaurants while additionally collecting and trapping solar radiation. High visibility provides openness and safety in public.

Practical Implications:
 Place transparent wind shields to **block Northern wind from seating areas**. Ensure that these shields are **at least 1.5-2m. high** to effectively block wind for sitting and standing. **Enclosed transparent structures can be placed to create sun traps**, similar to greenhouses, although the structure should **incorporate openings** to ensure ventilation.

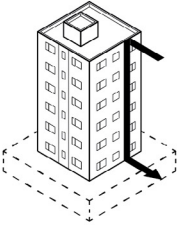
(City of Edmonton, 2017)

Complementary	E3, E8, E14, E16, E19; S11, S12
Alternative	C6; E17, E20, E24, E25
Conflicting	E7, E9; S7
Embedded	-

E19
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Extruding Podium

Tall building step-backs slow down wind patterns at pedestrian level by compacting the street plinth, while also blocking downdraft from above.

Empirical Back-up:
Wind design guidelines show that isolated tall buildings influence the wind patterns above creating downdrafts, harsh winds directed downwards, creating turbulence at pedestrian level. This downdraft can be minimised through irregular shaping of the building, adding podiums around the building, or creating a set-back form.

Practical Implications:
Add 1-2 storey podium extrusion to isolated tall buildings, maximising the possible set-back. In limited space environments, the extruded structure or dense vegetation can be limited in the direction of the prevailing wind or the consistent wind direction during cold spells. These podiums can add mixed-use functions into neighbourhoods or community shelter spaces.

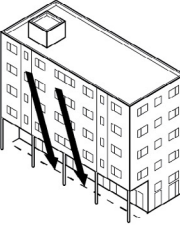
(Chapman et al., 2018;
City of Edmonton, 2017)

Complementary	C1, C17, C18;	E3, E16, E17, E18;	S12
Alternative	E8, E20;	S4	
Conflicting	-		
Embedded	C18		

E20
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Tunnelled Plinth

Cantilevers and pushed-in ground floors protect interface spaces from wind and snow, while south facades are protected from direct sunlight.

Empirical Back-up:
Research in arid climates have illustrated that extended cantilever building can provide shading on the pedestrian level, protection from precipitation and limiting wind, which effectively improves thermal comfort for people walking or staying under the building. While wider spans enclose the street canyon and provide relief during peak hours, the lower Sky View Factor can maintain heat longer in the evening.

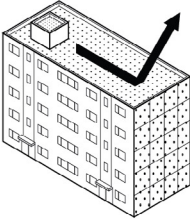
Practical Implications:
Design street canyons with extruded cantilevers, with largest extrusions for Southern facing walls, intermediate for West and East facing facades and limited extrusions for North facades. Design walking paths to be situated under the cantilevers, similar to Bologna's Porticoes.

(Kharrufa et al., 2024)
Bologna's Porticoes

Complementary	C14, C18;	E3, E9;	S4, S7, S10, S11, S12, S13
Alternative	C6, C15;	E8, E14, E15, E16, E18, E19, E21	
Conflicting	E6;	S1	
Embedded	-		

E21

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Cool Envelope

Bright exterior walls and roof surfaces stays cool and in the sun by strongly reflecting sunlight and by quickly emitting thermal radiation, not heating up inside and outside spaces in the evening.

Empirical Back-up:
Heat absorption, storage, and release all contribute to urban thermal comfort as well as interior comfort and building energy consumption. During heatwaves, cool roofs and walls, that reflect a large portion of solar radiation, can reduce building cooling energy consumption and ensure lower amount of heat released into the surrounding spaces.

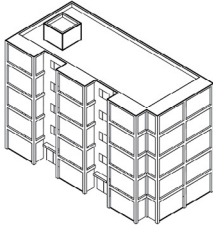
Practical Implications:
Ensure all building roofs have reflective materials. Reflective walls can brighten the spaces in colder seasons while increase the amount of reflected heat towards people in warm periods. Design cool surfaces in open spaces, areas with large vegetation canopies or urban environments where the street canyon ratios are lower than H/W 0.5.

(C40 Knowledge Hub, 2019;
Ornam et al., 2024)

Complementary	C7, C18;	E22, E24;	S4
Alternative	E13, E20, E23		
Conflicting	E6		
Embedded	-		

E22

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Second Envelope

Constructing an additional transparent façade or expanding the insulating layer reduces cold exposure for buildings by trapping heat between the cladding layers.

Empirical Back-up:
Adding an additional outer layer to a building's facade, creates a buffer zone, where air inside traps solar energy and prevents heat loss. This reduces the building's energy consumption required for heating, while also providing a transitional space that can be utilised by residents as private or communal spaces.

Practical Implications:
Design double-skinned facades for new buildings and retrofit older structures. Ensure the space between the primary and secondary facades are at least 2m, to allow people to occupy and move through the space. Design the urban form to integrate these structures on the South-facing walls. Integrate ventilation or shading options to ensure the spaces do not overheat during warmer seasons.

(Atelier Kempe Thill, 2019)

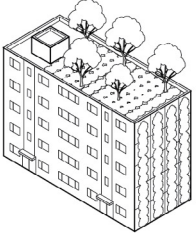
Complementary	C7, C18;	E6, E13, E21, E25;	S4, S12, S14
Alternative	C6		
Conflicting	E23		
Embedded	-		

E23

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Green Envelope

Green roofs and vertical vegetation reduce heat exposure for both the building and its surroundings through evaporation and lower heat absorption.

Empirical Back-up:
Covering the building's structure with vegetation reduces the impact of solar radiation by shading and humidity. Studies have shown that green walls outperform other heat reduction design strategies, although are more costly and require maintenance. Green roofs additionally benefit by collecting rainwater and reducing thermal stress through evapotranspiration.

Practical Implications:
Implement **extensive low maintenance greenery on high-rise buildings**, while for low-rise and mixed-used developments **ensure intensive green roofs to incorporate larger plants**. Combine green roofs with **rainwater collection systems**. Use **vertical greenery for Southern facing walls and ground floor stories**, that are situated near active public spaces.

(C40 Knowledge Hub, 2019; Ornam et al., 2024)

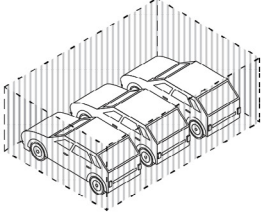
Complementary	C7, C18; E24, E25; S1, S14
Alternative	E2, E5, E10, E12, E13, E15, E16, E21, E26
Conflicting	E22
Embedded	-

E24

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Shielded Parking

Enclosing, hiding or placing parking areas underground ensures that these spaces are not exposed to high heat accumulation and do not amplify the environment's heat stress.

Empirical Back-up:
Large parking areas are unattractive to human activities and due to their built qualities, such as paved surfaces, open spaces and standing vehicles, are exposed to heat absorption, retention and release in the evening and unprotected from cold breezes. By limiting these spaces or shielding them from direct solar radiation, the city can limit high exposure areas for both heat and cold.

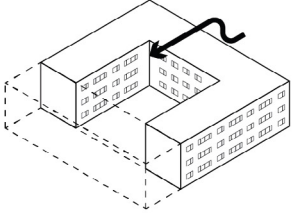
Practical Implications:
Plan parking spaces underground for new developments and examine possibilities to **transform current large parking spaces to smaller sheltered spaces**. Above ground service parking spaces can be **shielded with vegetation, canopies or integrated PV panels**. Ensure that enclosed parking structures are **ventilated** to not retain pollutants and heat within the space.


(Alexander et al., 1977)

Complementary	C13, C16, E3, E11, E12, E13, E14, E15, E16, E21, E23, E25, S7, S9
Alternative	C6; E17, E18
Conflicting	-
Embedded	-

E25

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Sheltered Block

Interior enclosed blocks that limit cold wind from the North, can extend the usability of the courtyard, considering cold temperatures.

Empirical Back-up:

Cold Northern winds, or cold season prevailing winds, drastically influences thermal comfort and longer periods of exposure can impact the person's health. Block forms with a continuous perimeter and compact courtyards conduct wind over the structure. Compact courtyards also provide constant shade from their buildings, making building-surface transition spaces the most protected from climatic factors.

Practical Implications:

Design compact block typologies with an enclosed Northern, Western and Eastern sides, while Southern sides can implement openings to utilise solar gains and allow cooling prevailing winds in warm periods. Incorporate social spaces, such as entrances, playgrounds and active spaces, within the sheltered block.

(Chapman et al., 2018;
Pressman, 1988)

Complementary C1, C2, C3, C4, C6, E5, E10, E14, E15, E16, E17, E22, E23, E24, S1, S5, S6, S8

Alternative E3, E4, E8, E18


Conflicting E7



Embedded C18

Social Well-being Patterns

S1

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Courtyard Gardening

Interactive green spaces encourage participation and communal working, fostering community ownership. Additionally, increased and maintained greenery reduces exposure to heat.

Empirical Back-up: Urban gardens integrate nature-based solutions into the built environment, supporting social cohesion, mental well-being and ecological resilience. Gardens act as microclimate buffers reducing urban heat and improving the air quality. Additionally, these spaces provide opportunities for urban agriculture and environmental education.


Practical Implications: Only design the **placement of gardening spaces** and allow residents to decide and manage these locations. Situate urban gardens in **transitional spaces** to allow these green spaces to work as filtering buffers. Provide **sheltered seating** to encourage people to spend their time in these environments.



(Hanson et al., 2021;
One More Tree Foundation, 2024)

Complementary	C1, C2, C3, C4, C6;	E5, E6, E10, E12, E17, E23, E25;	S5
Alternative	S2		
Conflicting	E20		
Embedded	C8		

S2

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Quiet Nature

Remote spaces situated in natural areas improve health and reduces stress, increasing well-being for their visitors. Additionally, natural greenery reduces exposure to heat.

Empirical Back-up: Literature has shown that green spaces buffer noise-related stress by reducing annoyance and promoting cognitive restoration. Clear sight of green spaces also enhances well-being. Exposure to these positive environments reduces stress, sleep disturbances, and risk of cardiovascular diseases.

Practical Implications: Designing quiet nature spaces requires **dense and compact vegetation** to act as buffers between urban areas and nature soundscapes. Situate **paths and gathering spaces within natural areas**. Use **curved pathways** to reduce direct sightlines, creating relaxing seating areas. Ensure **accessibility** while maintaining the valued **qualities of nature**.

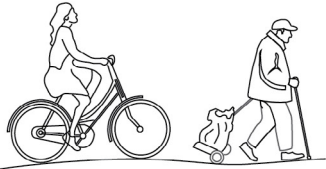
(Gidlöf-Gunnarsson & Öhrström, 2007;
Nieuwenhuijsen et al., 2022)

Complementary	E1, E2, E5, E15;	S3, S5	
Alternative	S1		
Conflicting	-		
Embedded	-		

S3

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Urban Hike

Prioritising pedestrian and cyclist movement with dedicated paths throughout the neighbourhood is an effective way to encourage slow mobility, which provides physical and psychological well-being.

Empirical Back-up:
Walkability and walkable cities provide many values from social, recreational and transportation opportunities to promoting mental and physical health, as for walking 30 minutes per day for 5 days can reduce the risk of several chronic and age-linked diseases.

Practical Implications:
To develop slow mobility and a pedestrian network, **connectivity with other land-uses and alternative modes of transportation** is essential. Path's context establishes a recreational or transportation function. High movement spaces should focus on **short distances**, while recreational paths should be **integrated with green spaces spanning at least 2-4km** to achieve health benefits.

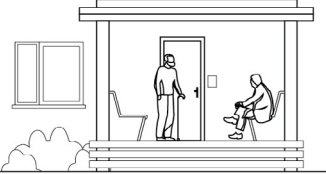
(Southworth, 2005;
Ungvari et al., 2023)

Complementary	C5, C14, C15, C16;	E1, E2, E11;	S2, S7
Alternative	-		
Conflicting	E12		
Embedded	C12		

S4

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Our Home Entrance

For apartment buildings, the main entrances act as the main gathering place, ensuring social cohesion between the building's neighbours.

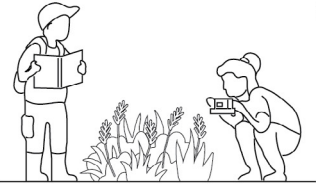
Empirical Back-up:
Relationships between neighbours indicate the strength of the local community. Studies have shown that dense apartment buildings result in isolated residents. Adequate common spaces can relieve this separation by providing spaces for communication. One of the most significant meeting spaces is the building entrance.

Practical Implications:
Place main entrances **towards social environments**, incorporating the building to the lively neighbourhood. These spaces should be **emphasised and perceivable** from the surroundings. While **sheltering** these spaces increases their usability throughout temperature extremes, **natural light** is essential for people to stay. Design at least **two sets of seating groups** to allow neighbours to sit without requiring them to interact.

(Stoiljković, 2022)

Complementary	C1, C2, C4, C6, C17;	E6, E13, E14, E16, E20, E21, E22
Alternative	E19; S9	
Conflicting	-	
Embedded	-	

S5



Learning Spaces

Indoor and outdoor learning spaces are essential for a child's cognitive development and improvement of their interpersonal skills.

Empirical Back-up:

With various studies illustrating that children learn in distinct ways, different learning spaces provide children with a variety of learning opportunities in their education. Integrating outdoor spaces as educational environments increases students' productivity, attention and ensure they are more actively involved.

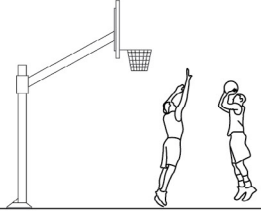
Practical Implications:

Design learning spaces, such as schools or kindergartens, **to easily transition from indoor to outdoor environments**. These environments should overlap with spaces further than the institution to allow the **neighbourhood to be a teaching ground**. Learning areas should **incorporate quiet, physical, social, nature and sensory spaces**. **Sheltered** learning spaces provide protection for children from intense weather, that do not know better.

(Sam & Kouhirostami, 2020; Virtual Lab School, 2023)

Complementary	C3, C4, C5, C8; E2, E5, E12, E15, E25; S1, S2, S6
Alternative	S14
Conflicting	-
Embedded	C8

S6



Sporting Grounds

Dedicated sports areas allow residents to participate in physical activity, that not only improves physical, mental and emotional health, but strong relationships and community attachment.

Empirical Back-up:

By the World Health Organisation's (2018) data a quarter of adults, and 3 quarters of adolescents do not meet global recommendations for physical activity. To promote active lifestyles and healthier cities, public urban sporting zones provide equal opportunities for residents to exercise and promote social communities by participating in group events.

Practical Implications:

Efficient sporting areas allows people to choose their activities, which requires **developing multi-sport fields** and providing for all ages. **Barrier-free access and shared storage** for equipment allow everyone to participate. Rather than developing many isolated and private sporting grounds, **larger shared courts** bring together the neighbourhood. **Sheltered seating areas** integrates the space with the context, creating resting and spectating functions.

(WHO, 2018)

Complementary	C3, C5, C6, C14; E8, E11, E14, E17, E25; S5, S14
Alternative	-
Conflicting	-
Embedded	-

S7

Safer Streets

Prioritising street safety for pedestrians, will decrease injuries and fatalities that occur due to vehicular collisions, heatwaves or cold-related accidents.

Empirical Back-up:
 Street canyons are dominant morphological urban features, that people use to traverse the city. These spaces, which can exhibit microclimates that intensify thermal stress, together with traffic related risks, such as stagnant CO2 emissions and slippery road conditions, pose a threat to people walking through these places.

Practical Implications:
 Assure that streetscapes have adequate **dedicated space, minimum of 1.5 meters** for pedestrian travel zones, which are **shielded from harsh weather patterns**, such as direct sunlight or strong winds. Provide protection from traffic by implementing **low-speed areas and a safe transition** to other forms of movement, with planting or service zones.

(Mehaffy et al., 2020; Zhang et al., 2025)

- Complementary** C14, C15, C16, E8, E11, E12, E14, E15, E20, E24, S3, S8, S10, S11
- Alternative** C13
- Conflicting** E18
- Embedded** C7, C12

S8

Play Zones

Playgrounds serve as a social space that promotes social learning among children and interaction between generations.

Empirical Back-up:
 Playing games are essential for children's growth, supporting cognitive development, social learning and strengthening physical health. Playgrounds provide safe, open and inclusive spaces for children to grow up together. Additionally, playgrounds allow parents or guardians to socialise while looking after children.

Practical Implications:
 Inclusive play areas **ensure clear view between children and their caregivers** and **provide seating nearby**. To encourage playing together **provide group play structures**, such as swings and climbing structures. These spaces should be **protected from environmental factors** for children and grownups nearby, to ensure healthy play.

(Ginsburg et al., 2007, de Jong, 2023)

- Complementary** C1, C3, C5, C6, C8; E8, E11, E25; S7, S14
- Alternative** -
- Conflicting** -
- Embedded** -

S9



Central Civic Spaces

Accessible and inviting gathering spaces are the core community development spaces, where celebrations, discussions and knowledge sharing activities occur.

Empirical Back-up:

Public space theories emphasise the importance of civic spaces, that serve as forums for public gatherings and encourage political engagement, discussions, protests and community decision making. Civic spaces strengthen democracy as they provide a stage for the community to reach out to government institutions. These are outdoor areas, such as courtyard meeting spaces or city squares, or indoor places, such as libraries or community hubs.

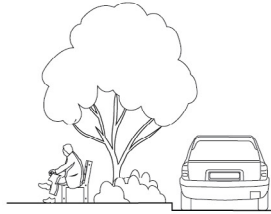
Practical Implications:

Communal meeting spaces should be situated centrally and in a visible space, to ensure everyone taking part has a view of the space and can easily reach it from their home. Seating should incorporate enough spaces to accommodate for every representative from each of the buildings.

(Mehta, 2014; Project for Public Spaces, 2009)

Complementary	C5, C6, C17; E4, E9, E24; S10, S12, S13
Alternative	S4, S14
Conflicting	-
Embedded	-

S10



Urban Spectator

Rest areas within the public realm support community networks by providing a space for people to observe and engage with each other.

Empirical Back-up:

One of the main optional activities, that are crucial for vibrant urban environments, is observing the public space. This passive engagement creates social cohesion through indirect interactions and ensures space safety through public surveillance.

Practical Implications:

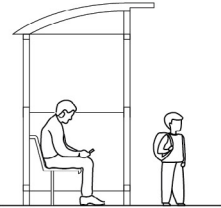
To design successful resting and observing spaces, consider the possible viewing zones, that have a clear view of active urban environments and are situated higher. These spaces can be combined with other activities. Incorporate movable seating to allow people to situate themselves, while fixed seating should be sheltered and positioned near soft edges, such as low structures or plantings, to create a pleasant space.


(Gehl, 2010)

Complementary	C6, C15; E4, E7, E13, E15, E17, E20; S7, S9
Alternative	S11
Conflicting	-
Embedded	-

S11

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Waiting to Go

Interchange areas not only connect far public spaces into a system but are also temporary meeting spaces that bring-in residents and allow them to wait and travel together.

Empirical Back-up:
Studies highlight the importance of the urban contexts to create various waiting activities. While public transport stop spaces are characterised as a place to wait for transport, the implementation of other functions can include a variety of waiting practices, which serves as an integrated urban public space. Isolated and monofunctional spaces can attract one dominant group to appropriate the space or leave the space empty, discouraging other passengers from using it.

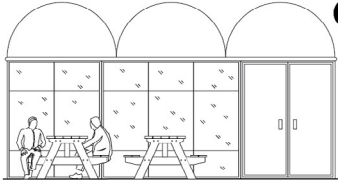
Practical Implications:
Design public transport nodes, that they create small centres of public life. These spaces should be considered as gates into the neighbourhood. **Situate them to cooperate other activities and amenities** in the area.


(Alexander et al., 1977, Tran & Hyeong, 2023)

Complementary	C11, C13; E7, E14, E16, E17, E18, E20; S7
Alternative	S10
Conflicting	-
Embedded	C12, C17

S12

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Social Plinth

Buildings that provide services benefit from an open and inviting façade, which additionally improves the outdoor environment and neighbourhood integration.

Empirical Back-up:
The ground floor of buildings, or plinths, shape the urban experience at eye level. They serve as the interface between interior spaces and the public realm, influencing how pedestrians interact with their environment. Research shows that vibrant plinths enhance social interactions, support local economies, and improve the overall quality of the urban life.

Practical Implications:
Incorporate large windows and multiple entrances to create visual and physical connections between indoor activities and street life. **Establish a metre width frontage zone** to allow the interior to cross outside. For commercial frontages, **the area can be expanded to fit outdoor seating**, although this requires consultation with the local authority.

(Van 't Hoff et al., 2012; Vilnius city municipality, 2021)

Complementary	C6, C9, C10, C18, E4, E6, E7, E14, E16, E18, E19, E20, E22, S9, S13, S14
Alternative	-
Conflicting	-
Embedded	-

S13



Social Shopping

Small shops and markets are the most socially diverse public spaces in communities that bring together people from various backgrounds around food, shopping and conversation.


Empirical Back-up:
 Small local shops and markets have illustrated to be more economically, socially and environmentally sustainable than large shopping malls, as these spaces promote local food and shorter food ways, economic benefits remain in the community and everyday interactions develop social inclusion and cohesion within the neighbourhood.

Practical Implications:
 Prioritise development of **small nearby local shops** or marketplaces with many individual and autonomous shops instead of large modern supermarkets. **Sheltered** markets ensures their usability despite the weather. To sustain commerce, these spaces require to be **situated near major movement corridors**, however service spaces, such as **parking, should be hidden** to not block pedestrian access.

(Alexander et al., 1977; Caramaschi, 2015; Navapan & Charoenkit, 2022)

Complementary	C9, C10, C16, C18;	E4, E14, E16, E20;	S9, S12
Alternative	-		
Conflicting	-		
Embedded	C17		

S14



The Community House

Public buildings or services managed by the city that also function as community hubs foster social interaction, trust, and civic engagement.

Empirical Back-up:
 Well-designed mixed-use spaces sustain urban vitality and increase the public participation. By integrating shared community-oriented spaces within public buildings, such as libraries, museums, hospitals, public schools and other institutions, creates multi-functional environments that serve different groups of people. This not only utilises the current social infrastructure more efficiently but also increases trust between people and governmental institutions.

Practical Implications:
 To transform public buildings into community hubs requires a better integration with the public realm by **orienting the shared spaces with active public spaces, ensuring easy access and a visible interior**. Spaces should be flexible to **accommodate different functions**.

(Gehl, 2010; Jacobs, 1961)

Complementary	C8, C9, C10, C16, C18;	E14, E22, E23;	S6, S8, S12
Alternative	S5, S9		
Conflicting	-		
Embedded	C17		

Coping Networks

C1
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Degrees of Publicness

A clear distinction between public and private spaces ensures an understandable allocation of functions and control of spaces, allowing people to maintain their own spaces.

Empirical Back-up:
The subdivision of social spaces into public and private domains is a significant feature how groups of people organise themselves. Situating oneself in these different domains affects the individuals' mental state, regulates their behaviour, and develops activity patterns and structure for human interactions.

Practical Implications:
Make a **clear distinction** between three kinds of spaces – calm inner spaces, active areas on busy streets, and semi-public spaces in-between. Ensure that **inner spaces are physically secluded**, intended for immediate residents, more **public spaces should incorporate amenities or economic activities**. The spaces **between should cater to residents of the neighbourhood** to buffer the very public from the reserved private.

(Alexander et al., 1977;
Madanipour, 2003)

Complementary	C2, C3, C4; E2, E8, E19, E25; S1, S4, S8
Alternative	E4
Conflicting	C5
Embedded	-

C2
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Residents' Land

Granting land ownership to residents fosters a stronger sense of responsibility and community ties, as it encourages care of shared spaces and collective environmental adaptation.

Empirical Back-up:
When residents have a formal or permitted control of their living environment, they are more likely to invest time and resources to improve and maintain their spaces. Theories on Commons, collective action and self-governance support the idea that collective ownership empowers communities to manage shared resources responsibly and sustainably.

Practical Implications:
Urban policies can support resident ownership through **local initiatives, cooperative housing models, community land trusts, or participatory planning processes**. Communal spaces should be managed by shared governance structures, with elevated voice given to the community. Publicly owned housing estates should **relinquish ownership to the residents**, ensuring transparent decision-making and equitable participation.

(Ostrom, 1990)

Complementary	C1, C3, C4; E8, E15, E17, E25; S1, S4
Alternative	-
Conflicting	C5
Embedded	-

C3

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Neighbourhood Resources

Sharing resources, that allow active adaptation to temperature extremes, in public spaces ensures that the most sensitive groups have equal opportunities to adapt.

Empirical Back-up:
 Access to communal tools and items, such as shading devices, movable seating, fans, thermal blankets, snow shovels or communal gardening tools, increases a neighbourhood's adaptive capacity to respond to climate stresses. The concept of "sharing city" has illustrated how a circular approach can increase inclusivity and sustainability, which can be extended towards risk management.

Practical Implications:
 Encourage the use of adaptable, easy-to-use collective objects such as portable shade structures, water dispensers, misting devices, and weather protective gear. Establish lending systems and sharing storage areas for people to trade tools, clothing and equipment that provide heating or cooling. Encourage residents to co-manage these resources promoting inclusive access.

(de Jong, 2025)


Complementary	C1, C2, C4; E11, E12, E17, E25; S1, S5, S6, S8
Alternative	E14
Conflicting	-
Embedded	-

C4

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Neighbourly Help

Having an active and connected community ensures that during temperature extremes sensitive groups can quickly receive help and support from trusted people.

Empirical Back-up:
 Strong social networks are crucial for community resilience and adaptability, particularly during climate hazards. Research shows that social connection is a strong variable in many health outcomes for vulnerable individuals, as they are able to receive timely assistance. To increase the response rate from isolated people, there must be trust and familiarity.

Practical Implications:
 Adopt community building initiatives like neighbourhood groups, buddy systems or local care networks to ensure communication and support. Establish protocols for checking in on elderly or isolated residents during extreme temperatures. Encourage shared communication platforms to organise help quickly. Comunal spaces can host events that strengthen trust and connections before hazards occur.

(Kafeety et al., 2020)

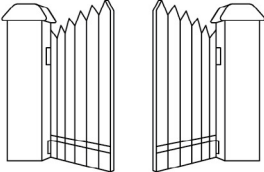
Complementary	C1, C2, C3, C8, C11; E25; S1, S4, S5
Alternative	C12; E16
Conflicting	-
Embedded	-

C5

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Opening Up

Connecting controlled public spaces, such as institutional grounds, within the public space, extends the usage and possible activities in these areas.

Empirical Back-up:
Observations prove that controlled public spaces, which serve a public function although have their access restricted for specific individuals, remain unused and segregated during other times than their primary purpose. The integration of these spaces into the public would enhance activity diversity and ensure a more resourceful use of spaces.

Practical Implications:
Design controlled public spaces **orientated to their surrounding active public space, incorporating flexible and soft barriers,** such as open gates, transparent barriers, and open shared amenities, can help foster a seamless transition from semi-public to public. While providing a specific function for an aimed group, these spaces should be considered as extensions of the public realm, **allowing the locals to utilise the spaces when not used.**

(Gehl, 2010)

Complementary S3, S5, S6, S8, S9

Alternative -

Conflicting C1, C2, C6

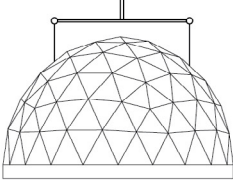
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C6

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Temporary Enclosed

Air domes or glass pods provide a temporary complete protection from outdoor climates, ensuring that the covered spaces can be used during any weather.

Empirical Back-up:
With increasing unpredictable weather conditions, urban spaces require quick transformations to be able to cope with extreme temperature hazards. Temporary enclosures create flexible and temperature robust environments, that can be quickly assembled and dismantled. Calculations have shown that energy required to maintain such structures are lower than regulating traditional buildings.

Practical Implications:
Design public spaces that **can be temporarily enclosed** during temperature extremes. These enclosures can function as markets, gathering spots, sports or leisure activities. Ensure they are **transparent with a visible entrance** to blend into the surroundings space, while also attracting people. Examine if these structures can **become permanent** within the environment transforming from open to enclosed spaces.

(Gaoshan Tent Building Technology, 2024)

Complementary E6, E25; S1, S4, S6, S8, S9, S10, S12

Alternative E3, E4, E14, E15, E16, E17, E18, E20, E22, E24

Conflicting C5; E7, E9

Embedded -

C7

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Help from the City

Municipality assigned subsidies and budgets for public space adaptation are essential for vulnerable spaces, that are limited in their ability to transform their spaces.

Empirical Back-up:
 Studies highlight that adaptation is capabilities of different regions and neighbourhoods vary due to unequal due recourses and capital. Similar to the climate finance's principle of "common but differentiated responsibility and respective capabilities", public subsidies and targeted funding can empower and allow local vulnerable stakeholders to adapt their spaces to temperature extremes.

Practical Implications:
 Municipalities should **establish dedicated funding programs** aimed at supporting the adaptation of under-privileged and sensitive neighbourhoods. These could include **grants** for local communities or **assistance programs** offering adaptation expertise. Participatory community projects could be **developed together** with municipal projects to share materials and transform spaces simultaneously.


(UNFCCC, 2025)

Complementary	C8, C9, C10, C11;	E21, E22, E23
Alternative	-	
Conflicting	-	
Embedded	-	

C8

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Learning Adapting

Knowledge sharing empowers communities to adapt to temperature extremes by operating accessible climate resilience recommendations and informing these communities of their possible resources.

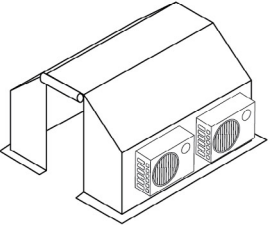
Empirical Back-up:
 Research shows that, when local communities are informed about climate risks and equipped with practical solutions, they are more likely to implement adaptive behaviours and demand climate adaptation strategies. Knowledge-sharing initiatives increase awareness of temperature-related risks for local communities and lead to innovative adaptation solutions across different sectors.

Practical Implications:
 Establish **platforms for knowledge sharing** that educate communities on climate adaptation strategies. **Public workshops, neighbourhood climate action plans or informational signs and booklets** in public spaces can efficiently share information. **Collaborate with local organizations**, such as schools or cultural institutions to spread climate awareness and provide practical learning opportunities.

(European Environment Agency, 2017)

Complementary	C4, C7, C9, C10, C11, C12;	E12;	S5, S8, S14
Alternative	-		
Conflicting	-		
Embedded	-		

C9



Cooling Centre

Air-conditioned spaces that provide refuge from heat and supply water to the public reduce the risk of heat-related harm and mortalities.

Empirical Back-up:

Enclosed spaces with regulated temperature prevent or reduce the negative health impacts of severe heat. Additionally, here people can learn about the impacts of heat and the measures they can take to address these.

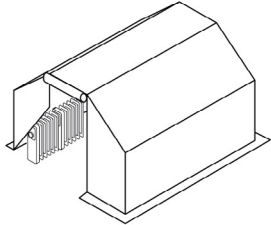
Practical Implications:

As these interior spaces incorporates mechanical cooling systems, such as air conditioning or geothermal cooling, energy efficiency must be considered. **Renewable energy production**, especially during heatwaves, can utilise **solar energy** to operate the shelter. **Passive design**, **suitable materials and insulation's** careful implementation minimises the energy demand required to maintain these structures. These spaces can be **set up** in response to heat waves or **integrated in the interior public structures**.

(Anticipation Hub, 2024; COMPAC, 2024)

Complementary	C7, C8, C10, C12;	S12, S13, S14
Alternative	-	
Conflicting	-	
Embedded	C11	

C10



Heat Bank

Well-insulated and heated shelters provide a space for unsheltered and isolated people to limit exposure to cold and offer a robust meeting space for the neighbourhood.

Empirical Back-up:

Heat banks have been on the rise due to the cost-of-living crisis, as they provide needed relief for those struggling with heating. There is an intersectionality of marginalised groups that are disproportionately affected from extreme cold and are less likely to adapt due to them being elderly, unhoused or unable to pay their bills. Collective heated spaces reduce cold-related health risks and promotes social inclusion.

Practical Implications:

Develop **well-insulated, energy-efficient heated shelters** in accessible locations such as **community centres, libraries, and public buildings**. Ensure operations during cold seasons are **extended and communicated** to the public. These environments should be inclusive and provide resting and meeting space. Examine the **possibility to incorporate reserve sustainable energy** heating capabilities.

(Libraries Connected, 2023; Shine, 2022)

Complementary	C7, C8, C9, C12,	E6;	S12, S13, S14
Alternative	-		
Conflicting	-		
Embedded	C11		

C11

Did You Hear?

Weather alerts with clear guidance that inform populations of incoming or existing temperature extremes, enables people to be more prepared and precautions for these hazards.

Empirical Back-up:
 Studies highlight that successful early warning systems are comprised of knowledge of the risk, monitoring and prediction abilities, communication and listener response capabilities. While accurate forecasts can determine the upcoming threat, communication and people-oriented readiness can significantly reduce health risks.

Practical Implications:
 Implement **user-friendly weather alert** systems that reach a broad audience through **multiple communication platforms**. Combine warnings with **actionable advice**, such as where to find cooling or warming centres, recommended clothing and activities. **Integrate these alerts into public spaces**, such as transport hubs, schools, and shopping areas.

(Basher, 2006)

Complementary	C4, C7, C8, C12, C16;	E4;	S11
Alternative	-		
Conflicting	-		
Embedded	-		

C12

Essential Workers

Local service workers support a functional urban environment during temperature extremes, as they maintain infrastructure and ensure public safety.

Empirical Back-up:
 Essential workers, such as maintenance staff, emergency responders, and other public service providers, are vital to ensure continuous urban functions and provide critical support during temperature extremes. However, these workers are highly exposed to temperature hazards due to them working in these conditions, placing urban resilience at risk.

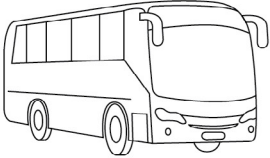
Practical Implications:
 Include these workers into **public space adaptation strategies**, ensuring they understand their role and have adequate **tools** to maintain critical spaces, such as de-icing services or pavement watering. **Develop resting spaces** for workers in excessive maintenance areas and longer regular breaks during temperature extremes.

(C40 Cities Climate Leadership Group, 2024)

Complementary	C8, C9, C10, C11, C13;	E11
Alternative	C4;	E14
Conflicting	-	
Embedded	C7	

C13

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Protected Transport

During periods of extreme temperatures, increasing and protecting public transport services is essential to ensure safe and reliable travel for all.

Empirical Back-up:
 Accessible, dependable and exposure reducing public transportation plays a vital role in protecting people with limited mobility options during temperature hazards. While studies have shown that temperature extremes reduce public transit ridership, sheltered interchange stops and shorter waiting times can mitigate this decrease. In extreme temperatures, such as waiting in -30 degrees, hypothermia can set in in 10min, when without proper clothing.

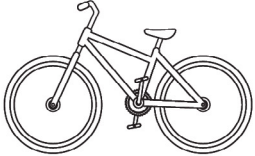
Practical Implications:
 Increase frequency of public transport services to ensure that **waiting times are lower than 10min** in high cold exposure areas. Incorporate transit vehicles with **climate-control systems** and transit stops with **temperature exposure reducing strategies**. **Coordinate transport routes to connect to temperature shelters.**

(CBS news, 2019; Miao et al., 2019)

Complementary	C12, C16; E24; S11
Alternative	C14; S7
Conflicting	-
Embedded	C7

C14

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Two Wheels Less

Developing cycling infrastructure extends access to distant public spaces, promoting sustainable mobility and enhancing connectivity.

Empirical Back-up:
 Studies have shown that development of safe cycling networks increase in the number of people who choose to cycle. Cycling is considered as sustainable slow mobility, that extend the reach of public spaces and amenities while offering an alternative to private vehicles. Additionally, the correlated reduction of traffic and air pollution decreases production of anthropogenic heat.




Practical Implications:
 Design cycling networks that **link neighbourhoods with cooling public spaces**, such as parks and cooling centres. Prioritise safe and comfortable **separated two-way bike lanes of 2.5m** or **integrated within slow-traffic roads of 1m, on each side**. Include **supportive infrastructure** such as bike parking and repair stations.




(Lowry & Loh, 2017;
 Rérat & Schmassmann, 2024;
 Vilnius city municipality, 2021)




Complementary	C15, C16, E4, E6, E14; E20; S3, S6, S7
Alternative	C13
Conflicting	E12
Embedded	-

C15

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Urban Stepping Stones

Designing small, strategically placed resting spaces enables people to move through the city at their own pace, providing comfort and shelter in varying weather conditions.

Empirical Back-up:
Repeating resting spaces provide travelling pauses for people, who need to frequently stop to rest when walking between their home and local amenities. While an average person's 5-minute walking distance is around 400m, people with limited mobility have a shorter walking threshold, in this study limited to 300m. During harsh temperatures, regular protected shelters along the walking path can limit the pedestrian's exposure to climate stressors.


Practical Implications:
Integrate small scale resting places, such as **sheltered, at least two-person, seating areas, at regular intervals of 100m,** along pedestrian and cycling routes. Ensure these spaces are **thermally comfortable in summer and in winter. Design them with clear sightlines,** to be inclusive and enhance safety.


(Newton, 2012; Strinu, 2020)


Complementary	C14, C16, C17; E8, E11, E15; S3, S7, S10
Alternative	E20
Conflicting	-
Embedded	-

C16

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Multi-Modal Routes

Designing multi-modal routes enhances connectivity by integrating walking, cycling, and public transport options, ensuring adaptable movement across the city.

Empirical Back-up:
Multi-modal transport refers to a person's use of many modes of travel to reach their destination instead of a single mode, such as private vehicles. While this method is a more environmentally beneficial and increases the use of public transport systems, its success is dependent on comfortable transitions and transforming car-oriented habits. Multi-modal systems are essential for people to travel with limited movement abilities.

Practical Implications:
Design **interconnected routes** that allow continuous transitions between different modes of travel. Ensure paths connect to interchange nodes and are **designed for universal access,** accommodating strollers, wheelchairs, and slower walkers. **Include supporting amenities, such as bike parking and repair services.**

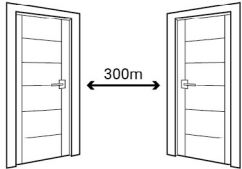
(Environmental Resilience Institute, 2025; Fu et al., 2024)

Complementary	C11, C13, C14, C15; E14, E24; S3, S7, S13, S14
Alternative	C17
Conflicting	-
Embedded	-

C17

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Door to Door

Prioritising short, direct routes from doorsteps to vital services and social spaces supports walkable and temperature-proof neighbourhoods.

Empirical Back-up:
The concept of the “15-minute city” suggests that daily needs should be reached within a short walk, bike or public transit ride. The importance of proximity and access encourages environmental sustainability and active mobility. When adapting this concept to climate hazards, harsh temperature extremes and the focus on sensitive groups, limits the concept to 5-minute distances or 300 metres.

Practical Implications:
Design direct pedestrian and cycling routes to essential services, such as shops, health facilities and social spaces, that are **safe, accessible, and thermally comfortable.** Remove physical and perceptual barriers while **integrating directional elements and functional lighting.** If essential services are not within the 300m pedestrian shed, **integrate these functions within the space.**


(Moreno et al., 2021)

Complementary	C15; E2, E4, E5, E19; S4, S9
Alternative	C16
Conflicting	-
Embedded	-

C18

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Public-Private Adaptation

Collaboration between public authorities and private stakeholders grants recourse for adaptation to climate challenges by requiring developers to invest in improving of public spaces.

Empirical Back-up:
Adapting to climate change requires significant investment, which the public sector cannot meet. While private sector involvement in financing adaptation is limited, this has been slowly changing due to shifting governmental priorities. By offering incentives, alternative finance models, increasing allowed building densities, municipalities can encourage private entities to contribute to adaptation projects.

Practical Implications:
Negotiate planning approvals with developers, **requiring them to fund public space adaptation projects as a condition for additional building rights or including an adaptation tax for each square meters built.** Ensure **mix-used zoning** and require new development projects to **integrate alternative shelters** for the larger community.

(Choi et al., 2023)


Complementary	E19, E20, E21, E22, E23; S12, S13, S14
Alternative	-
Conflicting	-
Embedded	-





04

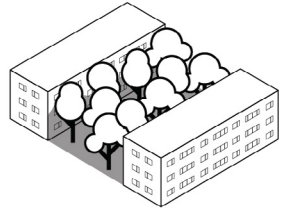
Integrated Patterns

E26

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In-fill Parks

Densely planted street trees with overlapping crowns create continuous shaded corridors that provide safe passage ways for pedestrians and cyclists by blocking direct solar radiation and cool down the street.

Empirical Back-up:
 By closely arranging trees, the spaces can replicate similar environmental conditions to forests by creating a continuous canopy. These canopies maintain cool spaces by blocking solar radiation and increasing humidity through transpiration, with studies emphasising that a minimum of 30% of canopy cover can prevent a large number of premature heat-related deaths. Additionally, green spaces contribute to psychological well-being and improving air quality.


Practical Implications:
 Design **multiple continuous rows of trees, in place of the street**, that when fully matured can enclose the street with their crowns. Plant tall trees to **leave the street's plinth open** to ensure visibility and social functions. **Connect these linear forests with larger natural spaces** to create ecological connections, increasing biodiversity.





(lungman et al., 2023)

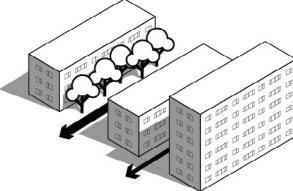
- Complementary** -
- Alternative** E2, E23
- Conflicting** E8
- Embedded** C14; E5, E7, E9, E10, E12, E15; S6, S7, S8, S12, S13

C19

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Heat-proof Canyons

Diversely adapted regional and local connections, that are adapted towards a specific time of the day provide multiple alternative movement paths to reach regional shelters.

Empirical Back-up:
 High-mobility regional streets are vital to connect residents to cooling or heating shelters, such as parks, lakes, and community centres. However, compact urban form often limits space for available adaptation strategies in streets, that are fully functioning as transport corridors. By integrated direct adaptation measures, different canyons can focus on mitigating exposure in different times of the day, proving safe paths for multiple mobility options across the whole day.

Practical Implications:
 Design East-west streets to prioritise **evening shading**, while North-south corridors to provide **afternoon cooling**. Develop **pedestrian paths through shaded urban blocks** and **increase heat dissipation within the streets** to provide a more comfortable walking environment in the evening.

(Developed through Design)

- Complementary** -
- Alternative** E1
- Conflicting** -
- Embedded** C6, C13, C14; E7, E9, E12, E16, E20, E23, E24; S7, S12

S15

Garden Communities

Inner residential courtyards into car-free garden spaces co-managed by resident collective's support climate resilience and social cohesion.

Empirical Back-up:

Increasing vegetation to moderate extreme heat by removing parking enables full green coverage. Small one storey structures within the courtyard slows down wind proving protection during cold periods. Adaptation to temperature extremes is achieved through different zones: outdoor gardens offer cooling during heatwaves, while extended building entrances and small structures such as greenhouses provide meeting and socialising spaces, that are comfortable during extreme cold.

Practical Implications:

Convert inner courtyards to **car-free communal spaces**. Include densely planted **trees around summer spaces** and **wind buffering pavilions**; building entrances or open greenhouses. Prioritise **greening south facing facades and apartment entrances**. Minimise the paved surfaces to essential walking paths.

(Developed through Design)

- Complementary** -
- Alternative** -
- Conflicting** -
- Embedded** C1, C2, C6; E10, E13, E15, E22, E24, E25; S1, S4, S9

C20

Oasis Corridors

Shaded and vegetated local streets with resting zones, that provide wind protection, ensure continuous, temperature robust paths for pedestrians and cyclists.

Empirical Back-up:

Local streets are essential to protect from exposure to temperature extremes, as they play a key role in connecting homes, amenities and larger natural areas. Strategic vegetation zones allow trees to develop a large canopy, which provides shading for summer. Encircled resting points with green windbreaks ensure cold weather comfort.

Practical Implications:

Line local streets with continuous tree rows to create a connected canopy. Situate the **tree lines to the south of pedestrian paths**. Integrate **vegetated windbreaks and enclosed seating stops every 100 m**. Ensure a large green space between vehicle and pedestrian **spaces to collect water and snow**.

(Developed through Design)

- Complementary** -
- Alternative** -
- Conflicting** -
- Embedded** C12, C14, C15; E10, E11, E13, E14, E15, E17; S2, S3, S7

S16

Schools for Everyone

Better integrated education grounds into residential environments provide a nearby multi-functional space, that serves both as shelters and community hubs.

Empirical Back-up:

Accessible school grounds with clear entrances and dedicated public functions, such as libraries, transform the school into an important node in the surrounding space. By reshaping the placement of buildings and fencing, these spaces can become more inclusive. Renovated or highly insulated buildings can provide adequate indoor shelters that do not require large amounts of energy to sustain.

Practical Implications:

Redesign school plans to open key spaces, such as libraries, gyms, and courtyards, which could be shared with the public. Replace fencing with permeable boundaries and place school building on the edge of the property to create an active plinth. Retrofit buildings with passive insulation and ventilation, enabling low-energy use as heating/cooling shelters.

(Developed through Design)

Complementary	-
Alternative	-
Conflicting	-
Embedded	C4, C5, C9, C10, C17; E8, E13, E15, E21; S5, S8, S14

E27

Thermal Collective Gardens

A defined structure between residential buildings can be optimised to create dual season outdoor spaces, with shaded gardens in the north and terraces oriented to the sun in the south.

Empirical Back-up:

Regulated building layouts, heights and roof forms can ensure high passive solar gains, while managing wind flows, creating comfortable environments. Height restrictions prevent overshadowing and create a dynamic urban form, while designated planting spaces ensures, that exposure to both extremes is limited

Practical Implications:

Apply solar-oriented development area requirements, such as north-side gardens with deciduous trees to regulate heat, south-facing terraces for winter. Create a continuous perimeter of buildings and low evergreen vegetation to block cold winter wind. Limit building heights to 2-3 stories, with angled roof to deflect cold northern wind. Merge the inner courtyard for communal food production to encourage resource sharing.

(Developed through Design)

Complementary	-
Alternative	-
Conflicting	-
Embedded	C3, C7, C8; E3, E6, E15, E17, E25; S1, S3, S4, S7

S17




Community Shopping Streets

Compact commercial nodes situated nearby public transport stops, with enclosed spaces and small shops provide a sheltered public life during cold seasons.


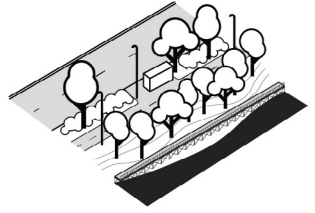
Empirical Back-up:
 Compact and covered pedestrian streets increase ambient temperature through passive solar gains, wind protection and protecting the space from snowfall. Mixed-use buildings ensure a more efficient use of indoor heating, as well as the commercial first floor can be integrated as public shelter for people living nearby. The small space providing essential amenities for the neighbourhood can become the main community space.

Practical Implications:
 Construct semi-enclosed arcades with south-facing transparent roofs between mixed-use buildings. Orient the corridors to buffer wind from the north, while ventilating from the south. Include spaces for open markets, seating and greenery. Prioritise pedestrian movement within the shared mobility spaces. Allow public transport to pass and restrict car parking.

(Developed through Design)

- Complementary** -
- Alternative** -
- Conflicting** -
- Embedded** C6, C18; E3, E4, E5, E8, E18; S7, S10, S11, S12, S13

C21

Traversable Landscapes

Multiple well-connected paths, that provide walking and cycling routes along large natural structures and to nearby public transport, linking homes to regional shelters, ensures a resilient mobility network during extremes.

Empirical Back-up:
 Access to regional amenities within 15 minutes by alternative transport modes improves health and climate adaptation. Spaces nearby large green areas benefit from their cooling properties, while reachable and heated public transport ensures accessibility during cold extremes.

Practical Implications:
 Develop local roads to prioritise pedestrian, cycling and other forms of slow mobility. Create public spaces in the transition between the built environment and nature. Install windbreaks, lighting leading to covered public transport interchanges. Use heated surfaces around the main interchanges and provide storage for multi-modal transport. Extend public transport into residential spaces, with mini buses.

(Developed through Design)

- Complementary** -
- Alternative** -
- Conflicting** -
- Embedded** C11, C12, C13, C14, C16; E1, E2, E14; S2, S3, S7, S11

05

Patterns Fields

Network of Patterns

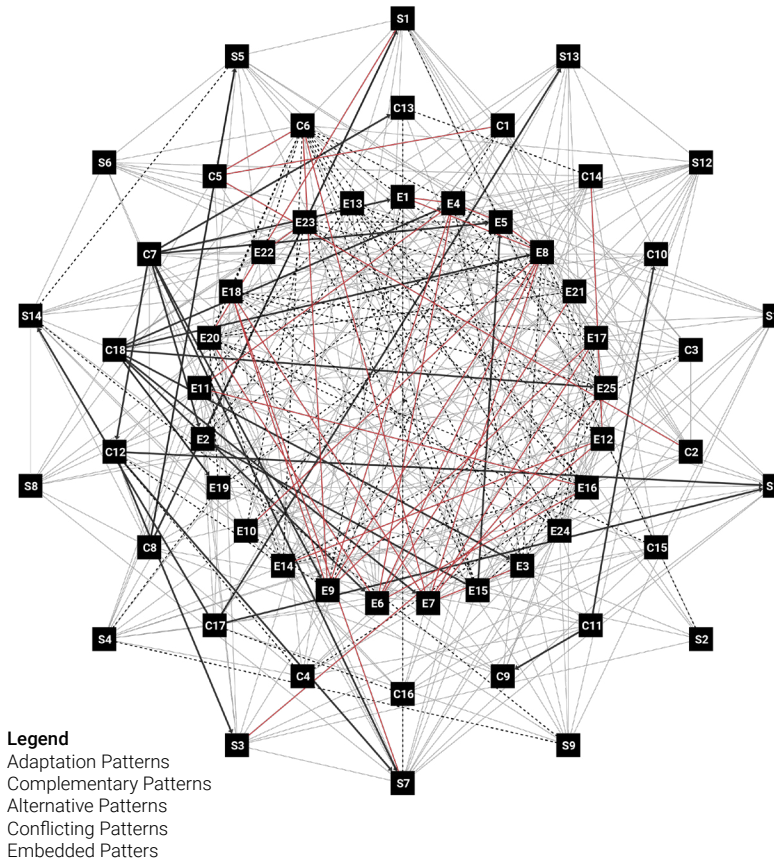
Two pattern fields were created to understand how the adaptation patterns can be implemented. The pattern field Network of Patterns illustrates the system of four possible relations between the developed patterns, while Implementation Stakeholders pattern field, signals, which parties are responsible for the patterns realisation and maintenance.

Throughout the process of designing public space adaptations and integrating various patterns into space, four possible relations between patterns were establish. These relations link patterns that are complementary, conflicting, can be consider as alternatives to one another or embedded within another. Complementary links illustrates that adaptation patterns provide benefits across the different pattern categories and informs the users of the Atlas, which patterns synergies. Most of the conflicting and alternative links were found between Exposure Reduction patterns, focusing on opposite extremes. Here the links show, which patterns diminish each other's effect and provide alternatives to deal with a specific temperature extreme. And lastly, Coping Network patterns were found to be more likely embedded within other pattern categories, showing the required initial pattern to achieve the desired adaptation design.

The full pattern field and all pattern links can be examined on the KUMU website, accessible by the QR code.



Explore the full Pattern Field Here



- Legend**
- Adaptation Patterns
 - Complementary Patterns
 - - - Alternative Patterns
 - Conflicting Patterns
 - Embedded Patterns

Figure 05. Pattern Field, illustrating the four relationships between patterns

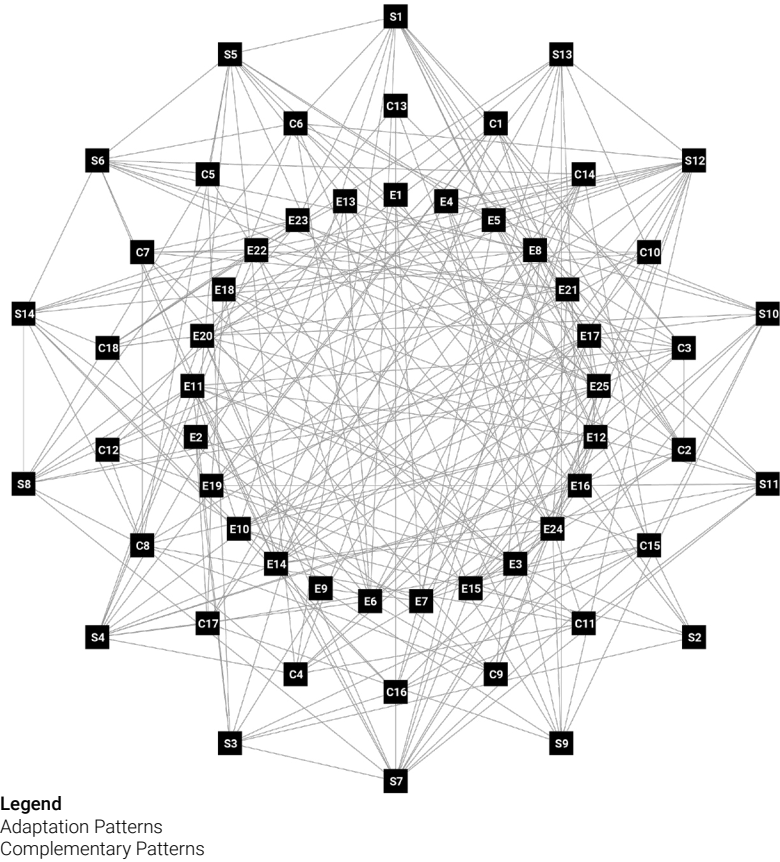


Figure 06. Pattern Field, illustrating Complementary relationships between patterns

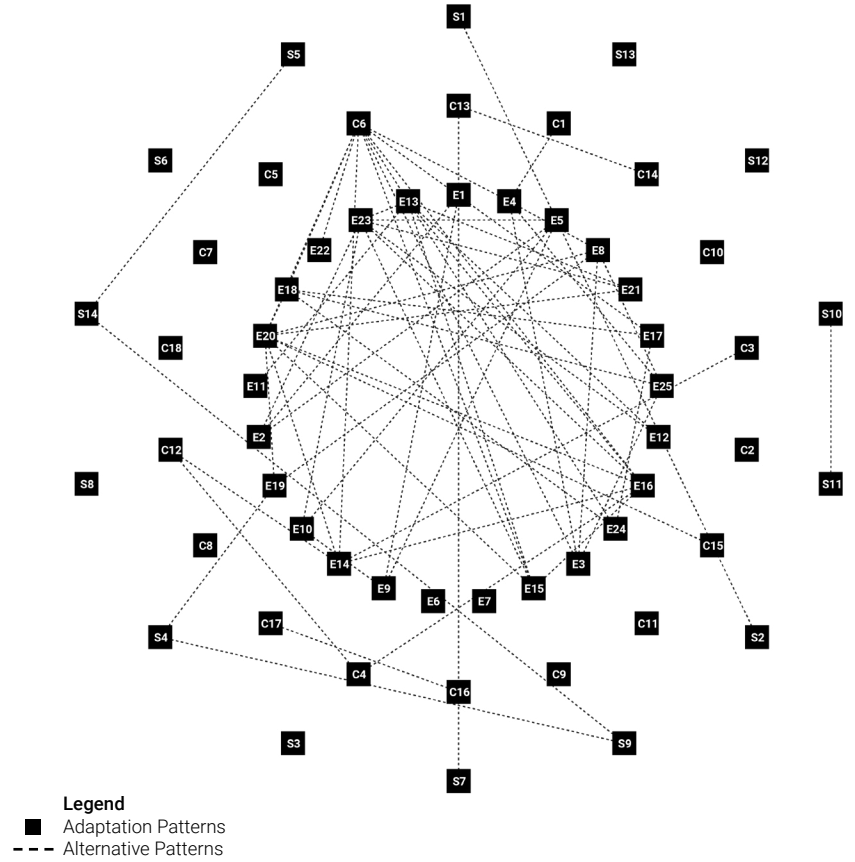


Figure 07. Pattern Field, illustrating Alternative relationships between patterns

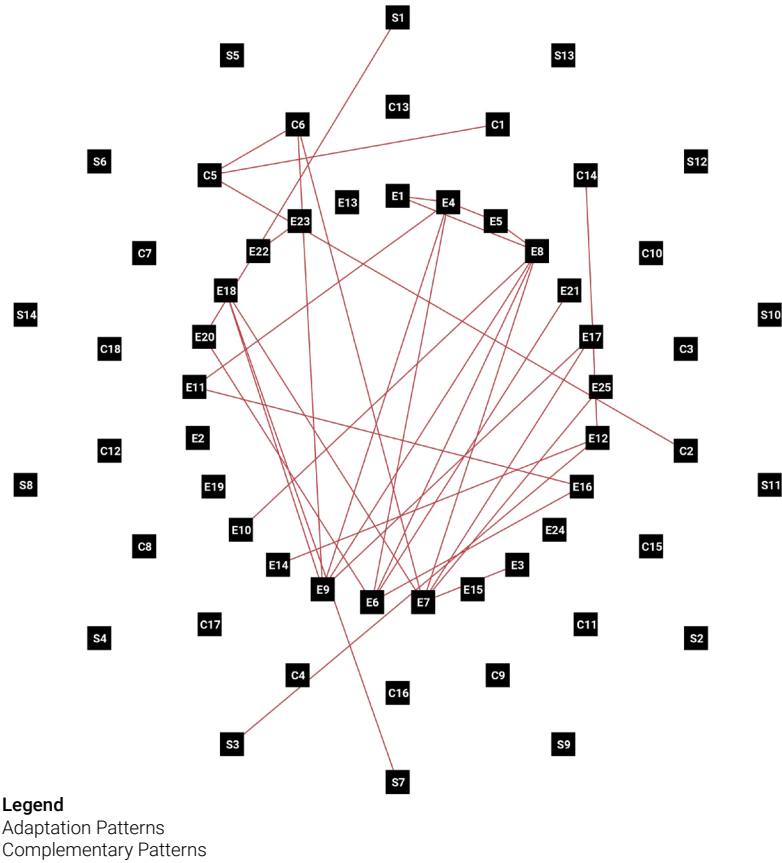


Figure 08. Pattern Field, illustrating Conflicting relationships between patterns

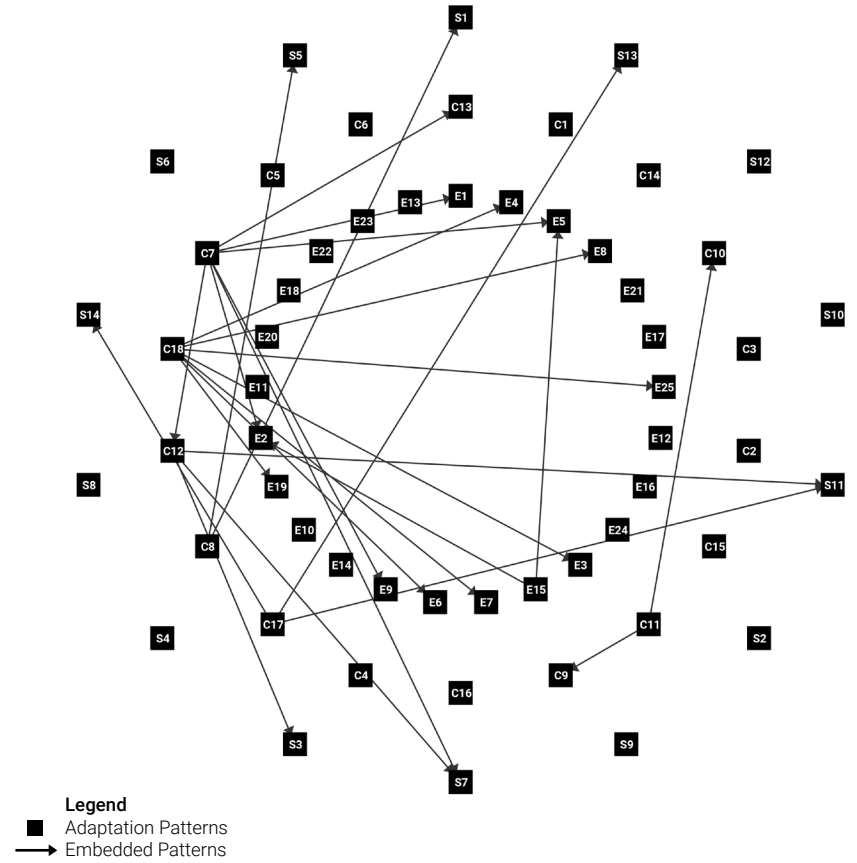


Figure 09. Pattern Field, illustrating Embedded relationships between patterns

Implementation Stakeholders

Clustering adaptation pattern categories to stakeholders, that are responsible to introduce and maintain these designs, demonstrates that adaptation strategies range from resident led bottom-up strategies to municipality regulated top-down transformations. All adaptation groups slanted towards top-down strategies illustrate, that, while residents can provide local changes, these projects require help, supervision and could be strategically reproduced in other similar cases by regulating bodies. Other clusters reveal, that to implement Exposure Reduction patterns, which transforms urban form elements, they rely on private-public partnerships to generate funding, to establish Social Well-being patterns, which maintain the most social collective spaces, requires community involvement, and lastly, Coping Network patterns, that ensures adaptive capacity, mobility and functioning temperature shelters, are dependant on public services. This distribution signals, that pattern implementation requires various stakeholders and their cooperation to achieve urban temperature adaptation.

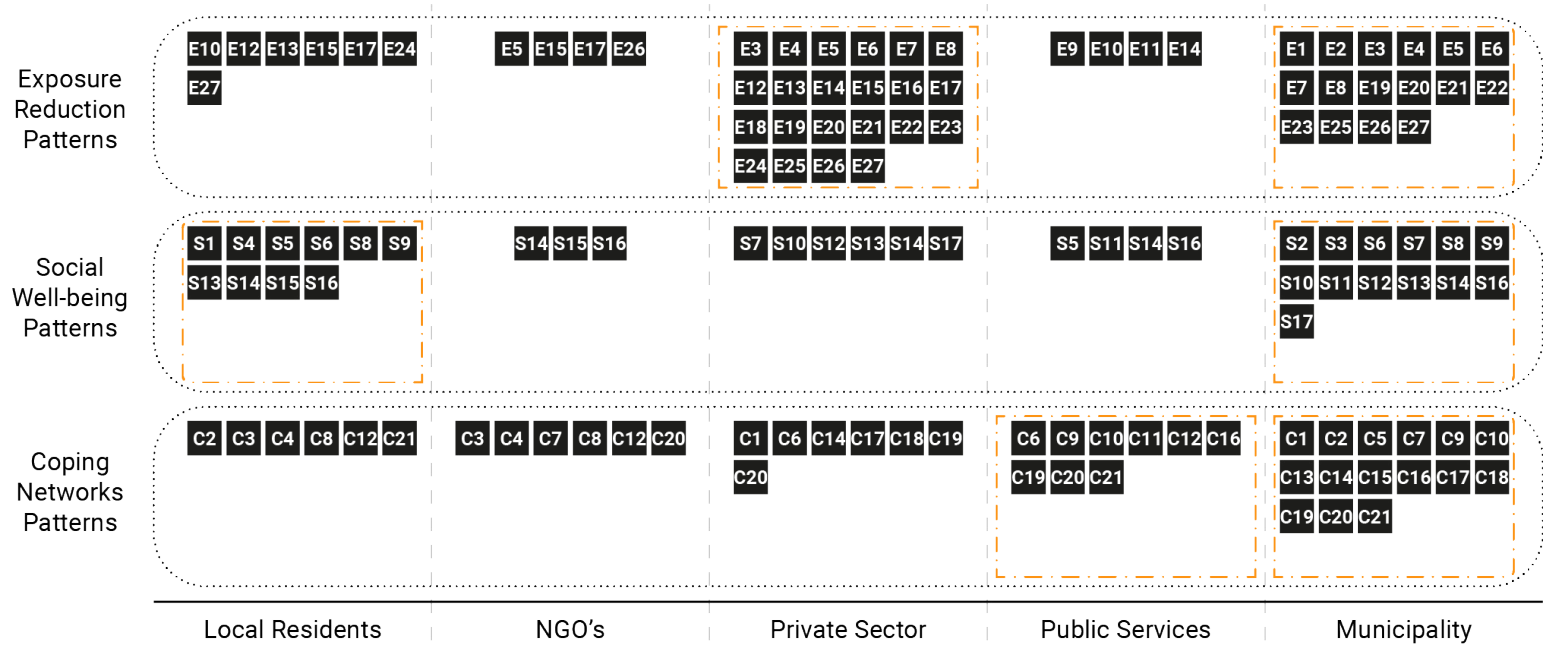


Figure 10. Pattern field, plotting the patterns to their responsible stakeholders

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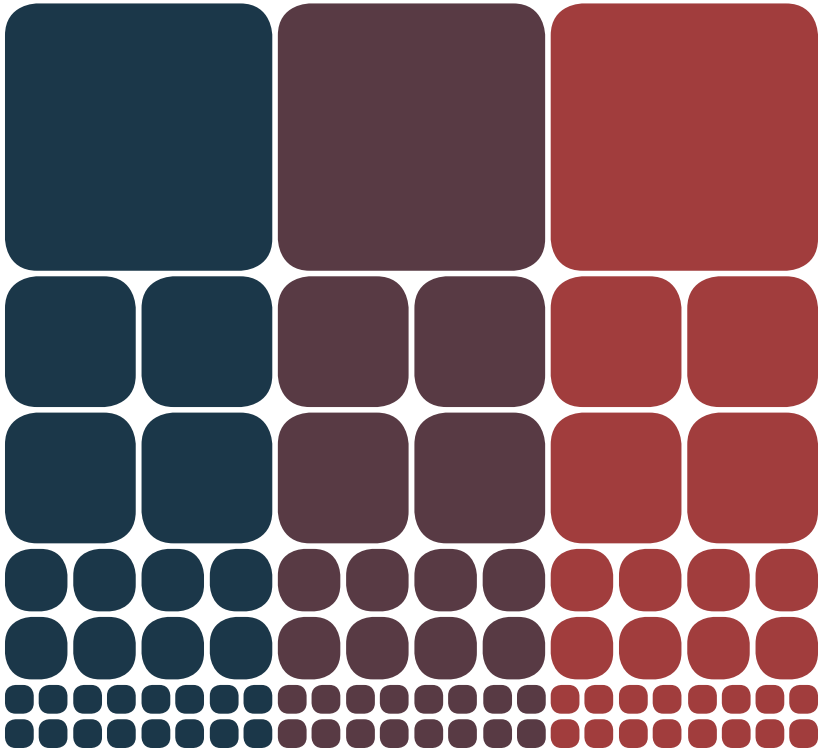
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