

Regenerative Design Strategies

IN THE NORDIC.

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Regenerative Design Strategies

IN THE NORDIC.

The case of Hyvinkää, Finland.

MSc. Thesis

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abstract

Supporting human wellbeing and natural regeneration through architectural and urban design choices should be the key driver in current projects. The regenerative design approach is about guiding architectural practice towards co-evolutionary systems, natural renewal and planetary health, as well as net-positive impacts across layers. This approach moves beyond sustainability. A holistic strategy that actively takes into account aspects of nature and biodiversity, emissions and circularity, society and cultures, co-design and continuous learning, urban context and mobility networks, doing this throughout the project life cycle. The thesis frames the question of how to transform existing buildings and sites into regenerative ecosystems that foster both human health and ecological restoration.

By identifying key indicators, tools, and strategies, the thesis aims to provide a comprehensive framework of regenerative design. This provides the basis for a wide set of impact metrics that can show measurable regenerative value, and thus clarify the benefits of the approach.

The practical application implements a variety of the defined strategies, showing a way of redesigning existing sites into better living environments for all. Set in Hyvinkää, Finland, two school buildings and their site are reused to build a resilient mixed-use living block and flourishing park that promotes local biodiversity. It is based on the initiative led by the city to save and reuse the old schools. The project highlights the potential of the regenerative design approach in reshaping existing urban fabric into thriving, life-enhancing environments. Design grows from the specific cultural and climatic context of Northern Europe. The applications emphasise accessible homes, inclusive social spaces, resilient energy systems, circular material flows, as well as urban nature. Set between restoration, adaptive reuse, and nature-based solutions, the project acknowledges the benefit of these existing practices and emphasises the advantage of systems thinking.

Recognising the limits of the thesis and the project, applied strategies are based on theoretical research and case studies, but the real regenerative impact of the solutions in this specific project is not measured for all key performance indicators, for some, it is estimated. Measuring and monitoring the true regenerative value requires project implementation, and post-construction and post-occupancy evaluation, which in this case was not possible. Nevertheless, the thesis could act as a guiding tool and inspiration for the future.

This thesis is part of a larger research project about regenerative design approach and nature-led design, conducted by prof. Roberta Ingaramo and Arch. PhD Maicol Negrello from Politecnico di Torino, as well as other researchers, practitioners, and students, in collaboration with Henning Larsen and Ramboll. The research and framework established here are to be further developed and expanded in the future.

Keywords: regenerative architecture, systems-thinking, nature-based solutions, adaptive reuse, climate emergency, circularity, net-positive, energy and resource efficiency, human health, wellbeing, ecological restoration, biodiversity, co-existence.

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01.

Introduction

01.1 Why Regenerative

The biodiversity of planet Earth is diminishing at a much faster rate than imaginable. Resources are being exhausted or damaged, very soon to the point of no return. We use faster than nature can regenerate, and our demand keeps growing. Since the beginning of the Anthropocene, the period during which human activity has had a dominant impact on climate and the environment, concerns such as global emissions, ecosystem damage and overreliance on fossil fuel have only kept growing (Chua & Fair, 2023). Global needs, consumption and populations have grown exponentially. From roughly 0.6 billion people in 1700 to 8.1 billion people in 2025 (Roser & Ritchie, 2023). With spikes in population growth came the need for rapid construction of homes, schools, hospitals and other public services. Priority has been, and still is, to provide a roof over people's heads, support human rights and bring social equity, which absolutely is a necessity. A close second priority should be how to do this in a planet-friendly way, so that we, and our descendants, have a healthy and livable planet in the future. More often, the second priority is the cost, or worse, the profit. More energy, more emissions, more waste, more money.

The construction sector alone is responsible for over 35% of waste generation in the EU (European Commission, n.d.). Buildings are responsible for 40% of carbon emissions, 14% of water consumption and 60% of waste production worldwide (Petersdorff, Boermans, & Harnisch, 2006). Easy to point out the difference we have a possibility of making by changing the way we design and build. We are at a critical point where we believe sustainable design practices are enough to combat the current climate emergency. That just mitigating the negative impacts would suffice. Not only do we need to exponentially lower the emissions of the buildings and construction sector, but we also need to reduce waste generation

and stop the depletion of virgin materials. The sector accounts for about 50% of all extracted material (European Commission, n.d.). Importantly, we need to actively find ways to repair the environmental damage we have caused and revitalise essential natural resources. We need to give back to the planet. Knowledge plays a major role in this combat. To educate and share knowledge between professionals: architects, designers, engineers, physicists, anthropologists, ecologists, geologists, etc, between the wider public of developers, decision makers, politicians and the common citizen. Together, explore the ways, implement strategies, enforce and relearn how to be regenerative in the construction and urban planning sector.

Initiatives from e.g. the European Commission to increase material efficiency and reduce climate impact, and promote circularity principles throughout the lifecycle of buildings, need to be adapted to practice fast. Like this, the dominating operating paradigm to face the economic and ecological crisis remains the reduction resource efficiency paradigm (Attia, 2016). Mitigation alone is not enough.

The regenerative design paradigm is based on the approach of co-evolution of living systems, to support natural renewal of nature, materials, and energy (Lyle, 1994), and to actively repair past environmental damage (He & Reith, 2022). The design process is about continuous learning and reflection, as well as compassion and consciousness towards the more-than-human world (Reed, 2007). Nature becomes the strategy that can help reduce climate change impacts on cities, as well as improve people's mental and physical well-being (Inagaramo & Negrello, 2023).

Due to the urgency of the situation, we need to take action in practice and do what we already know to be better, even if theoretical research on regenerative architecture is still in process.

01.2 Basis and Method

This thesis is a part of a larger research work on the regenerative design approach and nature-led design, in process by prof. Roberta Ingaramo and Arch. PhD Maicol Negrello from Politecnico di Torino, as well as other researchers, practitioners, and students, in collaboration with Henning Larsen and Ramboll.

My involvement in this research began at the Beyond Sustainability, International Summer School 2025, led by Ingaramo and Negrello in Turin and Copenhagen. With 12 chosen student colleagues from Politecnico di Torino, we conducted an intensive preliminary study on regenerative design approach. The summer school was an operational path towards regenerative urban design, including lectures, workshops, research, and transdisciplinary collaboration with experts. Through theoretical research and case study analysis, we built the basis for this study approach, exploring what regenerativity means and what could be potential regenerative design principles and strategies. Here, the idea of viewing regenerativity in different interconnected layers was born. This thesis developed this idea and delved deeper into regenerativity, systems thinking, and how to design ecological civilisations. The work produced with my colleagues during this Summer School served as a basis for the theory and has been further adapted and elaborated. All the respective students have been credited where their work was an essential reference.

This thesis follows the method of researching and establishing what is required to think regeneratively. Done through bibliographic research, exploration of scientific studies and articles, official policies and documents, and real-life applications to pinpoint different strategies, methods, and tools on how to design something that does more good than harm, and how to evaluate the

success of a project. Essential for the elaboration of the research work, as well as the design project, has been the tutoring received from my thesis supervisors, Ingaramo and Negrello from Politecnico di Torino, and from my co-supervisor, senior researcher Francesco de Luca from Tallinn Technical University. De Lucas' input was greatly valued for the definition of regenerative metrics and tools.

Following the establishment of the principles, a set of Key Performance Indicators is identified and organised into five layers of regenerativity. For each KPI, the evaluation or measurement tools, threshold, and design strategies or devices are described. These layers and the lists of KPIs aim to act as a guiding tool and inspiration for design projects that aim to approach regenerativity. It is critical to remember the interconnectivity of the layers and KPIs when thinking of them in the context of a project, and understand how some design strategies may benefit multiple regenerative targets, or some could be of disadvantage to another target. This should be an expected and customary thing for architects and designers to understand the benefit balance of decisions.

As an integral aspect of the regenerative design approach, continuous learning and feedback, the KPIs, tools, and strategies established in this thesis are also subjected to change and adaptation. I hope to lay the basis for an extensive work to be continued and further developed in the following years, rather than to conclude the work to be finished. The thesis in itself is and has been a learning process, where aspects, definitions, or solutions have been retaught and adapted as the work has progressed. Ideally, this work sparks new practical research and design possibilities in the future, relating to regenerative design.

After the identification of the KPIs and their strategies, a critical analysis of case studies was conducted. Six projects were chosen based on

their ability to address and support the principles of regenerative design. It is to be noted that none of these projects are necessarily completely regenerative, but rather make use of suitable strategies and solutions. The case studies concern different project typologies in varied contexts and with diverse strategies and design solutions. Some of them are landscape and public space projects, while others are building construction or reuse projects. The aim was to identify possible solutions that could be applied to the design transformation project of this thesis.

The design project consists of the transformation of an existing site and the reuse of two old school buildings standing on it, into a flourishing and resilient mixed-use community block. Located in Hyvinkää, Finland, the project begins with extensive site and context analysis. From here, the concept and main objectives of the project are developed and then worked into design decisions. The project realisation timeline is thought out together with suggested co-design and community engagement tasks. For the project, a set of KPIs is also identified, as per the research, and it is inspected which design solutions support meeting the corresponding regenerative targets or thresholds. The design project is strategy-based rather than a technical construction project. Emphasis lies in the holistic big picture, not the details of small individual solutions. It aims to bridge together the different aspects of regenerative design in the form of a reuse and transformation project.

Before concluding the thesis, a simplified look into the evaluation of the project regenerativity is presented, done with an evaluation radar diagram. With this, the calculated or estimated justification and reasoning for the value of each KPI of the project is presented.

02. Regenerative Design Approach

02.1 Beyond Sustainability

The regenerative design approach for architecture and urban design is still at an initial phase, with little theoretical backing and various interpretations. The concept of regenerative is subject to inconsistent usage in architectural discourse, including the meanings of increased sustainability, ecological restoration or biomimicry. The development of common approaches and quantifiable standards is made more difficult due to this variability. Despite the fact that regenerative thinking is based on sustainability, resilience, and systems theory, its practical applications are primarily derived from ecological design (McDonough & Braungart, 2002), living systems theory (Capra, 1996), and the principles of a circular economy (Ellen MacArthur Foundation, 2013). Other frameworks, like the regenerative design outlined by Lyle (1994) and the nested systems model proposed by Mang and Reed (2007), provide useful conceptual advice but remain nonfunctional.

In addition to the emissions, energy consumption and waste production of the construction sector, buildings increasingly overtake agricultural lands and wetlands or bodies of water, compromising existing wildlife. Energy remains the dominant aspect within the built environment research community, another limited resource being building materials within a building's life cycle. Materials circulate within a near-closed-loop system, contrary to energy and water. Most materials used in the current building construction have extremely long regeneration periods. They have been millions of years in the making, just to be depleted in decades. As much as oil does, water lubricates the building sector, necessary during construction and occupancy (Attia, 2016). We have at hand a large environmental deterioration, thanks to the large carbon footprint, fossil fuel consumption and pollution.

Sustainable design emphasises mitigating the negative effects on the environment and improving design with the idea of doing no harm. To sustain the health of the planet's organisms and systems over time. In architecture and design, we often think only in terms of buildings and technology. This is a step forward from the green design paradigm and two steps forward from conventional practice that focuses on high technical efficiency.

A step forward from sustainability is the restoration paradigm. An approach that aims to restore the capability of local natural systems to a healthy state of self-organisation, through the activities of design and building. Reconciliation, on the other hand, deepens the idea to acknowledge that humans are an integral part of nature and that we are one system. Regenerative design thinking bridges the paradigms together, evolving it into a whole-system thinking approach - place, community, watershed and bioregion. The design aim is to build the capability of people and the more-than-human participants to engage in a co-evolutionary relationship. Natural regeneration of the ecosystem. The benefits of regenerative architecture development cannot be fully measured or understood right at a project's completion, since it takes considerable time for regeneration to occur (Bankhele & Narkhede, 2019). Inherent for regenerative design approach is to develop circular resource infrastructures, design buildings and public spaces with a positive environmental impact while supporting the local biodiversity and communities.

It becomes clear that whole systems thinking is integral to the approach. The idea that the entirety of existence is interconnected, with complex inter-relationships - natural systems, human social systems, and the conscious forces behind their actions. In building design, we are engaged in direct and indirect reciprocal influence in the immediate community and the planetary systems we are a part of (Reed, B., 2006).

What would the planet want?

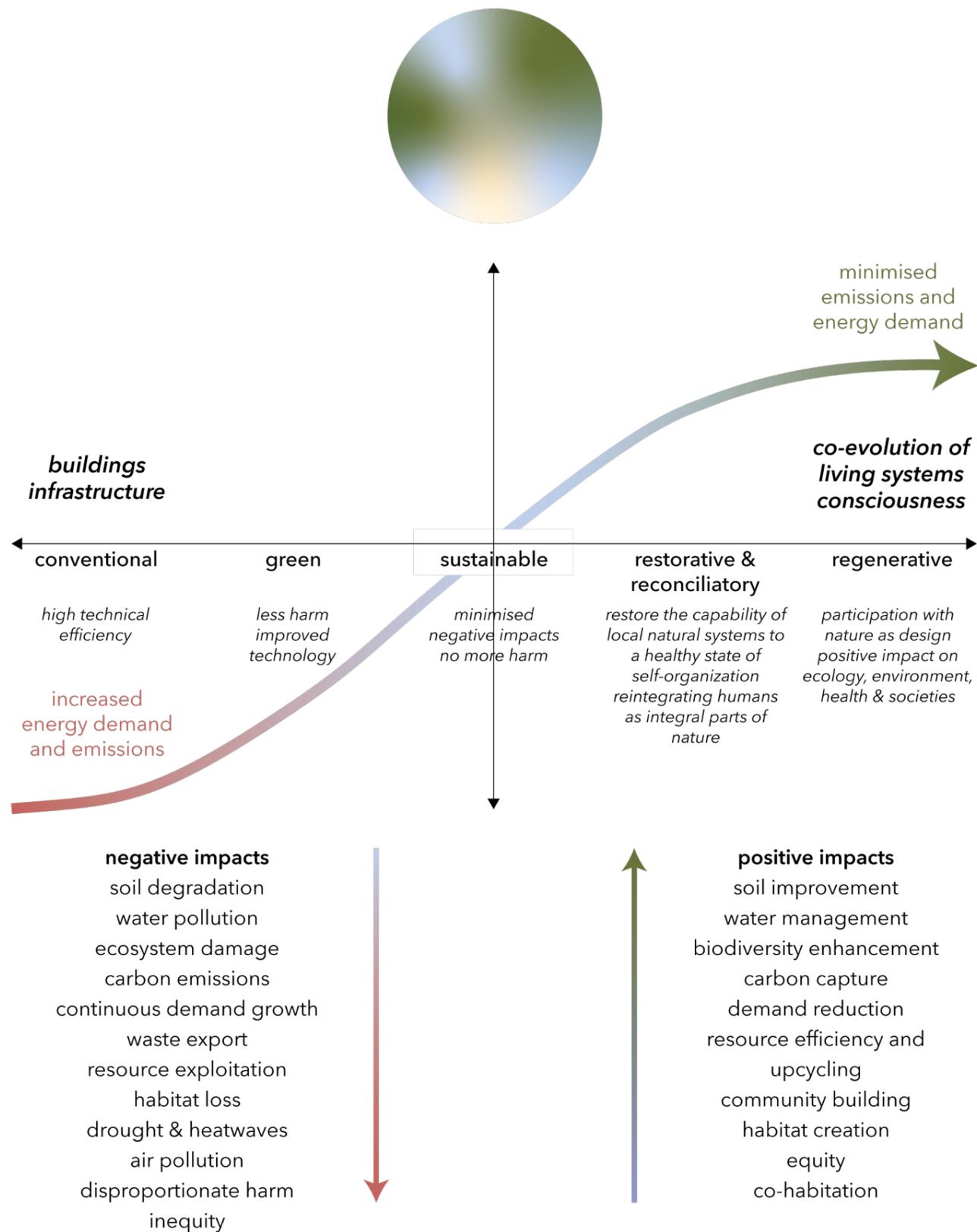


Figure 02.1. Paradigm Shift, (Nahkala, 2026).

02.2 Paradigm Shift

The efficiency paradigm remains the dominating one in sustainable building design. Net-zero energy building and zero carbon building goals seek maximum performance efficiency, with the aim of neutralising resource consumption. Restricting the sustainable goal to net zero limits achieving long-term sustainable building practices in comparison to a net positive goal. This limit could possibly discourage the potential of reaching fossil fuel-independent buildings (Attia, 2016). Moreover, net zero alone is not sufficient to combat the current climate crisis, but we need to aim for net positive buildings together with other sustainable and regenerative building approaches. To seek the highest efficiency in the combined management of resources and the maximum generation of renewable resources. To increase the carrying capacity of the planet by reversing the ecological footprint through positive development. Resource management of a building emphasises the viability of harnessing renewable resources, allowing energy exchange and micro generation within urban boundaries (Attia & De Herde, 2010, 2011). The regenerative paradigm is about integrating natural and human living systems to support and sustain greater health for both.

Regenerative design principles concern the topics of i.a. context, energy, carbon, waste, resources, circularity, biodiversity, ecosystems, sound, light, air, mobility, infrastructure, communities, cultures, politics, justice, economy, people, animals, ... always taking into account the full life cycle of a building or project. This multifaceted approach implies an in-depth knowledge of multiple fields, the involvement of several specialists and adequate tools to develop and frame approaches and solutions. Such tools and proper guidance are needed to support designers in addressing the challenge of regenerative design (Naboni & Havinga, 2019).

Transdisciplinary teams are key to fully meet regenerative design standards. Expert knowledge of the different fields, research, and sharing of information support a successful project. It is crucial to also help the client understand the options and their impacts, positive and negative. To show through data that regenerative measures don't always equate to higher costs. Developing life cycle cost assessments unravels the true cost of implementing regenerative design principles, and it can be done for energy, carbon, water and waste. It is also important to understand how to measure the social, cultural, and ecological impacts and express this through data.

Regenerative thinking redefines what architecture is. Not merely the practice of designing and constructing buildings (Merriam-Webster's Dictionary), but the art of designing living systems. Architecture is the country, the city, the neighbourhood, the site, the building, the systems, the energy, the people, the fauna and flora (Bankhele & Narkhede, 2019; Ramboll, 2024). Regeneration is possible when the architecture we design is producing more than it consumes, net-positive in all areas, all layers. Architecture in this sense needs to enable and support the production of surplus food, clean water and air, more energy than it consumes, give more space for nature, provide a richer diversity for the system, and enhance the cultural and aesthetic appeal of our living spaces.

According to the principles of regenerative thinking, it largely appears that the actually regenerative architecture is the one that already exists, since everything that is built anew damages the planet in some way. Nevertheless, populations are growing, houses are required, and climate change poses new challenges. Someone is going to be building new. Exploring, researching, and practising architecture that aims to give back to the planet and society is the best option, better than thinking it's impossible.

02.3 Regenerative Design Principles

Design as a Living System

Design projects as living systems embedded within larger living systems. A holistic approach, regenerative design thinking aims to actively foster resilience, interdependence, and synergistic benefits across systems. Healthy integration of human wellbeing and the cultural context, while understanding the flows of energy, materials and biodiversity. The well-being of nature and humans is rooted in co-existence and support, where mutual benefit is the goal. Acknowledging ecological value and nature's agency is to benefit humans as well. (Bankhele & Narkhede, 2019; Littman, 2009; Ramboll, 2024; U.S. Green Building Council, 2024; World Green Building Council, 2023).

Urban - and landscape design strategies include blue-green infrastructure networks that connect water, vegetation, and public spaces. Designing districts around resource loops (local energy sharing, water reuse, material exchanges). Enabling mixed-use zoning that supports daily life cycles (living, working, learning, socialising), within walkable distances. Architectural design strategies include designing buildings with interconnected passive systems that self-regulate with climate (daylighting, natural ventilation, thermal mass). Creating multi-functional spaces that can evolve and adapt in use over time. Construction strategies include the use of modular and demountable construction to allow adaptation, repair, and reuse. Selecting materials that participate in biological or technical cycles (compostable bio-materials or fully reusable components). Designing for disassembly and reassembly, avoiding demolition.

Place-Based & Nature-Led Design

The unique ecological, climatic, cultural, and social context of a site and its macro context is where the project should be rooted. Regenerative design works with local ecosystems and natural patterns. The built environment becomes a positive and active participant in its ecological landscape, restoring biodiversity, water cycles, and soil, and supporting wildlife habitat, rather than simply a neutral or harmful occupant. (Armstrong, 2023; Bankhele & Narkhede, 2019; Littman, 2009; Negrello, 2025; Ramboll, 2024; Sayer, 2024; U.S. Green Building Council, 2024; World Green Building Council, 2023).

Urban - and landscape design strategies include restoring natural hydrologies by the use of wetlands, bioswales, and permeable surfaces. Creating ecological corridors that link habitats across sites and neighbourhoods. Preserving and reinterpreting cultural landscapes and indigenous land patterns. Architectural design strategies include orienting buildings to local sun paths, wind patterns, and topography. Incorporating green roofs, living walls, and animal habitat features specific to local species. Be inspired by and make use of regional vernacular and climate logic for building forms. Construction strategies include prioritising locally sourced, bio-based, and culturally significant materials. Using low-impact construction techniques to minimise site disturbance and to protect the existing soil, trees, and waterways during construction.

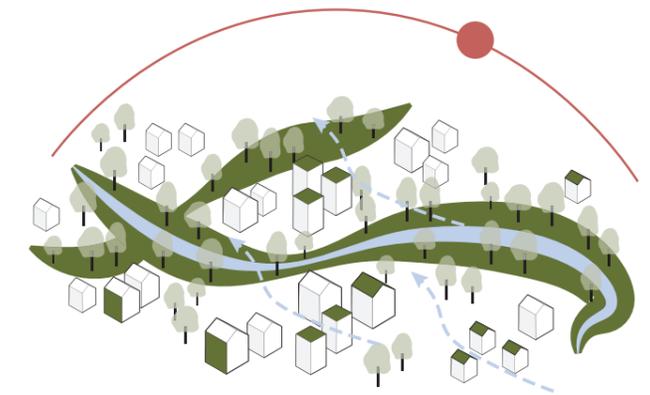
Net-Positive Regeneration

The intention is to produce more ecological, social, and economic value than is consumed or damaged. This includes generating surplus energy and water, supporting nature, and improving human health. A key point in regenerative architecture is to minimise virgin material extraction and waste through circular flows of energy and materials, design with passive strategies, low emission, and energy efficiency principles to reduce consumption, and to integrate renewable energy production for net-positive buildings. (Attia, 2016; Young, 2025; World Green Building Council, 2023).

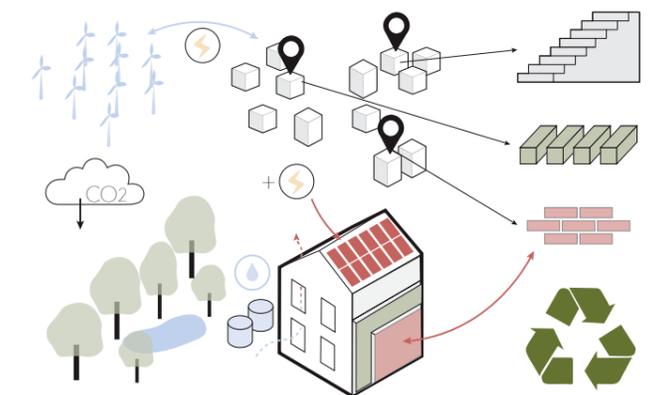
Urban - and landscape design strategies include developing district-scale renewable energy systems. Creating landscapes that sequester carbon and restore ecological health. Designing public spaces that deliver measurable social and economic value. Architectural strategies include net-positive buildings with on-site renewable energy production that exceeds demand. Passive design strategies, and full life cycle thinking and analysis from the beginning of the project through operation. Harvesting, treating and reusing rainwater and greywater on site through nature-based and architectural technological solutions such as basins, green roofs and living walls, roof catchment systems, canopies and shading structures with direct water storage. Construction strategies include carbon-sequestering materials (timber, hempcrete, biochar-enhanced concrete, etc.). Reducing embodied carbon through material efficiency and reuse. Reducing operational carbon through high-performance bio-building materials.



Design as a Living System



Place-Based & Nature-Led Design



Net-Positive Regeneration

Figure 02.2a. Regenerative Principles, (Nahkala, 2026).

Equitable Social Wellbeing & Co-Creation

Regenerative design approach actively supports human wellbeing, equity, cultural vitality, and social resilience. Inclusive community participation, co-creation and feedback are valued. Enable collective agency and shared responsibility to both emotionally and physically strengthen human dignity and relationships, sense of belonging, and long-term social capacity. (Bergquist et al., 2025; Littman, 2009; Ramboll, 2024; U.S. Green Building Council, 2024; World Green Building Council, 2023).

Urban - and landscape design strategies include designing walkable, human-scaled neighbourhoods with active ground floors. Providing equitable access to green space, services, and mobility. Participatory design process to co-create public spaces with communities. Architectural strategies include providing generous daylight, fresh air, and access to nature for everyone. Designing inclusive, accessible, and culturally expressive spaces, co-created public art. Encourage community interaction and mutual care through shared spaces. Construction strategies include ensuring fair labour practices and safe working conditions. Supporting local economies by engaging local craftspeople and contractors. Make use of construction processes as opportunities for learning, skills transfer and training.

Long-Term Resilience & Stewardship

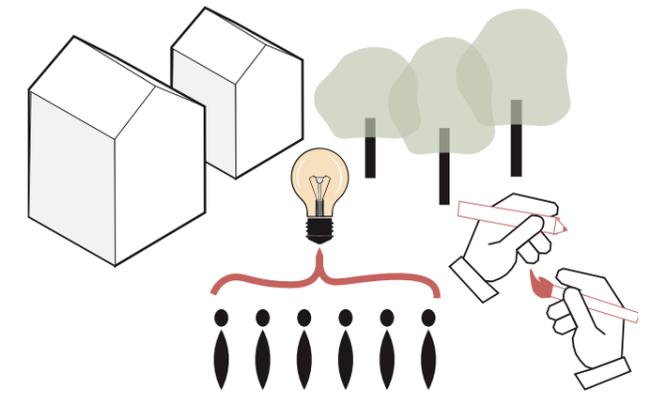
Long-term thinking, designing for uncertainty, climate change, and intergenerational benefit is embraced. The approach prioritises durability, adaptability, and life-cycle thinking, ensuring that projects remain beneficial and responsive beyond implementation. (Armstrong, 2023; Ramboll, 2024; Young, 2025; World Green Building Council, 2023). This includes material and element circularity, building reuse, and designing for disassembly. Regenerative thinking considers impacts over decades, or even centuries, which is particularly relevant for resource regeneration and natural evolution (Sayer, 2024).

Urban - and landscape design strategies include designing floodable parks, shade networks, and climate-buffering landscapes. Preserving land for future ecosystem recovery or changing community needs. Establishing long-term management and stewardship plans. Architectural strategies include designing structures for climate change and extremes (heat, flooding, storms, earthquakes). Allowing for future adaptation: expansion, contraction, or reprogramming. Using durable, repairable systems rather than short-life components. Making use of life cycle analysis and life cycle costing to balance economic cost and longevity. Planning for maintenance when designing is crucial to extending the lifetime of a building. Construction strategies include documenting construction and materials in detail for future caretakers and operators.

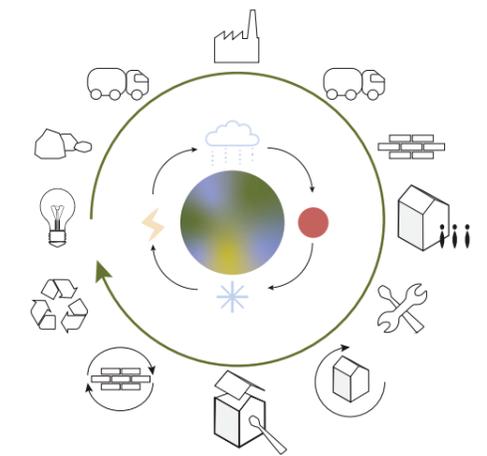
Continuous Learning & Governance

To continuously improve ecological and social outcomes in a changing environment, design teams need to establish feedback loops, monitor real-time performance, and adjust governance, operations or design strategies. Collaborating with the stakeholders to reflect and adapt is essential for sustaining regeneration. (Armstrong, 2023; Ramboll, 2024; Young, 2025).

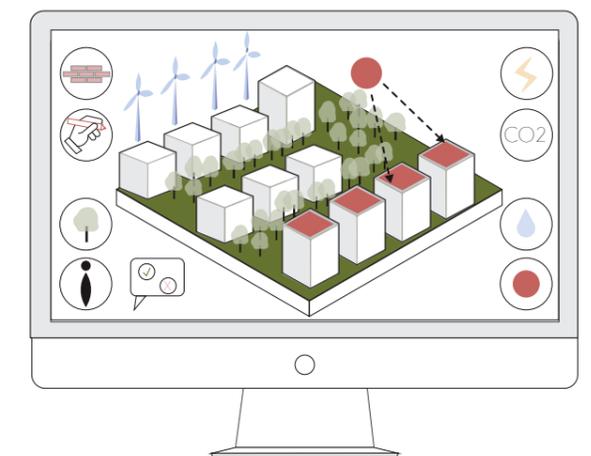
Urban - and landscape design strategies include using smart infrastructures to monitor water, energy, and mobility patterns. For adaptive management of shared assets, establishing governance structures, and piloting regenerative interventions to scale what is successful and effective. Architectural strategies include integrating building performance monitoring systems that are visible to users/occupants. Support experimentation and adaptation through space design. For easy system upgrades and modifications, provide well-thought-out access points. Construction strategies include collecting data on material performance and environmental outcomes, and implementing post-occupancy evaluation protocols. Learning from the mistakes, reflecting on the past, and adjusting construction standards accordingly.



Equitable Social Wellbeing & Co-Creation



Long-Term Resilience & Stewardship



Continuous Learning & Governance

Figure 02.2b. Regenerative Principles, (Nahkala, 2026).

Overlapping & Interconnected Layers

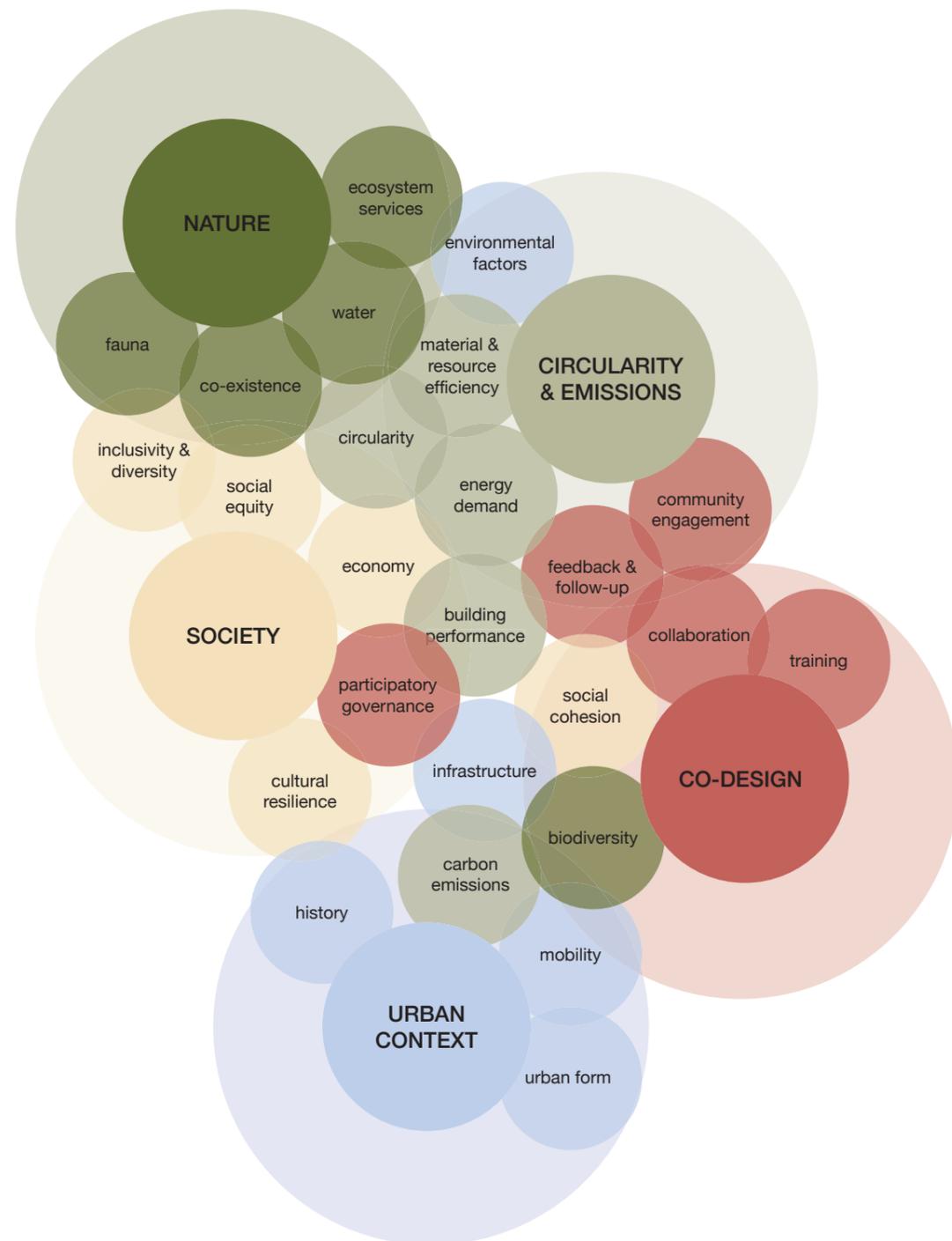


Figure 02.3. Layers of regenerativity, (Nahkala, 2026).

02.4 Layers of Regenerativity

In this thesis, five main layers of regenerativity were identified to guide the research and framework development. This was done through research on regenerative principles. The aim is to help understand the multifaceted principles in an efficient way and work towards a more in depth view of all kinds of regenerative indicators and metrics. Even though here the different aspects have been categorised, I want to emphasise the interconnectedness and overlapping of them. Regenerative design only works as a holistic practice where diverse perspectives are integrated and systematic thinking occurs during all scales and phases of development (Mang & Reed, 2012; Attia, 2017; Dervishaj, 2023). As introduced, this requires multi-disciplinary teamwork among professionals and experts to facilitate comprehensive and integrated design projects.

Nature

The wellbeing of nature and humans is rooted in co-existence and support, where mutual benefit is the goal. Supporting active restoration, healing and enrichment of ecosystems ensures a healthy and viable planet for all, for many lifetimes to come. Main topics concerning the Nature layer are biodiversity, ecosystem services, co-existence, multi-agency, and planetary health.

Circularity and Emissions

Minimising virgin material extraction, water consumption, and waste through circular flows of energy and materials. Designing net-positive systems that reduce emissions, regenerate resources and enhance performance across life cycles. Main topics concerning the Circularity and Emissions layer are energy, carbon, material and resource efficiency, circularity, and building performance.

Society

Ensuring inclusivity and accessibility, promoting societal wellbeing. Impacting the local economy positively and supporting affordable housing. Main topics concerning the Society layer are cohesion, social equity, inclusivity & diversity, economy, and cultural resilience.

Co-Design

Shared values, including the users in the design process, enable collective agency and shared responsibility. Designing for the specific cultural and social context. Main topics concerning the Co-Design layer are participatory governance, community engagement, collaboration (professional), feedback & follow-up, and training.

Urban Context

Shaping places and environments that are comfortable, adaptive, efficient, and safe requires the integration of the physical and sensory systems across all scales. Main topics concerning the Urban Context layer are mobility, infrastructure, urban form, environmental factors (light, sound, temperature, air quality), and history.

03.

Regenerative KPIs and Strategies

03.1 Identification of KPIs

For each regenerativity layer (Nature, Circularity & Emissions, Society, Co-Design, Urban Context (see figure 02.2)), a set of Key Performance Indicators (KPI) was identified and combined into tables (tables 03.1-03.7). The aim is to provide a comprehensive set of tables to guide a regenerative architecture or urban design project. Identifying these KPIs was essential for the research as it enables the translation of broad regenerative goals into measurable, performance-based outcomes. For each KPI, a set of analysis and measurement tools, a proposal of a regenerative threshold, and examples of regenerative strategies are provided. It is proposed that for a design project, a set of 15-30 KPIs (balanced across the layers) is chosen according to the appropriateness for the specific project, typology, and context. These can then be used as guidelines on what strategies and solutions to develop and what the regenerative thresholds are that can be met. In this research, a total of 54 KPIs were identified for the 5 layers combined.

The identification of the KPIs started by researching the theory on regenerative design and analysing case studies to pinpoint the relevant parameters that made the projects successful. Rather than imposing generic sustainability metrics or rating systems such as LEED or BREEM, the focus was to understand where specific KPIs originate and why they could be appropriate for evaluating the regenerative potential of a project. The Living Building Challenge (2025), with its seven "Petals" acted as a great resource for many regenerative design target factors/metrics. De Luca from Tallinn Technical University shared his expertise on metrics for analysing nature and greenery in the urban environment, as well as energy and carbon related metrics.

Investigation began from the pre-project realisation phase, the design brief, material choice,

origin and production, contextual climate, nature, social and infrastructure analysis, everything that happens before construction. The existing conditions of a site, or the existing building or components to be reused. Next, everything related to construction, such as techniques and solutions, material transportation on-site, energy and water consumption, waste production, damage to the existing nature, and emissions. Then the decades of operation, where time is key. A design project needs to withstand time, but also many regenerative outcomes need time to be distinguishable and assessable. Evaluating the ideally positive, social, cultural, economic, and ecological impact. Accessibility, inclusivity, adaptability, feedback, durability, building performance, water and energy cycles, carbon sequestration, biodiversity impact, etc. Finally, it is important to look into end-of-life scenarios, reuse, recycling or disassembly possibilities. Each KPI was selected based on its ability to capture not only current performance but also its contribution to long-term regenerative outcomes.

KPIs for the layer Nature include Biodiversity Impact, Ecological Connectivity and Water Collection. For the layer Circularity & Emissions, identified are KPIs such as Operational Energy, Embodied Carbon, and Reused or Recycled Content. For the Society layer: Diversity of Users, Tenure Security, Safety and Accessibility. For Co-Design layer: Learning Exchange, Co-design with Residents, and Civic participation. For Urban Context layer: Walking Access Time, Proximity to Services, and Environmental Comfort. These are just a few examples, and the comprehensive lists of all identified KPIs follow this chapter.

Multiple KPIs are connected to more than one layer, are interconnected, overlapping; common strategies benefit them. The KPIs were divided into the specific layers for a clearer understanding of the different indicators, and organised under the most appropriate, or primary, layer.

Table 03.1.1
KPIs and regenerative strategies

Adapted from the work led by Maicol Negrello and produced by Renata Rinaldi, Salvatore Tartaglia, and Stefano Teppex, for the Beyond Sustainability - International Summer School, 2025, with Politecnico di Torino, Henning Larsen and Ramboll. ¹(Department for Environment, Food & Rural Affairs, 2025) ²(Juhola, 2018) ³(Green Building Council Finland, 2026) ⁴(Becker, Giseke, & Mohren, 1990) ⁵(Ong, 2003) ⁶(European Commission, 2020; Grime, 2006; van der Maarel & Franklin, 2013) ⁷(Place Petal, LBC, 2025) ⁵(International Living Future Institute, 2024)

NATURE

Indicator	Description	Tool	Regenerative threshold	Regenerative design strategies
Biodiversity Impact	The impacts on biodiversity must be measured throughout the building's lifecycle.	Biodiversity Net Gain (BNG), Ecological Impact Assessment (EclA). Nature Calculator spreadsheet tool (finnish:luontolaskuri).	<ul style="list-style-type: none"> ≥ 10% habitat net gain (ideally 10-20%)¹ ≥ minimum 10/18.5 biodiversity points 	Design for flora and fauna, preserve and support vegetation, especially mature trees and endangered species on-site, native vegetation, stratification, animal habitats.
Green Factor	Planing tool that regulates the amount of greenery required in urban plots and block. It is used to guide stormwater management enhances biodiversity, and climate change adaptation in built environments. Widely used in Finnish cities. ²	Excel based tool to calculate the Green Factor (finnish: Vihkerrointyökalu) ARVO geospatial-based tool (coming in 2026) ³	<ul style="list-style-type: none"> residential areas (detached houses) 1.0 residential areas (dom. blocks of flats) 0.9 areas of services and office 0.8 areas of commerce and commercial 0.7 areas of industry and logistics 0.5 	<ul style="list-style-type: none"> Add and enhance vegetation Green patches and corridors, urban forests Green roofs and living walls Permeable surfaces Nature-based solutions for stormwater management Wildlife habitat features Multi-functional landscaping Quality and diversity is important
Biotope Area Factor (BAF)	Ecologically effective surfaces × ⁴ Ecological value factor per m ² of surface divided by total surface area of lot.	Input data: satellite images and project plans. Calculation of BAF.	site and context dependent ~ 0.6-0.8-1.0 BAF value	
Green Plot Ratio (GPR)	Urban planning tool used to measure the ecological value of a site relative to its total area. Similiar to BAF.	GPR= total green surface ⁵ area (weighted) / total plot area	0.6-0.8 GPR for dense urban plots 0.8-1.0 GPR for moderate- or low-density developments	
Planting Mix	Stratification (vertical layers and diversity of vegetation), share of native species, functional diversity.	Thoughtful site analysis, research of climate conditions and native species for a good planting scheme. Direct site investigations.	<ul style="list-style-type: none"> Canopy trees ≥ 5-10%⁶ Small trees ≥ 10-15% Shrubs ≥ 15-25% Herbaceous plants ≥ 30-40% Grasses & sedges ≥ 10-20% inc. groundcovers, mosses & fungi. 70-90% native species A single species max. 5% of total 	
Ecological Connectivity	Calculation of the Effective Mesh (m _{eff}) to quantify how habitat fragmentation affects animal movement. Higher values indicate larger connected areas with fewer barriers. ⁶	Input data: satellite images and project plans. Calculation: QGIS plug-in or graphab.	<ul style="list-style-type: none"> Fragmentation after project implementation < condition before. Urban blocks/city parks m_{eff} ≥ 0.25-0.35. Regional landscape m_{eff} ≥ 0.4-0.7 Protected/natural areas m_{eff} ≥ 0.7-0.9 	

Table 03.1.2
KPIs and regenerative strategies

Adapted from the work led by Maicol Negrello and produced by Renata Rinaldi, Salvatore Tartaglia, and Stefano Teppex, for the Beyond Sustainability - International Summer School, 2025, with Politecnico di Torino, Henning Larsen and Ramboll.
¹(International Living Future Institute, 2024) ²(WHO guidelines, 2021) ³(Singapore Index CBD, 2021) ⁴(Weisser & Hauck, 2025) ⁵(Gaston et al., 2021) ⁶(Kirk et al., 2023)

NATURE

Indicator	Description	Tool	Regenerative threshold	Regenerative design strategies
Water Collection	Share of the project's demand covered by the water harvested on site.	Water needs vs. collection capacity (liters/year).	Water collected \geq water needed ¹	<p>Reduction of potable water consumption. No water run-off.</p> <p>For on-source management and conveying of stormwater: green roofs and permeable surfaces, ditches, streams, and bioswales.</p> <p>For detention and infiltration: raingardens, ponds, basins and tanks.</p> <p>Restore natural hydrology</p> <p>Reduce peak water flow and total runoff.</p> <p>Improve groundwater recharge, evapotranspiration, and water quality.</p> <p>Perform better than the pre-disturbance condition.</p> <p>Draining pavement, porous material surfaces, green surfaces.</p> <p>Backyard habitats & biomimicry: bat crevices in walls, features for birds, beehives, insect hotels. Co-existence of species.</p> <p>Time-restricted lighting, shielding and directionality, light intensity and color control, dark zones, landscape buffering, monitoring.</p> <p>Avoidance of ecologically sensitive areas (wetlands, prime farmland, habitats). Animal Aided Design.</p>
Water Capture	Rainwater, greywater and blackwater capture and treatment.	On-site treatment system efficiency.	Zero discharge of untreated water ¹	
Stormwater Management	Ability of the site to manage, convey, absorb, and detain stormwater. Measure how effectively a design slows down, absorbs, or redirect stormwater compared to conventional development through the Peak Runoff Rate Reduction Q [%].	Area and capacity of stormwater retentions. Permeable surface ratio. Storm Water Management Model (SWMM), National Stormwater Calculator (SWC), Calculation of Peak Runoff Rate Reduction Q.	Stormwater managed on-site to mimic pre-development hydrology. ¹ 100 % of the water that pours on the site should stay on the site (no run-offs). ² Peak runoff coefficient ≤ 0.25 Peak runoff rate reduction $\geq 60\%$ $Q_{post} \leq Q_{natural}$ or $Q_{post} \leq 40\%$ of current peak runoff	
Permeable Surfaces	Share (%) of the total area of the site that allows water to percolate into the soil.	Satellite images and project plans.	Ratio $\geq 60\%$ ³	
Animal Life Support	Amount of Animal-Aided design features for local species implemented in project. ⁴	Project plans and local species survey. AAD checklists. On-site monitoring and sensor tools.	≥ 2 AAD features for local species in the project.	
Light Pollution	Reduction of light pollution is for the benefit of nocturnal animals and plant cycles. Avoid skyglow, glare and clutter of lights.	Illuminance measurement (lx) with light meter. Lumiance distribution. Night sky brightenss with tools like sky wuality meter (SQM) or datellite data.	$\geq 0.5-1$ lux in critical habitats at night 100% of outdoor lighting fully shielded. ⁵	
Habitat restoration or creation	Area (m ²) of restored/created habitats for animals.	GIS mapping and surveying for site type, habitats and ecological sensitivity.	no development on critical habitats restored/created areas \geq disturbed areas ⁷	

Table 03.2
KPIs and regenerative strategies

Adapted from the work led by Maicol Negrello and produced by Peppiina Pelagia Nahkala, Sabrina De Maio and Aleksandra Zakharova, for the Beyond Sustainability - International Summer School, 2025, with Politecnico di Torino, Henning Larsen and Ramboll.

¹(EU/2024/1275, EPBD)²(International Living Future Institute, 2024) ³(World Green Building Council, 2019) ⁴(EU/2024/1735, NZIA) ⁵(Energy Sustainability Directory,2025) ⁶(Husain, 2025)

CIRCULARITY & EMISSIONS

Indicator	Description	Tool	Regenerative threshold	Regenerative design strategies
Operational Energy	How much energy is used for building operation annually / how much less energy compared to a similar traditional building or a reference system [kWh/m ² /year].	Measured via energy bills or building energy simulation (e.g. EnergyPlus, IDA ICE)	Minimum energy class A, low energy building: total energy consumption doesn't exceed 30 kWh/m ² /year. ¹	Passive design strategies, high efficiency systems and renewables, smart building controls, material and construction choices.
Renewable Energy Share	Percentage [%] of total used energy, operational and embodied.	Energy meter and data. Energy modeling tools.	≥100% of energy from renewable sources. ²	Self-produced, or from the grid. Ideally on an urban scale.
Embodied Carbon	Upfront carbon: materials production, transportation, construction, end of life [kg CO ₂ e/m ² /year].	LCA calculations, material information from manufacturer.	≤ 250 residential buildings ³ ≤ 300 offices ≤ 150 refurbishments	Reused and recycled materials, waste products and natural biomaterials, building renovation passports.
Operational Carbon	Carbon emissions generated from the energy used to operate a building [kg CO ₂ e/m ² /year].	LCA calculations by LCA tools e.g. SimaPro, Carbon Trail or OpenLCA.	≤ 5 kg CO ₂ e/m ² /year as per EU 2030 target ⁴ Goal ~ 0 kg CO ₂ e/m ² /year ³	Passive design strategies, high building performance, quality material choices, and renewable energy.
Carbon Payback Time	Time [years] needed for operational carbon savings to offset embodied carbon, concerning the project. ⁵	Total lifecycle carbon emissions divided by the annual carbon emissions saved.	Regenerativity: when operational carbon savings offset the embodied carbon.	Balance of embodied - and operational carbon, energy source and consumption.
Energy Production (renewable)	Annual energy produced and/or delivered to the grid (MWh or GWh). Installed energy capacity (MW).	Reported values from meters, energy modeling tools (EnergyPlus, PHPP)	Target energy production ≥ Energy consumption. ²	PV panels, waste-to-energy, wind, hydro, biomass.
	MCI measures how circular a material is by assessing the share of recycled or renewable inputs, use efficiency and the reuse or recycling potential at end of life. ⁶	MCI calculation tool. Scale from 0 to 1. 0 = Fully linear 1 = Fully circular	≥60% recycled or renewable inputs ≥80% recyclable at end-of-life, with systems in place	Design for disassembly, durability and reuse. Digital material passport, open-access city material cadastre & exchange platform. Closed-loop supply chains.
Recycled or Reused Contents	Share of total construction materials / components. Important for closing resource loops, reducing embodied carbon, and restoring ecological balance. [%]	LCA tools and EPDs, EC3 calculator, material passport & inventory tools.	≥ 60 %? of construction materials should be from recycled or reused materials/components.	In house reuse, urban deconstruction, local material bank hub for dismantled components, modular and prefabricated systems, material layer separation.
Virgin Material Savings	Estimate of virgin material amount saved by using recycled and reused materials.	Construction documentation, EPDs, comparison to reference building.	≥50 % saved cf. to reference. ≤40% virgin material input in construction.	Use of reused and recycled materials and waste products. Refurbishment and DfD.

Table 03.3.1
KPIs and regenerative strategies

Adapted from the work led by Maicol Negrello and produced by Chiara Negrone, Jiaxin Huang and Ying Shang, for the Beyond Sustainability - International Summer School, 2025, with Politecnico di Torino, Henning Larsen and Ramboll. ¹(Kou et. al., 2018; Zhao et. al., 2023). ²(Zhao et. al., 2023). ³(Kou et. al., 2018). ⁴(UN Habitat, 2020; Hashim, 2021). ⁵(Zhao et. al., 2023). ⁶(Fainstein, 2010; Hashim, 2021). ⁷(CEN EN15251, 2006; BS EN 17037; ISO 7730; International Living Future Institute, 2024).

SOCIETY

Indicator	Description	Tool	Regenerative threshold	Regenerative design strategies
Diversity of Users	Degree of diversity estimated through demographic mapping and field observation.	Video capture, data sheet logs, demographic tags.	≥ 6 different user groups regularly present, e.g. weekly. ¹	Culturally inclusive signage, flexible furniture clusters, diverse activity opportunities and adaptable spaces.
Social Interaction Frequency	Interaction among users estimated through behavioral mapping, or tracking.	Gehl Public Life Tool, time-laps video.	≥ 50% of users in social or co-use settings.	Multi-user installations, games, shared use paths.
Sense of Belonging	Sense of belonging and shared identity of the users estimated through interviews, storytelling, or participatory tools. ²	Miro interactive online board, narrative mapping, cultural probes.	Shared identity themes emerge across ≥ 3 user groups.	Community murals, narrative walls, symbolic references, inclusive signage.
Cultural Representation	Presence of cultural, historical and symbolic elements in the space activating collective memory. ³	Co-design, history and culture analysis, narrative mapping, cultural probes.	Shared identity themes emerge across ≥ 3 user groups.	Community murals, narrative walls, symbolic references, inclusive signage.
Rent-to-Income ratio	Percentage % of average household income required for rent.	Data collection, Housing Affordability Calculator (OECD), Numbeo.	≤20-30% of income spent on rent. ⁴	Mixed-income housing, rent caps, social housing provision.
Residual Disposable Income	Can users afford basic essentials after housing costs.: (Income, rent, transport, utilities) ≥ basic needs.	Data collection, Household Budget Tools, MIT Living Wage Calculator.	≥ 20% of income left after essentials. ⁵	Subsidized utilities. Free health care and education.
Tenure Security	Percentage % of homes with ≥5 year leases.	CLT Toolkits (Grounded Solutions, Urban Institute).	≥ 30% of housing is non-speculative, (collaborative housing, non-market housing).	Enable land trusts, leaseholds, non-market models.
Diversity of Housing	Guaranteeing diverse housing typologies in terms of size, tenure, and price: studios, family units, accesible units, co-living...	Housing Data Explorer, Urban Footprint, Typology Matrix Tools.	≥ 4 housing typologies ⁶ Allow zoning for adaptivity and alternative models, eg. co-living.	Ensure adaptivity and alternative models in future through zoning. Co-living, Accessory Dwelling Units (ADUs).
Indoor Comfort	Indoor air quality, temperature, and acoustic comfort, together with daylight intake. Both real and perceived comfort.	CO ₂ , VOC, & PM measurements. Temperature and noise level (dB) measurements. Daylight Factor (%). Occupant satisfaction survey.	CO ₂ ≤ 800ppm ⁷ DF 2-5% depending on space use Noise ≤ 55 - 60 dB (A) Indoor air temperature ~12-24C° ≥ 70% report positive perception -0.5 ≤ PMV ≤ 0.5 ; PPD ≥10%.	Passive design strategies, cross-ventilation, insulation, appropriate activity allocation, non-toxic building materials, sunrooms and atriums, shading systems, site conditions, orientation analysis.

Table 03.3.2
KPIs and regenerative strategies

Adapted from the work led by Maicol Negrello and produced by Chiara Negrone, Jiaxin Huang and Ying Shang, for the Beyond Sustainability - International Summer School, 2025, with Politecnico di Torino, Henning Larsen and Ramboll.

¹ (Hashim, 2021) ² (Hemphill et. al., 2004) ³ (Commission for Architecture and the Built Environment, 2001; Pedro et al., 2021) ⁴ (UN Convention on the Rights of Persons with Disabilities) ⁵ (Al-Masawi, 2017).

SOCIETY

Indicator	Description	Tool	Regenerative threshold	Regenerative design strategies
Feeling of Safety	Percentage % population who feel safe	Surveys, perception questionnaires, KoboToolbox, Google Forms.	≥ 80% of surveyed users feel safe.	Safe pedestrian edges and zones, open plazas, passive surveillance zones, appropriate lighting and good visibility.
Perception of Night-Time Safety	Percentage % population who perceive the space safe during dark hours.	Questionnaires, on-site sessions, lighting plan and analysis of light reach.	≥ 80% of surveyed users perceive the space safe.	Appropriate lighting, good facial recognition, motion activated lights, perimeter luminaires, warm light (lower CCT).
Visibility	Visibility and openness of the space aid people to feel more safe. Blind corners are to be avoided	Site inspection, CPTED visual audit ¹ , sketch overlay, plan markups.	≥ 2 visible exit paths from all points in the space.	Visual connection between zones. Avoid long, narrow, closed hallways or paths. Outdoors: Low shrubs and tall trees.
Lighting Coverage	Percentage % of well lit public spaces.	Site inspection and lighting plans.	≥ 80% lighting coverage, well-lit public spaces. ²	Good facial recognition, good ground surface visibility and path identification.
Economic Impact	How the project supports and strengthens local and regional economy: jobs, income. Long term financial performance. Balance between economy, social, and environmental benefits. ³	E.g.: Economic Impact Analysis (EIA). Life Cycle Costing (LCC) for building level analysis. Cost Benefit analysis (CBA).	≥ 60-70% local spending ≥ 50% employment share ≥ 1.8-2. benefit cost ratio Threshold should be calibrated to local context and market conditions.	Mixed-use buildings and neighbourhoods. Flexible ground floors. Strengthening existing commercial streets. Partnerships with local education programs. Adaptability and durability.
Social Spaces	Number and typology of spaces designed for multi-age and multi-income use. Focus groups to understand functionality, sense of belonging, and safety.	Data collection, Space Syntax (by UCL). Interviews, narrative mapping.	≥ 3-6 social space nodes / hectare of project area. ≥ 90% of residents use the social & public spaces.	Social edge activation, rotational programming platforms, rewilded social microparks.
Accessibility	Physical barrier free design. Percentage % of routes/entries compliant with local accessibility law. % of site that is accessible.	NACTO Audit Tool, AARP Walkability, ISO 21542, UN-CRPD ⁴ .	100% of key routes accessible. ≥ 80% of site accessible. ⁵ ≥ 2 accessible living units in a apartment building.	Retrofit sidewalks, tactile surfaces, auditory signals, accessible apartments and indoor public spaces, ramps & lifts.
Green Access	Access to green infrastructure. Percentage % of population/residents withing <300m from nature.	Green Equity mapping, WHO indicators, municipal data.	≥95% of residents within 300m from nature: ≥1 publicly accessible green space of ≥ 0.5 ha, within 300m of every dwelling.	Linear parks and green networks, green roofs and terraces, modular eco islands, pocket parks, rain gardens and bioswales, garden cities, tree lined roads.

Table 03.4
KPIs and regenerative strategies

Adapted from the work led by Maicol Negrello and produced by Chiara Negrone, Jiaxin Huang and Ying Shang, for the Beyond Sustainability - International Summer School, 2025, with Politecnico di Torino, Henning Larsen and Ramboll.

¹(Arnstein, 1969; Manzini, 2015; UN-Habitat, 2020). ² (Meadows, 2008; Mang & Reed, 2012; Hes & du Plessis, 2015)

³ (Mang & Reed, 2012; Hes & du Plessis, 2015)

CO-DESIGN

Indicator	Description	Tool	Regenerative threshold	Regenerative design strategies
Co-Design with Residents	Percentage % of residents involved in the co-design activities.	Maptionnaire, Participatory GID, Design Charettes. ¹	≥ 15-25% of residents engaged in ≥ 3 participatory moments.	Mobile urban labs, design boxes, co-design signage, landmarks and public art.
Decision Making Power	Depth of influence the community had in planning and design decisions.	Post project implementation survey.	≥ 50% of ideas/insights realised or critiques objected	Co-design sessions documentation.
Learning Exchange	Number of community-led sessions.	Event tracking, surveys.	≥ 6 co-learning sessions / year	Open learning pavilions, temporary classrooms in public space. Modular knowledge kiosks (e.g. Urban Thinkscope). Mobile co-learning units (e.g. Library buses).
Empowerment Through Skill	New skills acquired by users.	Pre/post surveys, testimonials.	≥ 60% report new knowledge or skills.	Makerspaces in neighbourhoods, public art, co-design labs, skill-building workshop, community repair cafes.
Reflexivity & Awareness	Collect narratives of mobility empowerment.	Interviews, visual diaries.	≥ 75% demonstrate awareness of spatial or social challenges.	Participatory urban dashboards, story walls, AR/VR empowerment experiences, mapping games. (e.g. CityScope by MIT)
Civic Participation Events	Number, diversity, and consistency of public events, and engagement tracking.	Decidim, Co-Urbanize, MIT Civid Design Toolkit.	≥ 5 events/year with ≥ 15% population covering ≥ 3 different target groups.	Civic Agora Modules, interactive urban furniture, temporary urban gardens.
Feedback	Continuous learning and co-design of a project.	Feedback loops, participatory platforms, real-time, prototypes and pilots. ²	≥2 feedback sessions during design phase + during occupancy	Include feedback and co-design sessions into project schedule, demonstrate deeper learning in time, translate data.
Monitoring	Analysing and understanding how the project is performing across layers and is it achieving positive impacts.	Living systems mapping, scorecards/dashboards, performance monitoring. ³	Regular, automatic monitoring throughout building/project life cycle.	Co-create indicators with users, monitor relationships and patterns, learning.
Involvement of Local Associations	Number of local associations actively involved.	Stakeholder Power Mapping, Institutional Layering Analysis, Partnership Tracker.	≥ 3 active collaborations with local associations in recurring roles (not only consultation).	Urban collaboration, pacts, micro-associative hubs, living neighbourhood archive.

Table 03.5.1
KPIs and regenerative strategies

Adapted from the work led by Maicol Negrello and produced by Chiara Bossú, Seyedsaman Ghaffarifor, Sreelakshmi Gopinath and Zahra R. Khosroabadi for the Beyond Sustainability - International Summer School, 2025, with Politecnico di Torino, Henning Larsen and Ramboll.

¹ (Moreno et al., 2021; Khavarian-Garmsir, Sharifi, & Sadeghi, 2023)

URBAN CONTEXT

Indicator	Description	Tool	Regenerative threshold	Regenerative design strategies	
Walking Access Time	Average time in minutes needed to walk to essential services, public transportation stops, and soft mobility hubs,	Mapping, Google Maps, GIS, municipal data on services.	≤ 5-7 minutes walking to essential services and public transportation stops.	5/10/15 minute city model, mixed-use infill development, pedestrian and soft mobility city planning, mobile services. ¹	
Proximity to Services	Percentage % of residents within 5-10 min. from public transport stops and services, shops, schools, and other essential services.	GIS, GTFS data, Public Transport Accessibility Level (PTAL), Walk Audit.	≥ 90% of residents within 5-7min walk of ≥3 essential services.		
Transport Travel Time	Average time in minutes needed to reach essential and special services by public transport, bicycle, e-bike, or e-scooter.	Mapping, Google Maps, GIS, municipal data	≤ 20 minutes by bicycle or public transportation to reach services, schools, workplaces, hobbies, etc.		Rapid intermodal hubs (bicycle, public transportation). Well connected networks. Real-time displays of modal times.
Contextual Permeability	Contextually integrated mobility system. Takes account the degree of transversal accessibility: physical, ecological, and visual.	Mapping, data survey. Calculating the % of permeability weighted by context.	≥ 70% permeability (physical, ecological, and visual combined), of area/city.		Permeable road materials, vertical & horizontal permeability path, free ground floor for public spaces.
System Connectivity	How well a mobility infrastructure or network is connected to other systems, larger networks.	Number of interconnected nodes, degrees of access, and topological connectivity * %	≥ 70% system connectivity score of area/city.		Functional devices to ensure fast, clear, and accessible connections (interactive maps etc.). Rapid intermodal hubs.
Functional Ecosystem Integration	Ability of an infrastructure to integrate different functions. Number of integrated functions + ecological/functional quality per m or m ² , compared to a percentage scale .	Mapping, GIS, calculating, municipal data, site survey.	≥ 70% functional ecosystem integration score of area/city.		Multi-function design, multi-functional transport hubs, integrative infrastructure lines (energy, water collection, shading, biodiversity)
Bicycle Network	Coverage of safe, connected, bicycle lanes in the area or starting from the project site, in km.	Mapping, GIS, data survey.	≥ 15km of connected bicycle lanes.		Design for soft mobility, reorganise road hierarchy to include bicycle and pedestrian paths, a connected network.

Table 03.5.2
KPIs and regenerative strategies

Adapted from the work produced by Chiara Bossú, Seyedsaman Ghaffarifar, Sreelakshmi Gopinath and Zahra R. Khosroabadi for the Beyond Sustainability - International Summer School, 2025, with Politecnico di Torino, Henning Larsen and Ramboll.

¹(European Union, 2008)
²(World Green Building Council, n.d.)
³(Francis & Barber, 2013)

URBAN CONTEXT

Indicator	Description	Tool	Regenerative threshold	Regenerative design strategies
Air Quality	Air quality is analysed through measurement of the concentration of pollutants. Poor air quality is a danger for the human health, and for the wellbeing of nature.	Direct air pollution monitoring, PM2.5/10 sensor data. Air quality monitoring like Airly.	$PM_{2.5} \leq 15 \mu g/m^3/year$ $PM_{10} \leq 35 \mu g/m^3/year$ $NO_2 \leq 35 \mu g/m^3/year$ $SO_2 \leq 120 \mu g/m^3/24h$ $CO \leq 8 mg/m^3/8 h$ ¹	Green infrastructure, shift to clean renewable energy, clean and soft mobility networks, waste management, recycling and reuse, reduced GHG emissions, stricter industrial standards, green building codes. ²
Noise Pollution	Noise levels and acoustic comfort.	Direct noise measurement. CadnaA or SoundPLAN.	Noise $\leq 55 - 60 dB (A)$ ³	Sound barriers. Slow mobility infrastructure.
Air Temperature	How hot or cold the air temperature is.	Thermal mapping, direct measurement, data.	$< 32C^\circ$ in $\geq 80\%$ of relevant zones.	Shade by vegetation and technical solutions. Reduced density, light colours.
Perceived Environmental Comfort	Perception of environmental comfort in outdoor spaces, based on air, temperature, noise, and access to nature. Includes subjective wellbeing related to outdoor conditions.	Surveys, structured perception interviews, walking interviews, co-assessment cards.	$\geq 70\%$ report positive perception across comfort parameters. $-0.5 \leq PMV \leq 0.5$; $PPD \geq 10\%$.	Shade by nature or technological devices, urban nature for improved air quality and temperature, seating, microclimate adaptation, appropriate allocation of activities, passive design strategies.
Urban Heat Island (UHI)	Calculation of the temperature reduction provided by the project compared to the immediate surroundings [C°]. Avoid UHI, (when cities become significantly warmer than surrounding rural areas).	Direct temperature monitoring + Remote sensing data. UMEP.	Temperature reduction $\geq 2 C^\circ$ ⁶ City center temperature $\leq 2 C^\circ$ more than surrounding rural areas.	Tree canopies and maximised urban vegetation. Reduced building density. Shading systems, fountains, pergolas, light coloured materials.

04.

Case Studies

04.1 Desire to Design Better

An analysis of case studies was conducted to study and explore real-life applications of regenerative strategies, mediums, and devices. To learn how to design better public and living spaces in practice. The chosen case studies are located in Europe, mostly concentrated in the northern part, to aid with the targeted approach of this thesis to identify and apply regenerative design strategies in the Nordic context. Six diverse projects were analysed, and for each project, their most critical and successful regenerative 'mediums' and KPIs (chapter 03) were identified. The idea is to identify possible regenerative design strategies and solutions to apply to the design transformation project of this thesis.

For each case study a set of 'mediums' was identified and selected. In this context the notion of medium covers a multiplicity of concepts: design strategies, solutions, methods, values, applications, both tangible and intangible. Different aspects that aid to meet regenerative principles. Each medium was then connected to a regenerative KPI (or KPIs), that it supports, and then further connected to the six principles of regenerative design approach (chapter 02.3). None of the analysed projects cover all the layers or principles of regenerative design.

It was important that all the different layers of regenerativity (Nature, Circularity & Emissions, Society, Co-Design, & Urban Context, see chapter 02.4) were covered by the chosen case studies to provide a comprehensive analysis. The case studies include landscape and public space projects such as the Grønningen-Bispeparken and the Opera Park in Copenhagen, Denmark, which highlight the importance of nature-based solutions to address challenges of climate change and the power of green social spaces for the communities. Circular building design projects,

such as Resource Rows and Thoravej 29 in Denmark, tackle how to reduce CO2 emissions and resource consumption in the construction sector. Innovative residential buildings that take inspiration from traditional construction methods using passive design strategies and efficient, local, and sustainable material choices, tackling both embodied and operational carbon and energy, such as the Helsinki Bricklayer in Finland and Cork House in Eton, England.

I do not claim that the chosen case studies are completely regenerative projects, as the analysis also suggests otherwise, but rather want to highlight the effort the designers have made to shift from sustainability towards regenerativity. The keyword here is towards, the case studies, the applied strategies and solutions, aid architectural practice towards a regenerative future. It is also important to point out the fundamental shift in mindset. How these designers have approached their projects is not standard architectural practice around the world, but includes a wider lens, systems thinking, and a desire to design something of value for the communities and the planet.

04.2 Grønningen-Bispeparken 2024, Denmark, SLA

Grønningen-Bispeparken transforms a 20,000m² underused and neglected grass area into a lush, playful, biodiverse and art-filled climate park for all life. It is a paradigm shift in urban development, where the SLA designers wanted the form to follow nature and the aim was to give space for all life: humans, flora and fauna. The park secures the 1950s social housing estate's outdoor area against thunderstorms and flooding while adding social, natural and cultural values to the neighbourhood and its residents.

With the idea 'form follows nature', 18 bioswales were designed throughout the sloping green areas, that can collect, store and infiltrate more than 3,000m³ of rainwater. Five main 'swale' typologies define the park giving nature-rich and playful places for the community: 1. Wet Bio Oases give priority to nature and wildlife, 2. Between the trunks small and dry biotopes give room for play and relaxation, 3. Common Lawns are designed for sports, farmer's markets, community dinners and events, 4. Pocket Squares are small spots for informal resting and gathering, and 5. The Bunker Hills transform the old park's

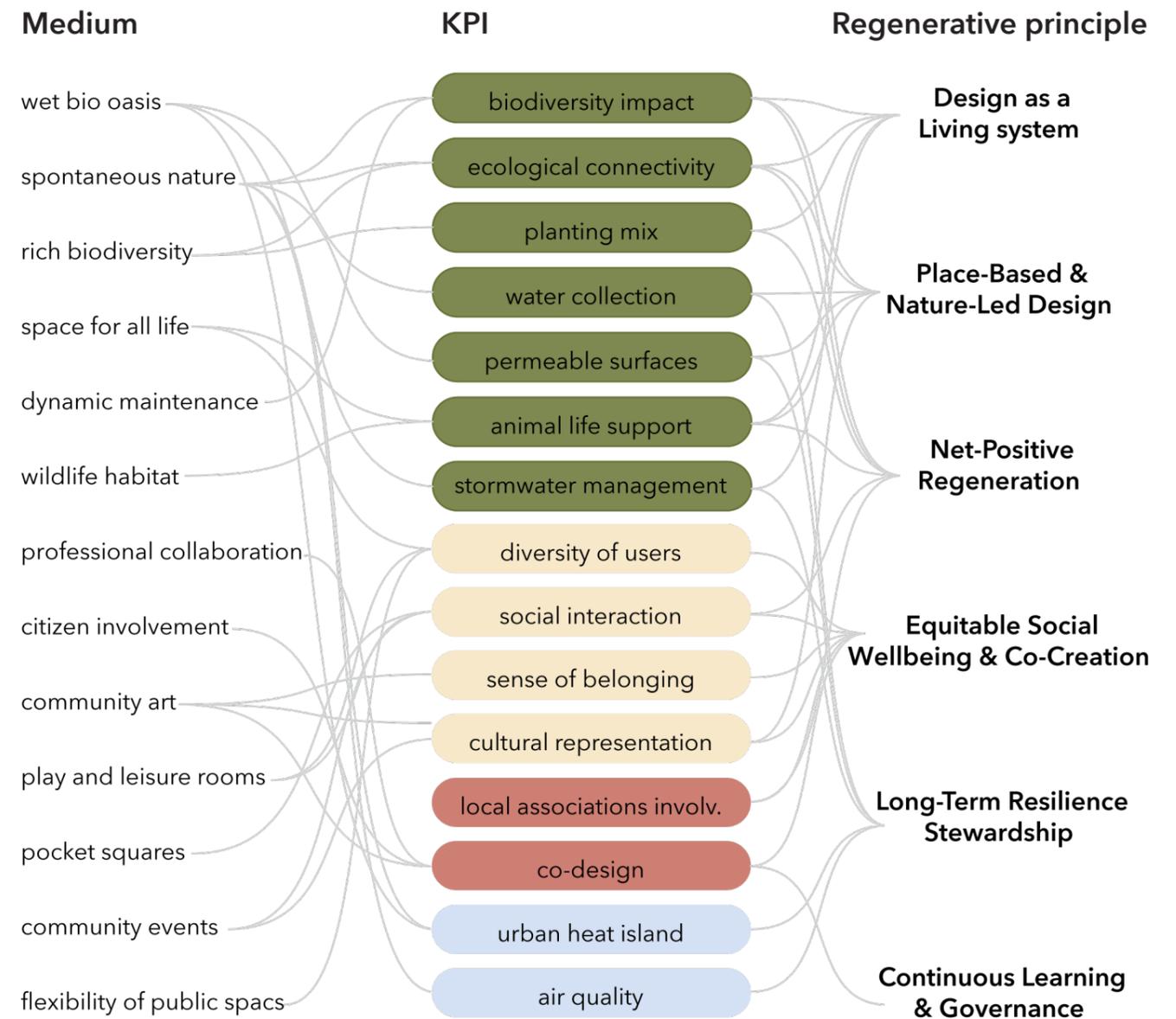
Cold War underground bunkers into flexible social places, to admire the sunset or sled in the winter.

A meandering yellow tile and gravel path joins the different areas and typologies. The path follows nature, weaving around the park with varying widths and permeable surfaces. Sometimes the path disappears into nature, recognisable only by bordering small light bollards or peaking from in between the grass.

Adding 149 trees of 23 different species, and more than 4 million planting seeds of specially crafted seed mixtures, the park enhances and supports local biodiversity. Balancing between 'wild' and 'orderly', the dynamic maintenance plan creates optimal biological and social living conditions for plants, wildlife and humans. Citizen involvement was an important part of the park's design process. SLA's team of anthropologists and sociologists collaborated with the area's residents and local artists to ensure that the parks is relevance and meaningfulness for all.



© SLA



© SLA / Marie Damsgaard

04.3 Opera Park 2023, Denmark, COBE

The Opera Park is a 21,500 m² urban green space next to the Royal Danish Opera in Copenhagen. As a year-round public attraction, the park offers places for relaxation, contemplation, and escape from urban density. It is intended as a “green oasis” tying nature to historic romantic garden traditions but addressing current urban challenges like biodiversity loss and water management.

The park consists of six different themed gardens representing the vegetation of different geological locations: the North American Forest, the Danish Oak Forest, the Nordic Forest, the Oriental Garden, the English Garden, and the Subtropical Garden housed within a greenhouse and atrium at its center. There is in total 223 different plant species, exotic and local. With more than 600 trees, 80 000 herbaceous perennials and bushes, and 40 000 bulb plants, the park is rich in biodiversity. The planting is intended to change with seasons in color, scent, and density, offering urban wildlife habitat for birds and insects.

Spring unfolds vibrant colours, summer brings layers of green, autumn foliage showcases yellows and reds, while winter by evergreen pines and frozen ponds.

Amenities such as the greenhouse café, underground parking, and a landscaped bridge, attract visitors and support the events of the Royal Danish Opera.

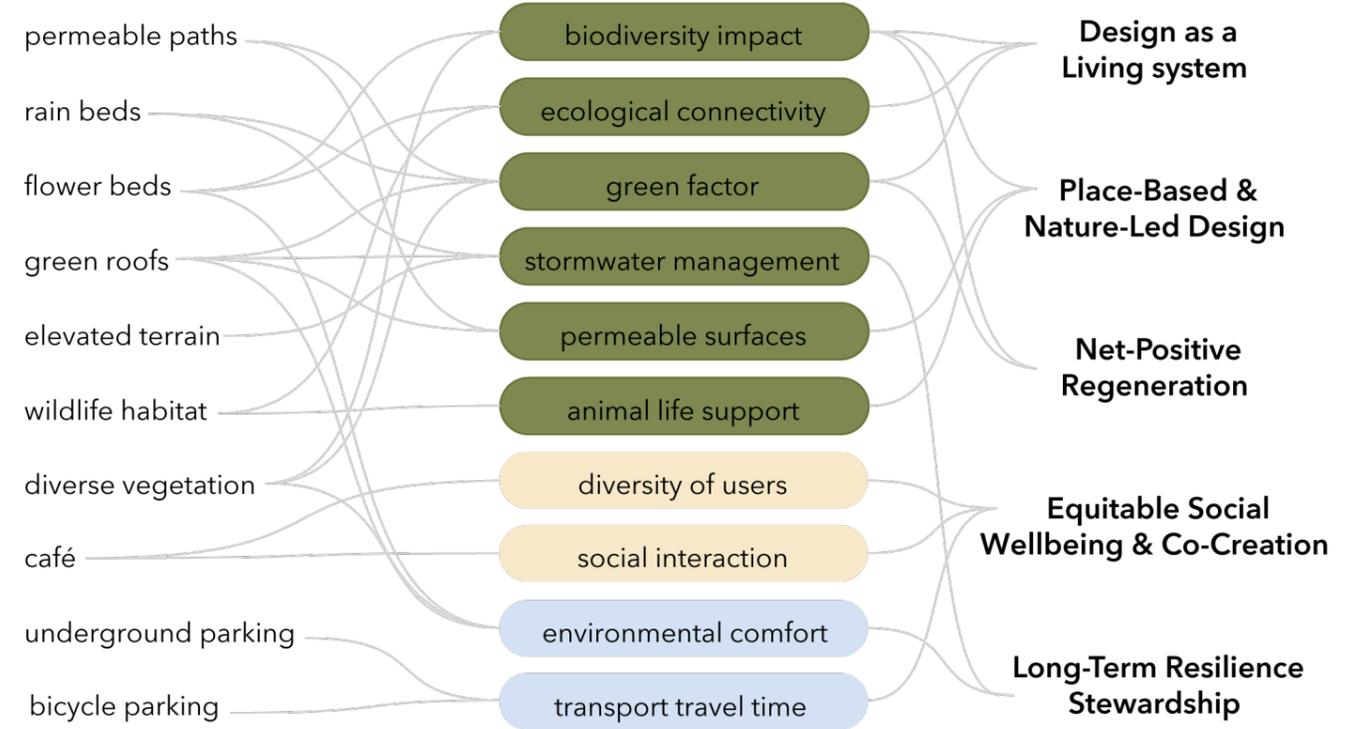
Designed especially with rainwater management in mind, the park captures roof runoff, uses permeable paths and rain beds. Additionally it features green roofs and elevated terrain for flood-protection.

This diverse garden offers unexpected features, hidden amid its meandering paths and organically shaped flower beds. The visitor can find in a water lily pond, a fountain, a reflecting pool, and hidden stone paths running across the little hills amongst the nature.

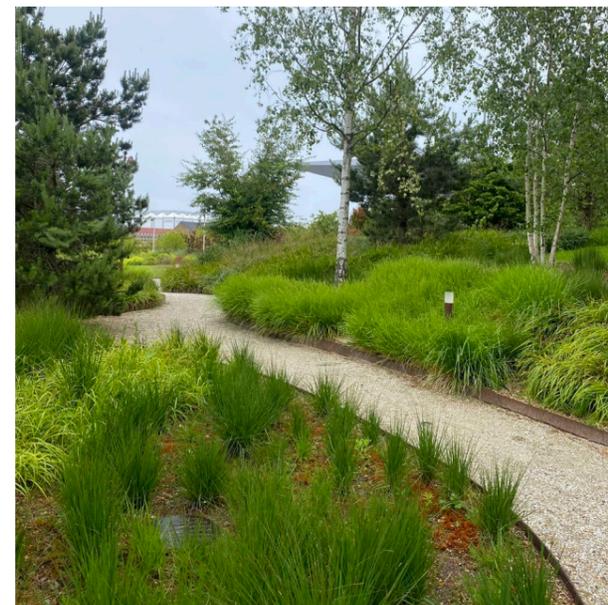
Medium

KPI

Regenerative principle



© COBE



© Peppiina Pelagia Nahkala

04.4
Thoravej 29
2025, Denmark, Pihlmann

Self-recycling withing the building is the central concept of the transformation of a 1960s factory building in Copenhagen into a open community hub. All structural elements and layers are seen as assets for the transformation, useful for the adaptive reuse of the building, even those that might traditionally be seen insignificant. Existing material is retained as much as possible and repurposed to meet programmatic needs. The original industrial structure is retained almost fully (95% of it), including the concrete slabs, steel beams, facade bricks, doors, and ventilation pipes.

Building’s material articulation and spatial configurations are a keypoint of the reuse logic. Some elements remain as is, while others have been transformed by shredding, compressing, repositioning or resurfacing. For example, the old TT-deck ceiling was cut and lowered to become a staircas, opening up the space for more natural light and reusing the existing concrete elements in a innovative way. Extra facade bricks were reused as flooring, while some doors were shredded and recast into tabletops.

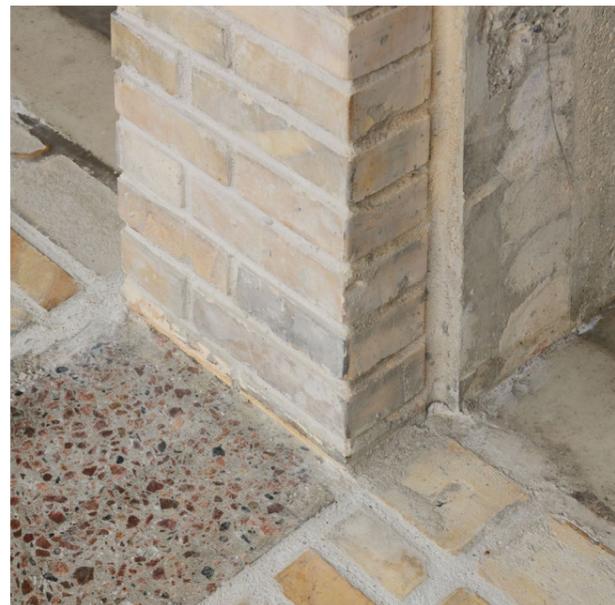


© Mathias Eis

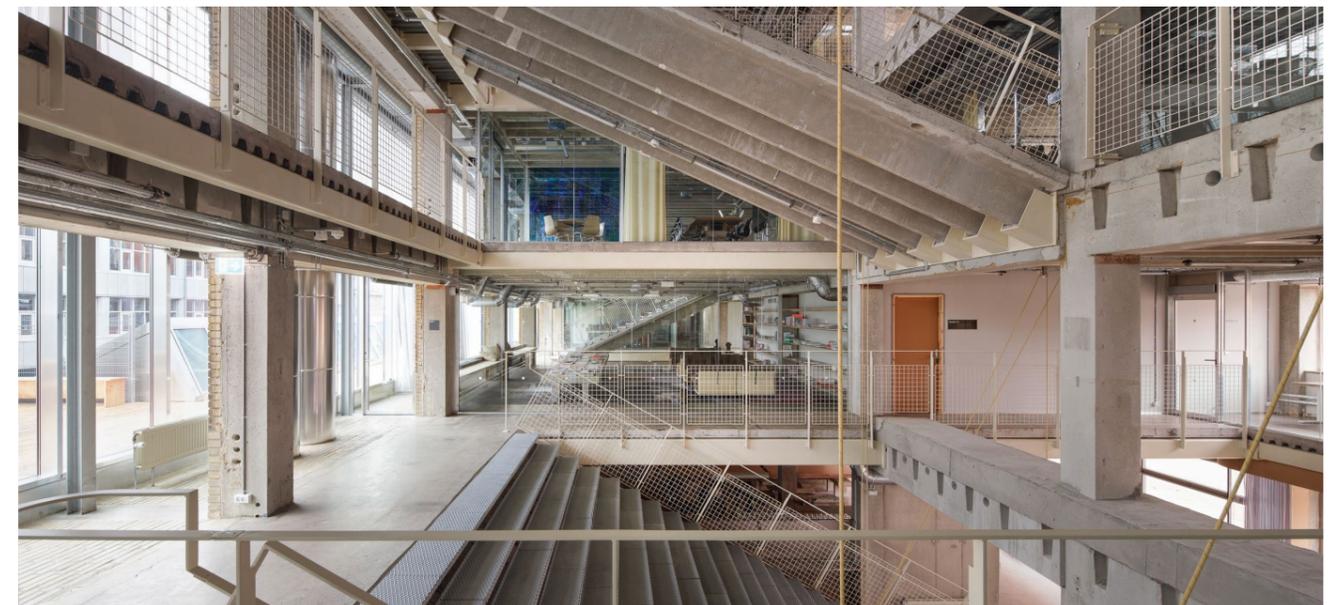
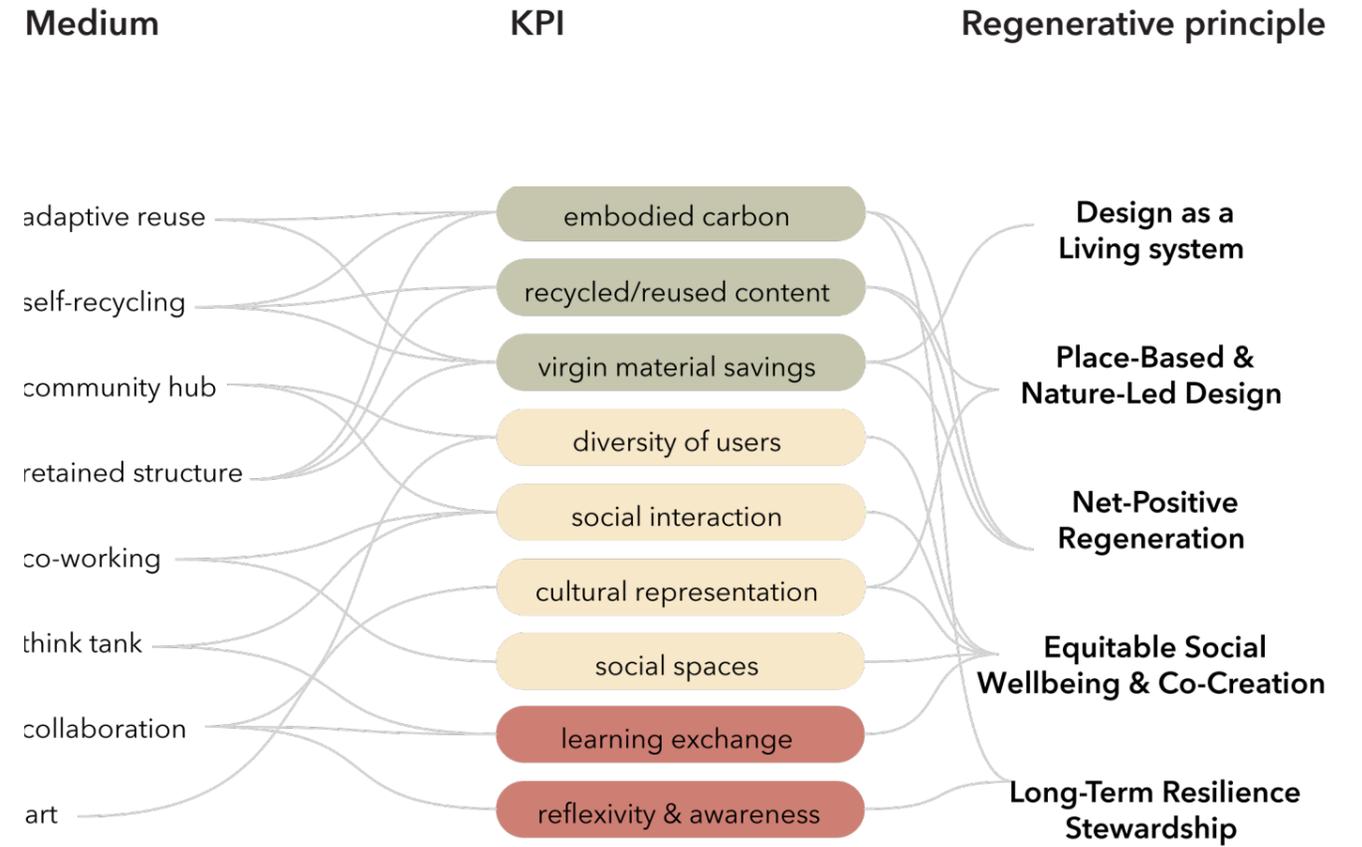
Elements with more than 10-15 years of lifespan left, such as the plastic windows, are not replaced just because of outdated aesthetics or standard, but will remain until replacement is necessary.

The result of the self-rycling approach is up to a 88% reduction in CO2 emissions in comparison to a new construction, according to a life cycle analysis conducted by DTU, and minimising 90% of all waste related to construction. Thoravej 29 reflects a pragmatic approach to the reassessment of the value of what exists, by treating the building as its own material bank.

“ At Thoravej 29, everything revolves around creating profound, positive change for people and society. A community where good intentions are transformed into real-world impact.” A cross-sector community of organisations working in art, social innovation, sustainability, politics and democracy, digital innovation. Thoravej 29 functions as a collaborative workplace, an innovation thinking hub for ambitious people.



© Pihlmann



© Hampus Berndtson

04.5 Resource Rows

2019, Denmark, Lendager

Resource Rows is a pioneering residential project in Copenhagen that emphasises circularity as a method for greatly lowering CO2 emissions. It systematically uses materials from demolished buildings, reducing waste and enhancing existing resources. Through the use of reused materials, the project proposes an innovative housing model, energy efficient and attentive to architectural identity.

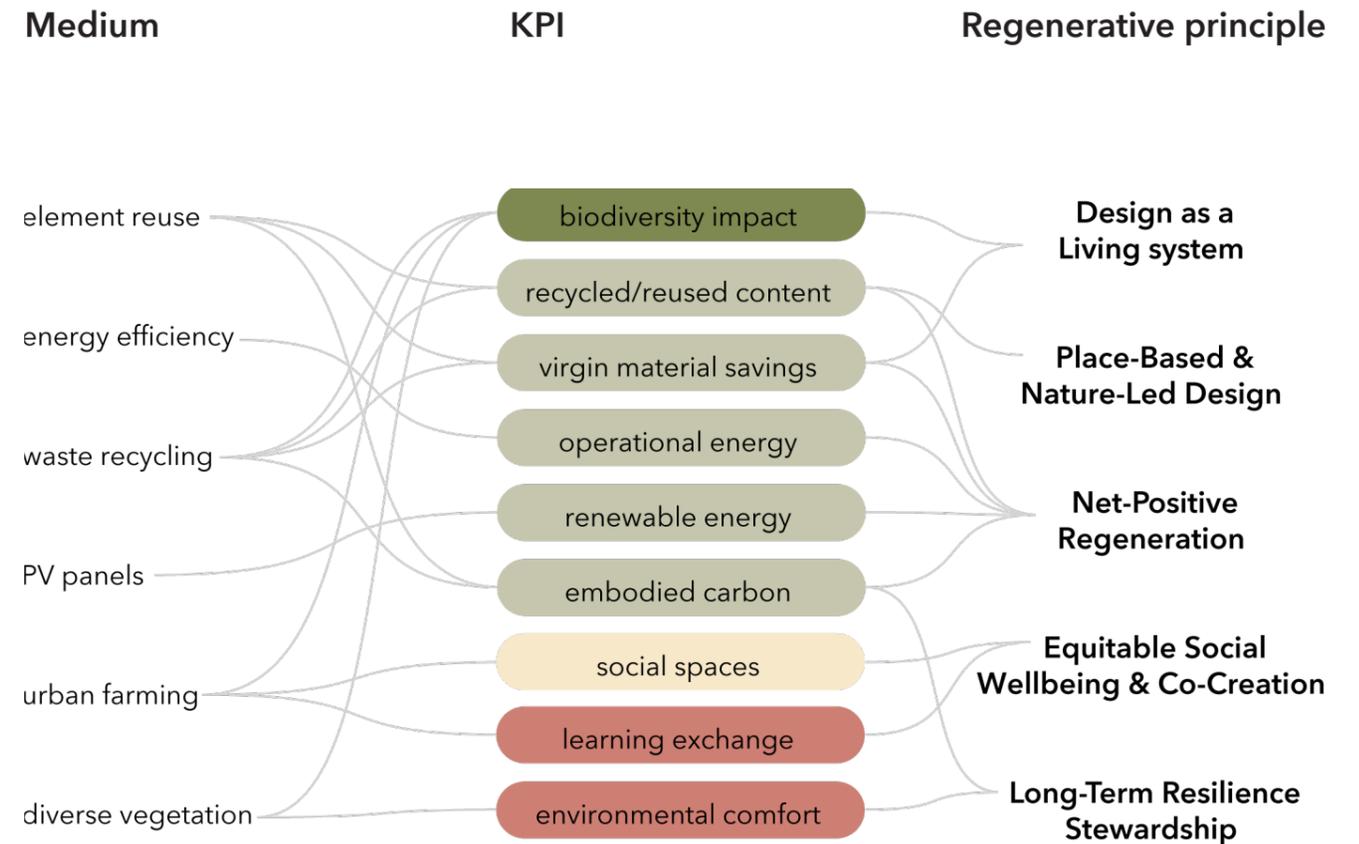
Lendager identified potentials to utilise waste streams that can be processed into valuable building materials to reduce the environmental impact of a construction through collaborations both inside and outside the construction industry. In total the project saves 463 tonnes of waste into materials, and through a large upcycling ratio, 29% of CO2/m2 is saved over 50 years with no additional cost, calculated through LCA and LCC. Even though Copenhagen's energy grid has a large share of energy from renewable sources, they decided to implement PV panels on the roof to sustain the building and give extra back to the grid. Building heating is done by water-to-air heat pumps, powered by the PV panels.

Resource efficiency and innovative answers to material constraints encouraged the architectural design and new creative ways to use materials. Old cement-mortar brick facades were cut out and reassembled into new facade modules. Additionally on the facade, waste wood from metro construction was used. Waste materials were also used to build rooftop garden houses. A recycled steel truss bridge connects the two rooftop terraces across the courtyard.

Material reuse not only saves CO2 emissions that come from material production cycle, but supports the minimising of virgin material extraction and thus local biodiversity at extraction sites. Resource rows courtyard is designed with diverse vegetation and urban farming for the residents, supporting biodiversity, self-sustainability and social interactions.



© Lendager



© Lendager

04.6
Helsinki Bricklayer
 2024, Finland, Avarrus Architects

Helsinki Bricklayer is a solid brick apartment building of 29 units, designed by Avarrus architects, developed by Kestävät Kodit Oy and built by SSA Rakennus Oy. It functions with passive ventilation and is a part of the city of Helsinki Re-Thinking Urban Housing Programme. The aim was to investigate how traditional solid brick construction and passive ventilation can offer an energy efficient, healthy and comfortable form of living in the contemporary era.

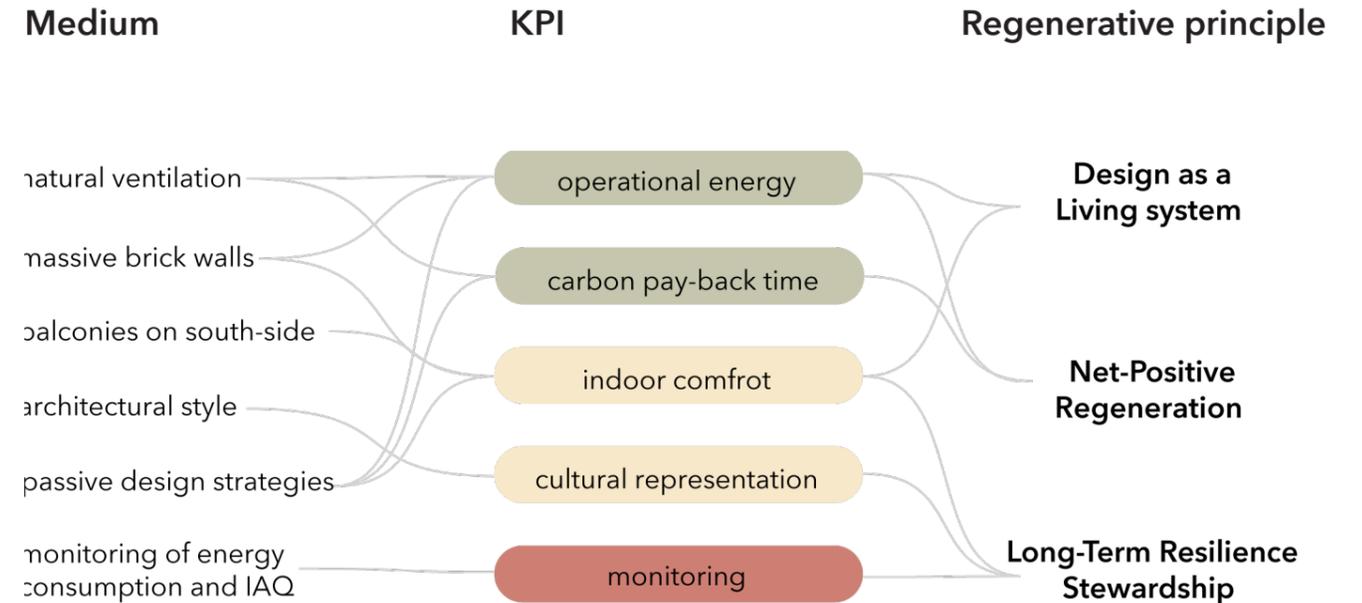
Solid brick, such as 1930 Töölö apartment buildings (a neighbourhood in central Helsinki) houses have proven to be long-lasting and energy efficient. Brick retains heat in winter and cools in summer, balances humidity and provides good indoor air. Brick is a natural material with reuse and recycling possibilities, providing a circular life-cycle. The perforated double brick walls (60-75cm) work both as the load bearing structure and as insulation together with air. The facade is built cleanly and interior walls plastered with breathable plaster. The structure is made out of cast-in-situ concrete.

Passive ventilation relies on natural air pressure and temperature differences. The air travels through supply and exhaust air paths without mechanical parts, which reduces the need for maintenance and energy consumption. The solution meets current building regulations, and the functionality is supported with thoughtful design: cross-ventilation possibility in every apartment, considered placement of chimneys and balcony zones that prevent overheating.

Architectural integrity and sustainability guided the design. The facades showcase hand-laid bricks and reliefs, thick walls bring solidity and window placement follows classic masonry building rhythm. The mansard roof with its exhaust chimneys form a memorable silhouette. The bricklayer apartment building works as a research subject, where the real energy consumption and indoor air quality is being followed for two years. The goal is to show how the traditional solid brick construction with passive ventilation can offer a sustainable alternative for modern mechanical multi-storey building.



© Tuomas Uusheimo



© Tuomas Uusheimo

04.7
Cork House
2019, England, M. Barnett Howland

An unusually complete attempt to design for the new energy conditions, the Cork houses designers Matthew Barnett Howland, Dido Milne and Oliver Wilton claim that its materials have taken more CO2 out of the atmosphere that they have put in it. Built of expanded cork, low-quality cork bark rejected by the wine industry and heated to produce a foam-like material which provided excellent thermal insulation. Structure of walls and roofs are all made of precisely cut cork blocks, made an airtight assembly with foam inserts. Sustainably treated wood is used to support the structure in vulnerable places. Heating demand is minimised with the excellent insulation and airtightness. When required, heating is done by a renewable fuel burning stove. Openable skylights carry heat out during the summer from the funnel-like roofs.

The Cork House aimed and succeeded to drastically reduce its embodied and operational energy and carbon, and the team has carefully thought about the house's end of life scenario, the reuse possibilities. Designed for disassembly, carbon negative at completion and with a

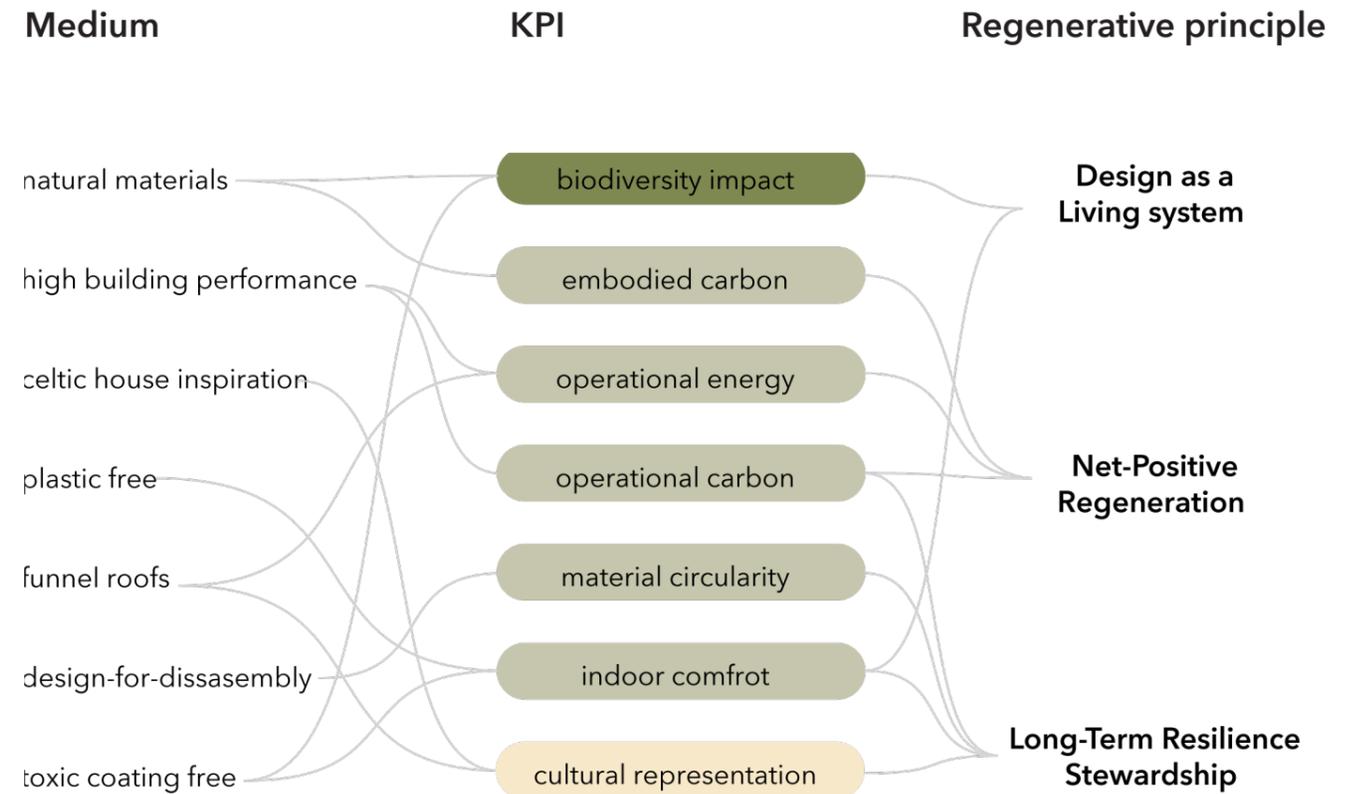
whole life approach to sustainability, from resource through to end-of-life.

The elements of the house have been designed for non-destructive disassembly, favouring screws instead of nails and glue, or simply gravity. Coatings on all materials are avoided as much as possible, as it complicates recycling. The cork is protected by running rainwater clear of it with well-designed drainage details. Internally fire protection is provided by sprinklers instead of fire-retardant coatings. Wood work is left exposed and untreated on the inside (Calder, 2021).

The design is a mix of architectural and ecological objectives. Structural form is inspired from the simple construction principles of ancient stone structures, such as Celtic beehive houses. Interior aesthetic is peculiar, the exposed solid cork is gentle to touch and has a pleasant smell to it, providing a sensory experience (Barnette Howland, 2019). Cork works well also as an acoustic insulator, enhancing a calm home environment.



© Ricky Jones



© M. Barnett Howland

04.8 Lessons Learned

The analysed case studies highlighted a diverse range of better ways of designing and aiming towards regenerativity, implemented in European projects, primarily in the Nordics. These examples demonstrate a shift from sustainability towards active regeneration and offer valuable lessons for both practitioners and students of architecture and urban design. They underscore the importance of systems thinking, local context, material circularity, nature integration, and community involvement in creating environments that not only sustain but actively regenerate ecological and social wellbeing. The analysis and learning from the selected case studies was not about copying solutions arbitrarily, but understanding the underlying principles, to be able to adapt them to specific contexts. This approach allows for the development of contextually appropriate regenerative design strategies that resonate with local environmental and cultural specificities. No one-size-fits-all model exists in regenerative design.

None of the analysed case studies are fully regenerative nor meet all the principles presented in this thesis. Some of them cover a larger span of different KPIs and connect to more regenerative layers than others. Valuable lessons were still learned. The importance of a holistic design approach, and systematic-thinking is highlighted. Crucial for the success of regenerative design approach is also the fundamental shift in thinking and working we as architects need to do. It is a shift in how we understand projects, their purpose, as well as our role as professionals (and students). A prominent coherence between intention and practice is pivotal. Regenerative design encompasses a desire to design better, to truly contribute and create meaningful value for the people, the communities, and the environment.

Grønninen-Bispeparken

Grønninen-Bispeparken demonstrates how urban green spaces can effectively manage climate change impacts, such as flooding, while simultaneously enhancing social, natural, and cultural values. With nature-based solutions, bioswales, the project is able to collect, store, and infiltrate over 3,000m³ of rainwater. The project caters to both human and more-than-human life with its playful and functional public spaces and rich biodiversity. Biological and social living conditions are optimised with dynamic maintenance plan, balancing 'wild' and 'orderly' aesthetics. Active citizen involvement in the design process of the park is an important aspect. This ensured the relevance and meaning of the space for its users.

The Opera Park

The Opera Park also addresses the topics of biodiversity loss and water management challenges in dense urban environments. It integrates various plant species and landscape features to create a rich and visually appealing oasis for citizens to escape to, while offering flowers for pollinators and habitats for small animals. Permeable paths, rain beds, green roofs and roof runoff capturing are some of the strategies implemented for stormwater management. The park is an attraction with amenities that offer relaxation, support events and attract visitors. A critical point of the Opera Park that collides with regenerativity is that it was built on a man made island.

Thoravej 29

Thoravej 29 shows how existing buildings are valuable material banks, and how adaptive reuse can drastically reduce CO₂ emissions (up to 80%) and construction waste (up to 90%) compared to new builds. Nearly all original structural elements and materials are retained and repurposed from the 1960s factory building. This self-recycling within the buildings leads to material innovation, inspiring new architectural forms and spatial configurations. A pragmatic mindset considering existing materials and their lifespan can guide towards a less wasteful and more regenerative architecture. In Thoravej 29, functional elements were retained until replacement is necessary.

Resource Rows

Resource Rows uses a systematic waste material utilisation, incorporating materials from demolished buildings into the new residential construction. This led to significant CO₂ emissions reductions through the circular construction, with no additional cost. Architectural innovation and new creative ways to use salvaged materials are born through the material constraints. Circularity and reuse of elements and materials not only reduces the embodied carbon but minimises virgin material extraction and its impact on biodiversity at extraction sites. The project integrates renewable energy production on site by implementing photovoltaic panels.

Helsinki Bricklayers

Helsinki Bricklayers makes use of traditional building methods to achieve a high-performance building without modern mechanical systems. The solid brick construction and passive ventilation create an energy-efficient, healthy, and comfortable living environment. The material choice can contribute significantly to a building's energy efficiency, indoor air quality, and circular lifecycle. Energy consumption and maintenance costs can be reduced by passive design strategies, while enhancing user comfort. Not only with traditional building methods, but reminiscent of early 20th-century style visually, the building is aesthetically pleasing and strengthens the city's landscape.

Cork House

Cork House showcases how waste materials can be transformed into high-performance, carbon-sequestering building components. The house achieved a carbon-negative status through the use of expanded cork from waste. Designing for disassembly was a key point in this project, complying with regenerative design principles. It is crucial for circular material flows and for extending the life of components. Elements were assembled with screws instead of nails or glue to facilitate future reuse and recycling. The designers' holistic whole-life approach, considering environmental impacts from resource extraction to end-of-life, is essential for achieving regenerative outcomes.



Hyvin Block

05. Site Analysis



05.1 History of Hyvinkää

First sources mention Hyvinkää town in 1495, when the most important source of livelihood was agriculture. In 1500-1600, mining was experimented at the Hyvinkää Hopeavuori ("Silver mountain"). The main street of the city follows still the line of the important Helsinki-Hämeenlinna road that travelled through the Hyvinkää town for centuries. The development of the city as we know it today was largely influenced by the Helsinki-Hämeenlinna railroad connection, completed in 1862. The original wooden station building still stands and welcomes travelers (see figure 05.1) New settlements emerged around the railway station, and summer vacationers found themselves to the ridgeland of Hyvinkää. The nature and recreation area Hyvinkään Sveitsi was being praised as a domestic tourism destination already in 1885. The city offered a tranquil working and living environment for many painters, such as the famous Helene Schjerfbeck, Tyko Sallinen and Yrjö Saarinen. (Hyvinkään kaupunki, 2023).

Nearby manors at Erkylä and Kytäjä had a significant role in the development of the city, one of them was the Linder family. They were generous and reform-minded, who from the 1860s onwards financed

local elementary schools and healthcare, and developed local sawmilling and industrial activities. A new phase began in the Hyvinkää station area in 1892 when Ossian Donner started a spinning and weaving mill. The wool factory buildings play an important role in the cityscape of Hyvinkää. The largest of them completed in 1896 (see figure 05.1) and around which the city centre started to form. The same year the main church building of the city was completed. Within a few decades Hyvinkää became an industrial settlement, the weaving mill employing thousands of workers. (Hyvinkään kaupunki, 2023).

Hyvinkää's importance as a destination for relaxation and wellbeing of Helsinki elite grew with the forming of the Hyvinkää Sanatorium in the end of 19th-century, and then the completion of larger sanatorium building, the jugend castle by Lars Sonck in 1906 (see figure 05.1). The sanatorium is set in the midst of a pine tree forest (*pinus sylvestris*). Finns have for long known that the smell of pine is healing, which is why also tuberculosis hospitals were built near pine forests. Pine pollen is said to increase general fitness and endurance. (Kivinen, 2020; Hyvinkään kaupunki, 2023).

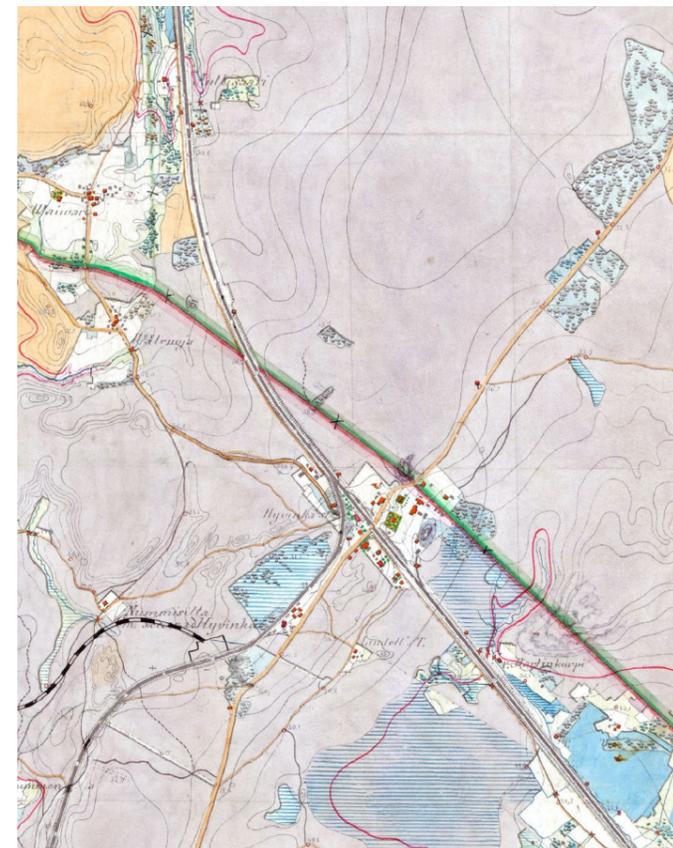
Historic maps of the city of Hyvinkää from 1785-1933
© City of Hyvinkää and the Finnish Railway Museum



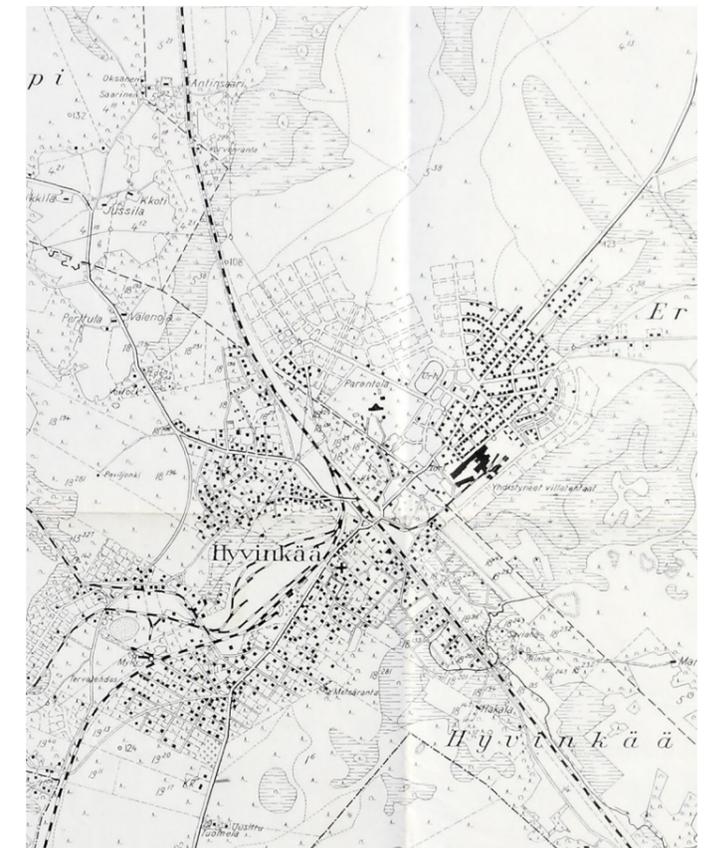
1785



1855



1870



1933

In 1917, the year Finland declared independence from Russia, Hyvinkää became an independent municipality. Railway and road infrastructure, growing economy and land planning politics brought new industrial factories to the municipality, many of them still operating. During the truce between Finland and Russia in between the Winter War (1939-40) and the Continuation War (1941-44), Hyvinkää built an airfield at the north-east edge of the city, which offered shelter for the citizens. After the Second World War, the Hyvinkää airport served as the primary civilian airport of Finland. The municipality's trade agriculture and parish activities were revitalised with the rebuilding after WWII and the evacuees from Karelia settling there.

The new modernist church of Hyvinkää was completed in 1961 close to the centre. As the city grew in population other public facilities and buildings were built, and the centre area former. The city library was completed in 1968 and the Taika museum centre in 1982 (see figure 05.1).

In the last decades, Hyvinkää has been transformed from an industrial city to a versatile place for work and living. Closeness to nature, calm environment, and proximity and easy access to the capital are characteristics that attract people to live in Hyvinkää. Nowadays approximately 47 000 inhabitants live in the municipality, making it the 23rd most populous municipality in the country.

Historic orthoimages of the city of Hyvinkää from 1936-1997
© City of Hyvinkää and National Land Survey of Finland



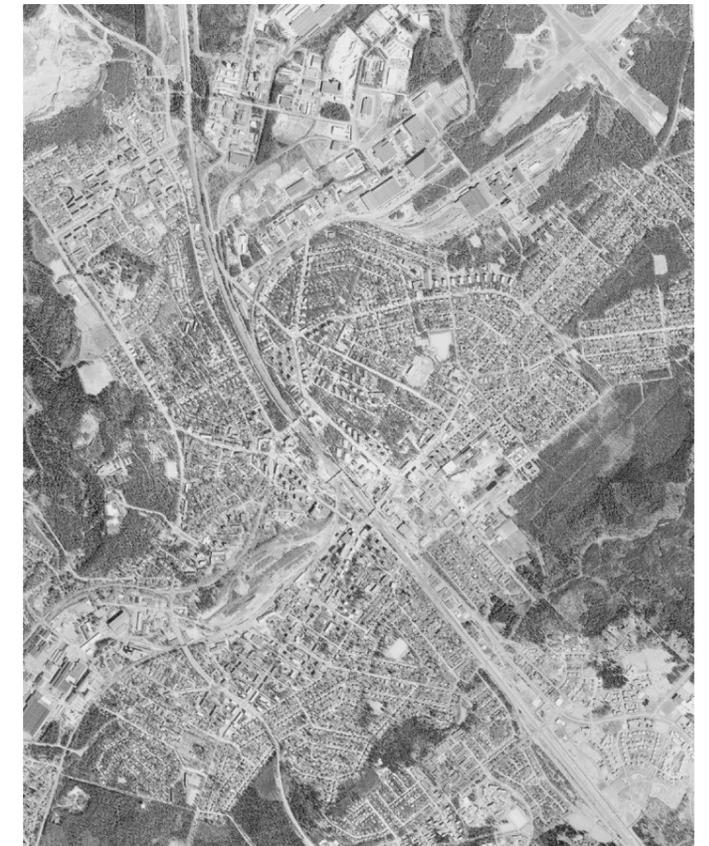
1936



1951



1978



1997

Hyvinkää 1:10 000 ⓘ



- 1. Railway station
1862
- 2. Railway museum
1870
- 3. Old church
1896
- 4. Wool factory
1896



- 5. City hall
1900 (r.2010)
- 6. Hyvinkää sanatorium
1906
- 7. Station school (wooden)
1913
- 8. Tilander's house
1947 (d.1956)



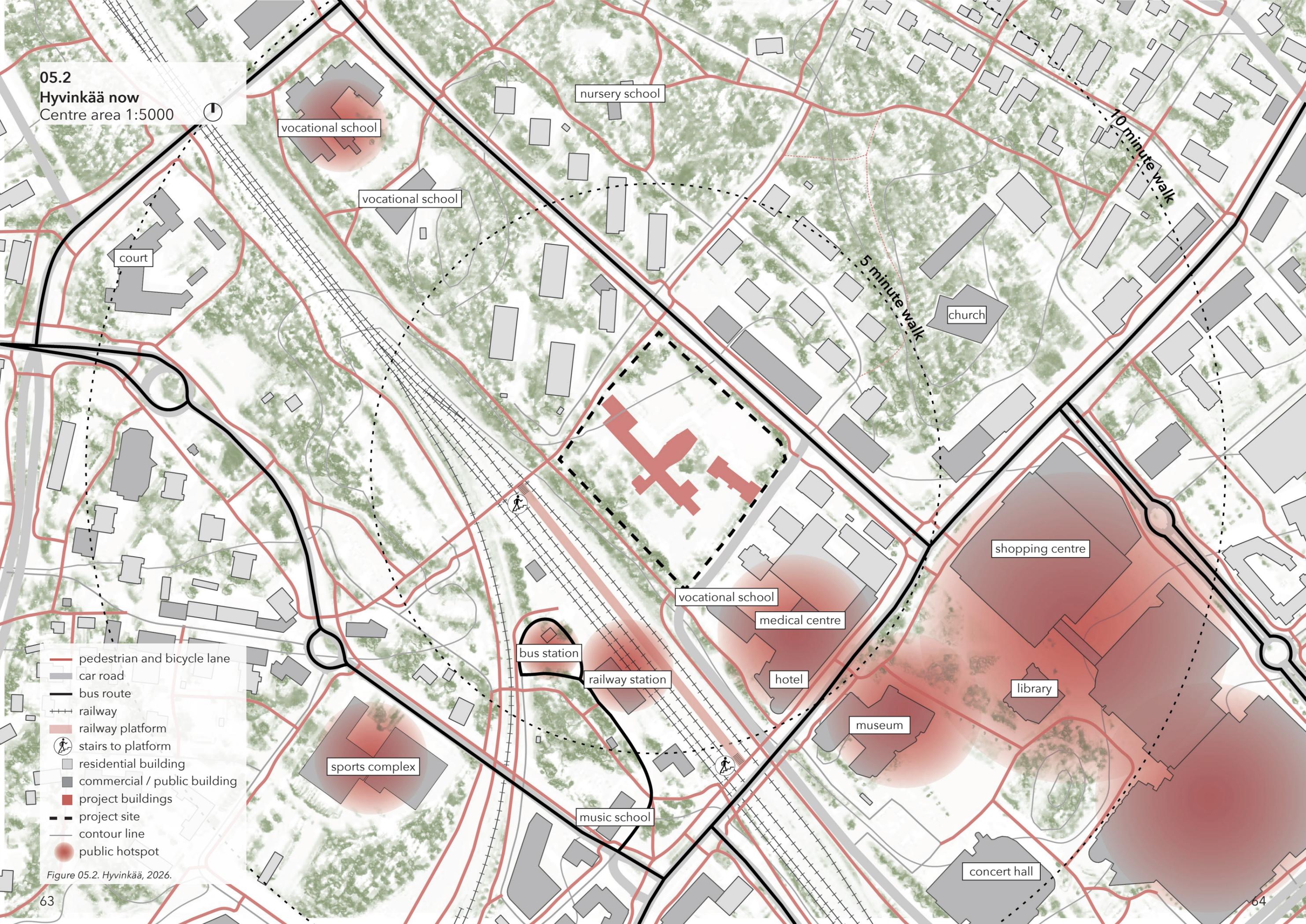
- 9. Puolimatka school
1952
- 10. Station school (stone)
1954
- 11. Hyvinkäänkylän school
1955
- 12. New church
1961



- 13. City library
1968
- 14. Taika museum centre
1982
- 15. Willa shopping centre
2012

Figure 05.1. Important buildings in Hyvinkää from mid 19th-century to the early 21st.

05.2
Hyvinkää now
 Centre area 1:5000



- pedestrian and bicycle lane
- car road
- bus route
- + + + + railway
- railway platform
- stairs to platform
- residential building
- commercial / public building
- project buildings
- project site
- contour line
- public hotspot

Figure 05.2. Hyvinkää, 2026.

05.3 Demography and Economy

Hyvinkää is situated in the northern part of Uusimaa region, approximately 60km from the capital Helsinki. It is the 23rd most populous municipality of Finland with 47 047 residents. The population has grown steadily and in moderation over the past few years (figure 05.3), due to migration, especially immigration (Hyvinkään kaupunki, 2025). The project site is located in the Hyvinkää city centre borough. With 9 887 residents in 2023 (figure 05.4), and a population density of 326/km². Overall, Hyvinkää has a relatively large share of retired people, 26,5% out of all the residents, but the share of employed people and children is also fairly large (figure 05.5). The centre borough's age range is wide, young children, young adults, working-age, and senior residents are all present (figure 05.6). There appears to be a small decline in population since 2021 in the city centre borough (figure 05.3), and in the whole city of Hyvinkää in the past year with estimates of the year 2025 population of the city being 46 912, which is 0,3% less than in 2024, (Suomen Kuntaliitto, 2025).

The most popular housing type in Hyvinkää is an apartment, where the majority of the city's households live, 54.0% in 2024. The second most popular type of housing is a single family home/detached house, where about 31% of households live (Statistics Finland, 2024). The share of single-person households in Hyvinkää's housing units is almost half of the total households, while a bit over 30% of households are comprised of two people (figure 05.7).

More than 60% of the residents of Hyvinkää belong to the Evangelical Lutheran Church of Finland, the main religion of the country, while about 35% of the residents are unaffiliated. The minority of the population belong to other religions such as Orthodox, Catholic, or Islam, (Statistics Finland, 2024).

Hyvinkää has a long history as an industrial city, and industry still has great importance for the city's economy in compared to the national average. The local economy and industry was firstly largely based on wool production, before a major Finnish elevator manufacturing company opened their factory in the city in the mid 20th century. Nowadays other major industries of the city include crane and cable manufacturing. However the primary employment sector of the city is the service one, which accounts for 72% of all jobs (Statistics Finland, 2022). In the centre, businesses are fairly equally divided across sectors, largest shareholders being the industrial and retail services (figure 05.8). The shopping centre Willa is located in the centre, just a few hundred metres from the project site, hosting over 100 shops and employing over 700 people.

The biodiversity of Hyvinkää is quite high, as the area includes forests, bogs, lakes, ponds and protected areas, providing suitable habitats for various animal and plant species. Larger mammals such as deer and moose are common, as well as small mammals such as squirrel, fox, and hedgehog, along with various bird species, which habit also in the urban areas. Nature richness of the city centre, and proximity to forests, brings animals into the urban arena, an important factor to consider in the design project: to acknowledge the more-than-human world and design for all life.

Hyvinkää population (31.12)

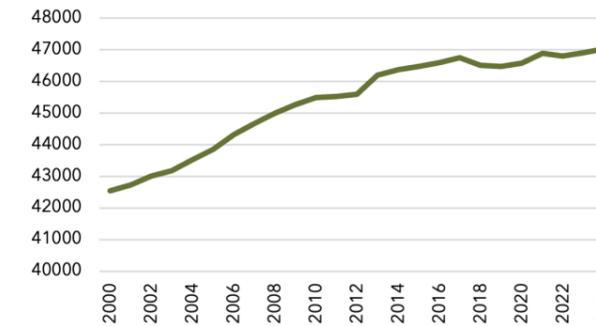


Figure 05.3. Data: Statistics Finland, 12.2024.

Residents in Hyvinkää centre borough

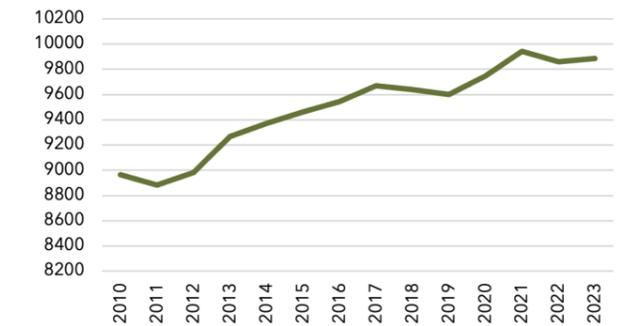


Figure 05.4. Data: Statistics Finland, 2023.

Population structure, Hyvinkää, 2025

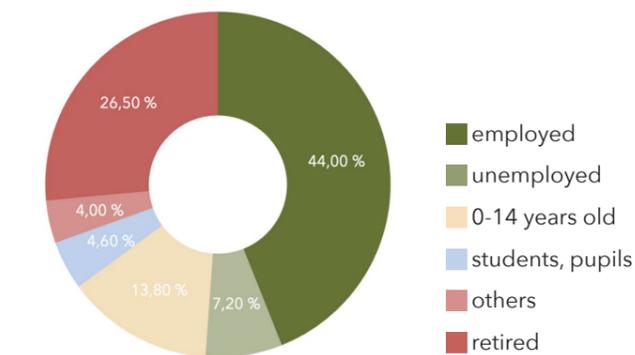


Figure 05.5. Data: Statistics Finland, 2025.

Hyvinkää centre borough age distribution, 2023

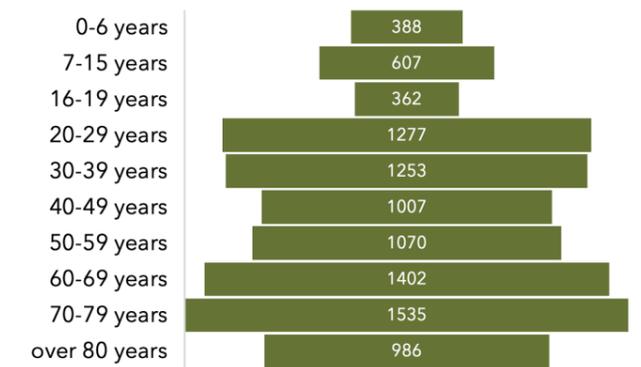


Figure 05.6. Data: Statistics Finland, 2023.

Household structure, Hyvinkää, 2024

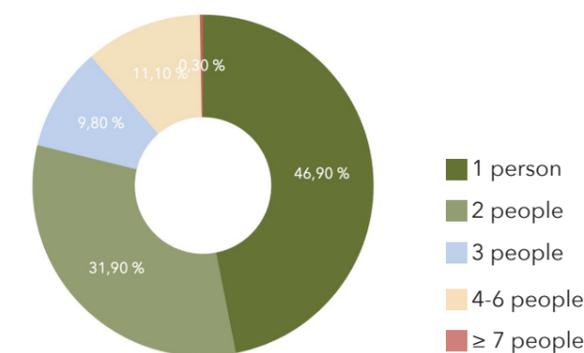


Figure 05.7. Data: Statistics Finland, 2024.

Hyvinkää centre business distribution, 2024

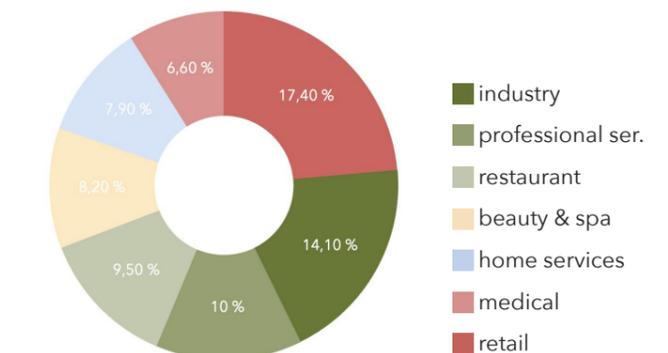


Figure 05.8. Data: Statistics Finland, 2024.

05.4

History of the Aseman koulu (Station School)

The Station school is located right next to the city centre and the railway station. The lot features two buildings, an wooden school building from 1910-1913 by the builder Johan Emil Hildén, and a modern stone school building built after the wars in 1954 by architect Antero Pernaja. The school was founded already in 1894 in a rental property, and moved a few years later to a house 'Tilanderin talo' that stood previously on the lot. The wooden school was built shortly after to meet the growing number of pupils. For the same reason the large stone school was built after the war due the population boom and evacuees from Karelia. The Station School and its lot has been valued as locally and provincially significant cultural heritage, as a part of the Hyvinkää centre. Across the railway, opposite of the school, lies the culturally significant and protected Railway station building. The school lot has not yet been protected in the valid town plan, although this has been proposed and it is stated that the school building's significant characteristics should be preserved (Härö & El Harouny, Finnish Heritage Agency, 2019; Ark-Byroo, 2022).

A building history report and study was executed by the architecture office Ark-Byroo on request by the city of Hyvinkää in 2022. This was done to support the local planning work, and to offer a basis on which to assess the building and the cultural historical values of the site, the need for building protection, and the various alternatives for local planning. The most significant archival sources for the study were the elevations and floorplans of the stone school building, obtained from the archives of the city of Hyvinkää. From the National Archives type drawings of the buildings from the late 19th and early 20th century were found. The Finnish Antiquities Authority's online service Finna and the Hyvinkää city map service were the most important sources for photographs.



Station school photographed from the southern corner of the lot.

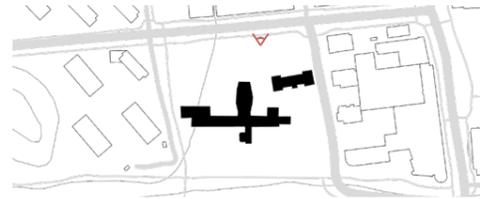
© Niilo Ristamo, 1955-60, Hyvinkää citymuseum, Finna.



Station wooden school in 1932.

© Hyvinkää citymuseum, Finna.

05.5 The Site and Buildings

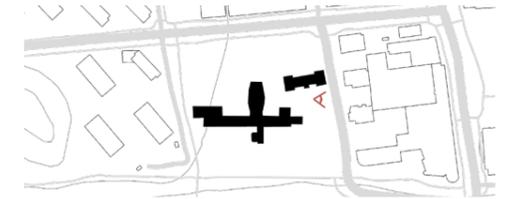


garden of sand

© Peppiina Pelagia Nahkala, 2025.

Viewing the site and buildings from north-east you see a large sandpit, underdesigned and drab, used assumably as a sports field for e.g. football and baseball by the school. This large area has plenty of potential for an outdoor public space, designing different rooms for varied activities, enhancing the cityscape for the users of the buildings and the whole neighbourhood. Currently the perception of this space is the feeling of missed opportunities. Not only lack of social or ecological function, but lack of purpose. The aim with the project is to design this public space to serve the full community, enhance the view of the buildings with a more welcoming and pleasant outdoorspace. Overall, to strengthen the site's identity, create a landmark block and add a new historic layer to Hyvinkää's cityscape.

The lot is located at a central point between the Hyvinkää railway station and town centre. Neighbouring buildings are a mix of styles, functions and eras. On the north-west side of the lot, 1950s apartment buildings form a uniform milieu with the stone school building. On the north-east side, a typical 1960s small strip mall hosts a few stores and restaurants, with a few 1960s apartment buildings on the back. On the south-east side of the site new apartment buildings were built in the 2010s in place of demolished wooden buildings from the 1920s and a stone apartment building from the 1950s. A forested hill borders the railway track on the south-west side of the site.

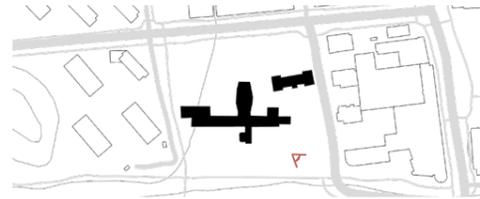


two eras, two styles

© City of Hyvinkää, 2025.

The stone school building (left) and the wooden school building (right) are of different architectural styles and eras. The 1950s stone building by Antero Pernaja is a typical school building of the time, five similar were built in Hyvinkää by Pernaja. It has three floors and a basement, in total 5539m². Structure is masonry and concrete, exterior walls are plastered with a light colour and roof is red tile. Floors are of reinforced concrete, and internally we find both painted concrete surfaces, wood paneling and mosaic concrete. It is a long rectangle with a clear and functionalist interior division. Central hallway runs through the building, dividing the classrooms. The style and materials of the building form a uniform milieu with the neighbouring 1950s apartment buildings.

The wooden school by J.E. Hildén represents early grammar school architecture with Jugend influences. The original appearance remains for the most part. It is a log frame one floor building, with an attic and a basement, total floor area of 537m². The exterior is boarded with horizontal wood paneling, the building foundation is made from natural stone and concrete fill-ins. The steep pitch roof was originally shingle or felt roof but now sheet metal. Rectangular and symmetric in shape, the building features a central entry hall that leads to classrooms at both ends. High floor to ceiling high and large multipane windows make the interior feel spacious and give plenty of natural light.

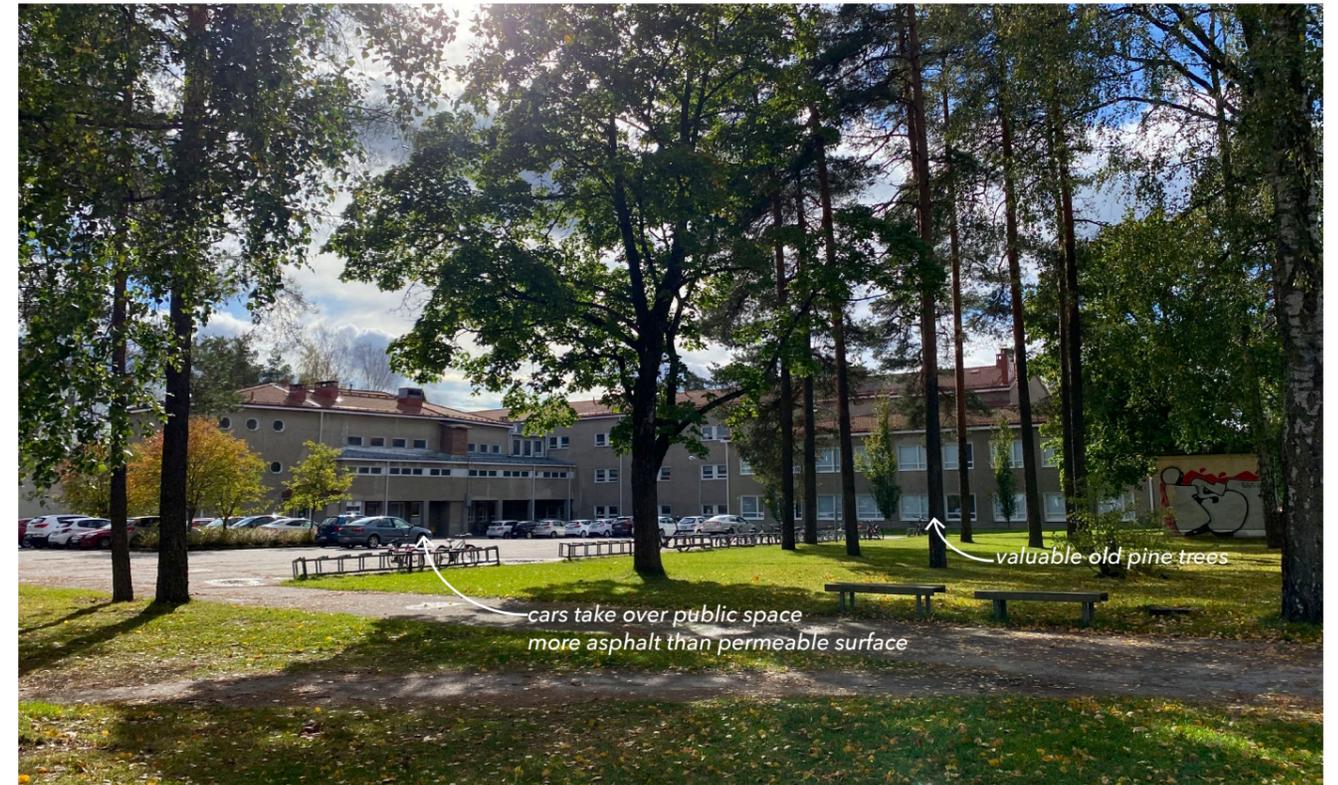
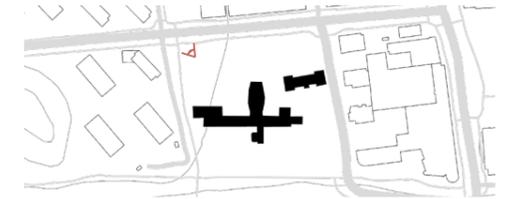


opportunities for green

© City of Hyvinkää, 2025.

On the south-west side of the buildings is the main school yard with some playground and sportgame elements. Without the summer sun and lushness of the vegetation, the site seems overall a bit grey. Here too, as on the north-east side, plenty of open land is waiting to be used. The stone school includes a pavilion like old dentist office in front the main entrance. With its decorative mosaic exterior, diverse of the main buildings facade, it is considered a little gem in the school architecture of its time. Entrances to the building are covered with arcades, visible here the central main entrance and the right side entrance.

Currently the site ground is in parts paved with asphalt, and in parts covered in grass or sand. The soil type of the area is sand, which does not retain water or nutrients well. To improve its fertility and the growing possibilities of vegetation, clay and rotted peat or compost can be added (Painokallio, 2025). Important in the redesign is to improve and support water permeability of the site, reducing impermeable paved areas, and use nature base solutions for stormwater collection, storage and filtering. Suitable solutions for on-source management and conveying of stormwater include green roofs and permeable surfaces, ditches, streams, and bioswales, and for detention and infiltration raingardens, ponds and basins. (Kautto, 2021). Minimum 1/3 of the site should to be permeable for water infiltration to meet good design standards.

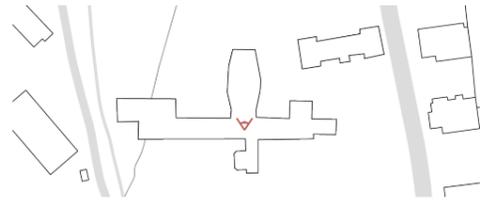


hierarchy

© Peppiina Pelagia Nahkala, 2025.

The park and forest feeling in some corners of the site is a pleasant break in the urban fabric. Trees create nice rooms or spaces under them for people to rest or enjoy a social activity, protecting from the summer sun, and cleaning the air. Vegetation can be used as a visual and physical barrier between car streets and the pedestrian areas. Unfortunately, the central area of site is dedicated for car parking, minimising the pleasant outdoor spaces for public use. Instead, the area could prioritise pedestrians and nature over cars, promote the ecological value of the existing old trees and enhance the biodiversity.

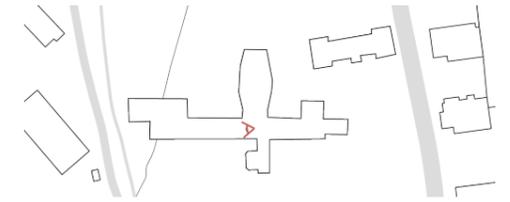
The school buildings and the site are surrounded by large old pine trees and some deciduous trees like birch, oak and maple, valuable to be preserved in the redesign. Pine is a traditional tree of Hyvinkää's urban areas, giving public spaces greenery all throughout the year. The first city gardener of Hyvinkää from 1950 to late 1970s, Erkki Melaja, brought up the idea of Hyvinkää as a forest city, where forest is intended to be preserved in its original sites. Having the majority of the trees in the urban spaces of the centre be the evergreen pine, provides also a greener winter landscape compared to cities with majorly deciduous trees. The city's name tree is the railway apple tree *Malus Hyvingiensis*, which is a great decorative small tree to be used in the redesign of the site, bringing spectacular flowering in the spring time.



design memories

Main hall and staircase, © Ark-Byroo, 2022.

Central element of the main entrance hall is the elegant curving staircase leading to the first floor. Round pillars give rhythm to the space, windows and large glazed entrance doors open the view to the south eastern yard. The hall has been used as students coat storage. In the readapatation of the building, this space offers opportunities for communal spaces for the residents, such as a small entrance lounge or library. The ceiling lighting fixtures are original Paavo Tynell, a prestigious Finnish modernist designer, and estimatetly from the mid 20th century. If in good condition, the lighting fixtures are valuable to be preserved as a homage for the history and era of the building.



identity

Al-secco mural, © Ark-Byroo, 2022.

A significant piece of artwork can be found at the second floor main hall, right above the central staircase. An al-secco mural from 1950s, by an unknown artist, representing growth, light and learning, specially done for the school context. It's a well preserved painting, and part of the cultural-historical significance of the building, recognised by the Finnish Heritagae Agency. The mural is necessary to be conserved and protected in the renovation and readaptation of the building.

06. Redesign



06.1
Concept

Hyvin Block

where wellbeing becomes a way of life

Hyvin means well in Finnish, **hyvinvointi** is wellness, wellbeing. The **Hyvin Block** in **Hyvinkää** aims to **promote and enhance the every day wellbeing of the individual people and the community**, as well as the **wellbeing of the nature** in the urban environment.

The project takes on the transformation of the Aseman Koulu (Station School) site into a mixed-use living block and flourishing park in the centre of Hyvinkää. Homes here are designed for everyone, families, workers, young adults, and seniors, with accessible and generous spaces. Public and private spaces blend gently into one another, creating moments of openness, belonging, and quiet retreat. Well woven into the surrounding urban fabric, greenery shapes the spirit of the block. Bioswales, raingardens, and permeable surfaces welcome stormwater as a resource. Existing old pine trees and other deciduous trees remain as witnesses of the past, while new plantings build a more diverse and vibrant urban ecosystem, providing wildlife habitats. With regenerative design strategies, the project is a living and evolving layer of the city, rooted in collaboration with the community and co-existence with the natural world. A place that elevates the landscape of Hyvinkää, and offers a way of living that supports and enhances the wellbeing of all life, for generations to come.

dimensions of wellbeing



social
Foster relationships, community and a sense of belonging.



physical
Support daily exercise, good nutrition, sleep and healthcare.



environmental
Healthy surroundings and connection to nature.



intellectual
Engage in learning, stimulating and creative tasks.



emotional
Calming and joyous environment that supports mental health.



financial
Affordable housing and services. Low maintenance costs.



green network

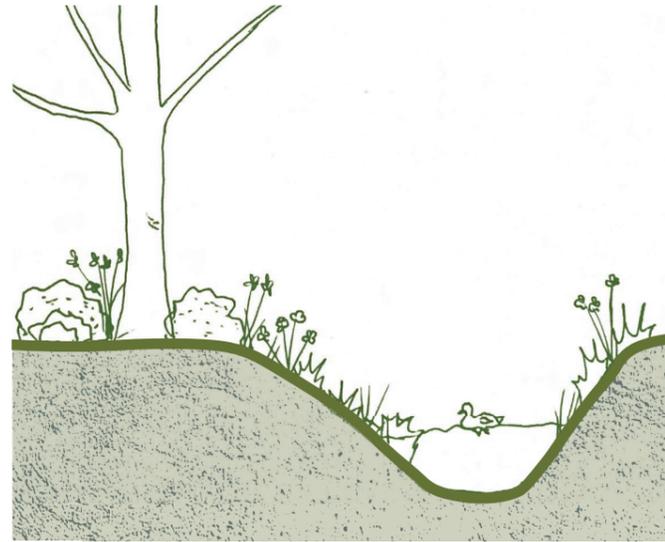


mobility — soft mobility - main path — soft mobility - slow path — car road

wellbeing grows where city and nature meet

nature as a resource

Rainwater is celebrated as a valuable resource. It is collected, filtered, and used to support both the environment and people. Space is left in the landscape for nature to design itself, evolve, and adapt over time: spontaneous urban wilderness. Existing vegetation is preserved and enhanced. The ecosystem provides essential services that benefit humans and support wellbeing, such as clean air, climate regulation, and food, fostering a healthy and resilient living environment.



design for all life

The site promotes rich biodiversity, creating vibrant wildlife habitats in the urban space that support animals such as pollinators, birds, and small mammals. Landscape is designed for everyone, inclusive and accessible spaces are provided for people of all ages and abilities. The environment is a place for learning, connection, and shared enjoyment for all, that integrates ecological richness with thoughtful human-centered design.



co-living & collaboration

Harmonious co-existence between humans and nature is encouraged. Opportunities to learn from, and be inspired by the nature and animals are provided. Social interactions and community engagement are fostered through productive ecological shared activities such as urban farming and beehives. Children get to play together and exercise at the playground, pocket gardens invite people for smaller gatherings while an urban plaza accommodates larger events.

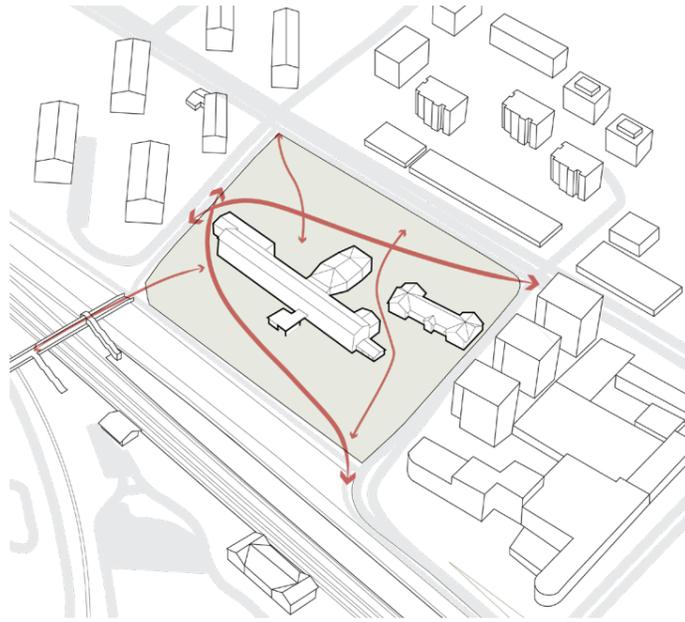


sustainable & healthy lifestyle

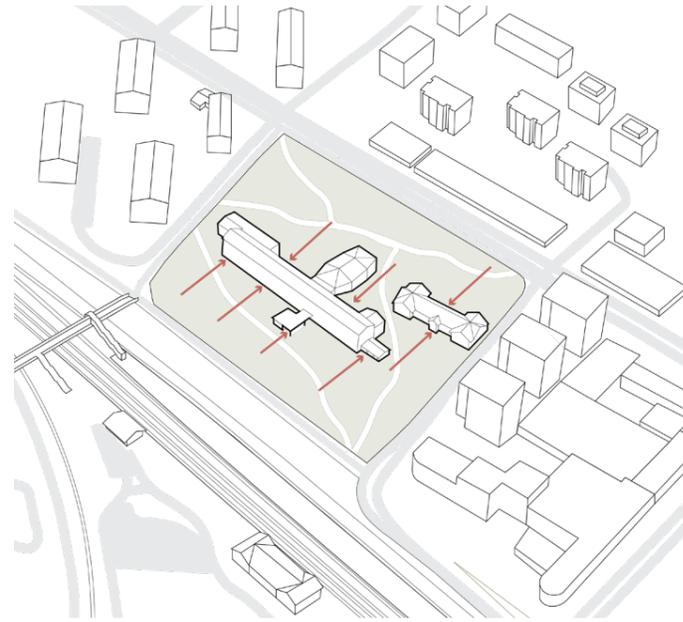
Everyday incidental exercise is essential for the health and wellbeing of people, and the living environment should enforce this. Supporting and preferring active mobility methods such as walking, cycling or skateboarding over cars for a sustainable everyday life. Offering space for un-organised and organised sport activities such as yoga, dance, ball sports or weight lifting. Advocating for healthy and balanced mind, offering opportunities to reduce stress by sauna, meditation, or connecting with nature.



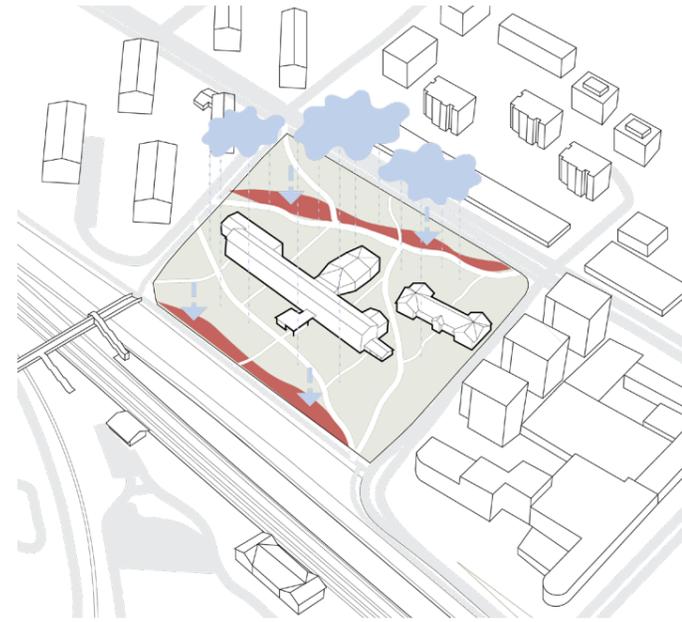
wellbeing and regeneration through design



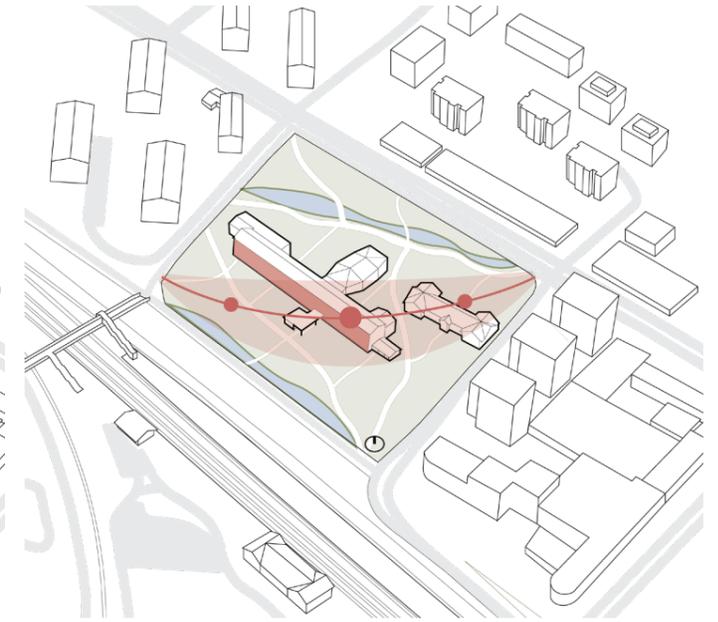
axis
Main access paths through the site.



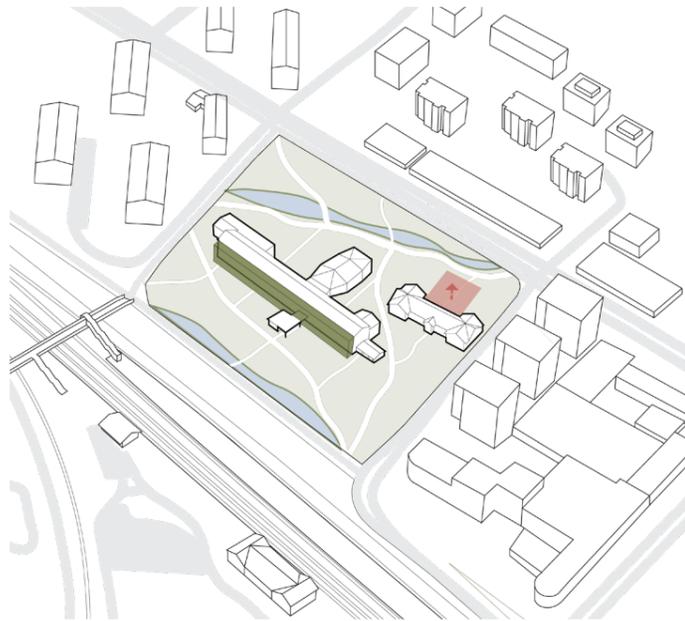
access to buildings
Entrances available from both sides of the buildings dictate the secondary paths.



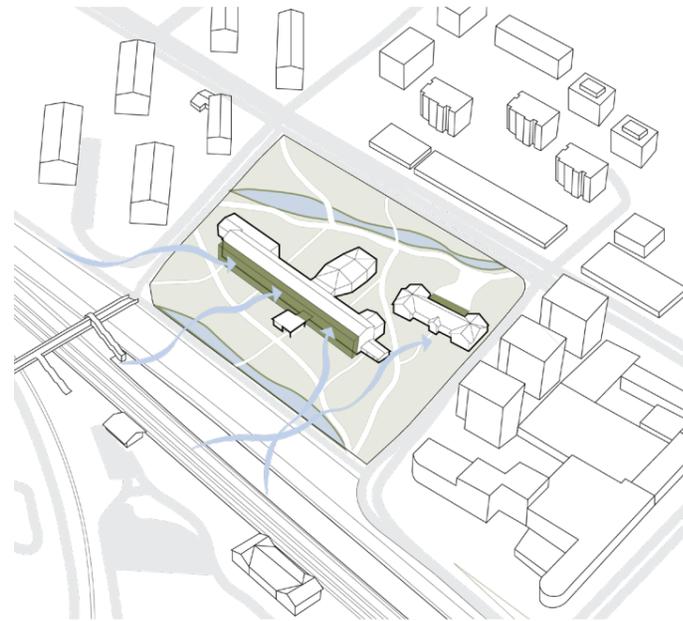
rainwater absorption and collection
Nature based solutions for rain- and stormwater management: permeable surfaces and bioswales.



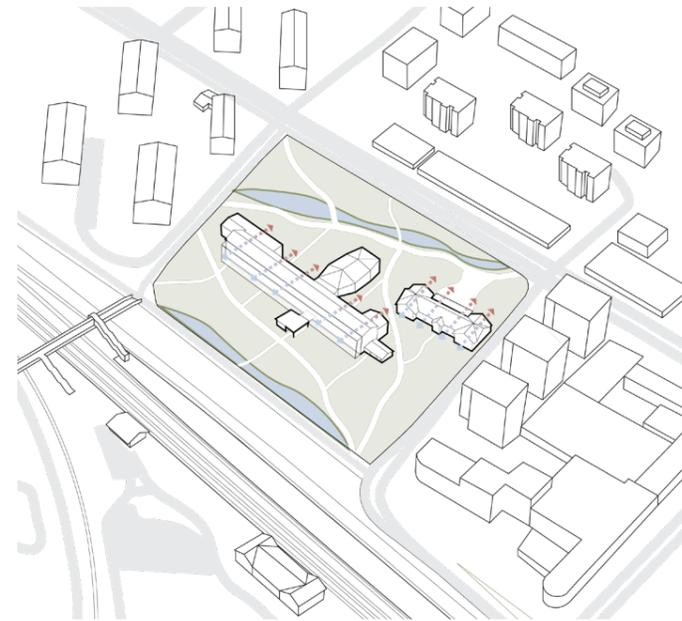
sun path
Protect from sunlight in the summer, maximise sunlight intake in the winter.



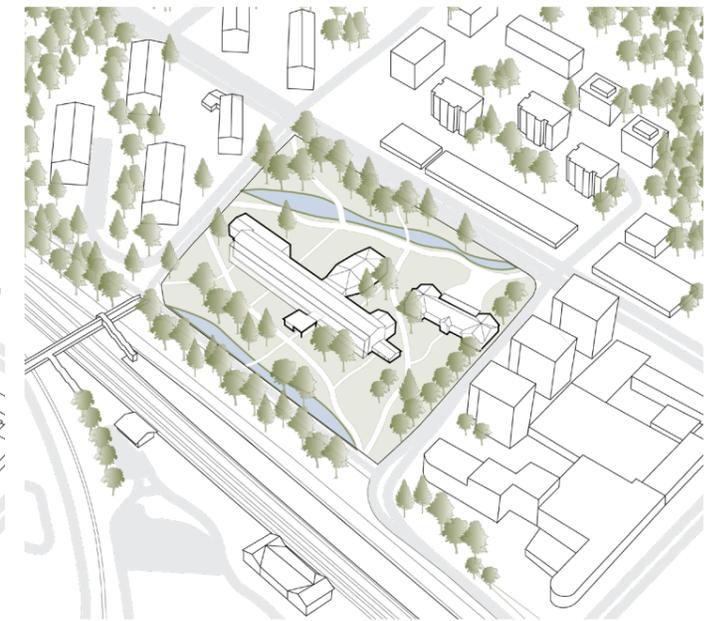
extended living spaces
A second skin of glazed balconies on the South-West facade provide versatile weather protected semi-outdoor space usable all throughout the year, reducing noise and heat transfer of the building envelope.



wind
The dominant wind direction in Hyvinkää, like most of Finland, is the South-West and West. Open terrace and plaza in front of the wooden building accommodate larger gatherings and public events.

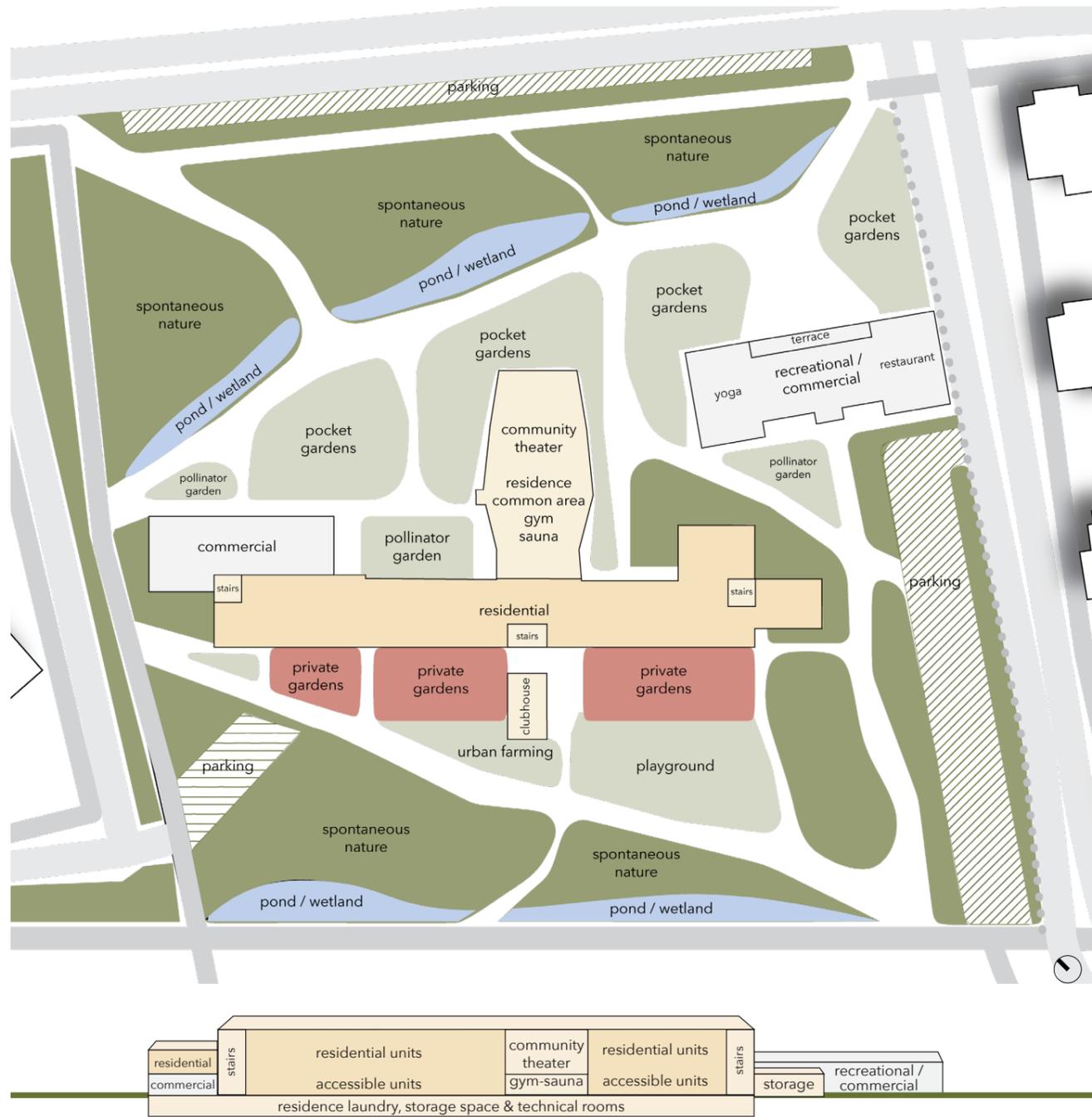


cross-ventilation
Maximise cross-ventilation possibilities to ensure high indoor air quality in the building units.



trees
Trees, a mix of evergreens and deciduous trees, are important to support the biodiversity, and a pleasant, healthy and resilient living environment.

06.2 Program



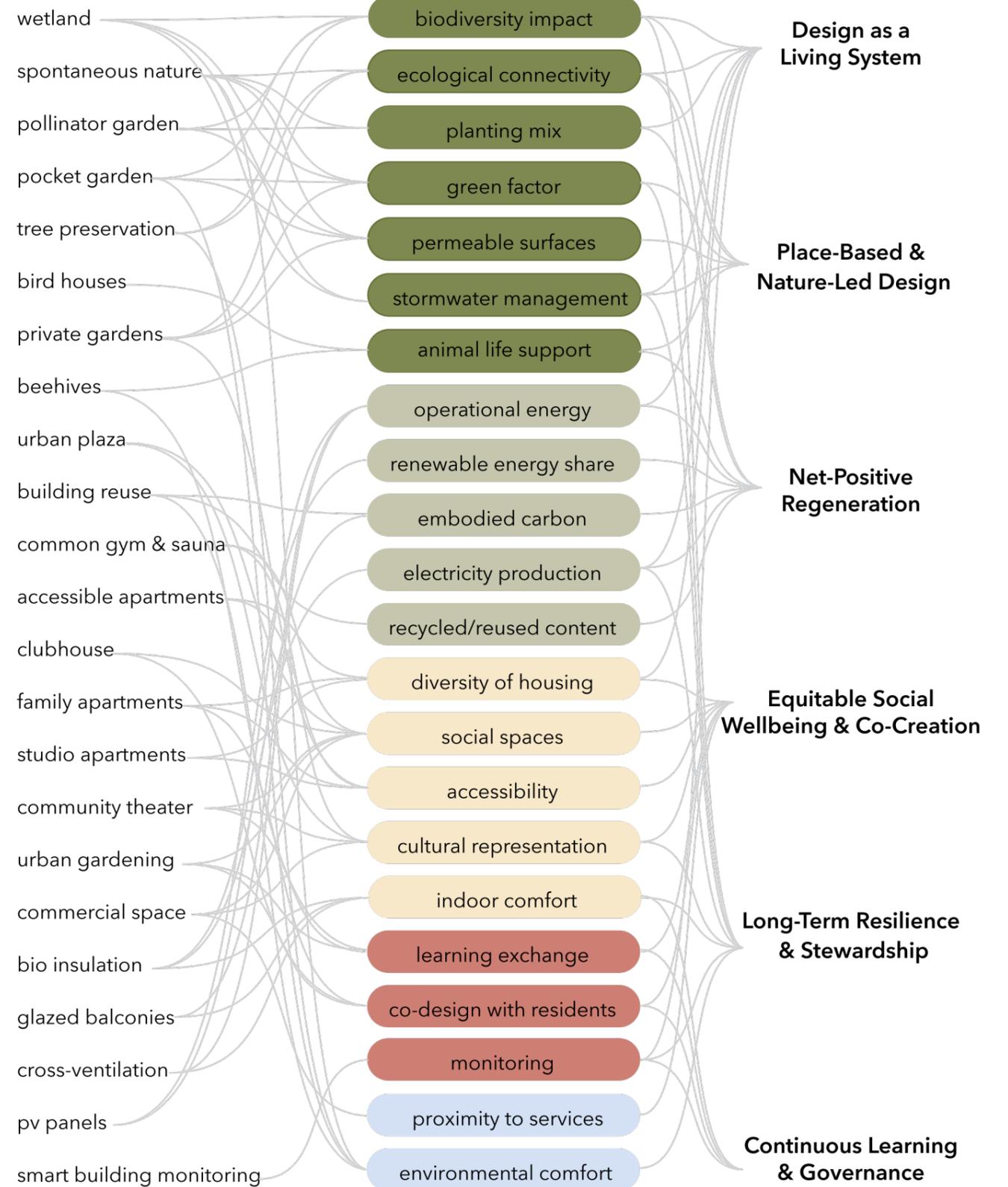
Planting Mix



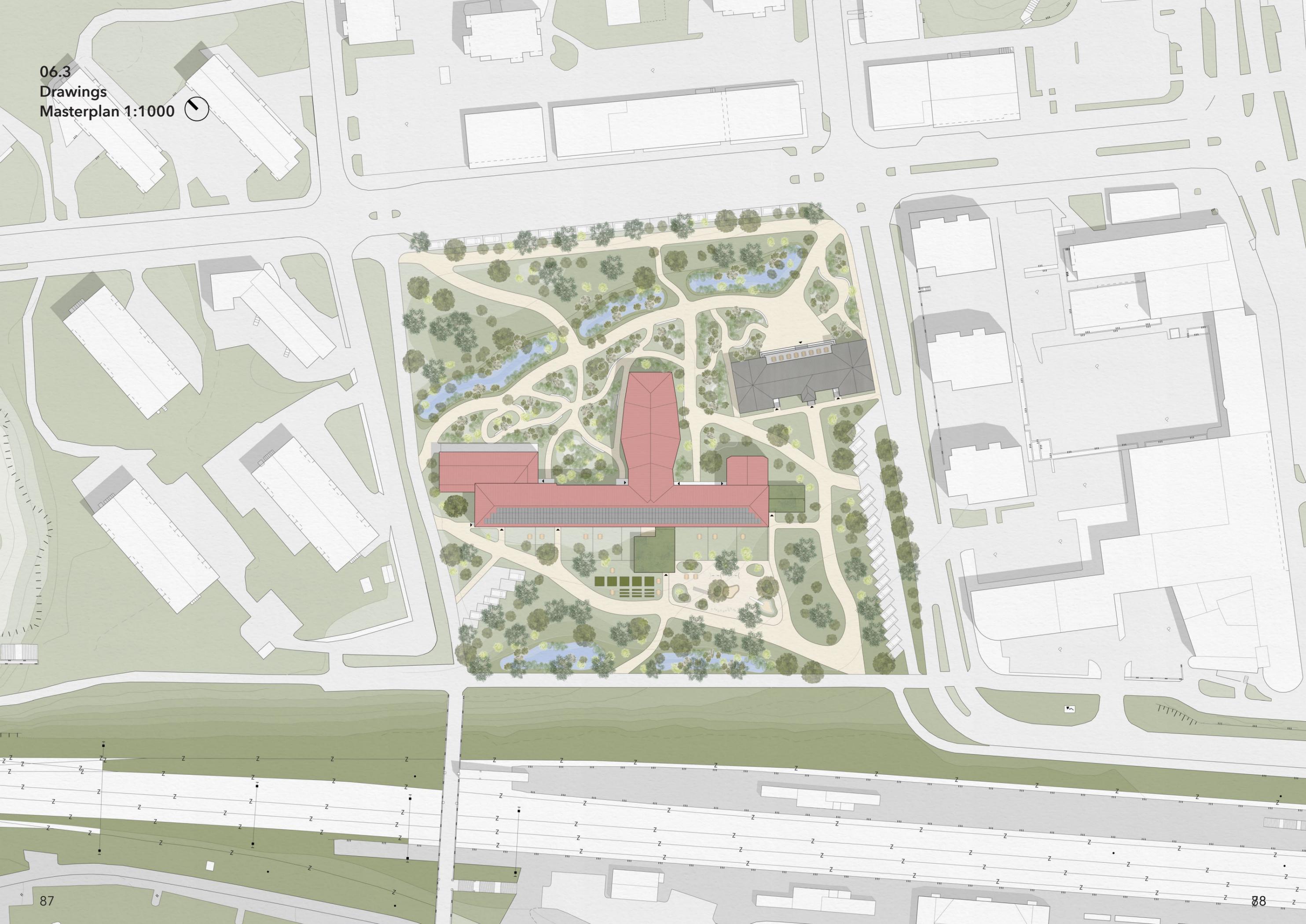
Medium

KPI

Regenerative Principle



06.3
Drawings
Masterplan 1:1000





new public space

The transformed site is a resilient mixed use living block and public park rich in biodiversity. A terrace and open space invite people for gathering in front of the wooden building. Small vegetation hills create pocket gardens for resting and relaxation.

Renders from Archicad 3D model have been enhanced with the use of Visoid AI tool.



climate resilience

Ponds and wetlands as nature-based solutions for stormwater management together with large permeable areas and semi permeable resin paving. Canopy trees offer shading from summer sun.

Renders from Archicad 3D model have been enhanced with the use of Visoid AI tool.



building extension

New second skin timber facade with glazed balconies as extended living space and climate control. Wood is left untreated to age naturally into a grey colour.

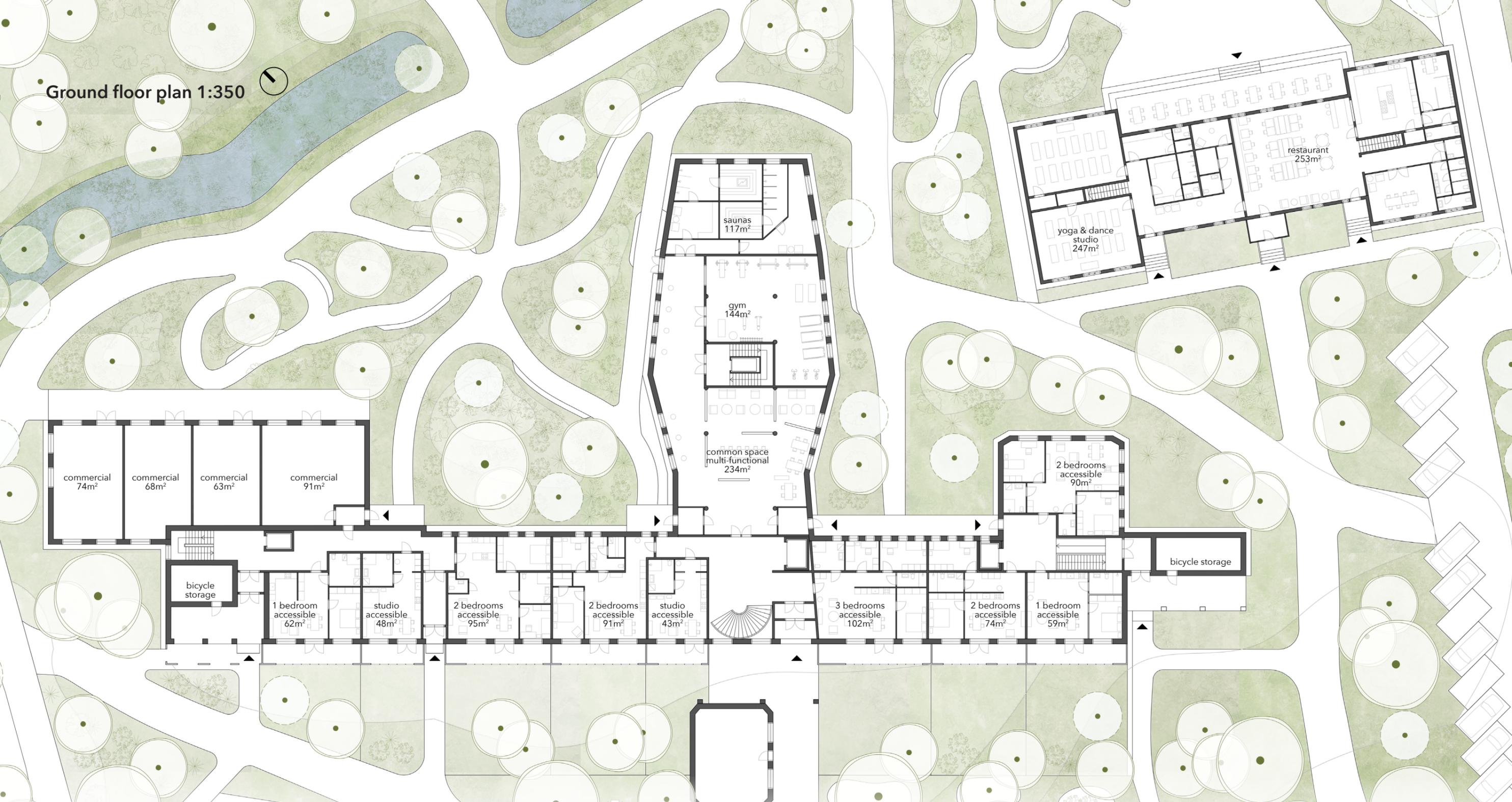


for the children

Playground on the residential side of the lot with natural wood chips surface and direct visibility from the apartments. Stringlights create a playful ambience, while the lightpoles offer visibility and safety.

Renders from Archicad 3D model have been enhanced with the use of Visoid AI tool.

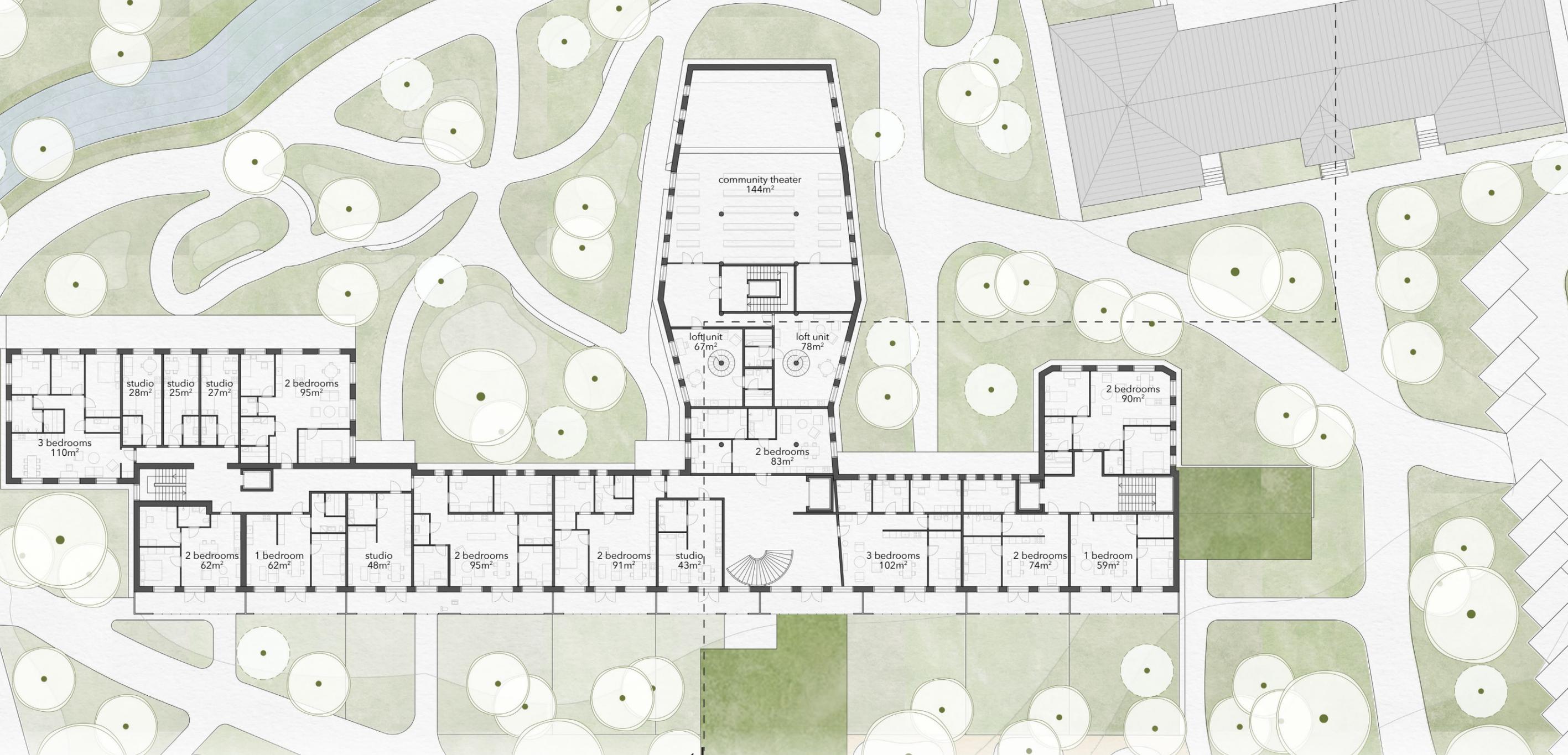
Ground floor plan 1:350



Elevation south-west 1:350

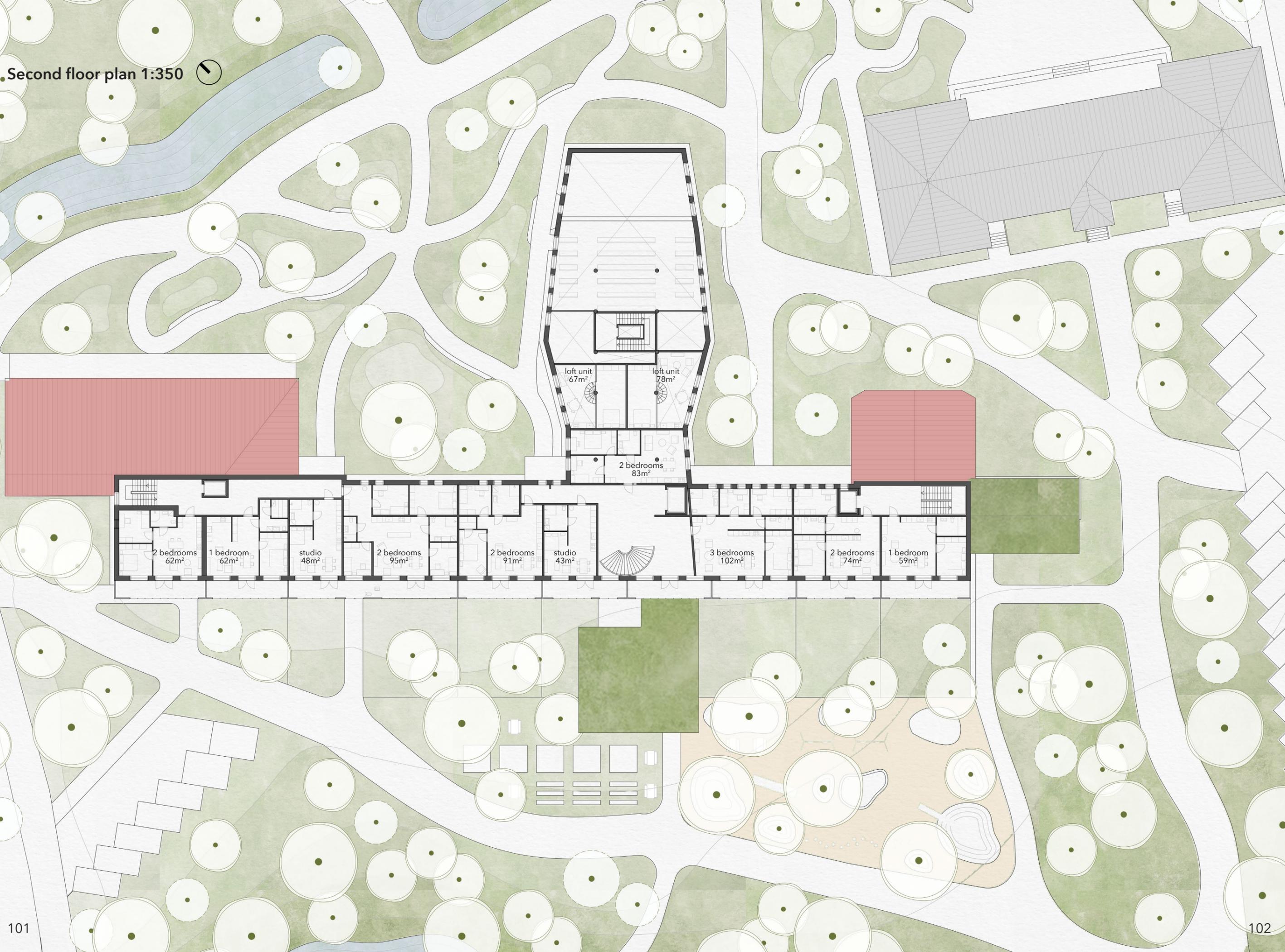


First floor plan 1:350



Section 1:350







residence common area (stone building)



yoga studio (wooden building)

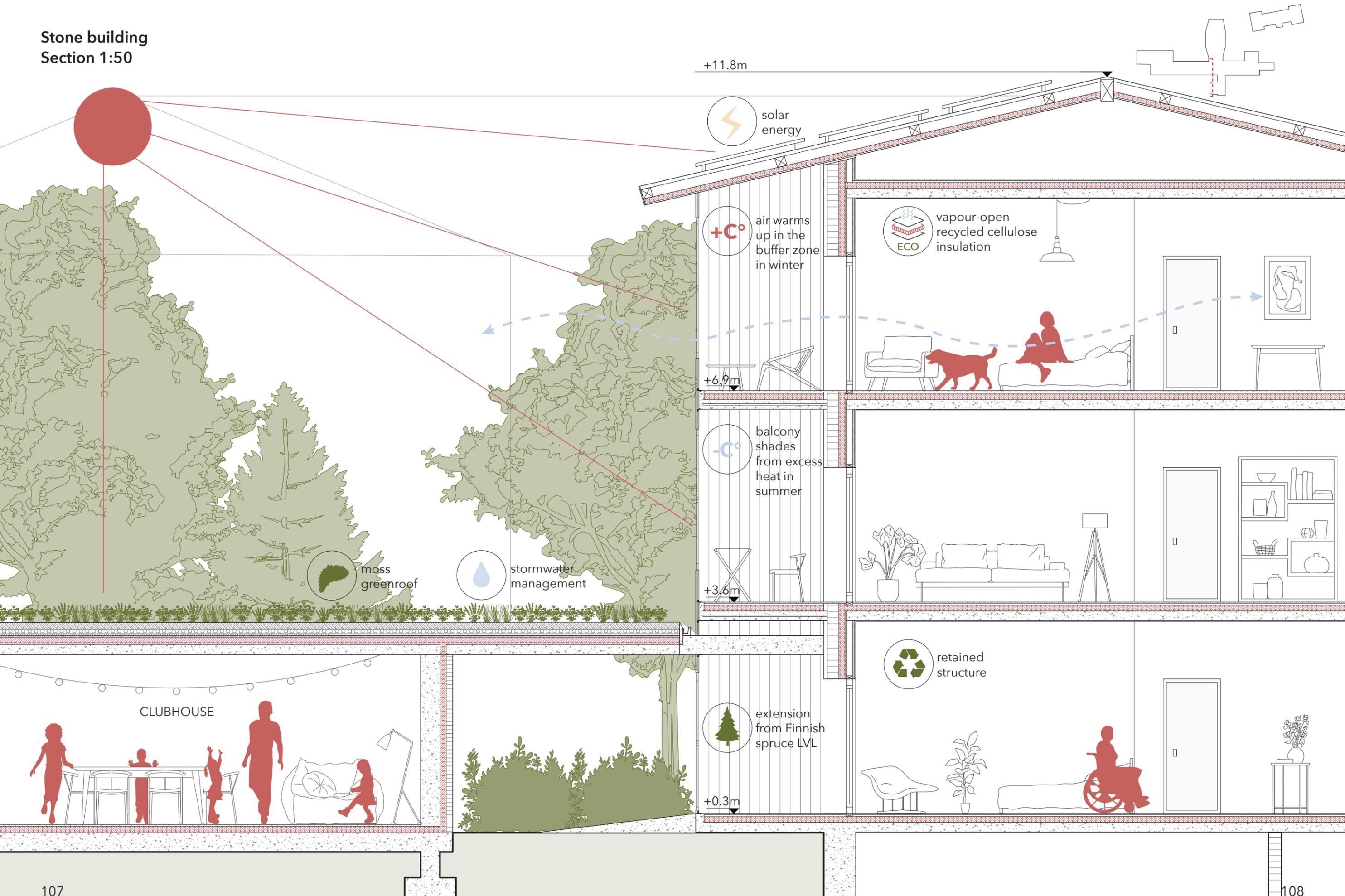


ground floor accessible apartment, living space

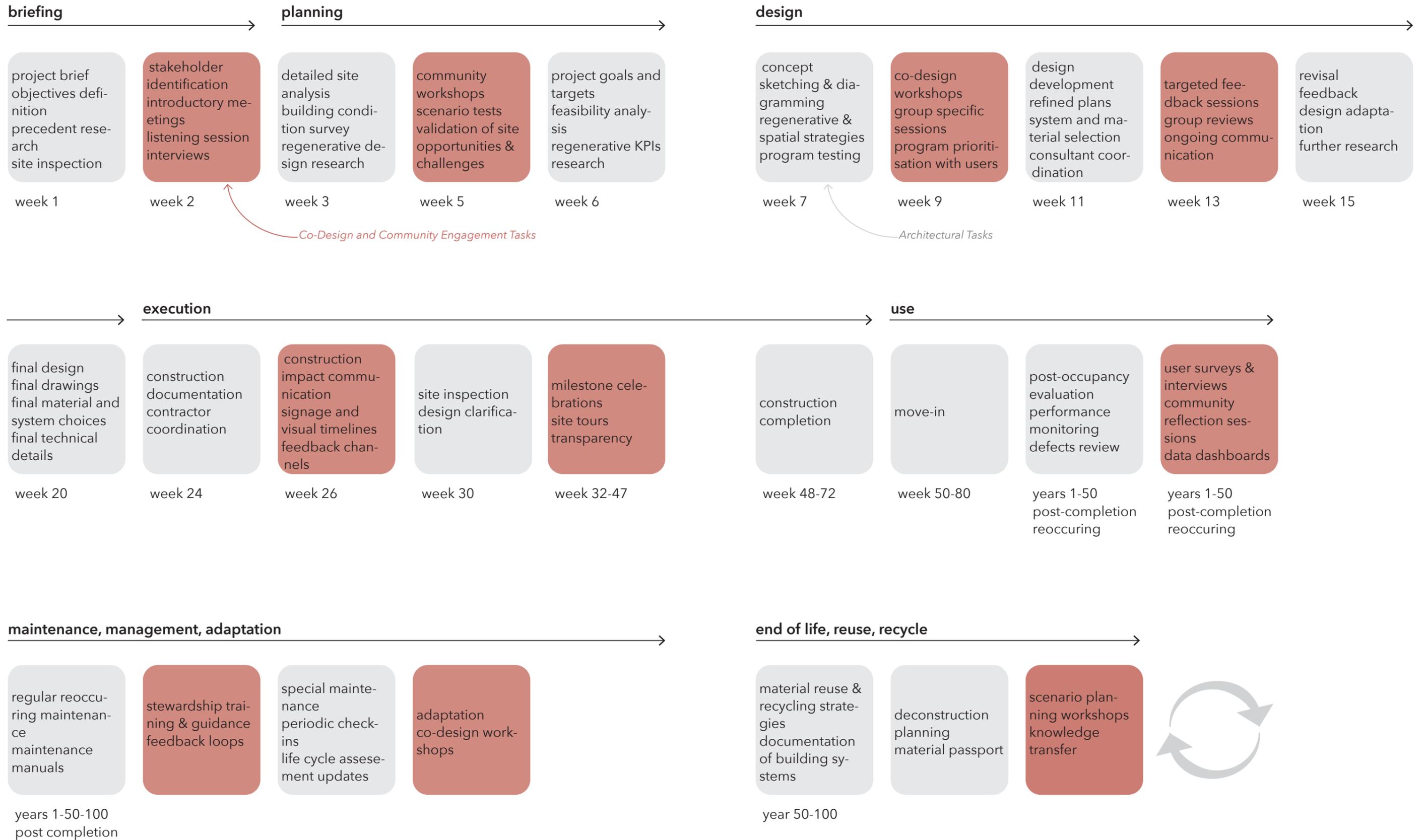


bedroom

Stone building
Section 1:50



06.4 Project Timeline with Co-Design and Community Engagement Tasks



07. Renovation Strategy

07.1 Renovation plan

This renovation and retrofit plan for the adaptive reuse of the two school buildings into residential and commercial spaces was compiled with the help of peer-reviewed research, Finnish and EU building regulations, and built case studies from similar climate contexts. Priorities for the renovation according to the regenerative design approach are whole-life carbon reduction, durability and moisture safe design, local and bio-based materials, as well as energy efficiency. The goal is to achieve net-zero energy building performance, and aim towards net-positivity. The project aligns with Finland's national carbon neutrality goals and the EU Energy Performance of Buildings Directive.

A building condition survey of the stone school was conducted by Sweco and Contesta in 2021 by the request of the city. This report together with the study "Renovate or replace? Consequential replacement LCA framework for buildings" (Huuhka, Moisio, Salmio, Köliö, & Lahdensivu, 2023) is used as a guideline to determine renovation needs and options for the building. The study researched whether it is more environmentally friendly in terms of CO2 emissions to renovate an existing building or to replace, demonstrating that in Finland renovation is a more climate-friendly alternative to demolition and new build. The stone school building of the project is the same 1950s building typology as one of the case study buildings used in the study by Huuhka et al. (2023), which showed extremely useful in determining to favour saving and renovating the building in support of regenerative design strategies, instead of proposing a demolition.

The building condition survey (Sweco & Contesta, 2021) shows that the stone building is structurally sound and generally dry. The conducted tests showed no major frost damage on the

facades, the structure's old bitumen waterproofing is still performing well and should have up to 100 years' lifespan, underground structures should have 50 years if surface water management is improved. The most critical renovation needs include facade plaster repairment, replacement of old windows, removal of old oil tank and odor-emitting floor layers, implementing a new ventilation system, repairing/replacing old sheet metal roofs as needed, and most importantly safely removing asbestos-containing materials.

The wooden school building from 1910s represents a collection of similar buildings of the era that intersect with social history and timber construction culture. Many these types of buildings are facing demolition due to perceived energy inefficiency and outmoded functionality. Research and built precedents luckily increasingly demonstrate the environmental and cultural superiority of adaptive reuse compared to replacement. The early 20th-century Finnish wooden public buildings typically rely on vapour-open log construction, natural ventilation, and seasonal drying. The renovation and conservation must preserve these mechanisms in order to avoid moisture damage (Viitanen et al., 2010).

Retaining the structures is a climate action.

Reusing the primary parts of the buildings saves enormously the carbon footprint of the project, as the embodied-carbon has already been paid.

Moisture safe design equals longevity. In cold climates, interior insulation of masonry buildings introduces moisture risks. Insulation needs to be vapour-open and capillary-active to prevent condensation build up. Recycled cellulose insulation was chosen as it is locally sourced, natural, and widely used in Finland, has a low embodied carbon, is breathable, fire and mould resistant, plastic free, and compatible with smart membranes.

Table 07.1.
Stone building renovation

Building part	Current condition	Renovation	Building part	Current condition	Renovation
Frame Exterior walls	Brick with plaster on top.	Target U-value: $\sim 0.25 \text{ W/m}^2\text{K}$ Wall build-up: 1. interior finish (gypsum/clay board) 2. service cavity 3. smart vapour membrane 4. timber stud frame 5. recycled cellulose insulation 6. existing brick 7. exterior plaster, repaired or replaced	Partition walls	Wood-framed and brick partition walls.	Retain brick partition walls and add new wood-framed partition walls as internal layout changes.
Roof Ceiling	Metal sheet roof. Wooden ceiling structures. Double-plate reinforced concrete slab with sawdust insulation in between.	Target U-value $\sim 0.09 \text{ W/m}^2\text{K}$ Metal roofing renewed completely. Install a continuous airtightness layer on the interior side, add safety equipments on roof. Retain existing timber structure and sawdust insulation where dry. Add supplementary cellulose (or wood fibre) insulation below the ceiling. On the roofs of the single story wings of the building (main and side entrance), an extensive moss green roof is added. Renewed roof rainwater gutters and downspouts. Include water storage tanks.	Ventilation	Natural ventilation.	Mechanical ventilation with heat recovery (MVHR). Heat recovery efficiency $\geq 75\%$. Demand-controlled airflow based on CO_2 and humidity. According to studies MVHR is essential in a Nordic context as heat losses dominate operational energy use (Hasan et al., 2022).
Intermediate floors	Double-plate reinforced concrete slabs with insulation.	Retain floor structures. Upgrade airborne and impact sound insulation to residential standards where necessary.	Heating	Central heating. Old oil tank that causes odor.	Remove oil tank A hierarchical approach: 1. reduce heating demand by reducing thermal transmittance of envelope 2. implement low-temperature heat distribution 3. supply remaining demand from renewable sources Ground-source heat pump, with district backup.
Ground-contact elements	Slabs: Concrete. Walls: Concrete, mineral wool and calcium silicate bricks insulation on the inside.	Remove odour causing floor layers Add insulation above the floor slab. Calcium silicate bricks of walls retained due to their capillary active moisture buffering. Improve airtightness at floor-wall junctions.	Electricity production	n/a	Rooftop photovoltaic system Remaining electricity demand from renewable sources through the grid. Currently full positive energy balance for a multi-storey building in Finland is challenging, but operational carbon and net-positive trajectories are achievable (Hasan et al., 2022).
Windows Doors Balconies	Wooden frame windows, single and double glazed. Wooden frame doors Reinforced concrete slab and steel parapet.	Windows target U-value $\sim 0.7 \text{ W/m}^2\text{K}$. New triple-glazed windows (timber or timber-aluminium frame). Target airtightness: $n_{50} \leq 1.0 \text{ 1/h}$. Install airtight tapes to interior. Doors typical for new construction. Damaged and unsafe balconies removed.	Interiors		Fully renewed for new functions, important design details restored
			New second-skin timber facade with glazed balconies		Added to the south-west facing long facade. Constructed from locally sourced Finnish spruce in the form of glulam or LVL, will age grey. The skin provides seasonal thermal buffering, passive solar gains, wind protection, increased multi-use living space, and long-term biogenic carbon storage. Timber extension have been shown to significantly reduce whole-life carbon compared to steel or concrete alternatives (Huuhka et al., 2023).

Table 07.2.
Wood building renovation

Building part	Current condition	Renovation
Frame Exterior walls	Log wall.	U-value $\sim 0.65 \text{ W/m}^2\text{K}$ Retain log walls, no interior vapour barrier. A thin interior service layer of wood fibre boards may be added where necessary.
Roof Ceiling	Wood frame. Sand and peat insulation Attic is a cold and ventilated space.	Target U-value $\sim 0.10 \text{ W/m}^2\text{K}$ Retain frame. Replace insulation with blown-in recycled cellulose. Maintain attic. Renewed roof rainwater gutters and downspouts. Include water storage tanks.
Ground-contact elements	Concrete.	Maintain and repair existing. Improve water direction from roof to soil.
Windows Doors	Wood frame windows.	Windows target U-value $\sim 0.7 \text{ W/m}^2\text{K}$. New triple-glazed windows (timber frame of original style). Target airtightness: $n_{50} \sim 2.5 \text{ l/h}$. Doors restored if possible or replaced with typical doors for new construction, in original style.
Partition walls	Wood-framed.	New wood-framed partition walls.
Ventilation	Natural, gravity-based system.	Hybrid system, restore gravity ventilation shafts with demand-controlled mechanical exhaust and localised heat recovery where required by new commercial functions. This preserves the drying potential.
Heating Cooling	Central heating. Passive cooling.	Hydronic heating system, ground-source or air-to-water heat pump. Low structural impact Cooling remains passive, condensation-safe, and appropriate for the climate.
Fire safety	n/a	Compartmentation. Fire-retardant-treated cellulose insulation. Sprinklers where necessary.

07.2 Limitations and Uncertainties

Despite the comprehensive building condition survey (Sweco & Contesta, 2021), and the presented analysis on the building, limitations and uncertainties remain. The exact composition and condition of insulation layers within the existing double-plate floor slabs are unknown. Their material type and degradation state could influence the refurbishment decisions, but it is assumed that these insulation layers are mainly acoustic than thermal. For precise material identification, further investigations would be required.

Workmanship quality plays an important role in the renovation. Especially the hygrothermal performance of interior insulation systems applied to historic masonry walls is sensitive to installation work quality, indoor humidity levels, and external climate exposure. The capillary-active assemblies were selected based on established research in Nordic context and Finland. Although they are vapour-open, the long-term performance cannot be guaranteed without specific hygrothermal simulation of the project. Simulation tools exist that can understand the moisture conditions and the effects of humidity in the building, such as WUFI. Due to the resource limitations of this thesis, such a simulation was not executed.

Similarly for the wooden building, limitations and uncertainties remain. Significant variability in construction quality, log dimensions, material properties, and later modifications are found in these early 20th-century wooden buildings. Unfortunately a building condition survey has not been conducted for the project wooden building, and thus information on its condition and material properties and remarkably less comprehensive than those for the stone building. As a result, the presented thermal and moisture performance values should be understood as indicative rather than absolute.

While Finnish restoration precedents provided valuable guidance for the renovation of the wooden building, no two buildings share identical conditions. Direct transferability of solutions is limited due to differences in location, microclimate, use, and maintenance regimes.

User behaviour and renewable energy yields have a great influence on the energy balance assumptions for net-positive operation. Variations in ventilation rates and electrical demands may affect the actual operational performance of the building, as does occupant behaviour which is perhaps the most unpredictable.

Life-cycle carbon assessments are dependent on system boundaries, data sources, and assumptions regarding service life and end-of-life scenarios. Even though the renovation strategy follows Finnish guidance and the European standard for LCA (Life Cycle Assessment, EN 15978), different methodological choices could lead to variation in absolute carbon values. The relative comparisons between renovation and replacement still remain strong. During later project stages, regulatory interpretations regarding e.g. fire safety and acoustic performance of retained structures could influence design solutions and material specifications.

Understanding the limitations is to understand areas where detailed design, monitoring, and adaptive management are required to ensure long-term performance. This does not undermine the previously presented renovation plan.

08.

Regenerative Value

08.1 Evaluation Method

To assess and evaluate the overall 'regenerative value' and impact of a design project, a radar diagram was developed to be used. For this evaluation, it is required to select the ~ 15-25 most appropriate and critical KPIs for the specific project, whether evaluating an existing project, or one in process. For the one in process, the KPIs are to be identified and selected and the start of design, as key guiding principles. The diagram shows the regenerative value in percentage terms, using a series of concentric circles that indicate levels of progress relative to a reference scale. From 0% to 100% we move from conventional approach at 0%, to green, sustainable, restorative, reconciliatory and to regenerative at 90%. This represents the theoretical maximum threshold currently achievable, recognising that the full regeneration of natural systems by architectural and urban design is still unfeasible in practice.

The evaluation radar is a simplified proposal for analysing and measuring the regenerativity of existing and new projects, based on the KPIs presented in chapter 3. In a real life application, the values require project realisation, technical measurements and calculations, post-project evaluations, surveying, mapping, remote sensing, simulation tools, interviews, and so forth. Due to the limitness of this thesis project and the impossibility to execute post-project evaluations, some of the values have been estimated based on a hypothetical situation.

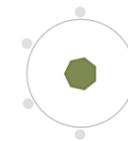
Where possible, the regenerative score of a KPI was correctly calculated or measured with the indicated tool. These results are indicative of the projects 'regenerativity'. It is important to note how the specific chosen KPIs for the project affect the overall regenerative value. As the project tackles many aspects concerning the nature layer, as well as the circularity and emissions layer, around half KPIs are from these layers. This yields a more favourable end result. It is important to acknowledge that too 'well' or narrowly chosen KPIs could influence a sort of false representation of the projects regenerativity.

Each axis of the diagram represents a KPI, 20 the most appropriate and critical for the project were chosen. The analysis of the individual vertices highlights the strengths and weaknesses of the analysed project, while the overall area of the resulting polygon provides a summary measure of the project's impact. Later the value calculation or estimation method is explained shortly for each KPI.

Future developments could strengthen this framework, to validate and expand the conceptual foundations outlined here. While many evaluation tools for the presented KPIs already exists, their cohesive and extensive use still proves to be a challenging task for many practitioners and firms, due to lack of time, money and resources.



IDEAL REGENERATIVE PROFILE
(MAXIMUM SCORE)



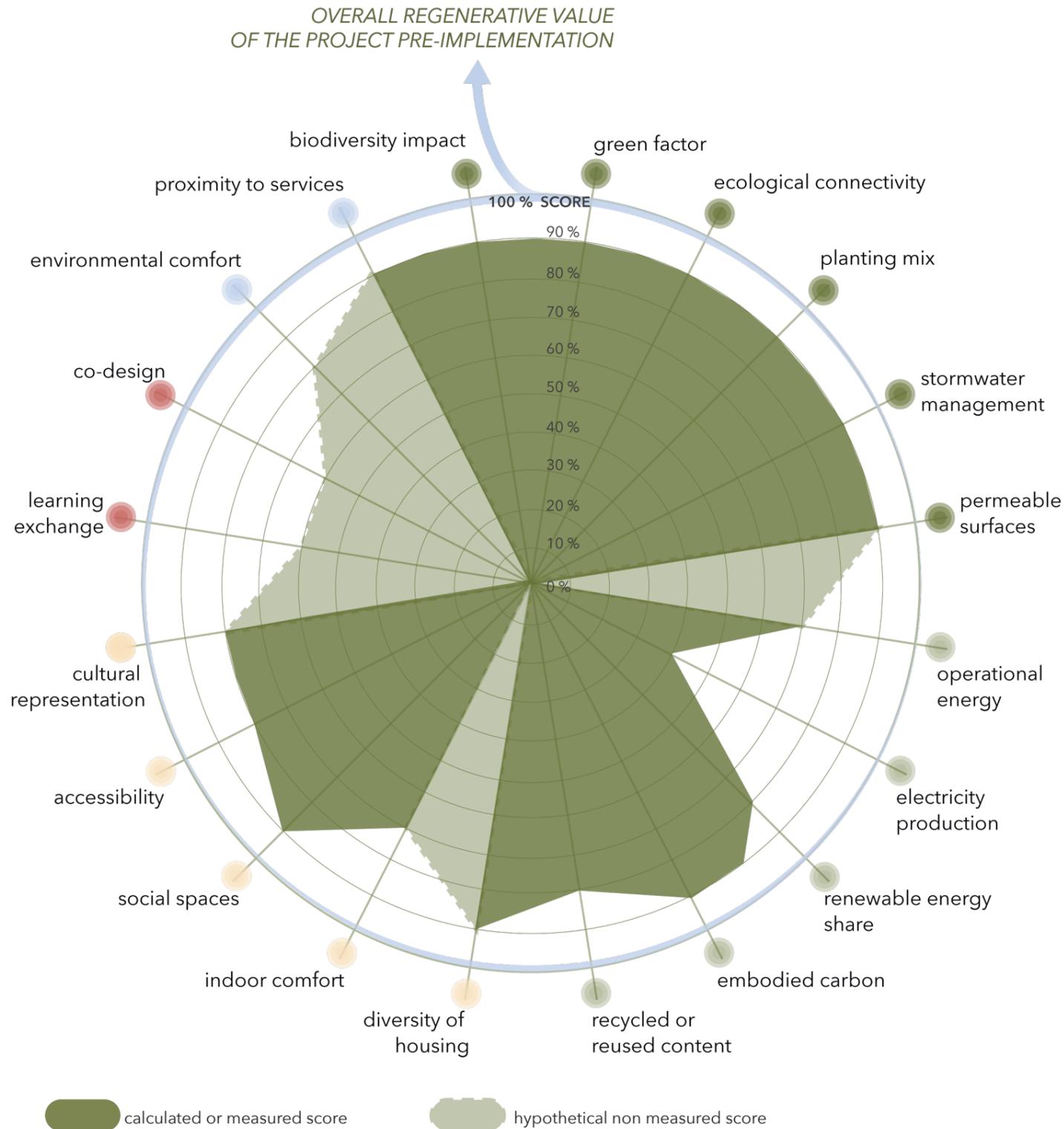
NON-REGENERATIVE PROFILE
(MINIMUM SCORE)



POSSIBLE
REAL-WORLD PROFILE

Figure 08.1. Regenerative value radar profiles

08.2 Project Evaluation



Note: 90% is used as the theoretical maximum in this evaluation as the projects development and effects after implementation cannot be measured. Most real regenerative effects require years of time.

Figure 08.2. Hyvin Block project regenerative value radar

KPI

calculation / estimation

biodiversity impact	The real impact cannot be measured before project completion and monitoring over time. The biodiversity score of the project plan can be measured with e.g. the Finnish Nature Calculator 'Luontolaskuri' tool: Biodiversity score = 15 points (> 10 regenerative threshold). Regenerative score = 90%
green factor	Green Factor is calculated with the Finnish 'Viherkerroin' spreadsheet tool: GF = 1.79 > 0.9 (regenerative threshold). This measures the green areas and stormwater management possibility of the site. Regenerative score = 90%
ecological connectivity	Ecological Connectivity is calculated through the Effective Mesh: $M_{eff} =$ (> 0.35 regenerative threshold for urban blocks/city parks). Regenerative score = 90%
planting mix	Planting scheme complies with stratification and functional diversity standards, vegetation will continue to evolve and grow naturally. Mix: 40% herbaceous plants, 20% shrubs, 20% grasses & sedges, 10% small trees, 10% canopy trees. Regenerative score = 90%
stormwater management	Peak Run Off Rate Reduction is calculated: Pre-development runoff coefficient $C=0.60$ and Peak Runoff $\sim 0.0092\text{m}^3/\text{s}$, Post-development runoff coefficient $C=0.20$ (≤ 0.25 regenerative threshold), and Peak Runoff $\sim 0.0031\text{m}^3/\text{s}$. Reduction = 67% (> 60% regenerative threshold). Regenerative score = 90%
permeable surfaces	Share of permeable surfaces in the project: $A_{permeable}/A_{total} = 12940\text{ m}^2 / 17930\text{ m}^2 = 72\%$ (> 60% regenerative threshold). Regenerative score = 90%
operational energy	Building should consume a maximum 30 kWh/m ² /year (energy class A requirement, regenerative threshold). An energy simulation was not in the resources and scope of this thesis. Hypothetical regenerative score = 70%
electricity production	300 PV panels on 595m ² roof facing south-west, would produce estimately 105 000 kWh/year. Operational energy demand if it was a class A building would be $\sim 237\ 000\text{ kWh/year}$. = $\sim 44\%$ of building energy need is met. (Regenerative threshold: energy production \geq energy consumption / 100% of building need is met). Regenerative score = 40%

KPI

calculation / estimation

renewable energy share

44% of energy is self-produced by PV panels, the rest is provided by the grid, most of it available from renewable sources. In Finland, estimatedly 19% of energy is from hydro power and 18% from wind power (Statistics Finland, 2024). Building share owners should be enforced to make green electricity contracts for their units.
Regenerative score = 80%

embodied carbon

Embodied carbon of the retained structures and building envelopes is counted as 0 kgCO₂/m²/year. The EC of new materials and elements has not been calculated, but can be done by EDPs and a LCA. ≤ 250 kgCO₂/m²/year (regenerative threshold).
Regenerative score = 90%

recycled/reused content

Structure and building envelopes are 100% reused. Windows and roofs are new, while some retrofitting materials are recycled materials such as recycled cellulose insulation. Interior finishes and technical systems are mostly new. Regenerative score = 80%

diversity of housing

6 unit typologies (> 4 regenerative threshold). Goal is to allow zoning for adaptivity and alternative models, eg. co-living.
Regenerative score = 90%

indoor comfort

Calculated values:
DF 2-5% depending on space use ≥ regenerative threshold
-0.5 ≤ PMV ≤ 0.5 ; PPD ≥ 10% ≥ regenerative threshold
Other thresholds, not measured for project:
CO₂ ≤ 800ppm
Noise ≤ 55 - 60 dB (A)
Indoor air temperature ~12-24C°
≥ 70% report positive perception
Hypothetical regenerative score = 70%

social spaces

~ 10 social space nodes in total, total area = 2.1188 ha.
= ~ 5 nodes / hectare of project area ≥ 3-6 (regenerative threshold).
Unable to measure the use intensity of the spaces.
Regenerative score = 90%

accessibility

100% of key routes accessible = regenerative threshold
~ 50% of site accessible < 80% (regenerative threshold)
9 accessible living units in a apartment building > 2 (regenerative threshold).
Regenerative score = 80%

KPI

calculation / estimation

cultural representation

The restoration and renovation of two culture-historically significant buildings from two different eras is a strong act to support cultural representation of the site. The buildings themselves are symbols of the past and elements inside such as the mural in the stone building enforce the cultural identity. The new proposed activities aim to enhance the representation of local culture, such as saunas and urban garden.
Regenerative score = 80%

co-design

Unable to measure without realisation. Goal is ≥ 6 co-learning sessions / year. A strategy and timeline for co-design and community engagement tasks has been produced.
Hypothetical regenerative score = 60%

learning exchange

Unable to measure without realisation. Goal is ≥ 15-25% of residents engaged in ≥ 3 participatory moments.
Hypothetical regenerative score = 60%

environmental comfort

Unable to measure without realisation. Goal is that ≥ 70% of users report positive perception across comfort parameters. Predicted Mean Vote and Predicted Percentage of Dissatisfaction should be: -0.5 ≤ PMV ≤ 0.5 & PPD ≥ 10%.
Hypothetical regenerative score = 80%

proximity to services

0-5 minutes walking to essential services and public transportation stops ≤ 5-7 (regenerative threshold).
Regenerative score = 90%

08.3 Additional insights

The presented and evaluated KPIs are the ones the project tackled with primarily. KPIs such as air quality or Urban Heat Island are extremely important from the perspective of user comfort, climate emergency and the health of the planet. In the case of Hyvin Block, these KPIs were not chosen as the critical ones nor measured as the existing condition of the site and city is already good for these indicators, and it is not possible to measure the effects of the project without realisation.

The air quality in Hyvinkää is mostly good, meaning that pollutant levels are low and pose minor to no risk for most people (AQL.in, 2026). Air quality in the Uusimaa region, which Hyvinkää is a part of, has occasional local variations due to traffic emissions and residential wood burning (Helsingin seudun ympäristö palvelut, 2025). The city of Hyvinkää will implement a mobile monitoring station in the city centre in 2027, to monitor realtime air quality in busy traffic environments (Hyvinkään kaupunki, 2023). Nonetheless, the design project includes the primary strategies to improve air quality, such as enhancing green infrastructure, reducing carbon emissions and favouring reuse and recycling, renewable energy sources. From this perspective, it can be stated that the project would most likely have a positive effect on the air quality of the neighbourhood.

No studies or official statements have been made that Hyvinkää would suffer from critical UHI. The city is very green and with dominantly low buildings, the risk of the centre area being noticeably warmer on hot days is smaller than in larger Finnish cities. Hyvinkää city's climate risk analysis and adaptation planning do acknowledge the need to consider climate change impacts, including heat stress and UHI, in urban planning strategies (Hyvinkään kaupunki, 2024). The project includes strategies to tackle UHI such as tree canopies and maximised urban vegetation, and light coloured building materials.

Measuring the KPIs concerning the economic-financial wellbeing and equity of the society was not unfortunately a part of the thesis scope or resources. In architecture studies, we generally might not talk so much about how we can have an impact on housing prices, which are driven by demand (demographics, household preferences, financing conditions) and supply (construction activity, zoning and building regulations, labour, competition, etc.) (Lindblad, Sariola, & Viertola, 2019). Nevertheless, our design practice can influence the affordability of housing. Key ways architects can lower housing costs include design efficiency, standardisation and modularity, and choosing cost-effective and durable materials. Additionally aspects such as optimising density and land use, and designing for adaptation, play important roles, as well as collaborating with municipalities and developers to promote inclusivity and affordability. (Aravena & Iacobelli, 2016; World Bank, 2019; UN-habitat, 2020). In good design practice the key, and challenge, is to balance the economic benefits with the social and environmental ones.

09. Conclusion



A paradigm shift beyond conventional sustainability practices is necessitated by the urgent planetary crisis: climate change, biodiversity loss, and pollution. With the construction sector responsible for over 35% of waste generation in the EU, and accounting for around 50% of all extracted materials, doing less harm is not enough. While traditional approaches tend to focus on mitigation and minimising negative impacts, they are insufficient to address the extensive environmental damage that has already been caused. With the aim to actively repair past environmental damage, support ecological restoration, and co-evolutionary systems, this thesis advocates the regenerative design approach. Approach that promotes net-positive impacts across ecological, social, and economic layers. To ensure a healthy and liveable planet for future generations amidst a growing population projected to reach 9.9 billion by 2050 (Population Reference Bureau, 2020).

The research establishes a theoretical foundation rooted in the paradigm shift from sustainability and the efficiency paradigm, to a regenerative one that integrates natural and human living systems. The regenerative design approach presented here provides a comprehensive guide for architecture and urban planning. Integrating whole-systems thinking, ecological design, living systems theory, and circular economy principles, it draws from extensive research on theory, studies and real life applications. The approach acknowledges the complex interrelationships between place, community, watershed, and bioregion. Highlighted is also the fundamental shift in thinking and working we architects need to do. Transdisciplinary teams are the key to completely meet regenerative standards, together with collaboration and constant learning while giving the platform for feedback. Regenerative design encompasses a desire to design better,

to truly contribute and create meaningful value for the people, the communities, and the environment.

To translate the concepts and principles into tangible and actionable practice, the thesis identifies five interconnected layers of regenerative: Nature, Circularity & Emissions, Society, Co-Design, and Urban Context. The compiled Key Performance Indicators across the five layers are a crucial output of the developed framework. For each KPI, a set of measurement and analysis tools, a regenerative threshold, and application strategies were presented. The goal of the KPIs is to translate broad regenerative goals into measurable, performance-based outcomes and aid in evaluating a project's true, long-term, regenerative potential.

The analysed six case studies from Europe, primarily from the Nordic, illustrate diverse strategies and practical design applications for buildings and landscapes. Essential regenerative design benefits that these projects demonstrate include significant reductions in CO₂ emissions, promoting circular material flows, enhancing biodiversity, managing stormwater, and fostering community engagement. Projects like Grønnings-Bispeparken and The Opera Park highlight the critical role of integrating biodiversity and nature-based solutions for water management in urban design. Thoravej 29 and Resource Rows exemplify the potential of existing buildings and waste as valuable material resources, to promote circularity and lower emissions and waste. The Helsinki Bricklayer and Corkhouse projects give insights into traditional and innovative material use. The former utilises solid brick construction with passive design strategies to achieve energy efficiency. The latter achieves carbon-negativity through the use of expanded cork waste as the main construction material and a design-for-

disassembly strategy, emphasising the importance of whole-life thinking. These case studies highlight that strategies must be adapted to local cultural and climatic contexts.

The theoretical framework, identified principles and case study learning were practically applied in the Hyvin Block project in Hyvinkää, Finland. Hyvin Block, a place where wellbeing becomes a way of life. This project reimagines an existing site and two school buildings as a flourishing park and resilient mixed-use living block. The design prioritises adaptive reuse over demolition, nature as a resource, designing for all life, and promoting wellbeing and health. The design solutions applied in the project are based on the extensive research, and the most appropriate strategies and tactics for this specific context were used. Evidently, the project does not concern all the more than 50 identified KPIs, and that is not the aim of the KPI toolbox, but it chooses around 20 KPIs as the primary targets, given the scale and programmatic focus. Important is that a project tackles issues and opportunities across the layers of regenerative design, and works in a holistic and systematic way.

To assess the impact of such a project, regenerative value evaluation tools and a radar chart was developed. This chart utilises the selected KPIs to visualise the progress towards regenerative thresholds, across layers.

The Hyvin Block project somewhat succeeds to reach towards regenerative principles and receives good scores in the regenerative evaluation. It is good to recall the limitations of this thesis in measuring long-term regenerative impact. The real regenerative impact of the Hyvin Block cannot be empirically validated without project implementation, construction, and post-occupancy evaluation. Additionally it is good to note

the nature of the project to understand why some of the calculated regenerative scores are actually good, and thus the applied strategies do reach towards regenerativity. Reusing existing buildings eliminates one of the primary issues with environmental friendly construction: embodied carbon and energy. Focusing also on the design of a lush park aids to meet many of the regenerative thresholds for the nature layer. Another type of architectural or urban design project, a new residential building or for example a mobility infrastructure, would have a bigger challenge to meet regenerative standards. Nevertheless, the design project demonstrates that by integrating systems thinking, circular material flows, and a deep commitment to the more-than-human world, we can transform existing urban environment into thriving, life-enhancing places, that can support regeneration.

In essence, the thesis underscores the critical necessity to move beyond sustainability towards regenerative design. Architecture needs to be broadly redefined as a practice that actively contributes to the health of both human and natural systems, striving for net-positive outcomes across the board. Hopefully this work serves as an inspiration for students and practitioners alike, and provides some guidance into the complex topic of regenerative design. With continuous learning and development, transdisciplinary collaboration, and a concern and sympathy towards the more-than-human world, we can advance towards a truly regenerative future for all. How we design and construct has a large impact on the wellbeing of humans on this planet, in their cities and communities, inside their own homes, and it is important that when we build new or transform existing, we ensure the planet stays viable for generations to come.

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