PILOT PROJECTS FOR SUSTAINABLE ARCHITECTURE

CIRCULATION OF MATERIALS, COOPERATION, SPACE FOR NATURE AND THE HOLISTIC CITY

AARHUS SCHOOL OF ARCHITECTURE

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FOREWORD

In 2020, the Danish Parliament approved a special research grant of two million kroner for the Aarhus School of Architecture dedicated to pilot projects on sustainable architecture aimed at promoting the green transition. In an initial application process at the school, the grant was allocated to five projects selected by a broad committee based on sustainability, cooperation and future perspectives, among other criteria. Two additional submitted projects that were characterized by a particularly artistic approach received financing from a separate fund at the school dedicated to artistic development work.

All the projects were initiated in early spring of 2020, but because they involved both interdisciplinary collaboration and physical trials and experiments, several of them suffered significant delays or limitations as a result of the COVID-19 lockdown in 2020. Thus, when the Aarhus School of Architecture received another special grant of two million kroner for the same purpose in 2021, it was decided to increase funding to all the projects to enable the inclusion of additional elements and thus generate more results. Part of the 2021 grant was allocated to the dissemination of preliminary results through the present publication.

Architecture and the green transition

The seven selected projects address sustainability in different ways and thus illustrate that there are many different architectural approaches to the challenges described in the United Nations' 17 Sustainable Development Goals (SDGs) and other contexts. Architectural research addresses our physical environment on every level, from the global scale to the smallest detail. Its scope is not limited to physical and technical manifestations but also includes the behaviour and interfaces that the architecture enables. Especially in combination with other disciplines, architectural research can contribute creative and innovative proposals that promote and facilitate the green transition by shaping both our built environment and the way we inhabit it. In other words, placing architecture at the centre expands the concept of sustainability considerably.

The seven projects presented in this publication illustrate the wide range of efforts required to move architectural development in a more sustainable direction. The projects fall into the general areas of *climate adaptation and biodiversity, rethinking resources and building technology and holistic architecture and partnerships for change*. These areas match the topical focus of the school's three research laboratories: *Transformation* as well as *Technology, Building Cultures* and *Habitation and Radical Sustainable Architecture*.

Thomas Bo Jensen
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CLIMATE ADAPTATION AND BIODIVERSITY

Conditioned by Nature and Landscape

The main challenges in urban and landscape planning today relate to biodiversity and climate change. Rapid urban growth and the need to provide more housing and expand infrastructure are putting nature under pressure, shrinking plant and animal habitats and upsetting the balance of ecosystems. This has led to drastic decline in biodiversity in recent decades, and some of our researchers are therefore exploring how nature close to urban environments can help preserve biodiversity. As nature pushes back, increased rainfall and rising sea levels are now causing problems in densely populated areas where the water can no longer drain away or infiltrate into the ground. Rather than viewing water as a problem, some of our researchers argue that we should consider its potential. This approach has led to the formulation of new tools that can be understood and used in interdisciplinary methods and facilitate urban development with greater long-term sustainability.

01. Letting water and landscapes guide the blue-green transition

02. Aarhus Landscape Laboratory's nature transplantations contribute to biodiversity and new nature experiences

LETTING WATER AND LANDSCAPES GUIDE THE BLUE-GREEN TRANSITION

Climate change places Denmark at a heightened risk of flooding, both from the sea and from extreme rainfall. However, the risk of flooding is not due to climate change alone. Part of the explanation lies in our approaches to urban planning and development, says landscape architect and PhD.

MISSING LINK: WHEN THE WATERS MEET IN THE CITY

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Scan the QR code to read more about the project

Climate change is going to increase the frequency of extreme weather events, including extreme rainfall and storm surges, and when sea levels rise, so will the groundwater in coastal areas. Once the water is here, and towns and cities are flooded, it becomes obvious that despite our technological advances in water management, we still depend on our underlying landscapes; landscapes that otherwise seem to lie hidden underneath the built environment.

Researchers from Aarhus School of Architecture have developed visual methods for considering towns and cities in conjunction with landscape and water as well as concepts that are based on and combine tools that are already in use in urban planning.

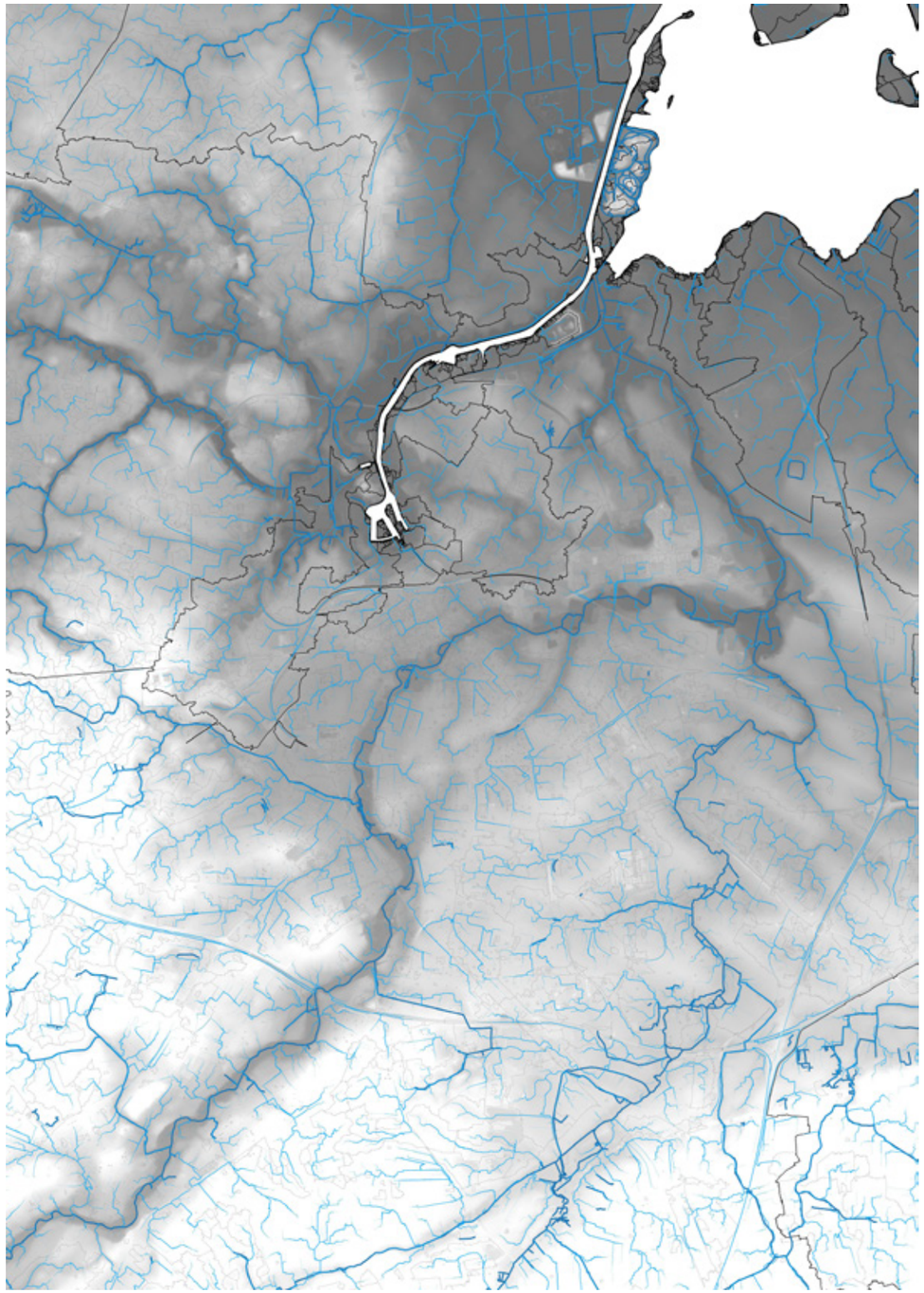
Climate change, resource scarcity and struggling biodiversity force us to rethink our planning, architecture and dwellings. Our ability to be proactive in considering how best to place buildings in the landscape and transform our cities over time will be crucial – we need to live with water and the underlying landscape, not in opposition to them.

The landscape holds underutilised potentials for water management. Potentials that can also contribute to holistic urban and landscape development as we undertake the blue-green transition.

Two concepts investigate holistic blue-green planning

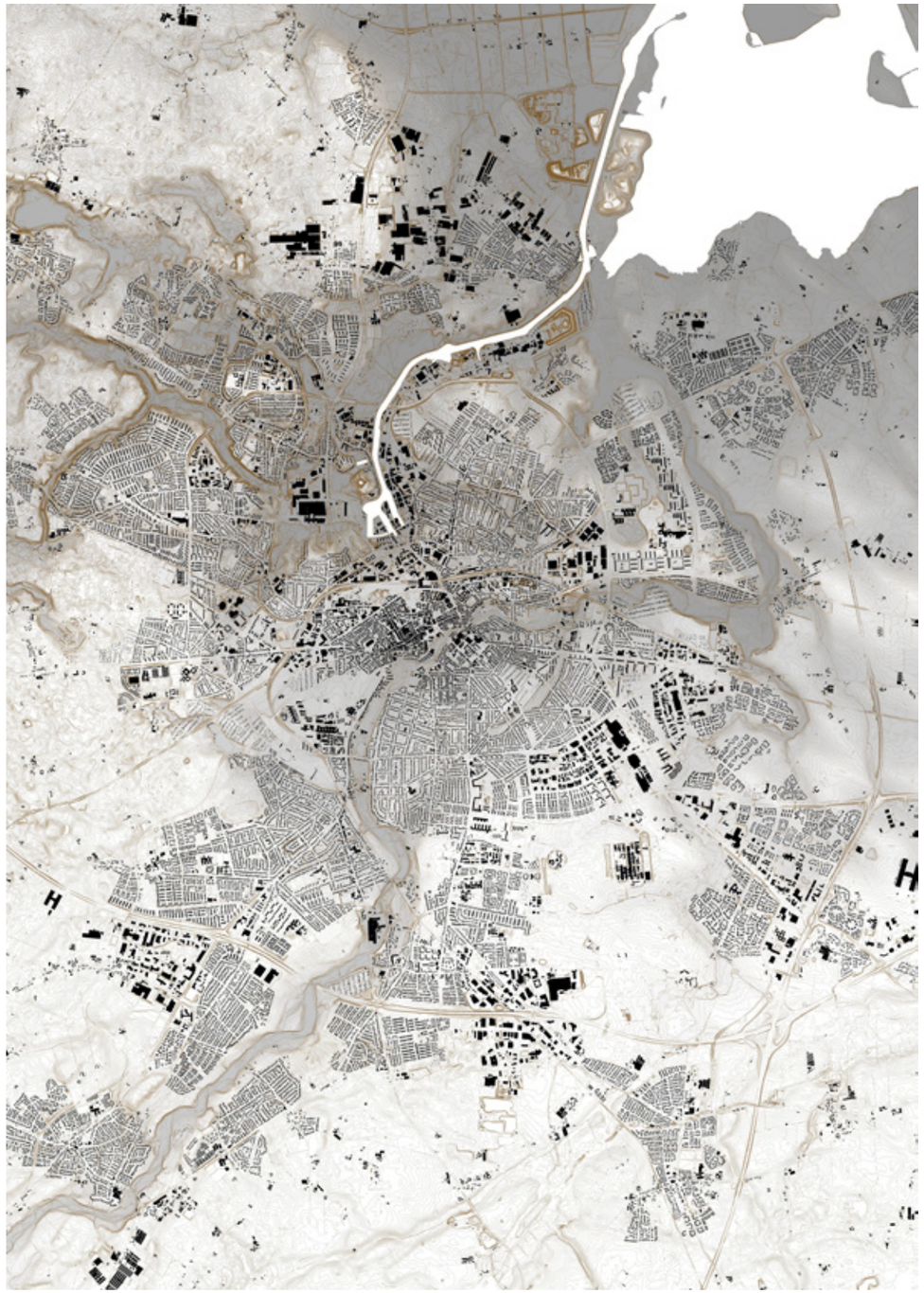
The pilot project 'The Missing Link – when waters meet in the city' explored two concepts. One is the way in which we see the city. Here, the concept of the Urban Atlas of Water (in Danish: Vandets Byatlas) was used as a lens to visualise the built and planned environment along with deep landscape structures, the movement of water and water connections on a map. The purpose of the Urban Atlas of Water is to make water and landscape visible along with the built environment.

The other concept, Catchment Neighbourhood (in Danish: Oplandskvarter), was examined as a potential link between different planning and scale levels for a given area. A topographic water catchment represents both the slope of the terrain and the movement of surface water. It also includes geographic delimitations that can be shown on the map, as we know it from planning and land registers. The difference is that the delimitations of the water catchment are based on both the landscape and the built environment, not on administrative boundaries. Hence, Catchment Neighbourhood is site-specific by nature, meaning that local potentials are always in focus. The Catchment Neighbourhood concept was explored as a possible addition to the existing planning practices for detail, sector, development and municipal plans.

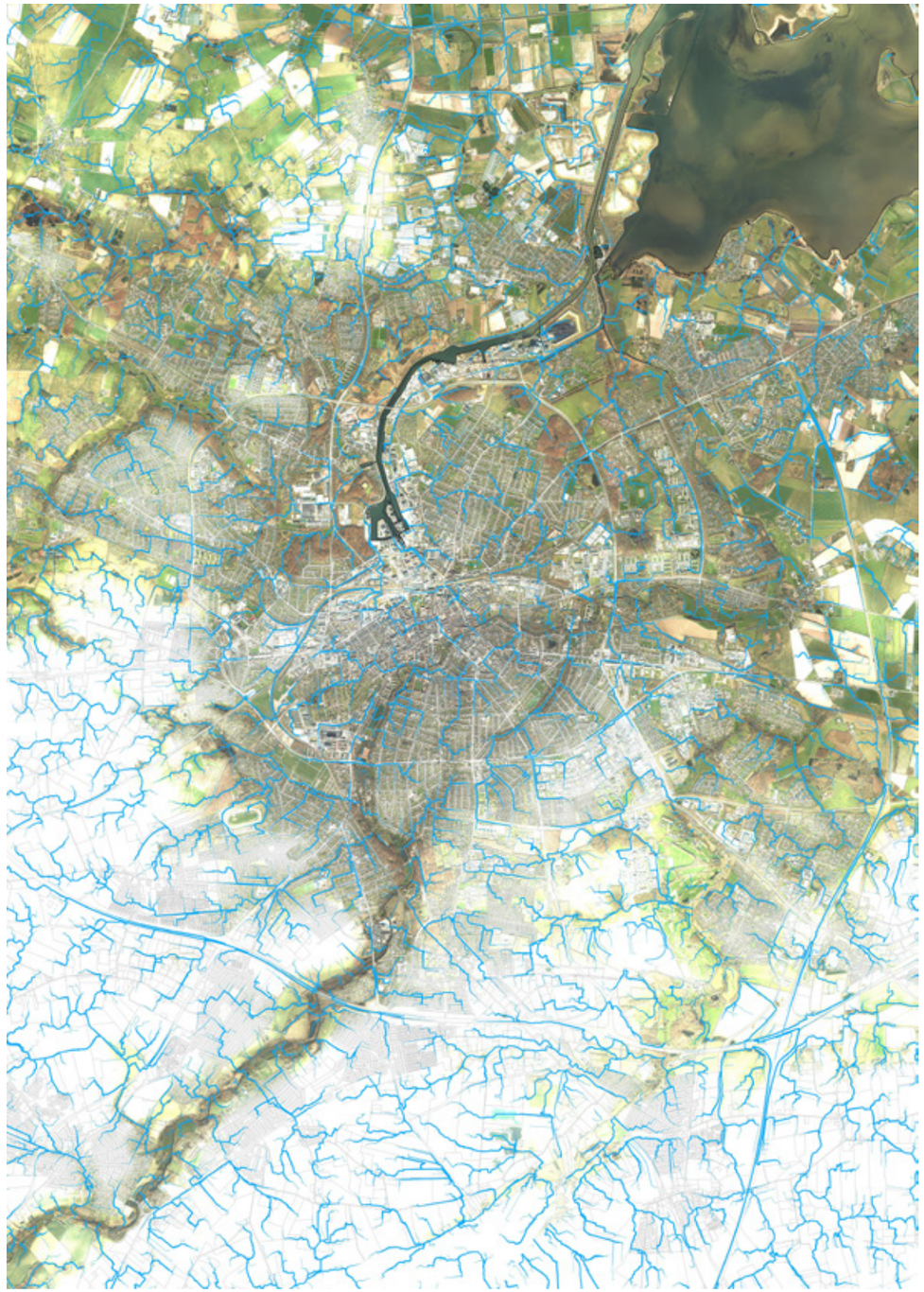


III. 1. Landscape elevations, large, coherent features and major streams around the city of Odense. Darker greys on the map mark deeper terrain. The sea is shown in white, while the blue lines show water connections in the form of flow paths, canals and streams.

Cities have typically emerged on sites with access to water, and cities with a long history are often situated on the coast near the mouth of a river, which provided access to the sea as a primary transport route. Water-based connections flow in a clear direction from rural zones, through suburbs and built-up areas and towards the port and inlet.



III. 2. Odense with its terrain and contemporary buildings (2020). In some areas, we see how buildings have been placed in low-lying areas. On the map, this is shown as black buildings situated in dark grey areas (as darker greys indicate lower terrain). These buildings are thus at heightened risk of water building up from the catchment area.



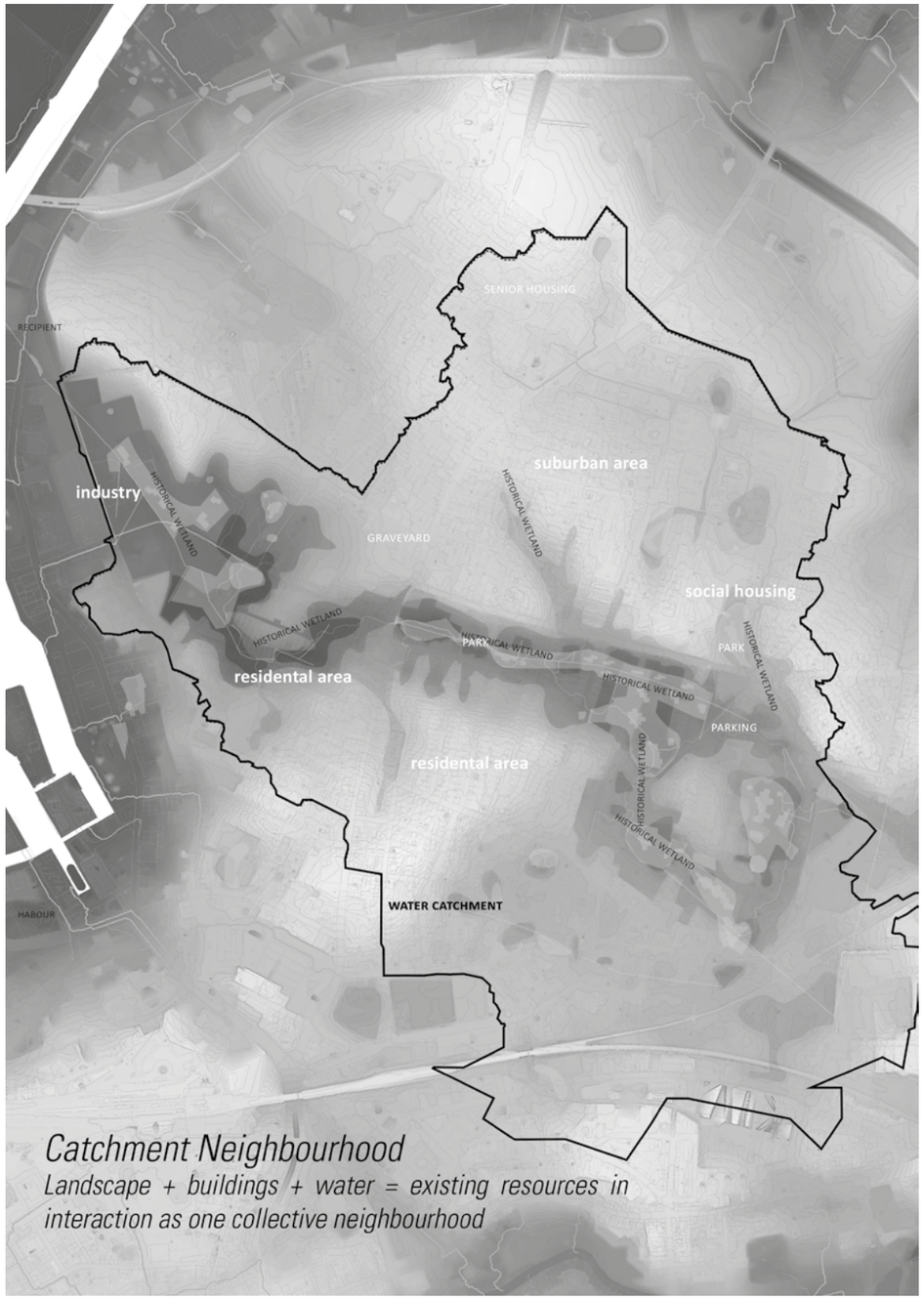
III. 3. The deep structures of the landscape (green) and the water connections (blue) in the city. Darker greens indicate lower terrain.

III. 1, 2 and 3 are examples from the Urban Atlas of Water, Odense (Vandets Byatlas Odense). Background data come from a data extract from the Danish Agency for Data Supply and Efficiency (SDFE) 2020, Scalgo and SDFE extract 2020, the map collection Høje Målebordsblade 1849–99.

Because the green transition requires knowledge and cooperation across a wide range of fields, the pilot project partners included representatives of utilities and municipalities. As a mainstay of the project, the methods can be adapted and combined with existing practices in urban planning and will be relevant to stakeholders who are not necessarily planners or water management professionals. Thus, the focus has been on how to make water visible in cross-disciplinary contexts, so that water, city and landscape can be decoded and considered from a holistic perspective. The research also aims to identify potentials of already exists in order to make the most of our existing resources and to generate synergy and added value. In the studies, the term 'catchment area' is treated as synonymous with 'neighbourhood', since 'neighbourhood' offers a conceptual reference for built-up areas and the sense of cohesion and community. Conceptually, 'neighbourhood' can articulate both site-specific qualities – built as well as natural – and relationships between areas and people. This connection between the built and the natural environment and the way people relate to both are key to the concept of 'catchment neighbourhood'.

Planning distinguishes between different functions, such as industry, housing, preschools, commercial activities and so forth. However, within a given water catchment area, these different functions are interrelated and mutually dependent. One area may lead water into the next, regardless of functional distinctions or building typologies. In planning, for a number of reasons, we draw a sharp distinction between rural and urban zones. However, these zones may be part of the same water catchment and thus be connected by water; often at the disadvantage of lower-lying, built-up areas which receive water from higher-lying areas in the same system.

In the catchment neighbourhood, the water creates interconnected situations across ownership, functions and interests. This holds potentials, for example, for identifying rural zone areas with the capacity to delay or use the water or for identifying urban areas with the capacity to relieve flood-prone areas further down the system. From a catchment perspective, it will be possible to incorporate these connections at a strategic level that can be incorporated fairly directly into detail plans. This, in turn, holds possibilities for increased biodiversity, recreation, connections for pedestrians and cyclists or CO2 absorption at a larger scale than the purely local level.



Ill 4. In Odense, the water catchment of the Vinkælderrenden stream was examined as a potential for the concept of the Catchment Neighbourhood. The black line indicates the local partial catchment that delimits the Catchment Neighbourhood. The landscape is shown in grey with markings that indicate the locations of lower-lying areas and historical wetlands. The white text marks examples of functions and building typologies in the current city.

Urban development is detached from the landscape

In recent years, Denmark has developed best-practice examples as part of climate adaptation projects. At the same time, however, the way we build produces problems with both surface water and groundwater. One of the fundamental problems is that we often take a fairly local view in urban development, failing to consider the connections in the landscape. Another key problem is that we have been getting used to being able to handle water in pipes in our cities and buildings.

From a very local point of view, our buildings and built facilities often direct and push water in unfortunate directions. Paving on car parks, roads and streets quickly leads the water on to the nearest accessible low-lying area. This is because many of our built developments, particularly from the 1950s on, are situated with scant concern for landscape properties, such as slope and soil conditions.

Thus, the greater context of the landscape seems to be neglected in urban development and represents an area with possibilities that are currently underutilised. By incorporating the landscape as a pillar in our understanding of our cities along with water and landscapes, we can create urban development – including climate adaptations – that goes across city boundaries and detail plans.

Together, water and land define the city

Previous wetlands are often reflected in current street names, which recall the very water that was drained or diverted – for example Åvangen, Rørvangen, Kærløkken og Kildehaven (River Meadow, Reed Meadow, Pond Loop and Spring Garden).

These former wetlands represent an important part of the solution. Historical maps from the second half of the 19th century give a fairly precise indication of where there used to be water and blue-green connections. In today's cities, these landscape connections are often severed or hidden under asphalt. Invisible or not, they still represent an asset as potential future blue-green passages that can be linked up and included as part of a holistic approach to urban development and water management.

Historically, the knowledge that landscape has the capacity to lead and absorb water has been taken for granted. Administrative divisions marking, for example, rural zones, urban zones, detail plans and property lines are often disconnected from the contexts of landscape and water on a larger scale. Somewhat simplified, this means that in case of extreme rainfall, water flows to and collects in inconvenient places, which renders our built environments vulnerable.

Potentials in what already exists

In the pilot project *'The Missing Link – When the waters meet in the city'*, PhD and landscape architect Katrina Wiberg explores the possibilities of a blue-green transition based on what already exists: the major landscape features, water and an extensive built environment.

The initial focus is on climate adaptations with the aim of handling larger amounts of water as well as dry spells, when the water becomes an attractive resource. The goal of the project is thus to contribute to a blue-green transition with a focus on derived, positive effects, such as biodiversity, clean water, mobility for pedestrians and cyclists, health and physical activity, social cohesion and beautiful urban spaces. Additional goals include the possibility of reducing the carbon footprint of material use or even to capture CO2 through natural solutions, for example through the re-establishment of wetlands or woods.

The project sees an underutilised potential in working with the natural and the built environment in combination and using this approach actively in the general transformation of our cities that is always taking place. This includes ordinary road renovation, new bike paths, landscaping around social housing estates and preschools or the ongoing refurbishment of suburban neighbourhoods. Fundamentally, the most sustainable choice in many cases is to use the resources that are already in play. In this context, the landscape and its capacity to guide the flow of water is an obvious focus area. Specifically, the goal should be to use the water and the landscape proactively. This means working with the natural conditions and natural processes rather than working *against* them.

Figure 5. The asphalted area around the car wash, shops and car park is a former bogland, where water will also collect in the future, and which has major flow paths passing through it. Soil conditions and slopes make the area attractive for using and delaying water above ground and underground, because the water naturally flows to the area. The site's potential can be utilised over time by reducing the car park, altering the pavement or making room for water in case of persistent rainfall. The area also has an underutilised potential for becoming more attractive and beautiful.

Figures 5, 6 and 7 show examples of how we have built on former wetlands throughout the 20th century with the expectation of being able to control the water, typically by forcing it into underground pipes. The figures may also be read as examples of local potentials for water management.

Figure 6. The day nursery is situated in a former wetland. Renovation of the pavement, street and nursery grounds within a short span of years would be beneficial and could include water management features, as water naturally flows this way.

Figure 7. The social housing estate is located on the edge of a former bogland and the former Mosegaard (Bog Farm). The grounds might be expected to undergo aesthetic or functional renovation some time within the coming decades. Such renovation could include climate adaptation synergy effects.

Planning for water, step by step

With the two concepts of the Urban Atlas of Water and the Catchment Neighbourhood, the researchers behind the Missing Link project developed preliminary methods for taking a strategic approach to water, landscape and city over time. Their work includes examples of how different types of buildings and functions can be included in holistic solutions that pave the way for new forms of added value.

As examples, the researchers in the project describe local opportunities for climate adaptation with synergy effects for a range of sites, including public institutions, commercial and industrial areas, social housing estates, privately owned housing blocks, single-family houses, streets, roads, car parks and farmland.

The methods incorporate a particular focus on long-term sustainability. In order to promote a durable, resource-conscious and holistic approach to sustainable urban development, they are based on the current surroundings and what already exists. As part of this effort, the researchers take a step-by-step approach to make it possible to launch initiatives in connection with scheduled renovation or transformations of urban areas and thus achieve synergy effects. This step-by-step approach also ensures that the transition can absorb changes over time, for example to accommodate official policy changes, economic fluctuations, new knowledge about water management or the acceleration of global warming.

Figures 8 and 9 show examples from Urban Atlas of Water, Fredericia (in Danish: Vandets Byatlas Fredericia). Background data: SDFE data extraction 2020, Scalgo

Figure 8. The greyscale map shows the terrain, with darker greys indication lower-lying areas. Buildings are shown in black. In Fredericia, some of the buildings are located inside the historical ramparts along a deep structure – a unifying spine that guides the water flow towards the port and the sea. The white line in the middle marks the water's primary path towards the sea. The white numbered arrows indicate the main destinations of any additional water flow. A '0' marks the encounter with the sea as the bottom, final step in the water flow, which is further described in the pilot project through the development of an antenna diagram. The higher the number, the higher the level of the terrain above the sea. Together, the line and the arrows illustrate how the amount of water swells on its journey to the sea.

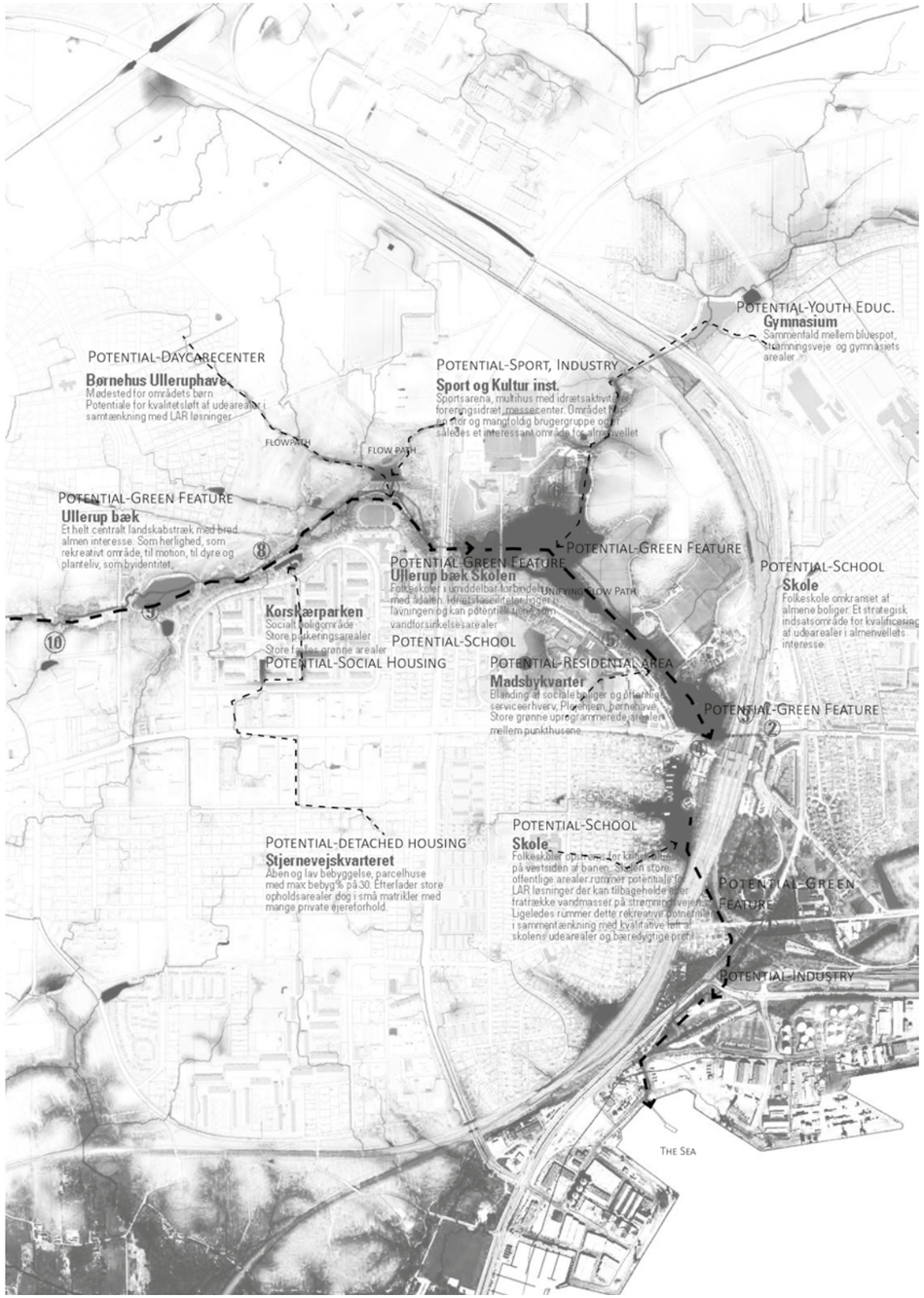


Figure 9. Section of the area shown in Figure 10, indicating flow paths that show connections between very different types of areas. These areas, with their different expressions and functions, are tied together by water – exemplified by text on the map.

This drone photo, which is repeated in Figures 10–12, shows a section of the area shown in Figures 8 and 9.

Figure 10 shows examples of flow paths connecting different types of areas.

Figure 11 identifies potentials for transformation with sustainability synergy effects.

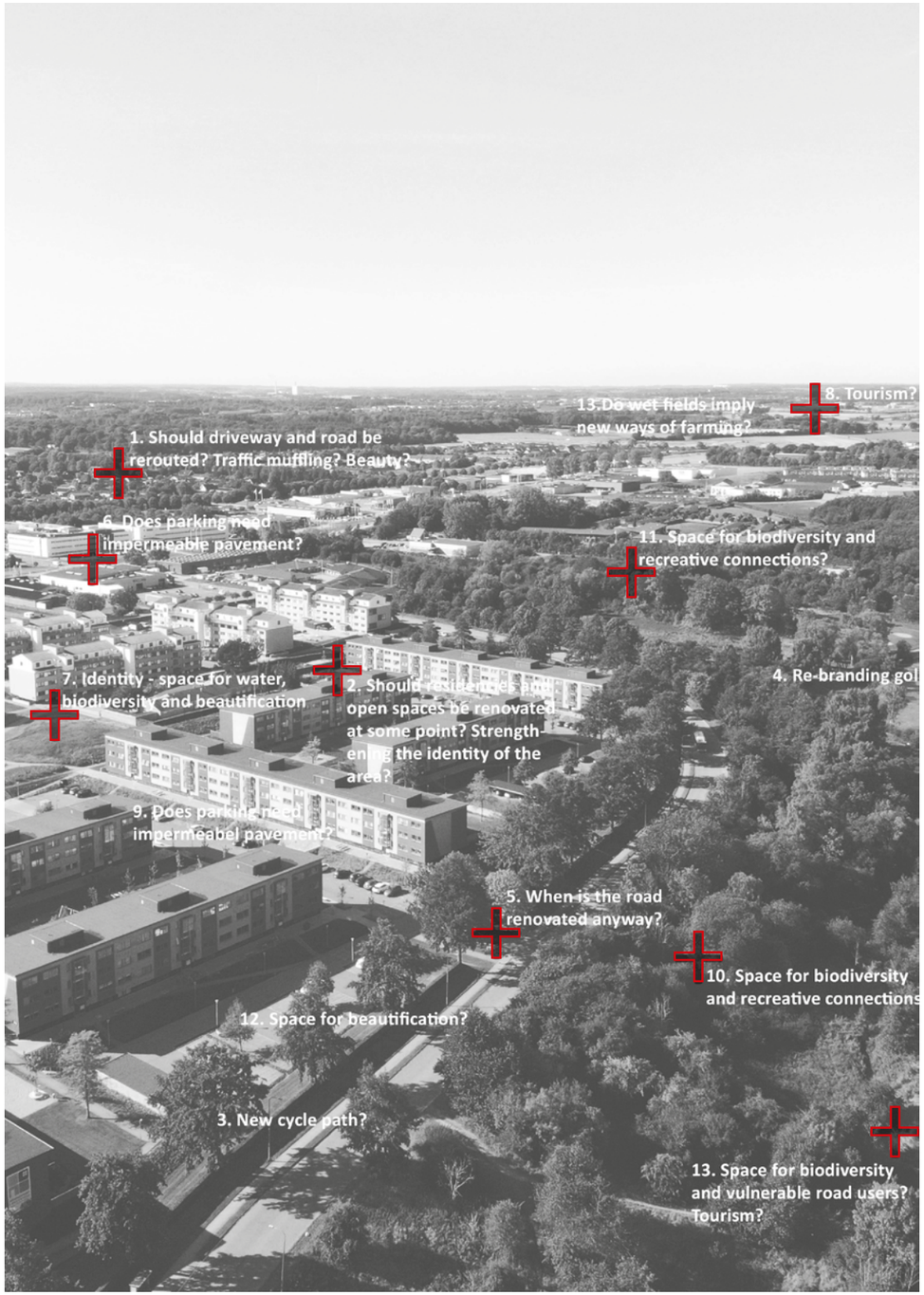


Figure 12 shows examples of how the area can generate increasing synergy effects through a holistic approach that combines climate adaptations on a larger scale. Such an approach also holds potentials for sustainable forms of added value, for example by carving out areas with room for some degree of biodiversity, which may over time be connected with other areas and thus increase the total space of possibilities for a range of benefits, including biodiversity, mobility for pedestrians and cyclists, tourism, beauty, recreation, CO2 capture, health and social cohesion. The examples shown in the map illustrate that each initiative can be launched when transformation or renovation is needed anyway.

Collaboration among different actors produce synergy effects

In Missing Link version 1.0, the methods were developed based on cases in Fredericia and Odense. Going forward, the researchers see a potential in developing the methods further in other urban areas and municipalities.

Climate adaptations and the blue-green transformation require collaborations and contributions across the board. The methods applied in Catchment Neighbourhood contribute with a more intuitive visualisation of water management aspects, which can be translated into formats that are relevant for a wide range of professions and stakeholders. The purpose of this effort is to establish a space for increased collaboration and strategic planning with a wide scope across different fields.

In this way, the methods aim to facilitate potential collaborations among professionals and experts, citizens and politicians and associations and businesses by visualising and highlighting water and site-specific potentials within a given Catchment Neighbourhood.

For example, when the grounds of a nursing home undergo renovation, one can hardly expect the actors involved to possess specialised knowledge about water or urban development. The visual methods in the Catchment Neighbourhood concept can facilitate insight into water connections for people without expertise in water management before the renovation begins. The methods thus aim to enable synergy effects between climate adaptation and the purpose of the renovation, such as increased access to outdoor spaces, beauty, meeting places, physical activity and biodiversity.

The topographic water catchment is a shared premise for all sites, while the site-specific potentials for transformation with water and landscape will vary across locations. Here we see a potential for further developing the capacity of the methods to identify local opportunities and to anchor Catchment Neighbourhoods in a way that makes them locally meaningful and attractive. The project's focus on site-specific potentials in existing settings makes it possible to connect urban visions, sector plans, detail plans and project areas in an urban development approach with a strategic perspective on water management.

Scenarios for water management and added sustainable value based on functions and buildingtypologies

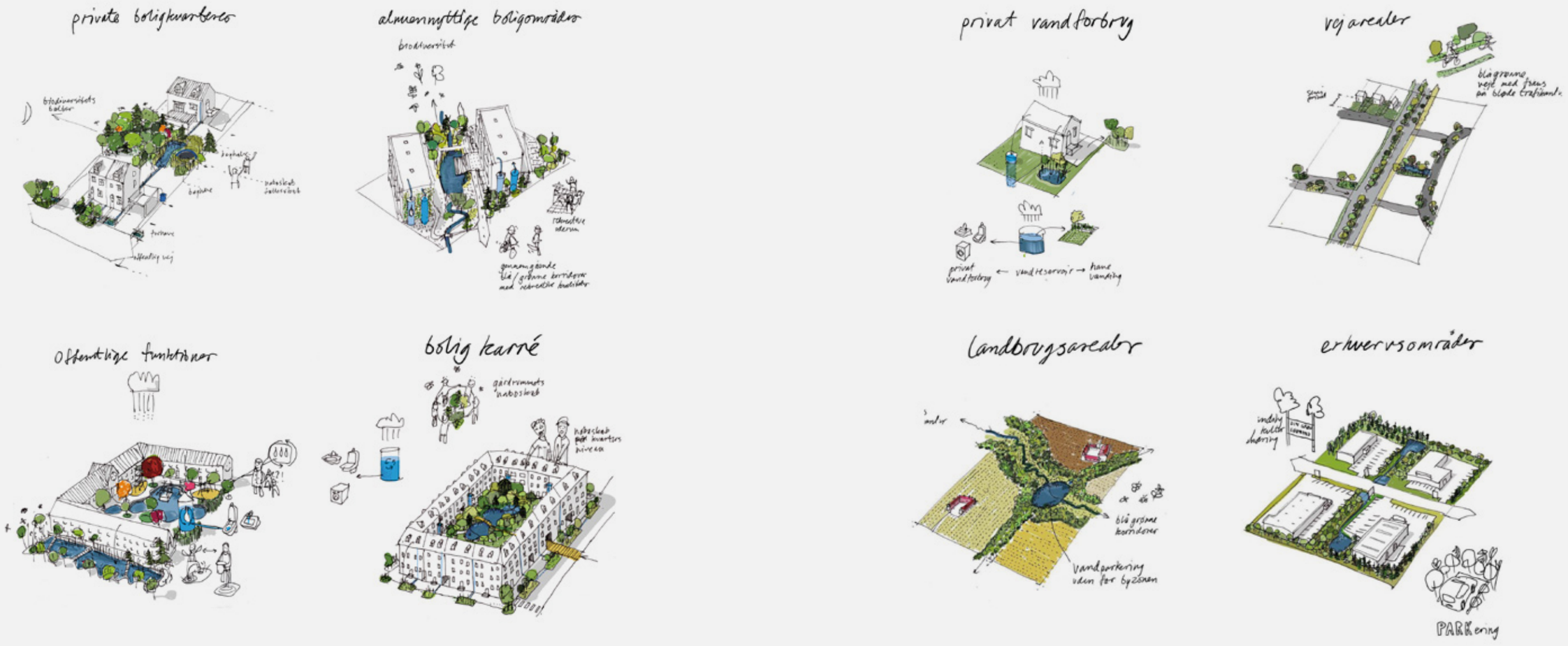


Figure 13. Examples of different functions, dwelling types and building typologies, such as perimeter blocks, housing associations, single-family houses, streets, commercial areas and farmland. Each of these typologies holds its own local potentials for transformation with water.

Ensuring the ongoing effort for the UN's Sustainable Development Goals

The methods contributed by Missing Link offer a pilot model for the future blue-green transition of urban landscapes in practice. With this, Missing Link offers a direct contribution to the effort to achieve the UN's Sustainable Development Goals as well as the wider climate effort.

The project provides examples of scenarios and added value related to the UN's Sustainable Development Goals. The purpose was to demonstrate possibilities without making detailed recommendations or designing individual areas or elements. In practice, at this level, good, existing examples and knowledge development are the best way to shape meaningful solutions in terms of function, design and local conditions.

Working with existing everyday landscapes holds a potential for climate adaptation and added value across areas that do not necessarily have the economic clout to finance and operate large-scale climate adaptation projects. This is done by visualising potentials for collaboration and, thus, joint financing and efforts, including latching on to the renovation projects that are carried out in any area over time.

Using the Catchment Neighbourhood method, the project looks at possibilities across large and small local scales – and across stakeholders. By combining climate adaptation and water management measures at multiple scales, this approach can achieve synergy effects and added value that promote the achievement of Sustainable Development Goals and are meaningful at a local level. One example might be to incorporate the interaction of urban areas and farmland that can be expected to have to deal with flooded fields over the coming decades. Another example might be to rethink the placement of paved car parks that might delay the flow of water and to create more green areas. The transformation of urban landscapes that might connect and make room for water can be linked directly with efforts to promote biodiversity, physical activity and health and, not least, recreational and aesthetic experiences. Reduced risk of flooding, fewer problems during heatwaves and increased access to green areas can also make areas more attractive.

Efforts are often more robust if they are developed with a holistic and long-term perspective and if they address the concerns of multiple actors at once. By employing methods that connect areas on a larger scale while also addressing site-specific concerns, blue-green solutions can become locally meaningful and attractive initiatives to contribute to. This can help ensure broader ownership and bring together a wider range of partners working together – also when unanticipated events occur.

It is time to incorporate landscape and the flow of water as a pillar of our urban development and adaptations of everyday urban areas, suburbs, commercial districts, summer cottage areas and ordinary residential areas. A pillar that is capable of connecting visions for the good life, the municipal plan, sector plans, development plans and detail plans in an approach where water and landscape are integrated as supportive elements in a blue-green development, and where we do not build in a way that exacerbates our problems or put off the tough decisions for future generations to deal with.

AARHUS LANDSCAPE LABORATORY'S NATURE TRANSPLANTATIONS CONTRIBUTE TO BIODIVERSITY AND NEW NATURE EXPERIENCES

In recent years, the cities have been growing and more people are moving to cities like Aarhus. Correspondingly, the construction of new builds has been high, at the cost of nature areas and their flora and fauna. In the Aarhus Landscape Laboratory project, landscape architects and biologists are relocating nature areas and monitoring the development with a focus on biodiversity and nature experiences.

Aarhus Landscape Laboratory

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All over the world, biodiversity has been significantly depleted in recent years. As more people gravitate towards the cities, urban residential areas expand, and natural plant life and wildlife must give way.

Biodiversity often takes a hard hit when new areas are developed, ecosystems are disturbed, food chains are disrupted and the interaction between land and nature is transformed, often drastically altering conditions for insects and plants. The City of Aarhus expects a net population growth of over 45,000 by 2031 and a total growth of just under 13% over the next 9 years. Thus, the crystal ball shows a continued expansion of residential areas, infrastructure and other aspects of the built environment, while the future for the life that is currently unfolding largely undisturbed in these areas seems uncertain.

In the pilot project Aarhus Landscape Laboratory, landscape architects from Aarhus School of Architecture and biologists from Aarhus University study how new nature can contribute to improved biodiversity and nature experiences in the city. The project is an interdisciplinary collaboration between Aarhus School of Architecture, Aarhus University's research centre Biochange, Natural History Museum Aarhus and the City of Aarhus.

With the addition of new areas in 2021, the lab now, in 2022, includes three project sites: Godsbanen, Eskelunden and Åbo Wood. Together, the tree sites cover almost 130 hectares. They are located along Aarhus River in a tract extending from the dense urban landscapes near the former goods railway site Godsbanen to the transitional landscapes between dense and more scattered urban areas near the wooded area Eskelunden to landscapes on the urban periphery in Åbo Wood.

The project has established a physical platform for interdisciplinary experiments with urban nature on a scale of 1:1. The collaborative effort is based on the notion that nature needs room, and that new insights in this field call for experimentation. The lack of room not only affects biodiversity in and around cities such as Aarhus but also affects our perception of nature and its potential role in our everyday landscapes.

A new home for 5,000 square metres of urban nature

In one of the first experiments in the landscape lab, landscape architects from Aarhus School of Architecture and biologists from Aarhus University explore the potential of transplanting nature areas from one place in the city to another. When undeveloped areas are utilised in new urban development projects, the existing nature pays the price. To address this, the project relocates areas with high biodiversity and studies the ability of nature to adapt in order to determine if life can continue in a new location.

The experiment was launched in 2017 in an area of over 5,000 square metres in Eskelunden. The so-called donor area containing the existing plant life and wildlife selected for relocation was situated at Godsbanen in Aarhus, a poor, sunny and dry area that had been a goods railway site for decades. Plans for extensive urban development in the area now threatened the existing high-diversity pant life and wildlife, so a methodical nature relocation was needed.

Relocating habitats from the donor area at the former goods railway site, May 2017.

The new site in the recipient area in Eskelunden has a higher elevation, and before the start of the experiment, the soil was more nutrient-rich, while biodiversity was low. Hence, studies of the adaptability of relocated nature is crucial to the project, landscape architect, PhD Stefan Darlan Boris points out:

– The goal of this experiment is to explore how nature adapts to the new and significantly different conditions in Eskelunden, both in the short term and in the future. This provides insights into how we can promote urban biodiversity while also offering interesting and unusual nature experiences.

During the design phase, the recipient area in Eskelunden was divided into 16 circular test plots, each with a diameter of 12 metres. The circular form was chosen for both aesthetic and practical reasons. In addition to drawing on themes from landscape architecture, the circular shape lets the project researchers return to the site year after year to measure how the relocated nature is developing and adapting to the new setting. With precise GPS coordinates for the centre of each circle, it will always be possible to measure a distance of 6 metres from the centre and thus record the content of each circle, even if the physical form disappears from sight as plant cover increases.

The recipient area in Eskelunden is being prepared, February 2017. The nutrient-rich topsoil was removed to make room for the transplanted urban natural habitat from the goods railway site.

Seeding the Eskelunden site with transplants from the Godsbanen site, seen from above in late summer 2021. The circular experimental plots have adapted to their surroundings and are almost invisible to the naked eye. The different material compositions are still evident in the landscape. .

In practice, the 16 experimental plots were divided into four different types, each containing materials from the Godsbanen site as well as a few boulders and tree trunks from the local area: four plots containing pebbles, four plots containing pebbles and dead wood, four plots containing both pebbles and boulders, and four plots containing only raw soil.

The transplantation itself was carried out in winter in a purely analogue process that involved scraping the top 10 centimetres off the identified area at Godsbanen. This top layer contained a large pool of seeds and overwintering insects. Lorries were used to transport the scrape-off layer to the recipient area in Eskelunden, which had been prepared by replacing the top 50 centimetres of nutrient-rich topsoil with 50 centimetres of raw soil, into which the donor raw material from Godsbanen was then placed.

The experiment continues for a number of years and will be monitored by the research team. An inventory of species carried out in late summer 2017 found that many indicator species from Godsbanen had survived the relocation. A follow-up inventory to be carried out in 2022 will seek to confirm or repudiate this preliminary finding.

Two of the 16 experimental plots shortly after and six months after the transplantation in 2017.

Additional transplants to secure sustainability

The experiment in Eskelunden does not stand alone in the effort to create diverse and natural areas. As part of the laboratory project, researchers will also transplant woodland floor from older woods in the City of Aarhus to newly established clearings in Eskelunden with the goal of investigating the consequences for plant life and wildlife.

The transplanted woodland floor is to be placed in eight 10-metre-wide clearings in a woodland area in Eskelunden that was planted only 30 years ago. That will provide an opportunity to study the relationship between the spatial character of the area and the potential increase in biodiversity in the young woodland area.

Incubator for interdisciplinary collaboration on the UN's SDGs

These experiments exemplify how efforts to achieve the UN's Sustainable Development Goals can help promote life on land, including enhancing biodiversity.

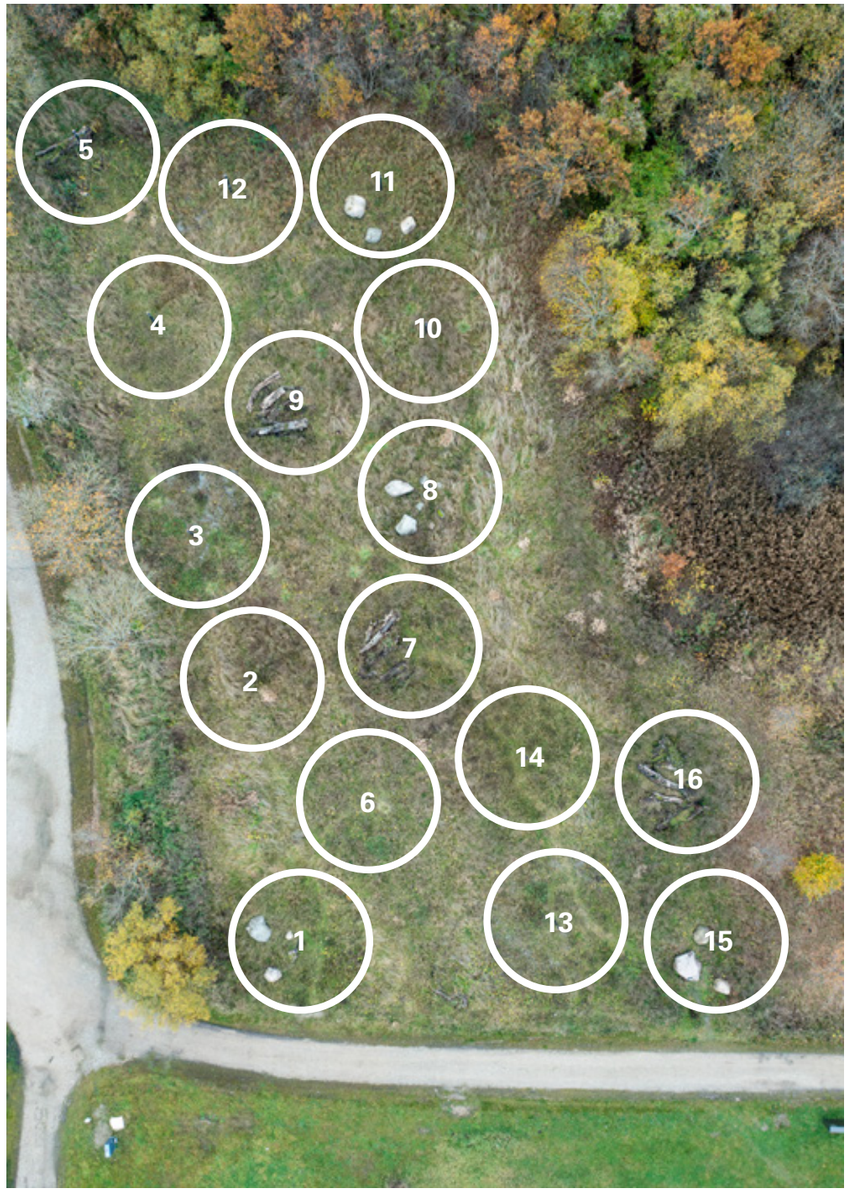
In the Landscape Laboratory, Aarhus School of Architecture focuses on urban nature from a sensuous and aesthetic perspective. The project also serves as an interdisciplinary platform for administration, education and research.

Currently, the Landscape Laboratory has three different project sites: half a hectare at the former goods railway site in the centre of Aarhus, 70 hectares in Åbo Wood and 50 hectares in Eskelunden. The three areas are located along Aarhus River, from the dense city centre to the city environs. Thus, their focus is on the river valley close to the city in accordance with the UN's Sustainable Development Goal of promoting positive connections between economic, social and environmental conditions in cities and their environs.

A key issue for the Landscape Laboratory is that urban nature – in the dense city centre as well as in the environs – should be a learning space and a driver of education.

– Nature is not just something outside ourselves. When we protect it, it can contribute to social cohesion. Research has documented the human health benefits of being in nature. Hence, an important focus in our education and student projects is sensuous qualities and the search for new ways of providing nature experiences, says Stefan Darlan Boris.

The Landscape Laboratory experiments are being communicated locally. In Eskelunden, visitors are invited to explore on their own and thus connect with nature.



This is an experimental site for urban nature relocation

A total of 16 circles, each with a diameter of 12 metres, have been seeded with stones, soil and plant materials from the former goods railway site Godsbanen in Aarhus in an attempt to save rare species and their habitats.

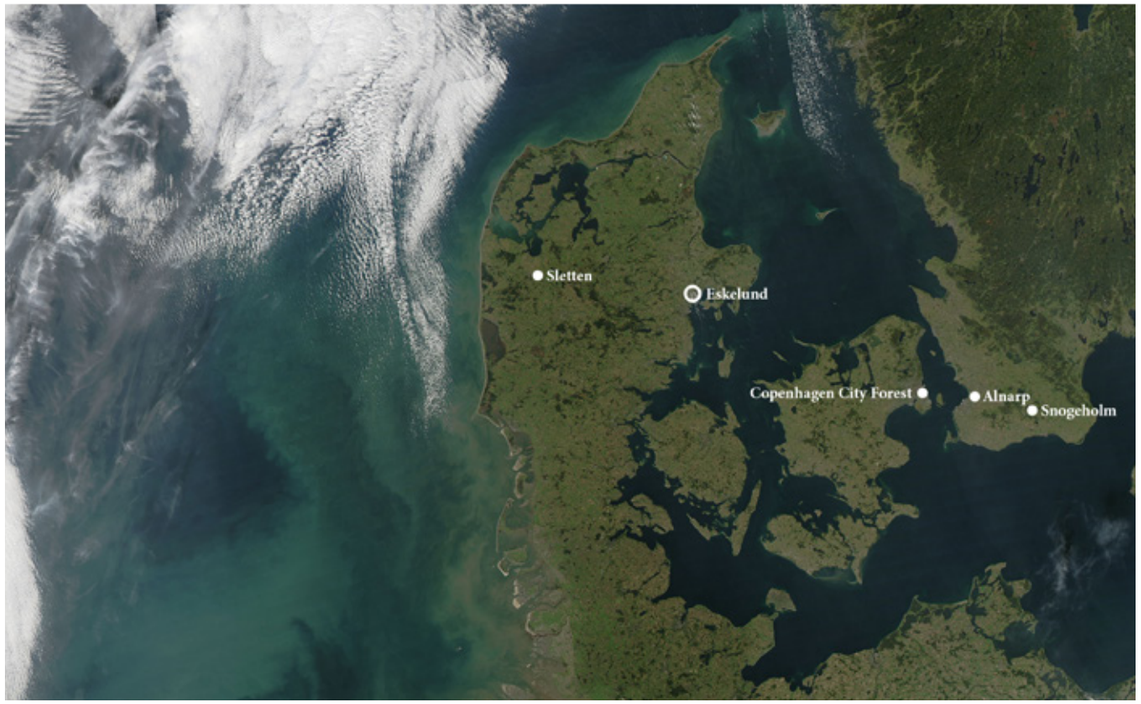
Urban development at Godsbanen made it necessary to relocate the species and their habitats, and they have now been rehoused here in Eskelunden.

If you explore the area, maybe you can discover some of the rare plants and insects.

Aarhus Landscape Laboratory uses and experiments with nature's spatial potential for discovery, learning and sensuous and aesthetic experiences in an interaction with the urban surroundings.

Thus, the transplantation experiments are part of the studies at Aarhus School of Architecture, where the students are involved in observing the development of the trials and in monitoring the long-term experiments.

The Aarhus Landscape Laboratory aims to engage biologists, historians, artists and landscape architects, among others, in a joint effort to develop new types of urban nature. This cross-disciplinary collaboration with an educational element will help give the activities of the Landscape Laboratory a long-term impact and promote sustainable innovation and experimental research.



In addition to Aarhus Landscape Laboratory, there are four similar landscape labs in Denmark and Sweden.

Science overlooks sensuous qualities

In the realm of theory as well, Aarhus Landscape Laboratory aims to expand our perspective on nature by providing a sensuous and aesthetic gaze.

The researchers point out that spatial and transformative experiments contribute to the debate about the planet's critical zone, which is an increasingly prominent topic within geoscience and the natural sciences. The critical zone is the thin layer that extends between the earth's atmosphere and the groundwater. It is within this zone that all life unfolds, and geological and natural processes interact – often over vast spans of time.

In this debate, so-called critical zone observatories play a key role: specific areas where researchers carry out interdisciplinary studies and share data, models and tools. The purpose of these observatories is to improve our ability to describe the planet's complex dynamics in a time when they are being radically influenced and transformed by human activity. With a sensuous-aesthetic approach, Aarhus Landscape Laboratory seeks to expand the scope of these types of studies.

The researchers point out that sensuous and aesthetic qualities are neglected because of the enormous complexity and knowledge of the planet enabled by geophysical measuring methods. The macro-perspectives this induces tends to drown out the complexity of the critical zones. As a result, the potential of nature's aesthetic and sensuous qualities is largely ignored in the debate and is not assigned adequate significance in our approach to nature. Aarhus Landscape Laboratory would like to challenge this research focus by underscoring the connection between human beings and nature.

Next step for Aarhus Landscape Laboratory

The experiments in Aarhus Landscape Laboratory have a long-term perspective, and the development of the transplants is being carefully monitored. Another next step for Aarhus Landscape Laboratory is to scale up some of the experiments from Eskelunden.

Even while the trials in the clearings in Eskelunden are still ongoing, there are plans to scale them up in Åbo Wood, which was planted by the City of Aarhus in 2014. Such a scale-up is relevant because Aarhus, like so many other municipalities in Denmark, is planning to convert more land into forest on the immediate periphery of the city. These plans are based on a strategy of encircling the city by woodland. This strategy was adopted by the City of Aarhus in 1989, and in recent years it has become increasingly relevant in light of the capacity of forests to store large amounts of CO2 in addition to providing natural areas close to the city and nature experiences in the citizens' everyday landscapes.

In 2021, landscape architecture students from Aarhus School of Architecture carried out initial experiments in part of Åbo Wood in the form of spatial interventions on varying scales that, over time, will form the basis of additional experiments in clearings in Åbo Wood. The intention is to identify ways for the City of Aarhus to provide nature experiences for the city's inhabitants, also in more recently established woodland. The knowledge and results generated by these studies over time may potentially be transferred to other municipalities facing similar biodiversity challenges.

Landscape architecture students in Åbo Wood in 2021, carrying out spatial interventions on varying scales with an emphasis on the encounter between nature and nature experiences.

Thoughtful transplantations

A full-scale transplantation method requires many resources. If the goal is to transplant an area from one place to another, it is crucial to choose the new site carefully. Both in order to minimise the strain on nature's adaptability and in order to maximise the utilisation of society's resources.

– Initially, we aim to investigate the potential and feasibility of this method. Naturally, it cannot be used over and over again on the same natural site over a short span of years. That would be both costly and untenable for the life we aim to promote, says Stefan Darlan Boris.

He also points out that knowing what biodiversity requires as well as the specific qualities of potential new sites can enable a more consistent approach to the design and management of city and nature.

– Planners, sites and citizens all need to be able to accommodate urban nature and the diversity of flora and fauna that it brings, says Stefan Darlan Boris.

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RETHINKING RESOURCES AND BUILDING TECHNOLOGY

Listening to Materials

The construction sector is one of the main culprits in the emission of greenhouse gases. In order to achieve the green transition, it is therefore crucial that we explore the potential for increasing the use of recycled or less environmentally harmful materials in the construction of new builds or the transformation of existing architecture. To address this challenge, one of our research teams is seeking to optimize material use through the combined application of advanced digital technology and leftover wood from the timber industry. Another team, composed of both researchers and students, is seeking to revive traditional, resilient building methods with the goal of incorporating them into today's highly regulated building practices. A third team is studying whether the much-maligned and highly polluting waste product of plastic can be gently upcycled, imbued with added aesthetic value and reused in construction.

03. From waste product to construction material: Technology is the key to utilising a wider range of timber

04. Leaving new plastic behind: Recycled waste plastic shows potential as an aesthetic building material

05. Testing local materials and historical techniques to reduce the environmental impact of construction

FROM WASTE PRODUCT TO CONSTRUCTION MATERIAL: TECHNOLOGY IS THE KEY TO UTILISING A WIDER RANGE OF TIMBER

Contemporary timber construction relies exclusively on standard products made from a narrow range of timber species, and in many regards, wood remains an underutilised resource. Researchers stands behind an experiment that has found that technology can embrace the diversity of curved oak and thus reduce monoculture forestry to the benefit of construction, biodiversity and CO2 emissions.

Scan the QR code to see researcher profile (this is also where the project will be published)

Timber Structures Made Of Naturally Curved Oak Wood: Prototypes and Processes

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Project partners
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(Hjerl Hede Open-Air Museum)
Geometrica Architecture OY, Finland

There is growing interest in using timber in construction, especially due to the ability of trees to capture and store CO2 and thus reduce the emission of greenhouse gases. Naturally, this presupposes sustainable forestry, in which all logging is matched by replanting.

Looking at the current alternatives to industrial concrete architecture, CLT (cross-laminated timber) and LVL (laminated veneer lumber), we see a timber industry calling for standardisation and mandatory certification. In other words, the industry has high standards for the timber, and only a limited number of timber species and completely straight trunks are considered suitable for construction.

This exclusive demand for certain species and shapes of timber permeates the entire supply chain, with nature ending up as the weakest link. The result is monoculture plantations and unsustainable cultivation methods, which has an adverse impact on biodiversity and the overall vitality of the forests.

Instead, a wider range of species can be made attractive to the construction industry by embracing new production techniques. To explore this potential, researchers from Aarhus School of Architecture used digital tools to study and document how irregular oak logs can be processed and used in construction and challenge our approach to timber.

Greater diversity in timber construction can benefit nature

The researchers created a curved construction made from 15 oak beams. This prototype demonstrates the practical effectiveness and usability of their method and procedures and also served as a complete test of the degree of precision in the approach.

In cooperation with BærLab at Aarhus University's Department of Engineering, the researchers tested the strength of the joints and found that the joints can handle a considerable load. This proves the relevance of the system on a large scale, which is a key success criterion for the project.

The project was undertaken by a research team from Aarhus School of Architecture comprised of Associate Professors Niels Martin Larsen and Anders Kruse Aagaard and research assistants Lynn Hyun Kieffer and Matthias Klith Hardarsson. The construction principle was inspired by traditional Danish building methods and developed in collaboration with Nikolaj Kirk from the Hjerl Hede open-air museum. Assistant Professor Markus Matthias Hudert and PhD scholar Lasse Weyergang Rahbek of Aarhus University's Department of Engineering contributed with analyses of the statical principles and test results.

The purpose of the research project was to demonstrate that architecture can utilise a wider range of timber shapes and species, which in turn promotes more diverse forestry, greater biodiversity and natural CO2 storage.

– You can imagine forests with a wider range of species that occur naturally in the landscape, which would serve as a habitat for a wider variety of plants and wildlife than you see in the typical plantation forest today. Such a forest would produce a higher share of irregular timber components, which can be used in construction, says Niels Martin Larsen.

In turn, forestry would benefit from a stronger circularity of materials that secures both sustainability and an efficient supply. The planting of more different species of trees in forestry not only promotes more sustainable flora and fauna but also reduces the waste of resources, Niels Martin Larsen explains.

– Our goal was to show how curved timber can be processed and used as building components and thus become more valuable and sustainable than if it's simply used as fuel in energy production, as it is today, he adds.

The surroundings influence the usability of the timber

With this project, the researchers went for a high-hanging fruit from the outset. Even though oak has traditionally been used for construction and has proved its resilience to the Nordic climate for centuries, it is poorly suited for today's production lines. More than half of the oak is discarded due to its twisted and curved forms.

To make better use of trees as a resource, the timber industry needs to be able to handle different shapes. Each piece of wood has unique properties as the result of multiple factors. Spruce and pine, which are among the most common conifers, are characterised by fast growth and long, straight trunks, which makes them ideal for use in construction. By contrast, some deciduous species, such as oak or ash, tend to have slower and more irregular growth and to form curved trunks and branches, which are more difficult to process in industrialised production.

In addition, the climate that the trees have been exposed to also makes a difference. The different sections of the tree have individual characteristics and strengths, and the drying process affects the form stability and utility of the wood. The hardness of the wood varies with the annual rings, alternating between spring and autumn wood, and this variation itself differs between species. The microscopic cell structure can show significant variation, which leads to particular properties in terms of strength along and across the direction of the fibres, elasticity, resistance to fungal attack and ability to absorb and emit moisture.

– The traditional woodworking craft is characterised by a strong grasp of the properties of wood and knowledge about the best use of different timber components. To utilise this, we have drawn inspiration from historical construction methods, traditional wood joints and wooden shipbuilding, says Anders Kruse Aagaard.

Prototype made from 15 beams on display in front of Aarhus School of Architecture in 2021. The construction follows a precise arch with the curvature increasing towards the top.

For example, oak was the Vikings' preferred shipbuilding material because of its strength and resilience. Historically, properties such as strength, elasticity, water-repelling ability and shape were favoured in the selection and processing of oak. Thus, the past inspired the researchers' development of methods for using curved timber.

The research team established a collaboration with the local sawmill Grønagergaard, which continually delivered timber that was discarded because it was irregular or curved. Most of these logs were oak, a high-quality and expensive material that would otherwise have neen burned.

Robot technology allows for a variety of shapes

Digital tools have been the key to incorporating irregular timber in the production and use of curved building components and thus reducing resource waste. Initially, the researchers used a database with 3D models of all the available tree trunks.

Today, modern sawmills use both X-ray and 3D scanning in sorting, processing and quality assurance in order to optimise the utilisation of the wood in the production of straight planks. In a parallel to this industrial practice, the researchers used some of the same technological methods, albeit in the slower pace of the laboratory setting.

This approach included the use of a handheld 3D scanner to record the exterior shape of tree trunks in the form of so-called point clouds. In order to utilise this data, an algorithm was used to produce a more manageable 3D model of each trunk.

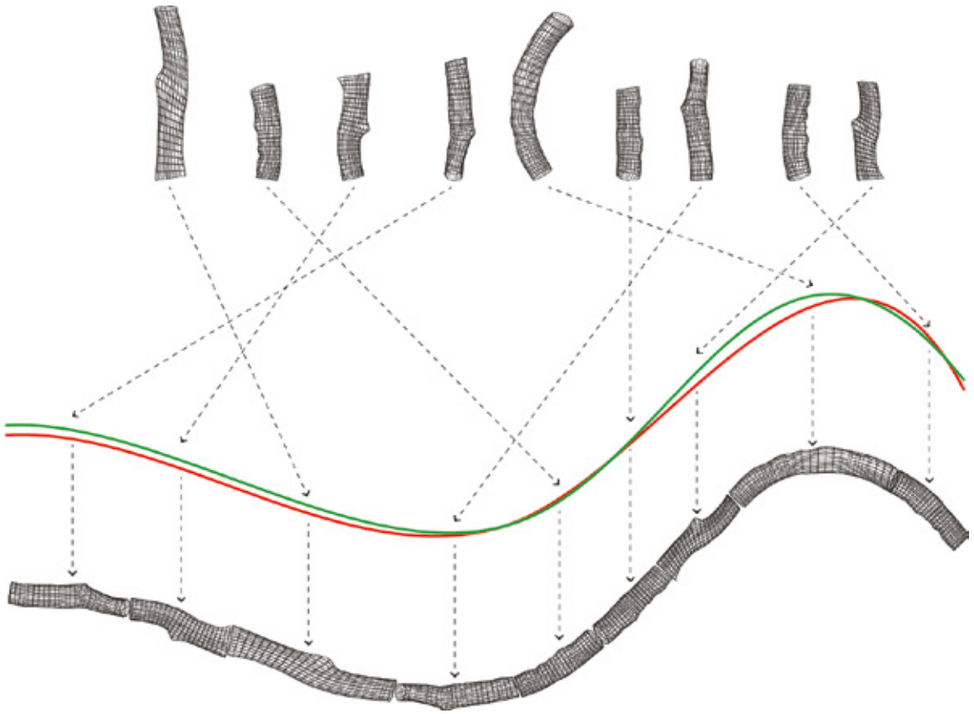
– To bring these virtual tree trunks into play, we need a design task. In the project, we used a 3D model – for a roof, for instance. Typically, a roof calls for a curved design and is thus able to utilise the curvature of the trunks. We developed a digital design instrument that is capable of distributing the individual logs in the construction, so that the logs that best match the shape of the beams are selected for further processing, Niels Martin Larsen explains.

Traditional timber frame buildings often included curved timber components in the construction. This photo shows a historical Danish stable at Hjerl Hede open-air museum (photo: Niels Nygaard).

The beams were fastened with oak dowels treated with linseed oil. When the oil hardens it strengthens the joint and increases the wood's resilience to moisture. This method draws on inspiration from traditional timber frame structures.

A hand-held scanner was used to digitise the tree trunks so they could be added to the database.

Diagram illustrating how the trunks that best match the design geometry are selected. The geometry of the construction can be adjusted to better match the available trunks (red and green curves).



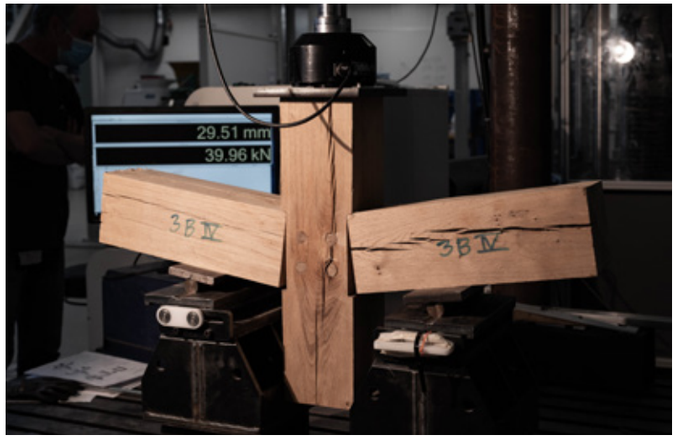
In the production of the individual beams, the challenge is to connect the digital model with the curved timber. For this, the researchers used a so-called OptiTrack system that matches marked points on the trunk with the points recorded during the scan. Next, the trunk can be turned into the desired form using robot technology.

Niels Martin Larsen explains that the development of the design and production method relied on visual rendering and, even more importantly, on the physical processing of timber in the architecture school's robot lab, where a series of prototypes were produced. These steps demonstrated that there were no directly applicable calculation methods for strength that could be transferred to the construction in question, even though the principle is well-known in timber-frame constructions.

The construction principle that was used in the resulting physical construction is a combination of a so-called Zollinger principle, which makes it possible to construct a large span using multiple small components and traditional wood joints. According to the researchers, this approach can be adapted to many different types of constructions.

An OptiTrack system is used to locate the marked points on the surface of the log and match them with the 3D model of the trunk.

A series of test joints were subjected to break load testing in BærLab at Aarhus University's Department of Engineering. The strength of the joints fully lived up to the high expectations.



In the construction of the prototype, the beams were first assembled in rows and then pulled together with clamps. Next, the assembled construction was lifted into place in the frame by crane.

CNC cutting of a trunk where a spindle is mounted on a robot arm. Using an automatic rotary table, it was possible to cut three sides of the trunk as well as the details of the joint without needing to move the trunk.

Mass production does not have to be uniform

According to the researchers, the systems and procedures are not just speculative possibilities that might become possible or useful in the future. On the contrary, the industry is ready, as the approach relies on existing technology.

–The possibilities are excellent. In construction, the timber industry has a highly advanced use of digital technology, Niels Martin Larsen says.

He, however, adds that the possibilities are not fully utilised in timber construction.

Thus, the research project demonstrates the untapped potential in taking a broader and more scientific approach to timber. Anders Kruse Aagaard argues that architects have a responsibility for using more as well as a wider range of timber in construction, because building in wood is faster, more sustainable and more efficient compared to other construction materials, including the ubiquitous prefab concrete.

–Timber construction integrates really well with the methods and approaches architects are already using, so there is a rich potential for experimenting with wood and pushing the envelope for what's possible in architecture, Anders Kruse Aagaard argues.

He further adds that the key is to develop procedures and work flows that are adapted to the natural form and properties of wood:

– Robots and CNC cutters don't care if they have to move in straight or curved lines. This means it's easy to imagine that we can challenge what we now consider the standard for the range of timber we use and how we use it. The problem and the standard thinking lies more in the production method than in the design process. We need to move away from the assumption that uniform mass production is necessarily the most efficient. In fact, technology is capable of adjusting to the variation that exists in timber resources while maintaining a high degree of efficiency.

LEAVING NEW PLASTIC BEHIND: RECYCLED WASTE PLASTIC SHOWS POTENTIAL AS AN AESTHETIC BUILDING MATERIAL

We need to start seeing plastic as a resource when choosing materials for new architecture. However, the stigma surrounding the material stands in the way of utilising the plastics that will not just disappear. Fighting the stigma, research from Aarhus School of Architecture has identified ways to recycle waste plastic and strive for components that stay beautiful, durable and interesting in the long term.

Scan the QR code to see researcher profile (this is also where the project will be published)

Recovered Plastics As New Building Components

Project team and contributors
Chris Thurlbourne, BA (Hons), Dip. Arch. (dist), associate professor, Aarhus School of Architecture (project manager)

Mads Hulsrøj Jæger, MA (Architecture), research assistant, Aarhus School of Architecture

When worn-out waste plastic floats by in places like Aarhus River, it pops out. The synthetic appearance of the material catches the eye as it is different from its surroundings. The scenario unfolds on a day-to-day basis and creates a sorry story: plastic is worthless and ends up in our nature, our cities and our waters for years after being utilised by us maybe only once.

To most people, the purpose of plastic is to contain valued goods – as wrapping, packaging or other practicalities. A highly available and low-cost material that is convenient and problem-solving rather than a material of value in itself. Instead, plastic as such is a problem-creator made from oil and it is harmful to nature and ocean wildlife-dependent industries. This has become the story of the material and is more or less inherent when we see plastic, placing the aesthetics of plastics at the epicentre for a potential turnaround of its image and reputation – and application.

There are indeed ways to tell new stories. Research at Aarhus School of Architecture has found different methods to make use of waste plastic's inorganic properties to make recycled building materials with good design aesthetics. The act of making and remaking needs to be revealed in the final component to create new associations with plastic. By identifying ways to make components from waste plastic with good design aesthetics, the demand for upcycled plastic can be stimulated in construction. This gives an eco-friendly, circular role to the billions of tons of plastics that are already produced as it serves as an alternative to new plastics. Good design aesthetics can help transform the current stigma towards plastic into a material that could be considered a resource rather than a burden. A shift in perception can lift construction into a perceived art form by exposing and exploring the qualities of plastic during assembly and material production. On a broader scale, this contributes to utilising waste plastic and creating circularity around the mainly oil-based material, leaving the production of new plastics increasingly redundant.

Stigma in the building industry

As an inorganic material, polymers will not biodegrade unlike organic materials such as wood. It is this lack of being able to break down that is perceived as alien, fake, and, consequently, a burden. Yet, in comparison to timber, plastic is not susceptible to water, rodents and insects. Once located in a specific place, assuming it is robust, it will remain there relatively unscathed. The green credentials of plastics are therefore unrivalled in so far as the material can perform its task ad infinitum. Yet, it is this quality of maintaining its original form and character that is also its downfall in our perception and relationship to it. The common phrase, "it's plastic", refers to identifying something that is not 'real'. Plastic tends not to age as such, unlike other materials. Plastic is something that is manufactured rather than grown, or sourced through excavation.

At the same time, imperishability and resilience to water, rot, rodents, plant growth, and insects are qualities in the building industry exemplified in the currency of materials such as concrete or components like bricks. Elements that are widely used in the building industry, even though they have a big negative impact on exhaust emissions during processing as well. They are simply considered and perceived as useful and resourceful.

Different plastics, different approaches to recycling

Based on two case studies, the pilot project 'Recovered Plastics as New Building Components' showcases a design that uses the architectural qualities embedded in control of production techniques. Moreover, the project focuses on longer-term patinas of surfaces made from recycled plastic to extend the aesthetic beyond the common judgements of polymers as short term, disposable, and clinical in its appearance. This way, the experiments have sought to utilise the inherent qualities of waste plastic by changing its appearance and how it is perceived.

It is not easy to rethink the way we use and reuse plastics in the architecture and building industry. Regulations, construction methods, and terminologies are formed around the current norms, what is tried and tested, and business-as-usual. Therefore, accepted norms have been left behind to find building materials hidden in discarded plastics from various sources such as domestic waste. In addition, there is not just one plastic. HDPE is different from polycarbonate. The way the material needs to be sourced and processed has also varied. A vital part of the research has therefore also been to find ways to identify waste plastic types. The two cases used in the research showcase that different methods reveal different acts of making and remaking, giving each prototype an aesthetically interesting appearance and narrative. Moreover, the plastic types applied in the experiments have been supplied by both industrial and domestic processing recycling centres and companies.

CASE 1
Finding ways to recycle polycarbonate

As part of the **first case**, a full-scale prototype of claddings for a building facade has been developed to test the melting, compression and moulding design and process of polycarbonate plastic. At 190-220 degrees in a fan assisted industrial oven, the soft polycarbonate was melted in predetermined jigs, testing and observing the pre-load compression, post-compression and temperature variations.

Associate professor at Aarhus School of Architecture, Chris Thurlbourne, and research assistant, Mads Hulsrøj Jæger, have followed an iterative prototyping process that goes beyond computer simulation into built artefact and production. More specifically, the scope for the design and design evaluation has moved in the process to include new frontiers in geometry, tool collaborations and environment interaction.

Design development and production of waste plastic have been done in a laboratory with a focus on finding designs that are applicable for practice. This has relied on an open-thinking approach as well as explorations of material performances of construction mock-ups and end products that are processed in ways that are fit for practice adoption and applications.

The primary material was recovered polycarbonate. The research development focused on techniques for producing stable building material that can be re-processed sometime in the future for further applications. Polycarbonate is an extremely strong material that is stable and durable with some grades being optically transparent. It has high impact-resistance and is therefore used in bullet-proof screens and vests. Polycarbonate, therefore, is suitable for construction and building component assemblies due to its strength and resistance.

Imperfection needs to be evident in plastic components

When we build with wood components like veneer plywood boards, every component has a slightly different structure and colour which is overt when placed next to each other. It is also apparent in the material production how it is processed, which provides authenticity and a sense of origin, human touch or transparency to its aesthetics. Often, you do not even hide the screws in the plywood boards, making the assembly of what is built highlighted as well.

Working with polycarbonate, the smooth and monotone look can make translucent roofing components for example appear too perfect, flawless, and without detail in contrast to their surroundings. And when the material will eventually tire, crack, break, it will be discarded. Therefore, the research-through-design interest has been to explore an afterlife for polycarbonates into new building components whereby the industrial, 'perfect' material production techniques are challenged with a new critical practice. Research development was driven by a fascination into striving and searching for imperfection, and, thereby, avoiding the smoothness that tends to alienate us from perceiving plastic as a relevant building component. In other words, to push the material so that it does not adopt the usual mass-produced appearance, but reveals the act of making.

Example of jig used for applying compression on plastic at predetermined positions.

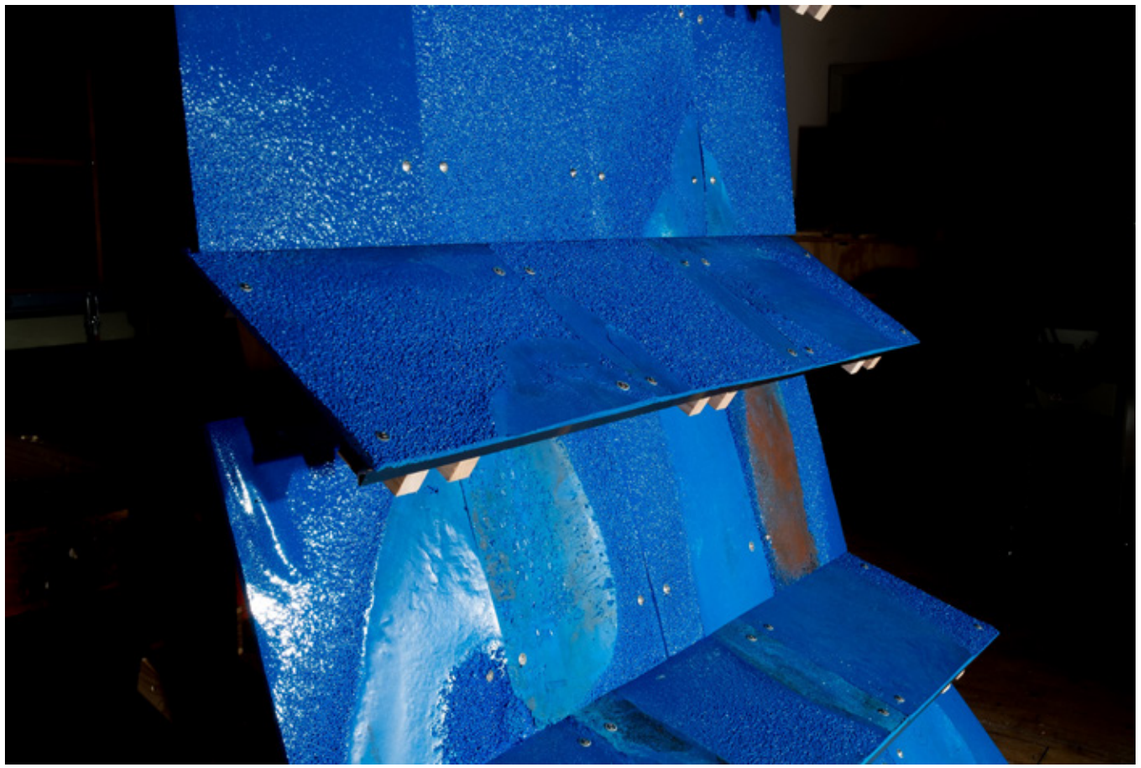
After initial explorations into extrusion techniques, a series of moulds were fabricated that served also as jigs. These allowed modulations of pressure to be applied on the exposed surface, creating a visible memory of the component's manufacture. The moulds, or jigs, were made from steel frames with different types of top-plate to explore variations in surface texture. Aluminium, stainless steel, and raw steel top-plates were used to test the finish. They were placed in the jigs whilst controlled pressure was applied to the plastic during the melting process in the oven, which facilitated a degree of random chance for the appearance of every piece. Just like traditionally made bricks, the techniques of making and firing makes sure that each brick is more or less unique.

Prototypes reveal the effects of patina

On purpose, the adopted techniques of making, melting and the post-oven pressing of polycarbonate panels were formed with degrees of chance and imperfection. This also means that a range of factors took part in the experiment to test the manufacture and end result. These factors are external weather conditions, imperfections in material quantity and quality per cast, contamination through non-clinical cleaning of the recovered material, difficulties in even heat distribution and variations in the period of time exposed to heat, and, naturally, human error.

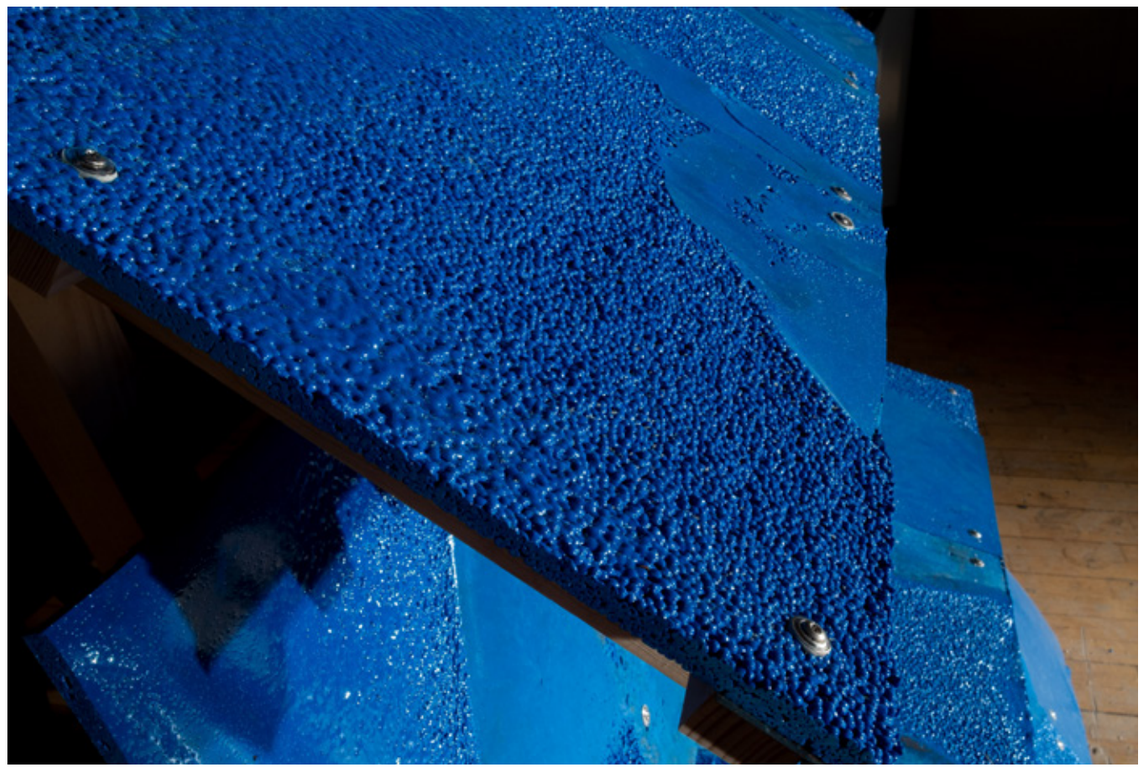
These tolerances of chance and imperfection were embraced and viewed as positive attributes as they have an impact on the long-term perspective on the aesthetics of the components. It adds to the purpose of the research project since it enables the building components to expose the assembly and material production as the principal architectural tectonic and aesthetic. Furthermore, the researchers explain, there are work patterns that could also be adopted in mass-production techniques through choreographing the interface between the operator and the machine.

The first prototype mock-up was specifically designed to encourage the polycarbonate plastic panels to patina. The design was a wall, fixed to a stud wall construction with alternating 'shelves' at different angles. This design was chosen to actively slow down the flow of rainwater discharge and concentrate water dripping into specific areas.



Polycarbonate facade cladding prototype. Patina traces give a sense of ageing to transform our perception of plastic as a material that is clinical and artificial.

The prototype was first assembled in a workshop, but later placed outside to track the impact of weather conditions on the facade. After an autumn, a winter and a spring of Danish weather, there is clear evidence that the plastic patinas, although beauty is through the eye of the beholder, produce a surface that gives early indications it will age well.



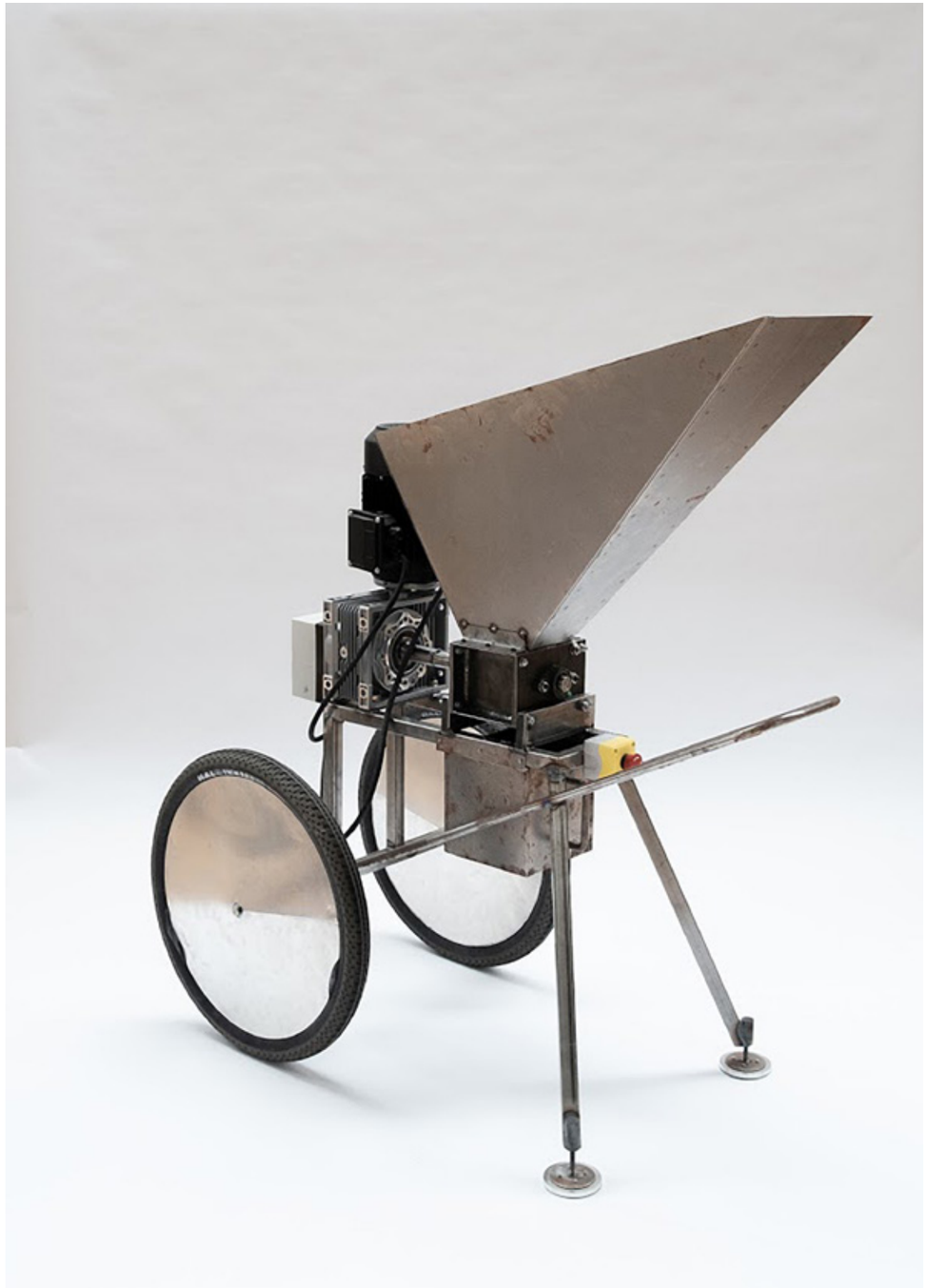
The design of alternating shelves was chosen to actively slow down the flow of rainwater discharge and concentrate water dripping into specific areas.

CASE 2:
Beauty can be found in waste plastic

The heated plastic in metal jigs is placed in a press during cooling. The press has also been used in later studies using casting sand to form new plastic building components.

One of the most common polymers used, HDPE, was tested in the research project's **second case** with the ambition to make this despised, ugly, throwaway plastic beautiful. HDPE is very ductile, strong and is often translucent – and most likely what your shampoo bottle is made from. It can be easily produced and as it is light and strong, it is predominantly used for single-use products – and then thrown away. Being softer than polycarbonate used in the cladding system from the first case, the research team built their own shredder for the HDPE, which they fed generously. Bottles, capsules and even the labels were shredded with the transparent material before heating it at 180 degrees.

For another prototype, the team have built a light modulator – a curtain – consisting of plastic shingles. It exploits the different levels of transparency from the mixed shredding creating illumination. At the same time, the shingles can rotate, expressing a degree of elegancy.



The shredder used in the second test case.

Shingle model facade. When allowing light to come through the shingles, the composites of the material are revealed. Colours of the HDPE flakes, along with different degrees of flake transparency, were randomly laid out emphasising the plastic being sourced from many product types such as plastic bottles, plant pots and cases.

Shingle cladding model facade. The aesthetics of the curtain wall changes according to the way natural day and sunlight pass through

Detail of the shingle cladding wall showing mechanically control-led cranks that open selected shingles

Shingle cladding exhibition facade at Onsite, Aarhus School of Architecture.

This plastic was sourced from domestic waste recycling so the material for production was entirely dependent upon people depositing their plastic and therefore not tested and regulated for consistency. The researchers wanted to compare production technique results using unregulated and unprocessed plastic with industrially sourced recovered plastic. The shredder produced plastic flakes that were more variant in size than the polycarbonate granular composites. They ranged from approximately 2-10 millimetres and were less rigorously sorted and cleaned.

For HDPE to be remoulded, it needs to be heated at a slightly lower temperature than polycarbonate, in the region of 180 degrees, for it to become soft but not burn. A different production technique was adopted, whereby panels were melted and formed with a consistent surface finish, but as thin as practically possible. A post-production compression technique was chosen, whereby the plastic flakes were placed in a form, softened in an oven and then pressed into shape after being removed from the oven, but still soft. The same metal frames were used from the first case study, demonstrating, to a degree at least, justification for making robust metal frames within a sustainable mindset. Relatively thin panels were produced – shingles – that were lightweight, flexible and offer a good degree of transparency.

After showcasing the results in an exhibition, articles and social media, there has been considerable interest in developing and using this research in practice. Local actors, like the local public recycling centres, a local music festival, and facade manufacturers have all expressed interest in learning and potentially become partners in achieving manageable large-scale applications. The research has hit a nerve in the sense that recycling should be considered more than scientific production. That there is aesthetics embedded in production that can promote both good architecture, but also a better appreciation of plastic as a partner in our lives that is more than a convenient yet disposable non-descript object, which is exactly where the research had started from.

TESTING LOCAL MATERIALS AND HISTORICAL TECHNIQUES TO REDUCE THE ENVIRONMENTAL IMPACT OF CONSTRUCTION

Traditional methods of overcoming resource scarcity are the key focus of an architectural research project at the open-air museum Hjerl Hede. By constructing barns for sheep and cattle, the researchers have tested what is possible when the goal is to achieve maximum benefits for climate, construction and students. Locally constructed barns are also the first step on the path towards sustainable buildings for human use.

Regional Potentials For Sustainable Sourcing and Application of Building Materials

Project team
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Project partners and acknowledgements
Studio 2D, Aarhus School of Architecture

Frilandsmuseet Hjerl Hede
(Hjerl Hede Open-Air Museum)

Recipient of the Danish Arts Foundation's Dristighedsprisen (Audacity Award) in 2022

Scan the QR code to see researcher profile (this is also where the project will be published)

On the edge of a wood at the open-air museum Hjerl Hede, researchers and teachers from the Aarhus School of Architecture are working with a team of master students to build dwellings for domestic animals in the form of barns and shelters for sheep and cattle. Although this client group has slightly less demanding comfort requirements than human occupants, the task still involves creating essential and durable construction solutions, from foundation to roof. This opens opportunities for reconsidering long forgotten construction techniques.

The purpose of the pilot project is to explore the potential for self-sufficiency in construction and to minimize the carbon footprint. Resource scarcity and a journey of rediscovery of historical building traditions set the course in the construction of full-scale dwellings for animals. Thus, the research project aims to revisit and learn from the most enduring construction principles from vernacular architecture with the goal of applying them in contemporary construction.

The long-term perspective is to explore the durability of environmentally friendly solutions and to develop them for use in sustainable human dwellings. The basic idea is that if the animals thrive and the buildings endure, the solutions hold potential benefits for human use that are in step with the sustainability agenda.

Sheep barn,
19 May 2021

Sheep barn,
25 May 2022

A modern yard of about 60 m2 built from locally sourced materials and without excavating or casting. The collective design process takes place both at the drawing table and on-site. The availability of materials on-site and nearby has had a significant impact on the process.

Physical construction shows how to build with fewer and local resources

With the project "Regional potentials for sustainable sourcing and application of building materials", the researchers aim to shape the future market, rather than trying to meet needs on the current market. Based on in-depth knowledge about materials and historical construction techniques, they search for solutions that can be applied in contemporary construction and thus help push the construction market in a more sustainable direction. A key element in the research effort has been the use of physical constructions. The researchers have tested alternatives to conventional and energy-demanding materials, such as concrete and steel, and faced challenges that they were ultimately able to reduce or eliminate in practice.

For example, the buildings are constructed using locally sourced materials, thus avoiding round-the-world transportation and the associated climate impact. The energy-consuming production of concrete and steel has been avoided as much as possible, as foundations and construction use no concrete and a minimal amount of steel. Another example is an investigation of the pile foundations, where stone foundation piles are locked into the building's load-bearing timber structure in order to minimise contact with the soil and thus the number of materials required for the foundation. As a further benefit, the foundations did not require excavating or casting. Instead, the builders used clay and lime, while the core-and-veneer wall that supports the pile foundations was built from reused cobblestones.

Another example of technical sustainability is the use of split wooden shingles for the exterior cladding. Split wooden shingles are more durable and has no waste of material compared to sawed wooden shingles. The researchers also tested the usefulness of invasive plant species, such as common broom, as roofing. Furthermore, the project aims to reduce the use of nails, screws and steel by using lashed joints, a technique known from shipbuilding.

Cobblestones sorted by size and ready for building. The stones were previously used in the driveway to the open-air museum Hjerl Hede; before that, they paved the main street in the Danish town of Skive.

With each course in the core-and-veneer wall, clay is rammed into the core to stabilise the cobblestone walls. In addition to keeping the animals and the deep litter in, this technique also helps stabilise the granite pile foundations.

Lime mortar from a nearby mortar mill is used in the construction of the cobblestone wall. The mortar is reinforced with hair from the horses at the Hjerl Hede open-air museum.

The large granite blocks for the pile foundations come from a quarry on the Danish island of Bornholm. With inspiration from traditional Japanese construction techniques, the tops of the blocks were cut to form an overlapping joint with the piles.

Roofing using shingles made from local common spruce.

Screen for a cattle shelter made from vertical stakes interwoven with horizontal withies, a technique known from older timber frame construction. The material is black cherry, Prunus serotina. The Danish Environmental Protection Agency designates this as an invasive species that should be destroyed, and as it is present in abundance it represents a free resource. The wood is hard and strong but also pliable, almost like bird cherry.

The researchers not only turned to Danish history books in their search for construction techniques to be tested. For instance, the design of the joint between granite and timber in the pile foundations drew on inspiration from traditional Japanese architecture. The techniques for manufacturing split wooden shingles and using them for roofing were developed with inspiration from Norway and Eastern Europe. The layered timber constructions were inspired by both Frisian and Japanese traditions. The ventilation principle and the shape of the roof were based on studies of Gothic and East-Asian architecture as well as tropical shanty towns and traditional Danish construction techniques.

The cattle shelter is built entirely from organic materials, meaning that the construction will be composted and dissolve into the forest floor if it is not maintained. The roof is suspended from the trees that also support the walls, so that the building literally has no 'footprint'. The flexibility of the lashed joints allows the living trees to grow and to move in the wind.

Felling in preparation for the construction of the sheep barn.

The research of locally sourced roofing materials naturally looked to heather, since the building is being constructed at a moor area. However, they found that common broom – another highly undesirable alien species in Danish nature – proved much more suitable. Like black cherry, common broom could be harvested in large amounts close to the building site.

Highlighting resource scarcity

The historical buildings at Hjerl Hede also served as a reminder that human existence has always depended on our ability to adapt to the site, grow our own supplies and optimize the use of scarce resources.

– Today, we choose materials and components based on generic preferences and building supply catalogues, but throughout history, people have constructed building using materials and techniques driven much more by necessity. Resource scarcity and the effort to maximise the utilisation of individual resources have determined construction approaches, says Nella Qvist, Research Assistant in the project.

Scarcity is still a key factor to consider in the effort to minimise carbon emissions.

– Resource scarcity remains a factor today, even if it is invisible to many of us. Nature cannot keep up with our overconsumption, and climate change is the price we have to pay. We need to extract and use local resources in a sustainable manner if we want to transform real-life architecture and construction into more sustainable industries that achieve the goal of CO2 reduction, says Niels Nygaard, associate professor at Aarhus School of Architecture.

Students engaging in hands-on construction

Fifteen Master's degree students have been the driving force in the physical construction of the barns. With guidance and instruction from Niels Nygaard and Nella Qvist, the students designed and developed solutions for the experiment, which is being constructed as a full-scale structure. By involving architecture students directly in the building process, the project embodies sustainable innovation and research as an educational element, says Niels Nygaard.

– In this course, we aim to develop a common understanding, also in the individual student, that the circular economy and the use of local resources are key conditions that architects are responsible for incorporating into construction practices going forward, says Niels Nygaard.

The 1:1 approach to education in craft and building methods in architectural history rests on the German concept of bildung, meaning the personal and cultural maturation that comes from giving tangible shape to something as one learns.

One important distinction between past and current resource scarcity is that today, scarcity is no longer physically conditioned but rather reflects a necessary mindset that we in the Western world need to relearn. Based on bildung, the aim was thus to impart an ethos to be reflected in the students' approach to sustainable construction.

This approach aims to prepare and enable the Master's degree students to challenge the business-as-usual culture in the construction industry and to strengthen the architect's role in future sustainable construction. The basic idea is that the responsibility for the well-being of local communities and nature does not rest with the individual architect but can only be achieved through a concerted effort.

For the students, this meant that each of them had to contribute with high-quality solutions with a view to designing and building the barns. This direct involvement and responsibility also enhanced the students' motivation, physical contribution and learning outcomes. In 2022, students and staff involved with the Studio 2D have received Dristighedsprisen (the Audacity Award) by the Danish Arts Foundation for their work on the project.

A need to look at the role of public authorities

The results demonstrate that many of the construction processes led to savings in terms of money, time and energy, just as the construction materials also appear to last longer with less processing. While the past has thus proven a useful source in the search for the green techniques of the future, society has introduced additional requirements to construction. Even though the techniques and materials in principle comply with the norms and regulations governing building practices today, several issues have come up that challenge the role of historical techniques in today's industrial construction and market.

The project's forward-looking research perspectives include challenging the technical standards constructions have to comply with today. By using locally felled and cut timber from the woods around Hjerl Hede, which does not have a CE label, the pilot project documented that it was possible to build at half the cost and in considerably higher quality than if imported, CE-labelled timber had been used. Thus, there is a research potential in engaging with the authorities to investigate how to adjust requirements to, for example, timber strength classes and labelling as well as technical requirements concerning heating, insultation and ventilation in a way that allows for the use of locally grown and processed materials

Additional studies revealed a tradition for thatching with common broom in the south of France and the north of Spain.

Beams for the cattle shelter, felled a few hundred metres from the building site. The whole trunk is used, and only the ends are split so they can grip the living trees, almost like an old-fashioned clothes peg.

Making split wooden shingles. The log is split along the radial planes in order to minimize the number of severed fibres. A discarded bicycle tube is used to keep the log together during this process. This method is time-efficient and produces shingles of a much higher quality and durability than sawing.

Further development of the project could include an assessment of the continuous development of techniques and this alternative approach to teaching affects the students' learning environment and training of architects in the future. A crucial question in this regard is what sort of architects educational programmes produce. So far, the project's learning approach and its emphasis on bildung produces architects with a more ethical orientation and a more holistic mindset with a greater understanding of resources, material properties and processes – and of the utility in revisiting tried and tested architectural techniques with the potential to facilitate the green transition of architecture and construction.

HOLISTIC ARCHITECTURE AND PARTNERSHIPS FOR CHANGE

Towards a Holistic Approach To Architecture

As reflected in the United Nations' 17 Sustainable Development Goals, the green transition is not just about physical changes but also about a change in mindset. Construction involves a wide and diverse range of actors, from engineers, contractors and aesthetically oriented architects to anthropologists and sociologists as well as clients and users, all of them with varying interests in economics or everyday practical use. Based on this premise, some of our researchers are currently studying what it takes to change the approach to – and collaboration in – construction to ensure that everyone is guided by a common goal of creating sustainable architecture. Other researchers focus on learning from and analysing both historical and contemporary Nordic architecture with a view to developing holistic methods that promote true sustainability.

06. Danish architecture projects can show the way from goals to actions

07. Mapping SDG collaboration to remove barriers of interdisciplinary partnerships

DANISH ARCHITECTURE PROJECTS CAN SHOW THE WAY FROM GOALS TO ACTIONS

In the past, architecture has collectively failed to considerably lower carbon footprints, leaving European and Danish sustainable goals in jeopardy and the climate predictions unsettling.
To avoid stagnation when aiming for new political milestones, the many Danish projects that strive for being more sustainable should lead the way, a research project points out.

Scan the QR code to read more about the research project

Danish Architecture Beyond 2020 (DAB2020)

Project team and contributors
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After the 2020 sustainability goals were not reached, NGOs, politicians and citizens have called the current state a global emergency. It has been proven that the narrow approaches to sustainable architecture focusing, for example, solely on energy reduction or material recycling are unable to answer complex, interconnected challenges of the climate emergency. In a time of drastic climate changes, natural disasters and military conflicts resulting in forced human displacement, it is necessary that design actions address global, also forthcoming, threats while undertaking local actions.

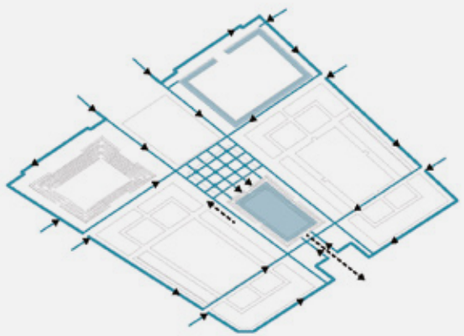
Researchers from Aarhus School of Architecture have looked at innovative ways which can help with sustainability in a comprehensive manner when drawing, designing, and building architecture. With the pilot project "Danish Architecture Beyond 2020", they have identified five Danish projects that each showcase a more holistic approach to sustainable architecture design. These projects are chosen as key examples of sustainable architecture among 100 Danish projects. All five approaches address global challenges connected to sustainability. Each of the projects is highlighted because they excel with an approach and succeed in carrying out sustainable ambitions on specific parameters. Therefore, the researchers conclude that it is only when we combine the design strategies explored in the five approaches, we can result in resilient sustainable architecture and long-term emissions reduction in the construction sector.

While environmental sustainability is part of the project's research interest, other approaches address other problems related to a sustainable future – such as social inequality or health and well-being. Issues that Danish society has achieved and now, for good reasons, take for granted. And in fact, this qualifies the Danish projects to showcase ways of leading sustainable action in collaboration with architecture firms and academia and explain the mechanisms of each approach. To understand each of the design strategies relating to the green transition, both the green transition projects and the projects dealing with issues such as social sustainability are highlighted to give a bigger picture of the approaches to sustainable architecture.

1: Flexible spaces give water a place to go

An increase of water from the sea and cloudbursts is the major climate crisis Denmark is facing now and in the future. Focusing on the built environment, the researchers have looked into climate adaption design approaches, questioning how we will live in and co-exist with unpredictable climatic futures. Here, context is key, meaning that buildings should be developed from and adapted to their specific climate, context, society and culture. This approach accepts and makes room for unpredictable futures and in this case water. Therefore, it differs from previous approaches which only sought to mitigate the issues of climate change – often hiding technical solutions from everyday society in underground pipes and infrastructure. By having a whole-systems approach to the problem, it looks beyond the technical issues and asks how a project can also give back to the social, cultural and environmental issues of an area. It offers a new way of thinking about how we plan public spaces, which are not static but flexible and adaptive to many different future scenarios.

The renewal of Enghaveparken in Copenhagen by Third Nature is innovative in the way it includes both everyday recreational activities and technical flood prevention requirements integrated into the same space. This allows for functional flexibility and gives water a place to go during extreme weather events such as cloudbursts. For example, the levee around the park allows it to hold 22,600 m3 of water. At the top, seating and water channels offer a recreational and educational element for sensual, relaxing and learning experiences. Sunken-in street-sports areas such as hockey and football courts, framed with ramps, act as seating and create play areas while also allowing even more water collection during flooding events. Climate change, in this instance, is not seen as a negative aspect, but offers an innovative example in the way it makes an opportunity for the transformation of urban spaces into robust, adaptive and loved areas of a city.



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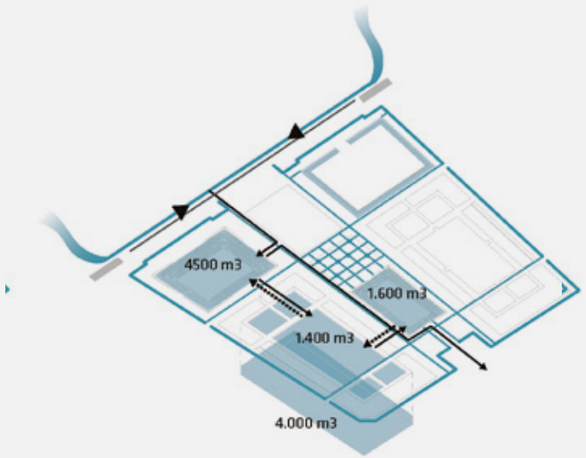

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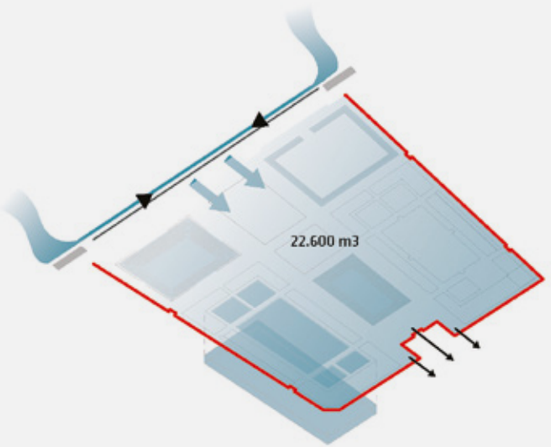

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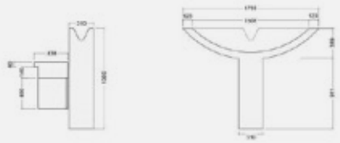
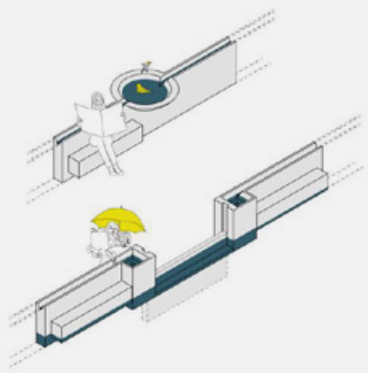
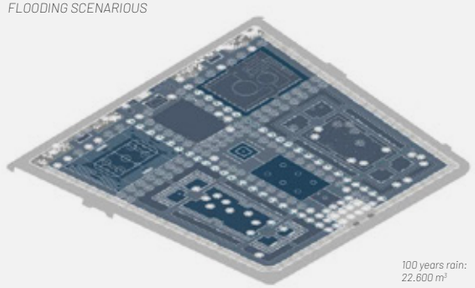
WATER CATCHMENT

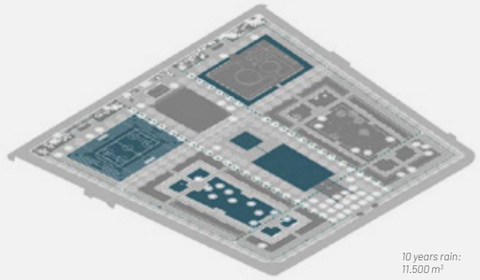




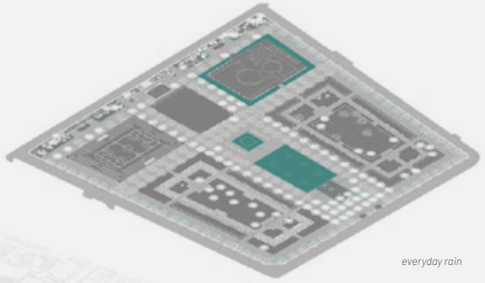
FLOODING SCENARIOUS



100 years rain:
22.600 m³



10 years rain:
11.500 m³



everyday rain

CONTEXT

cultural heritage:
Arne Jacobsen 1928

carlsberg byen

Analytical drawing of Enghaveparken. This drawing indicates the different flooding levels and solutions in different areas of the park. The series of drawings on the left show different flood scenarios with the colours representing what will collect the water at different volumes. Starting at the bottom, the yellow shows the cultural heritage of the existing park by Arne Jacobson followed by everyday day, 10 years of rain events and 100-year rain events. To the right, details of the flood protection wall are illustrated. The bottom shows the multipurpose nature of the wall and how the flood protection gate rises in rain events and at the top, the upper water catchment channels are dimensioned.

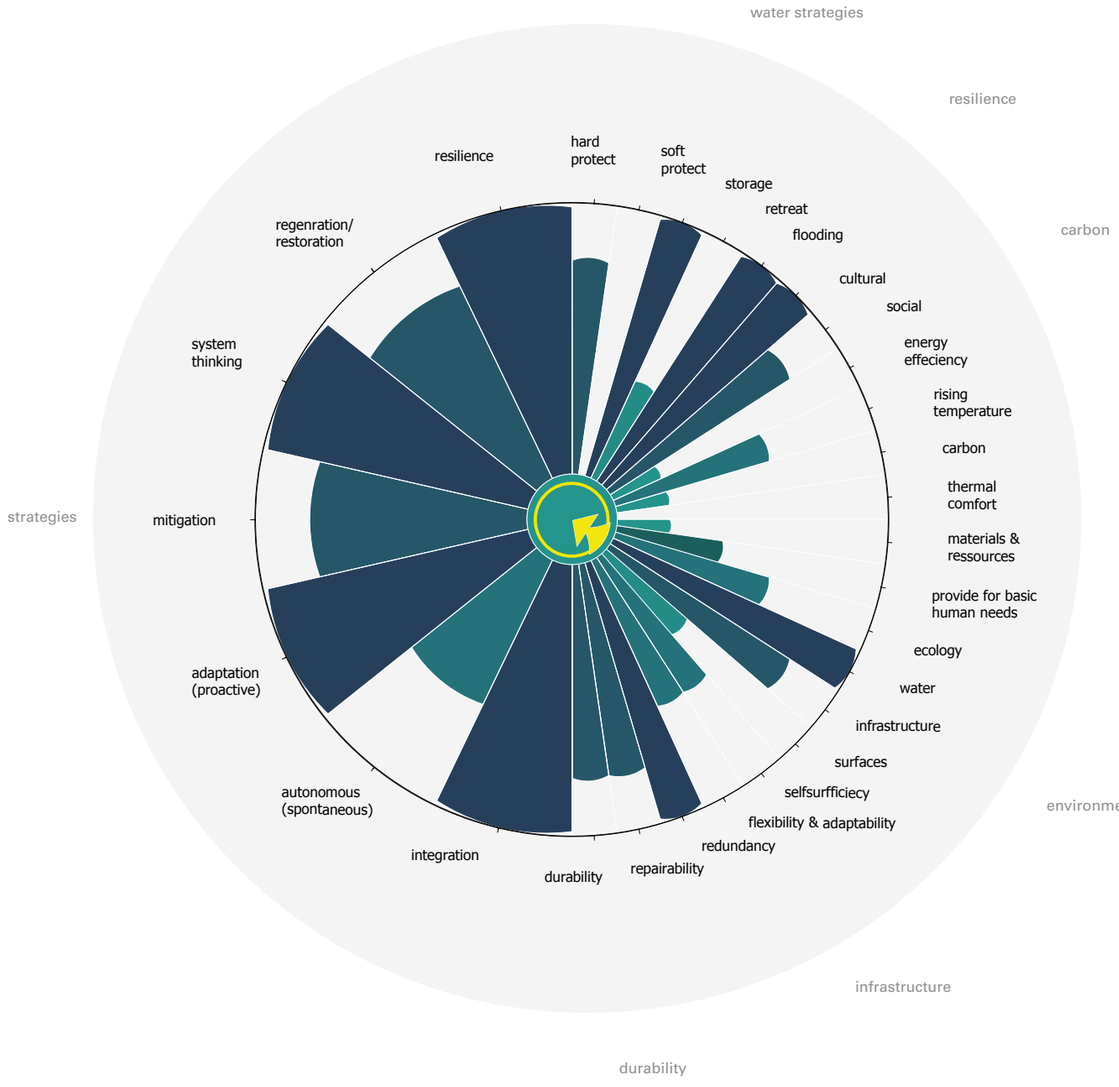
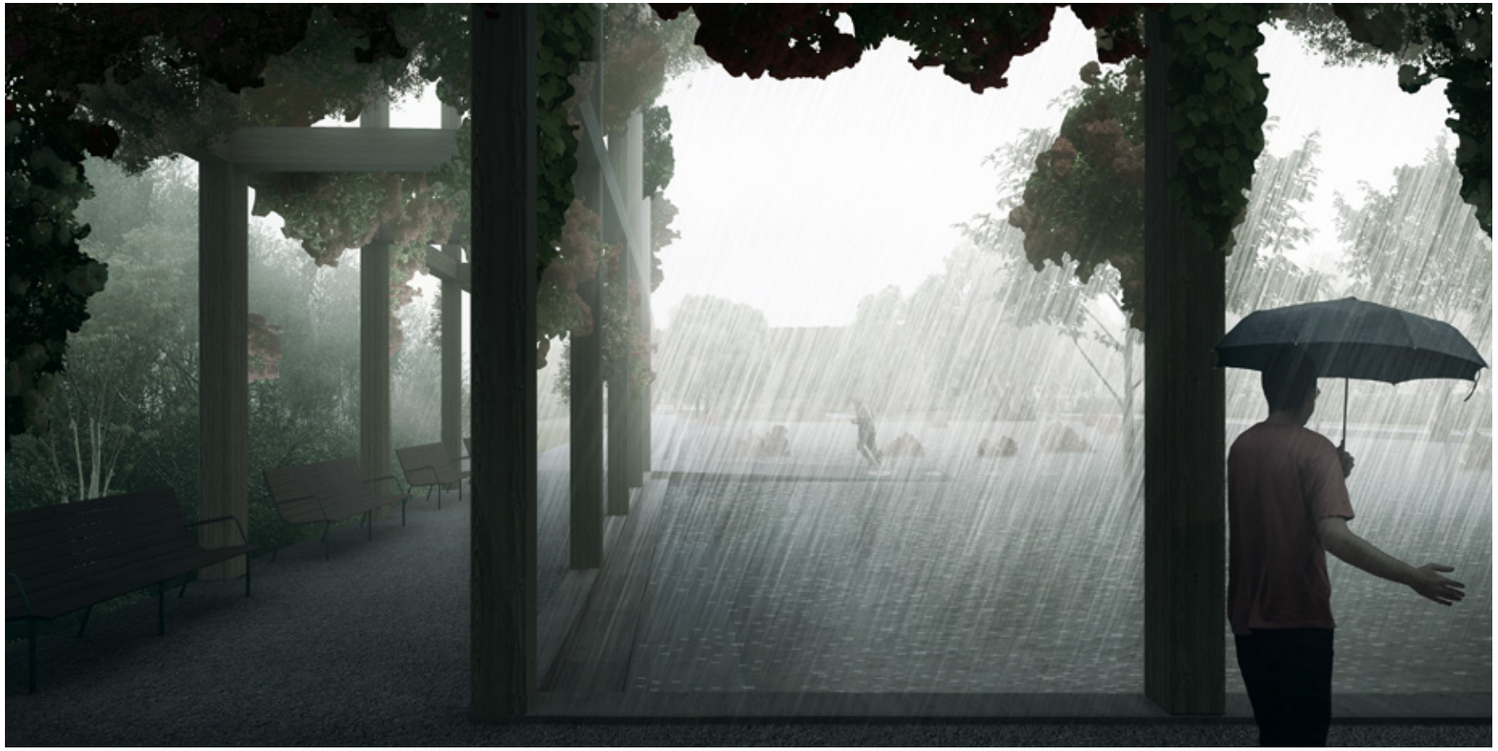


Diagram showing design strategies used in Enghaveparken. It indicates that the project is successful in notions, for example, of resilience, systems thinking, adaptation, integration as well as different specific water strategies. Due to the use of concrete, it is considered less successful in terms of materials and resources impacting long term climate change mitigation concerns.



Copyright: Third Nature

Lean more about Enghaveparken by Tredje Natur

2: Architects need to consider the lifetime of limited resources

Another tangible approach to sustainability is circularity which promotes life-cycle design strategies and renewable or reusable resources that can reduce the carbon footprint of currently built buildings. Our limited resources call for long term perspectives that consider the entire lifespan of the building, its function, usage, construction, maintenance, disassembly, and future reuse.

The researchers use Villa Wood in Copenhagen by Nord Architects to showcase this applied approach. The single-family house is designed as a flexible space with a partially open plan and section which can accommodate changing needs of its users in future. It uses natural ventilation, passive solar heating and a heat exchanger to reduce energy consumption. Apart from the concrete basement, Villa Wood is built with CNC-cut CLT wood elements, which has allowed to accelerate the construction process and reduce the carbon footprint of the building.

Moreover, prefabrication of modular components, legible arrangement of elements and reversible connections enable optimised use of resources and the future disassembly of the building. Reduced finishing and thermal impregnation of timber elements make it easier to recycle in the future. The implemented circular design strategies, combined with a minimised spatial footprint in that the usable area of the building is smaller than the usual single-family house, show a more sustainable alternative to a popular typology of currently built single-family houses in Denmark.

Circular strategies in architecture, also visible in Villa Wood, require that more renewable and recycled resources are used, that flexible buildings are designed to be disassembled in the future, and that the elements are reused to reduce generated waste and emissions. However, due to the lack of knowledge, extra costs or unsuitable building regulations, those activities still remain niche practices and need to be scaled up to make a real difference. In the case of Villa Wood, circularity and the focus on leaving a small footprint has been reached by using timber, a fabrication-simplified construction reducing the number of elements, as well as limited finishing of materials.

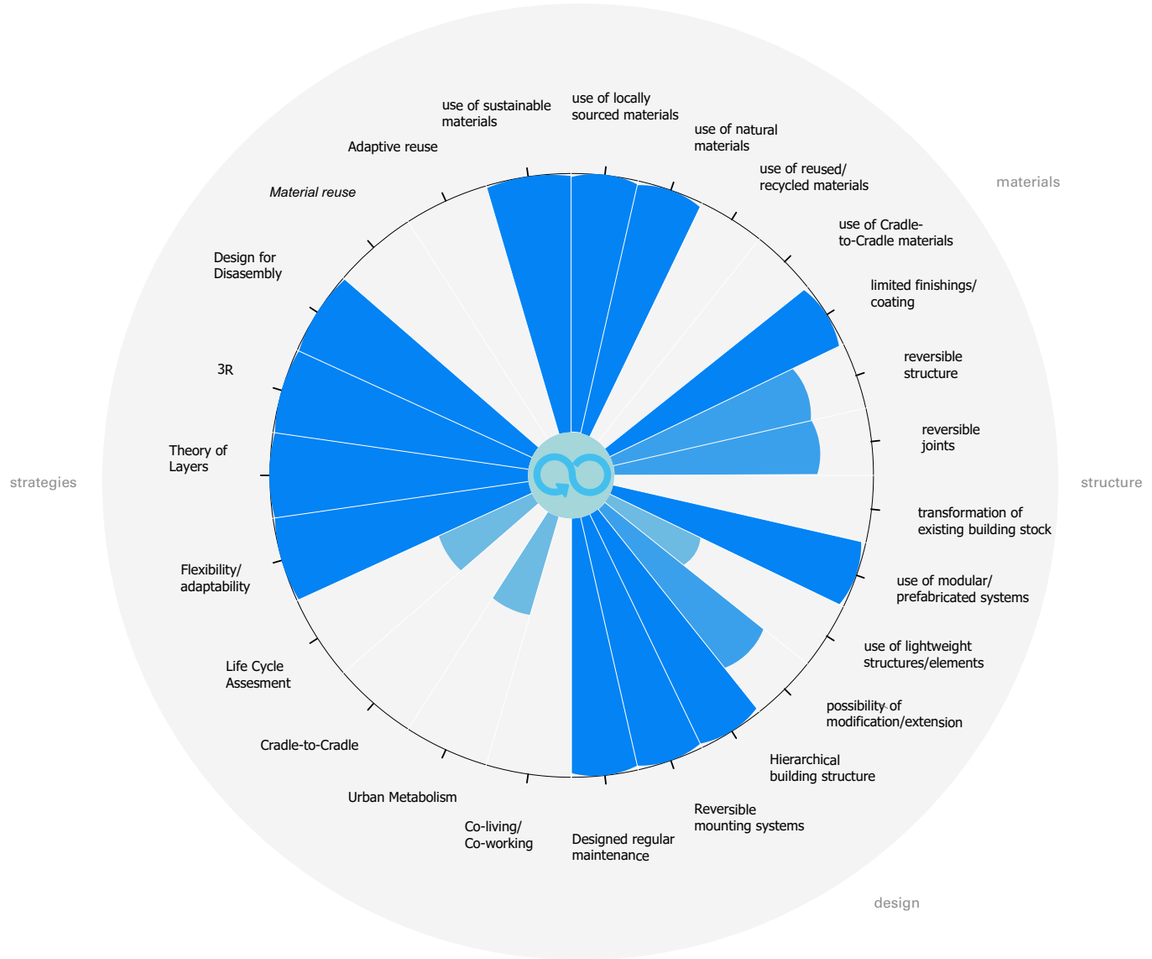
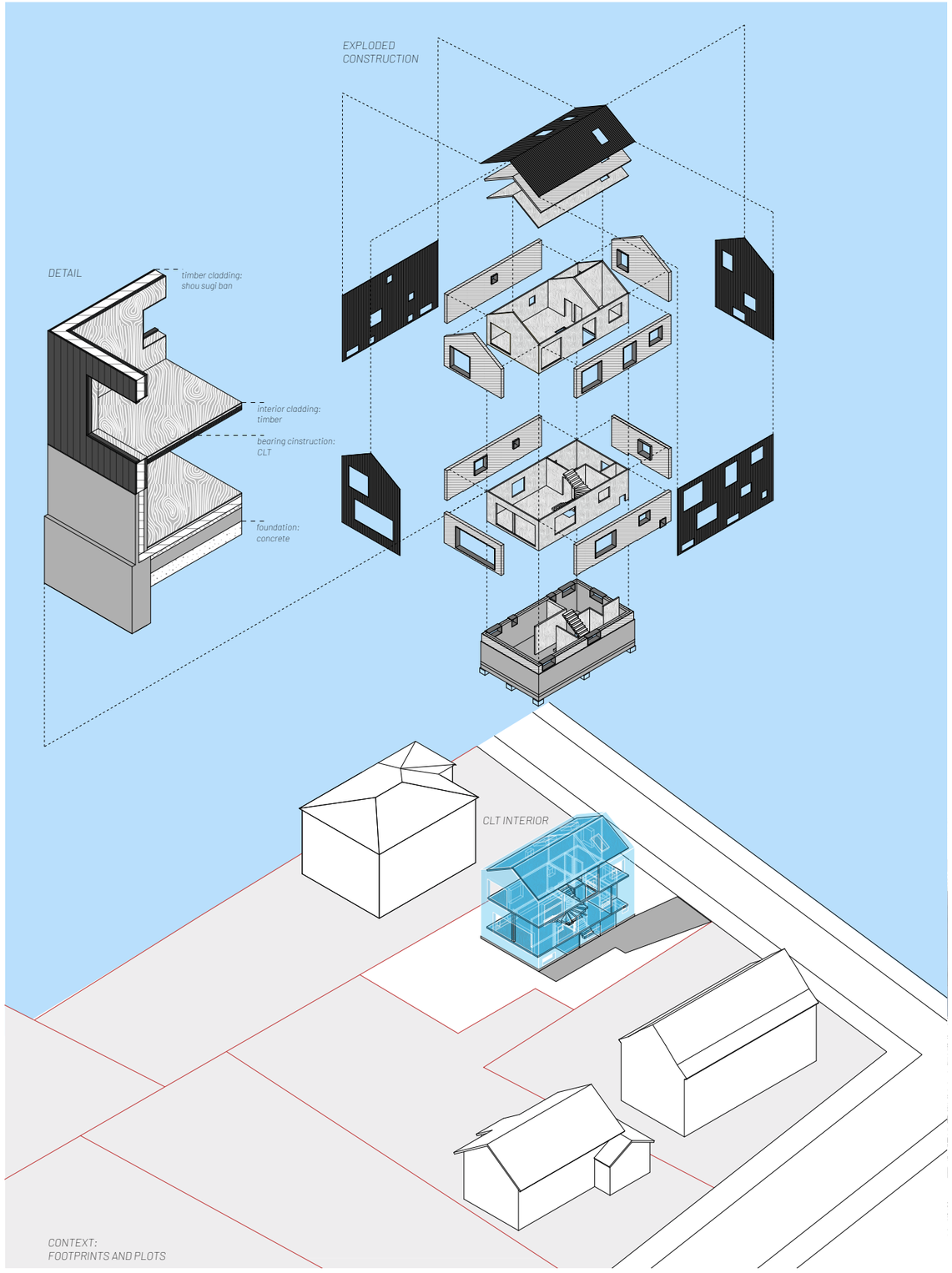


Diagram showing circular design strategies in Villa Wood emphasizing the choice of hierarchical, modular, prefabricated, reversible building system and flexible plan, and the use of sustainable materials with limited finishing.

Analytical drawing of Villa Wood. The drawing presents the legibility and reversibility of the construction system employed in Villa Wood. It highlights a clear organisation of building layers, modularity of CLT elements and limited finishing of materials that enable fast construction and future systematic disassembly. Moreover, the building's placement on the site provides a commentary on its minimised footprint.

Learn more about Villa Wood
by Nord Architects



Learn more about Villa Wood
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Photo: Adam Mørk

Photo: Adam Mørk

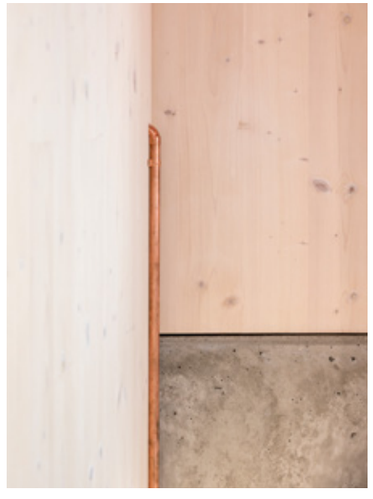


Photo: Morten Rask Gregersen

3: Affordable housing unites students and refugees around SDGs

Asking how a specific, strategic approach can lead to a climate emergency design action, which tackles social justice and equality, it is worth looking into Friendly Housing Plus in Friedriksbjerg, developed by ONV Architects. This building rethinks micro-living in urban areas. It focuses on social integration in a new co-living typology that provides an alternative and inclusive architectural answer to the migration crisis in Europe.

This affordable housing for Danish students and the refugees revolves around sharing practices manifested in the spatial layout. It is supported by an organisational set-up, which creates visual connections and strengthens the mutuality of cultural experience.

The typology supports frequent users' interactions in private living units. For instance, through shared living rooms and kitchens common spaces, such as extended staircases, common rooms and rooftops, and through public space as the courtyard. Moreover, it develops closer bonds and more personal support introduced in a buddy scheme, where Danish students act as more direct links to the Danish culture and society. This typology questions the prevailing ghettoization of migrants in Danish cities.

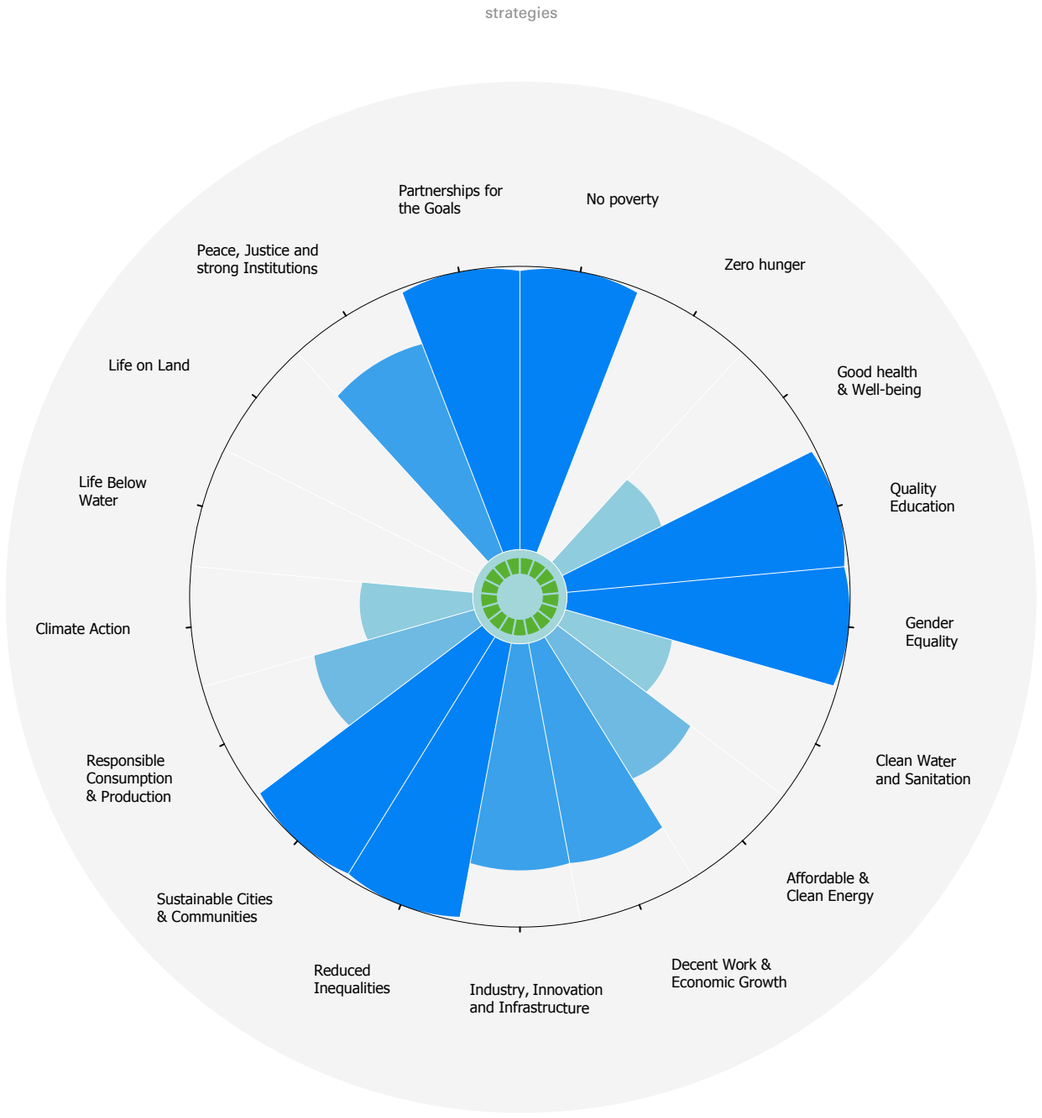


Diagram showing SDGs-related design strategies in Friendly Housing+. This building focuses on the goals concerning reduced inequalities and the development of sustainable cities and communities but also rates high in the partnerships for the goals, peace, justice and strong institutions or responsible consumption and production.

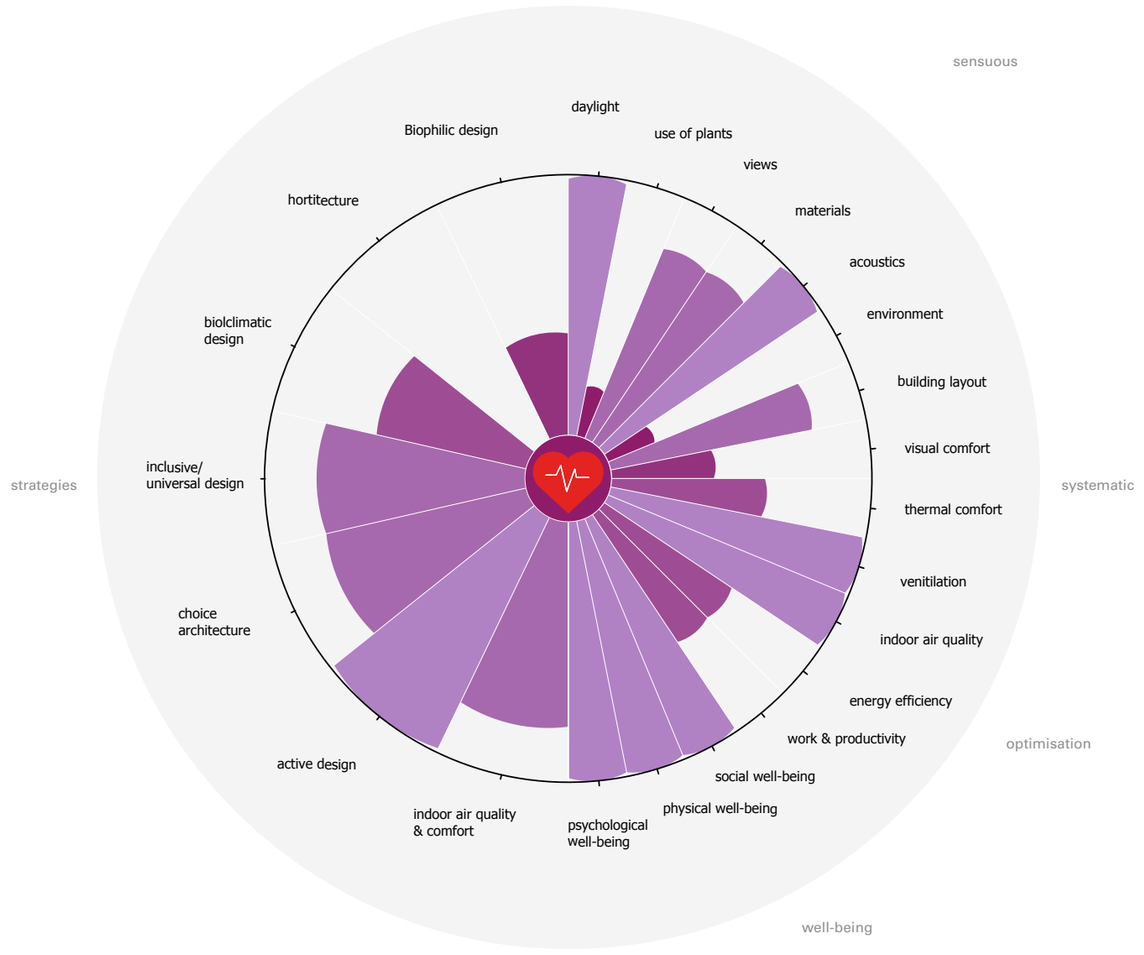
Analytical drawing of Friendly Housing Plus. The drawing explains how a modular building structure enables diverse users' interactions in private, semi-private and public shared spaces – starting from the shared living rooms and kitchens in the apartments, extended staircases and rooftops to a common courtyard on the ground floor.

Learn more about Friendly Housing Plus by ONV Architects

4: Well-being and learning go hand in hand

According to the Ministry of Environment of Denmark, we spend 80-90 % of our lives indoors. Therefore, ensuring our building promotes health and well-being physically, socially and psychologically is important for sustainability. We can build the most energy- and carbon-saving buildings but if they make you sick or not everyone is considered – including the environment and non-human species – they will become obsolete. In fact, Denmark is known for focusing on the people and activities the building is designed for. Even though the Danish regulations are endorsing healthy and non-toxic materials, more can be done to promote equality and well-being in buildings.

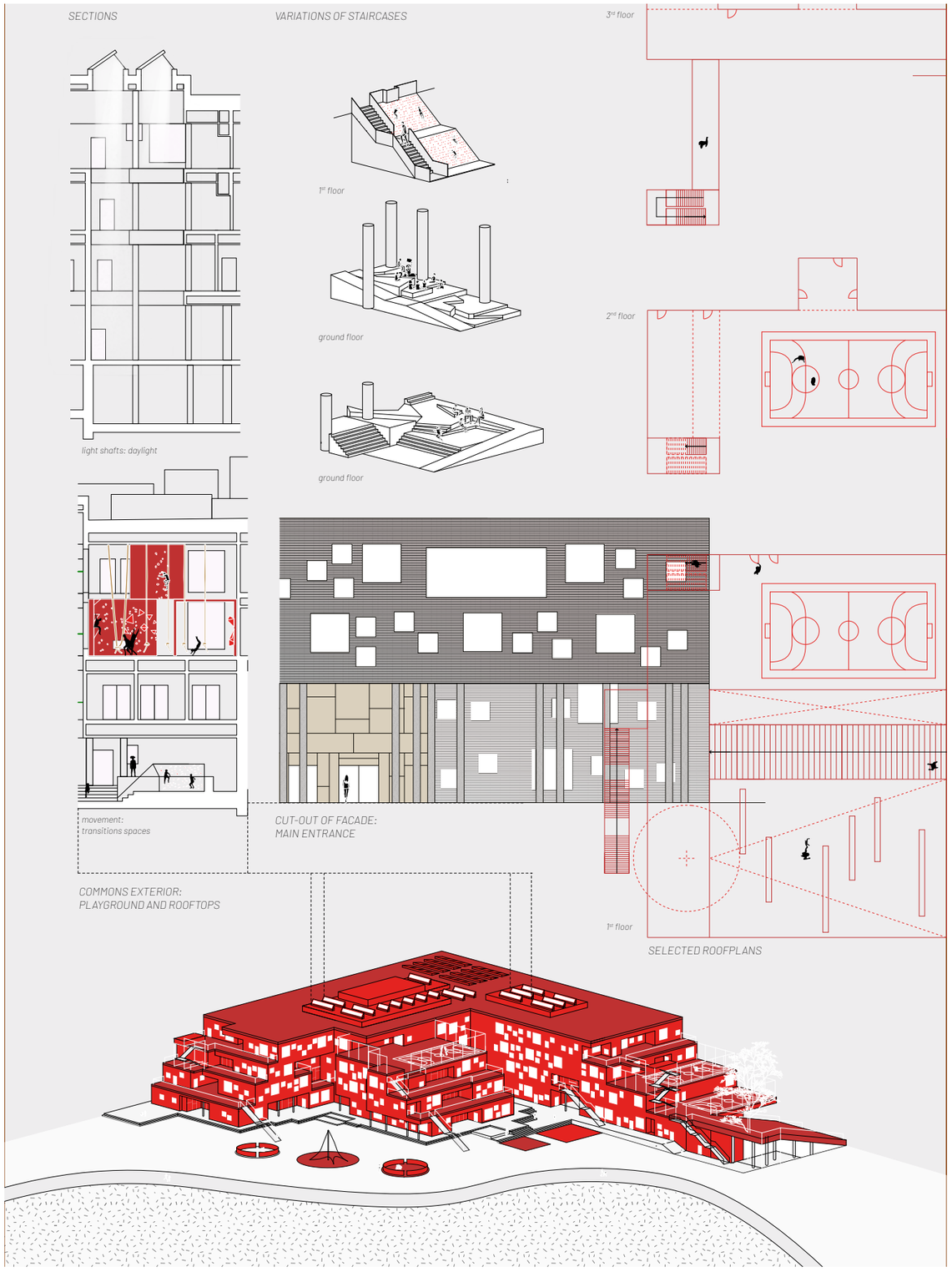
As one of the first schools to respond to the physical activity reform, Frederiksbjerg School in Aarhus by Henning Larsen Architects adapted a health and well-being approach. The kinaesthetic school understands that children learn better when teaching is combined with physical activity, movement and sense-perception. The building innovates new ways to navigate at the school by encouraging new activities at every turn. Additionally, knowing light, daylight and views impact learning, the project of Frederiksbjerg School reconsiders how a classroom could look and be used pedagogically to enhance education. Further, the school promotes social well-being, sharing terraces, outdoor areas and playgrounds with the public, where you can relax and play – showcasing how a building contributes to the wellbeing of the community.



Analytical diagram showing how health and wellbeing design strategies are implemented in Frederiksbjerg School – the length of the segment represented how different categories are present. From the analysis it is clear that this project successfully considers the physical, psychological and social or community wellbeing, especially through active design and several parameters of indoor quality. This includes daylight, acoustics, ventilation, air quality, thermal comfort and views all of which impact e the learning environment of this project.

Analytical drawing of Frederiksbjerg School illustrates how different strategies facilitate health and wellbeing. For example, on the right-side physical attributes such as outdoor seating or public basketball courts increase community and social wellbeing. In the center different stairs, ramps and climbing walls are shown which are used to increase physical activity. At the top left a section of the central core of the building showcases how balanced ventilation and natural light are used to create a good indoor environment.

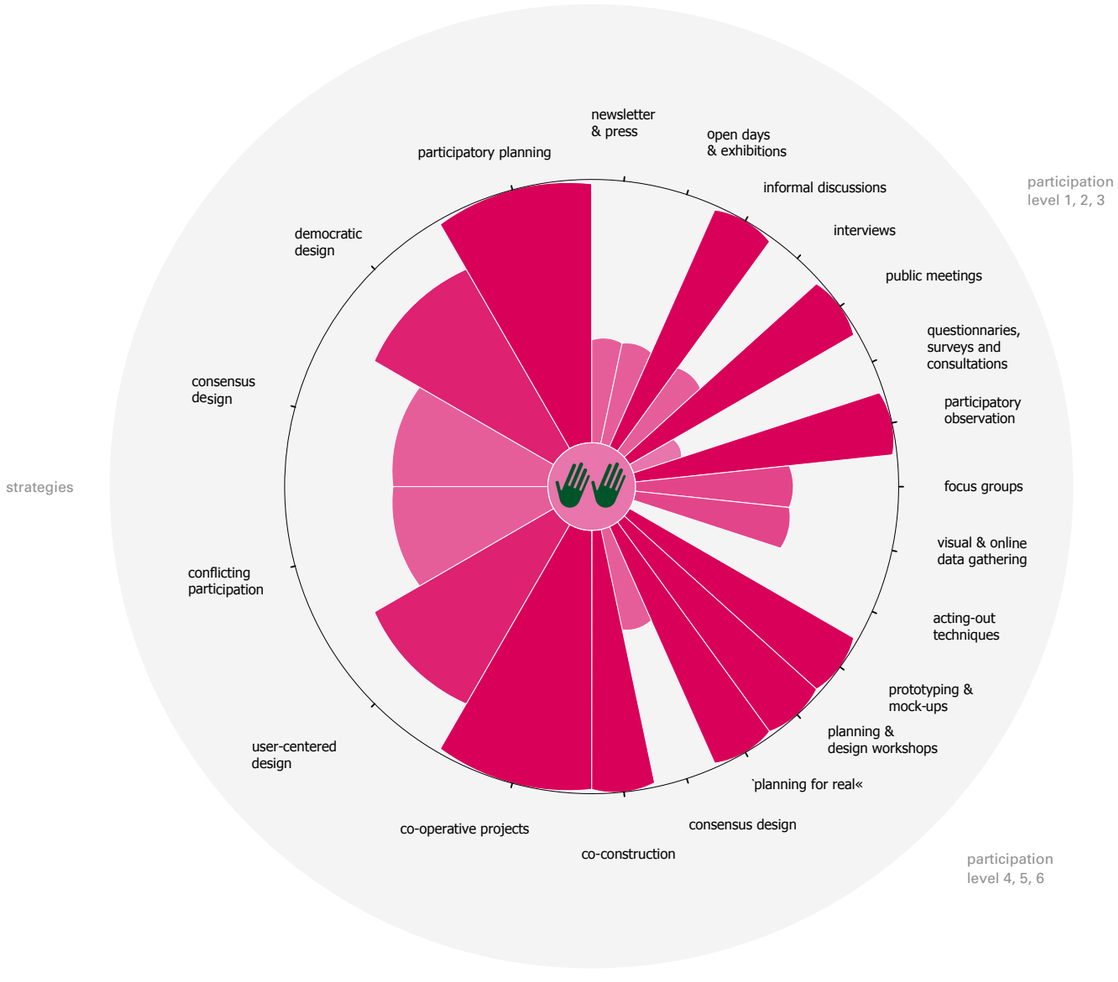
Learn more about Frederiksbjerg School by Henning Larsen Architects



5: User involvement creates communities and sustainable usage

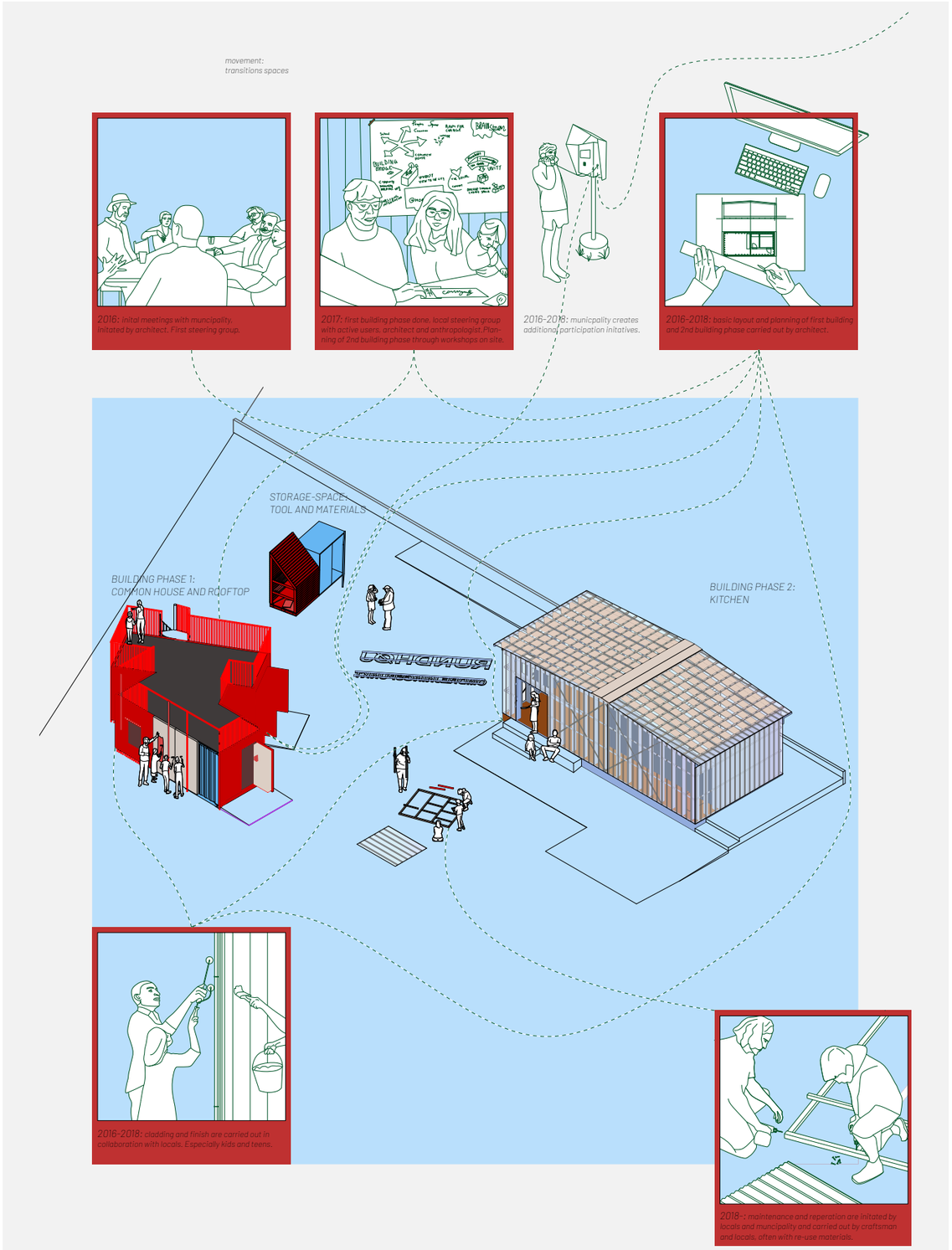
The research also highlights the importance of participatory practices in architecture. Such practices involve future users and local communities in the design process to develop places that address the current and future needs of the users – which result in long-lasting architecture due to continuous user engagement.

Rundhøj Turning Point in Aarhus by KONDENS is used as a case in the research with the architects' ambition to integrate the local, diverse community. The project was developed in a 1:1 participatory design process in close collaboration with the residents, local businesses and Aarhus municipality. The programme of the building, including a common house, a kitchen, a contact point, and toilets, was conceptualised, co-designed and built with the building's future users. The architect, constantly present on-site, acted as the initiator, moderator, facilitator, designer and organiser of the process. At the same time, the architect had the role of instructor and co-builder, pushing the boundaries of what a participatory project can be. The collaboration with the local community has resulted in a vibrant building that activates public spaces that were not used before as the former public spaces has been considered dangerous, dysfunctional or even ugly by the local community. However, despite the multiple precedents of participatory engagements in Danish architecture, the project highlighted the economic and organisational constraints that currently hinder this kind of design practice.



A diagram showing participatory design strategies in Rundhøj Turning Point explains democratic design that employs passive and active participatory actions, from participatory observation, informal and public meetings through planning and prototyping workshops to co-construction. Moreover, the diagram highlights the projects' user-centred and collaborative character.

Analytical drawing of Rundhøj Turning Point shows the diversity of participatory engagements that facilitated the project development – from informal meetings, negotiations with the municipality to co-designing and co-construction and follow-up activities.



Learn more about
Rundhøj Turning
Point by KONDENS

The approaches are lenses to look through

The five projects have been identified based on literature review and theoretical delineation of inspiring sustainable design practices. Using these approaches as a screening tool, 100 sustainable projects from practice have been mapped in an interactive map and analysed in-depth. The map is open source and can serve as a resource and inspiration for both researchers, educators and architects when striving for specific approaches to sustainable architecture.

- The approaches are lenses for architects to look through to understand the complexity of design parameters in sustainable architecture, Urszula Koźmińska, associate professor at Aarhus School of Architecture, says.

Further, each approach is a tool to unfold the suitable design strategy in the early stages of the project development as an architect. These stages include exploring the context, mapping environmental risks, choosing flexible typologies, and identifying means of user engagement and building materials, she points out.

And lenses often overlap and the explicit research division into five approaches often becomes more blurred in practice. While this is just the conditions of the pragmatic reality, the approaches offer a framework for architects to set higher and more holistic environmental goals while providing strategies, methods and tools to reach them when they develop buildings.

However, there is a need for knowledge sharing and examples of ways to address the goals to actual sustainable architecture that favours the coexistence of the human and non-human, associate professor at Aarhus School of Architecture, Elizabeth Donovan, stresses. The five projects demonstrate that Denmark is in fact capable of doing the job. Yet, inspiring actions of individual designers need broader systemic support such as policies, economic incentives, suitable building regulations, or educational programmes.

Designers are willing to push the standards

To disseminate and gather knowledge, the research team has hosted a free one-week webinar titled 'Future Perspectives - How do we design for Climate Change'. 14 influential speakers from academia and practice were joined by attendees from 50 countries.

The webinar brought together collaborative partners and the research team in online discussion. Each day, one of the approaches and case studies were put into the spotlight, hearing insights from architects, academia and other practitioners specialised in the field of the given approach. While discussions were both rich in details and broad in nature, the attendees showed a willingness to go beyond standard practices and get involved in politics and interdisciplinary partnerships. This sense of urgency among the architects can inspire future investigations and synergies of political agendas, supporting business models and public-private partnerships.

"Danish Architecture Beyond 2020" showcases built, doable examples of sustainable architecture. The researchers have provided a way to share and facilitate the know-how, design strategies and methods that work when developing new architecture. The lack of this know-how is often a hindering element in sustainable projects.

For the individual studios, sustainable solutions take time and money, because innovation requires research and testing. Moreover, it is essential that external industries like insurance companies become willing and able to take risks. To break the barriers, new business models as well as economic incentives, adequate policies and legal regulations need to be enabled in new ways. This opens research interests and new directions building on "Danish Architecture Beyond 2020". Specifically, to unfold the strategies within the approaches – especially climate adaption and circulation for strengthening environmental sustainability – more in detail, relating the strategies to the socio-cultural and political constraints to look for opportunities for developing new sustainable architecture.

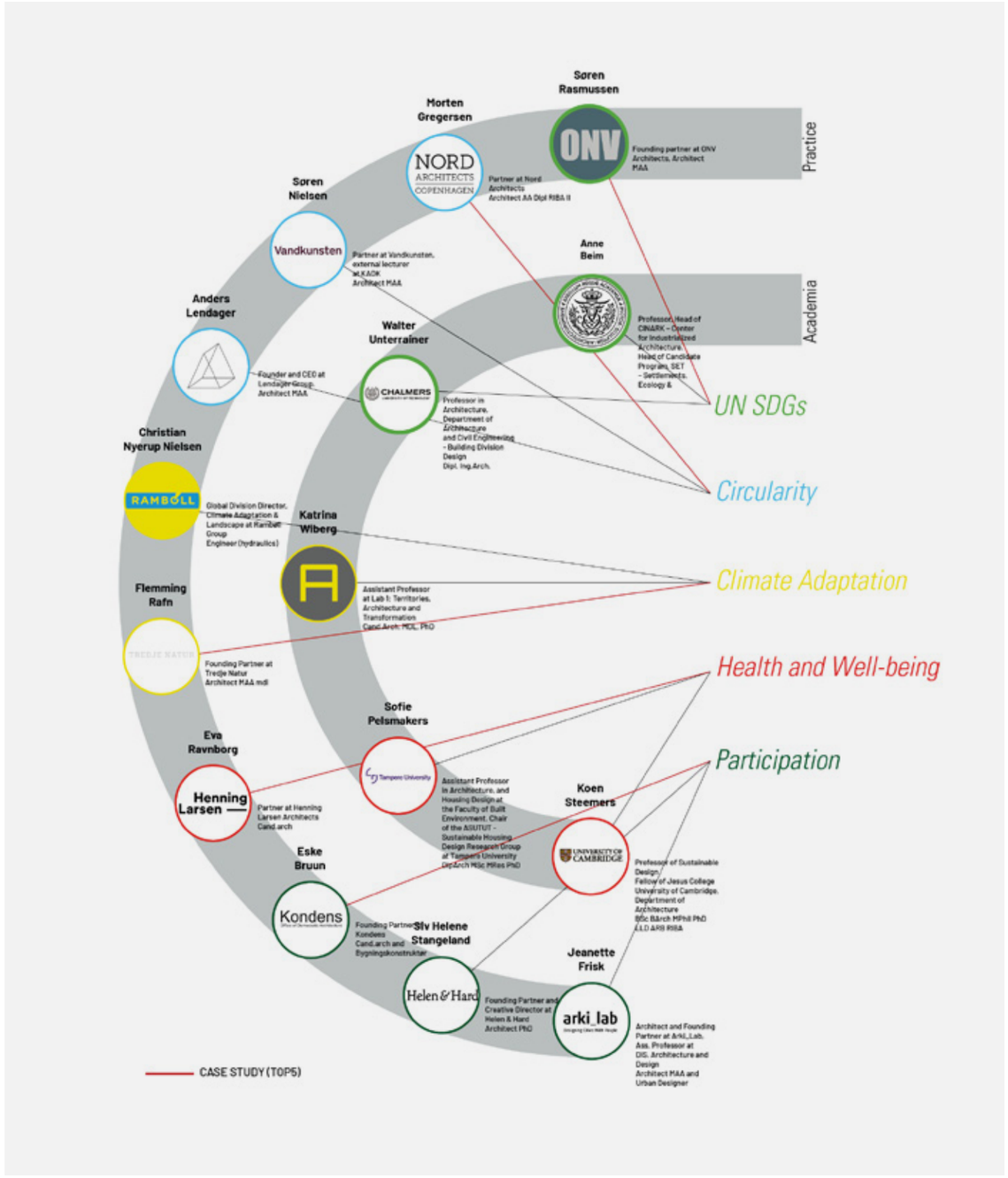


Diagram showing the different networks and connections which were used in the project. On the outer arch are actors from practice and on the inner, actors from academia. Lines indicate which sustainable approach they are linked to with the red line showing which connections are related to the five case studies.

Visit the map

MAPPING SDG COLLABORATION TO REMOVE BARRIERS OF INTERDISCIPLINARY PARTNERSHIPS

Research institutions, landscape and architecture firms and other stakeholders in the private and public sectors have much to learn from each other. Researchers from Aarhus School of Architecture wish to address the lack of transparency and coordination that is currently placing research and architectural projects on separate tracks. A digital map of SGD-related projects and partnerships now aims to enhance connections between education, research and practice and thus accelerate the green transition in architecture.

Partners For a Sustainable Future: Bridging Academia, Stakeholders and Practice (BASP)

Project team and contributors

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Heidi Merrild, Industrial PhD fellow, Aarhus School of Architecture (project manager)

Kevin Kuriakose, research assistant, Aarhus School of Architecture

Staff and students of Teaching Programme 3: Radical Sustainable Architecture, Aarhus School of Architecture

Scan the QR code to see researcher profile

Scan the QR code to read the publication

Once architects graduate from Danish architecture programmes and find their place in an architecture firm, they rarely look back. Urban growth requires architects to focus on efficiency in construction. However, with no room to adjust the approaches of architects or the construction sector in general, architects in practice risk pushing sustainable materials and methods into the background. It can be difficult to stay updated on projects from research institutions and to see a way to establish academic collaborations without compromising on established procedures, timelines and budgets. As a consequence, researchers are rarely invited into real-life building projects, despite offering useful results.

In order to communicate and enhance the potential for collaboration among education, research and practice – as well as other professionals and stakeholders – a research team at Aarhus School of Architecture has therefore created a digital platform for sustainability projects. The purpose is to make the projects visible, generate synergy and highlight the research institutions' willingness to get involved in pragmatic solutions that accommodate research interests as well as the conditions green construction has to meet, in the form of requirement specifications, tender rules, project partners, budget constraints and deadlines.

A key focus in the pilot project is to make more room for practice in architectural education. Hence, the map has been tested in connection with the establishment of project collaborations in connection with coursework. Whether the platform is used to reflect the practice field in education or to drive green solutions in a collaboration between practice and research, it has the potential to make interdisciplinary collaborations with a sustainable agenda more transparent. It can also form a basis for coordination and organisation, which is another aspect of the pilot project's ambition, with a peek at similar groups in educational institutions abroad.

Green actors and projects become visible

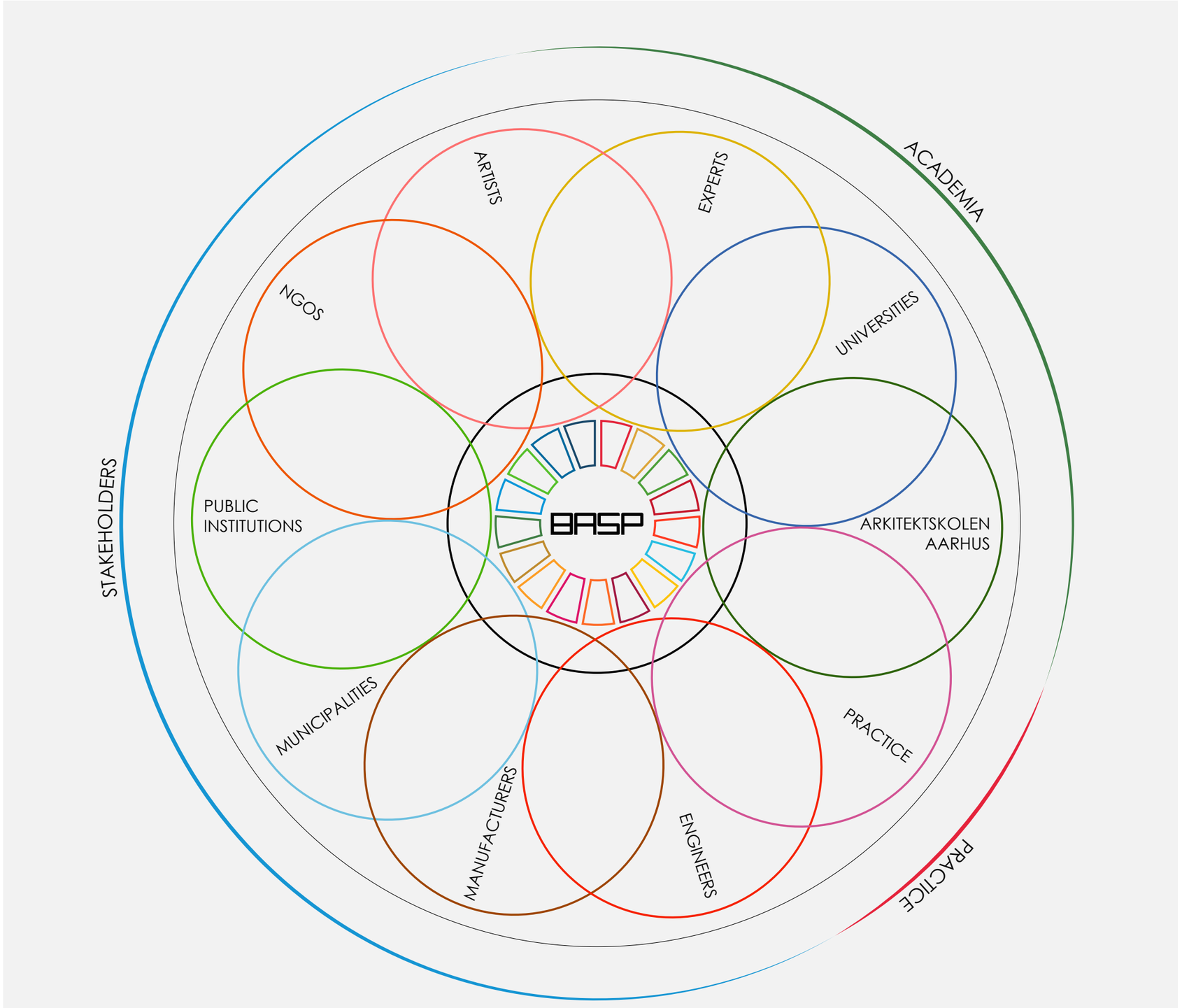
Imagine that you are an architect working on a new project, and you need to involve a biologist and a psychologist in order to carry out the project or take it to new heights. Where do you go to find them? Perhaps the answer could be the researchers' digital, interactive map of projects that contribute to sustainable solutions. With the map's search function and filters, you can identify relevant projects and project managers across the fields of research, education and business.

The map, which is accessed online, is part of the project Bridging Architecture, Stakeholders and Practice – or BASP for short. The purpose of the project is to create a basis for new forms of collaboration on sustainable projects for professionals from architecture, construction and countless other areas of expertise that are relevant for a given project, including biologists, anthropologists or artists. Thus, BASP is oriented towards the UN's Sustainable Development Goal (SDG) 17 of strengthening the means of implementation and revitalising the global partnership for sustainable development.

In this effort, the project addresses all the SDGs, which are shown in the centre of the map. Thus, if your project is focused on a particular SDG, you simply click on the goal, and related projects expand, while other projects are filtered out. This provides access to information such as project description, organisation and the geographic location of an ongoing or planned sustainability-promoting initiative.

A wide range of organisations, landscape and architecture firms and other actors related to construction and architecture are represented among the contributors – including universities, municipalities, artists, engineers and manufacturers. Thus, the map is a common platform for more than 350 elements and 750 connections, which architects and other green actors can identify through a search and then explore and segment. The potential will only grow, as more data is added. The initial contributors were vetted and included based on information from the school's archives, and interviews were conducted with external stakeholders and with the school's students, teachers and researchers.

Scan QR code to see the map



Distance between the industry and new knowledge

The focus of the pilot project is on exploring how education and research activities within the theme of Radical Sustainable Architecture can better connect with and become anchored in practice and in projects with real-life applicability at Aarhus School of Architecture.

– The BASP platform is a way of mapping the ecosystem that our education and research activities are a part of along with the many external stakeholders who shape the sustainable agenda in architecture. In a longer-term perspective, the map is intended as a hub and a shared platform for sustainable research, education and practice, says Thomas Hilberth, Associate Professor at Aarhus School of Architecture.

In fact, there is an independent point in centring the pilot project at Aarhus School of Architecture, which is to address the gap between practice and what is happening in research and education institutions. Not enough practice projects apply the approaches recommended by research, while research is only rarely carried out in collaboration with projects from practice and from the private sector in general. Due to this gap, the architects, researchers, educators and other actors in the aforementioned ecosystem risk pursuing separate tracks at a time when a common, sustainable direction is more needed than ever. The map has thus also served as a first step in examining the potential for facilitating interdisciplinary approaches and collaboration in a physical development context.

This example is based on research into sustainable architecture. Research fields are sorted and sized based on the number of persons and projects engaged in the field.

THE LAYOUT

THE CORE

The map is laid out in a radial segmented layout. The central area of the map is occupied by 4 different types of elements.

Research Area

Research topics and areas of interest that concern the subject of sustainability

Research Projects

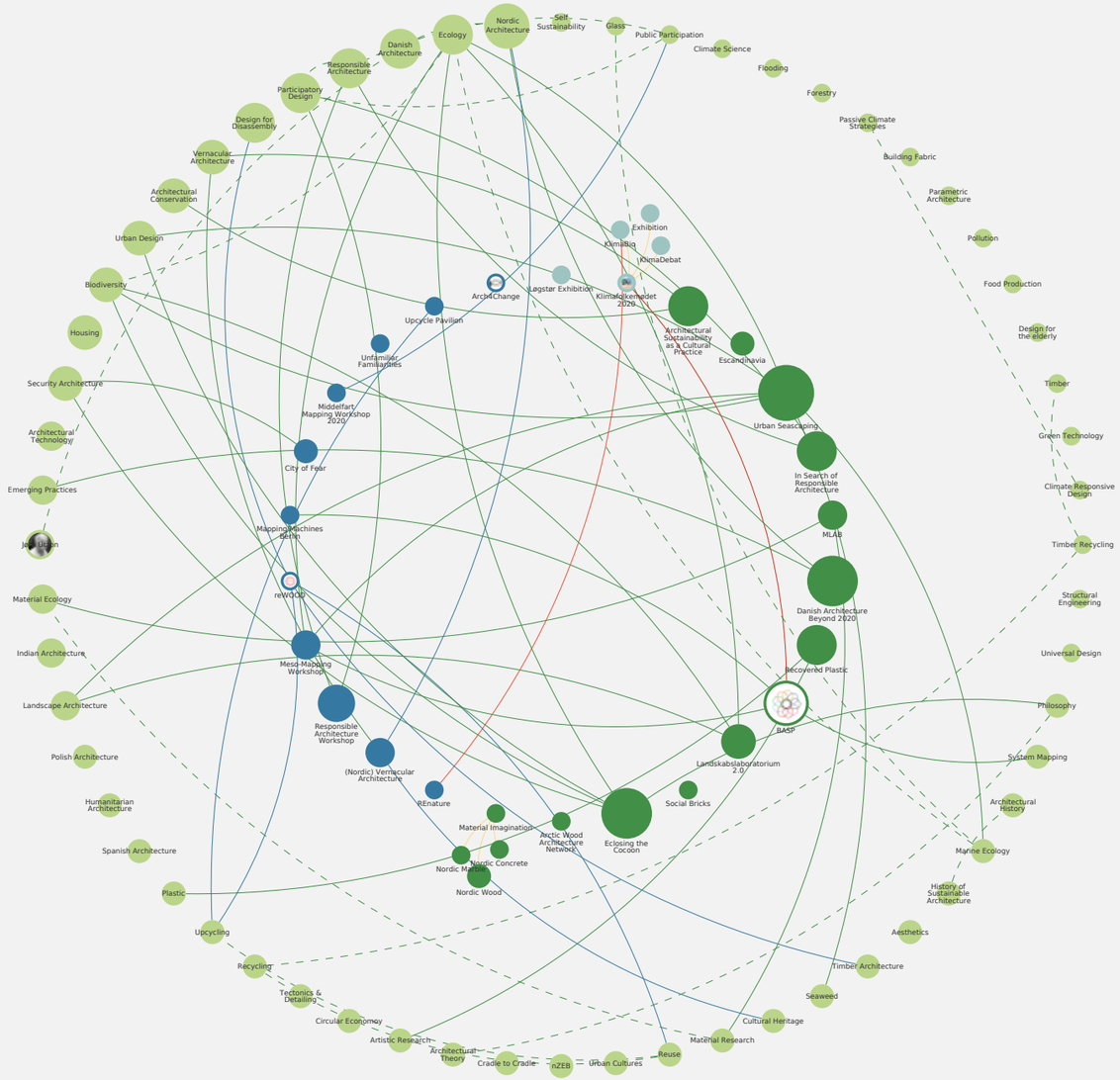
Projects, workshops and other activities associated primarily with research

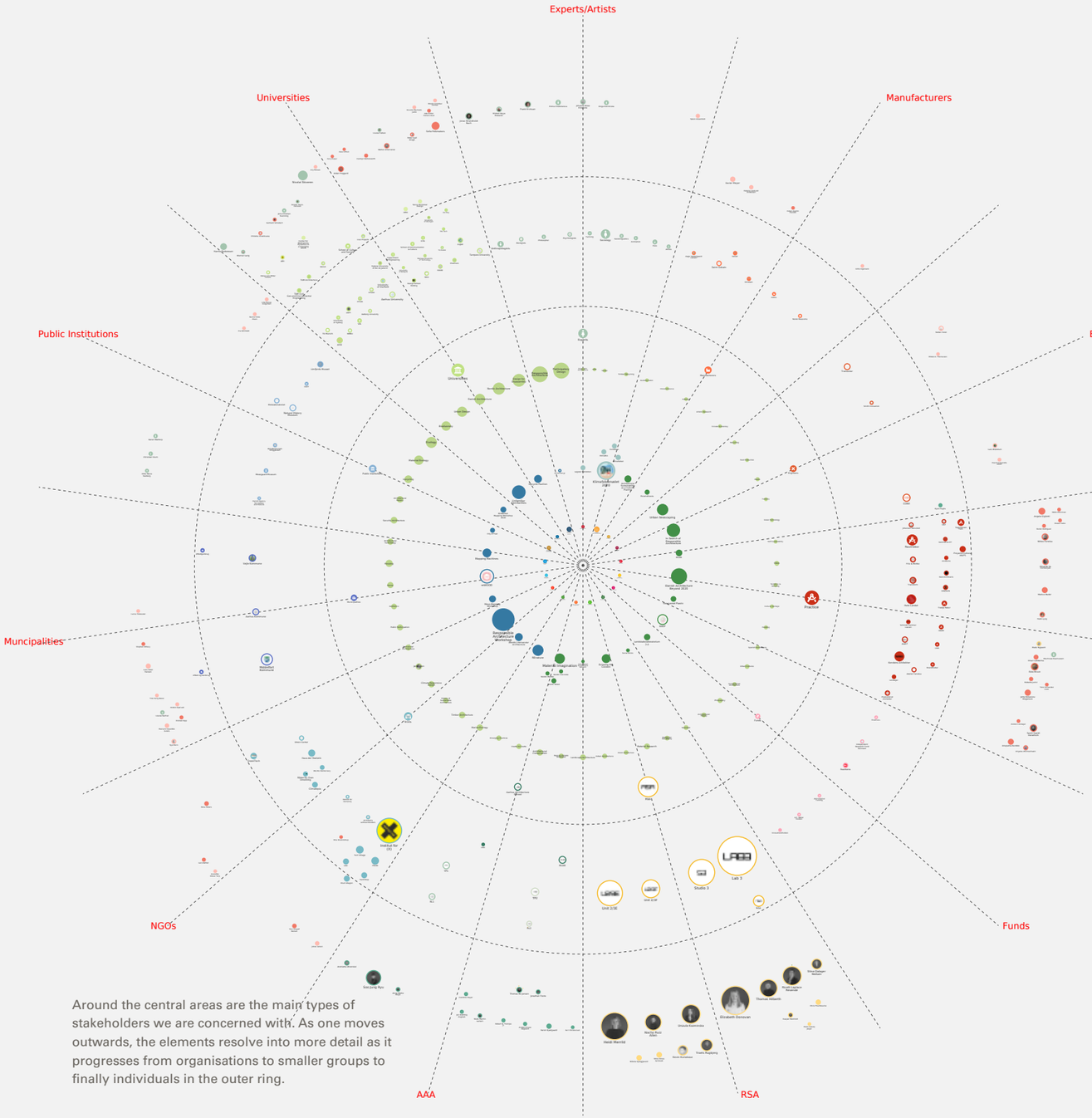
Teaching Projects

Projects, workshops and other activities associated primarily with teaching

Events

Events and activities that have been organized and conducted in collaboration with the AAA





Around the central areas are the main types of stakeholders we are concerned with. As one moves outwards, the elements resolve into more detail as it progresses from organisations to smaller groups to finally individuals in the outer ring.

Universities

An institution of higher learning providing facilities for teaching and research and authorized to grant academic degrees

Public Institutions

Encompasses organizations that are fully or partly funded by the state.

Municipalities

Municipalities (Danish: Kommuner, sing. Kommune) are local administrative authorities.

NGOs

A non-governmental organization (NGO) is a non-profit, citizen-based group that functions independently of government.

Experts/Artists

Persons who are experts in their various fields of study. This includes artists as well as sociologists, psychologists, etc.

Aarhus Architecture School

Elements that belong to or are affiliated directly with the Aarhus Architecture School (AAA)

Radical Sustainable Architecture

Units/Studios and groups associated with Teaching Programme 3 as well as Research Laboratory 3

Manufacturers

Companies or persons who are manufactures or distributers of a variety of goods or products

Funds

Organizations both private and public that provide funds and grants

Practice

Architectural practices or firms that provide architectural services.

Engineers

Engineering firms, consultancies and individual engineers with varying specialties.

The connections are categorised to illustrate the type of relationship that exists between different elements. They are also colour coded with shades of green corresponding to connections related to research, red for collaborations and yellow for affiliations.

Affiliations

Shows connections between affiliated elements

Research

Research interest of groups and organizations

Individual Research

Research interest of individual researchers

External Research

Research interests of entities that are not directly affiliated with AAA

Interest

Shows interest areas and connections that do not include active research

Collaborators

Maps out collaborations & stakeholders both active and past

Connection

Illustrates connections between elements that are not active collaborations or partnerships

Teaching

Connections that involve teaching related activities or workshops

Funding

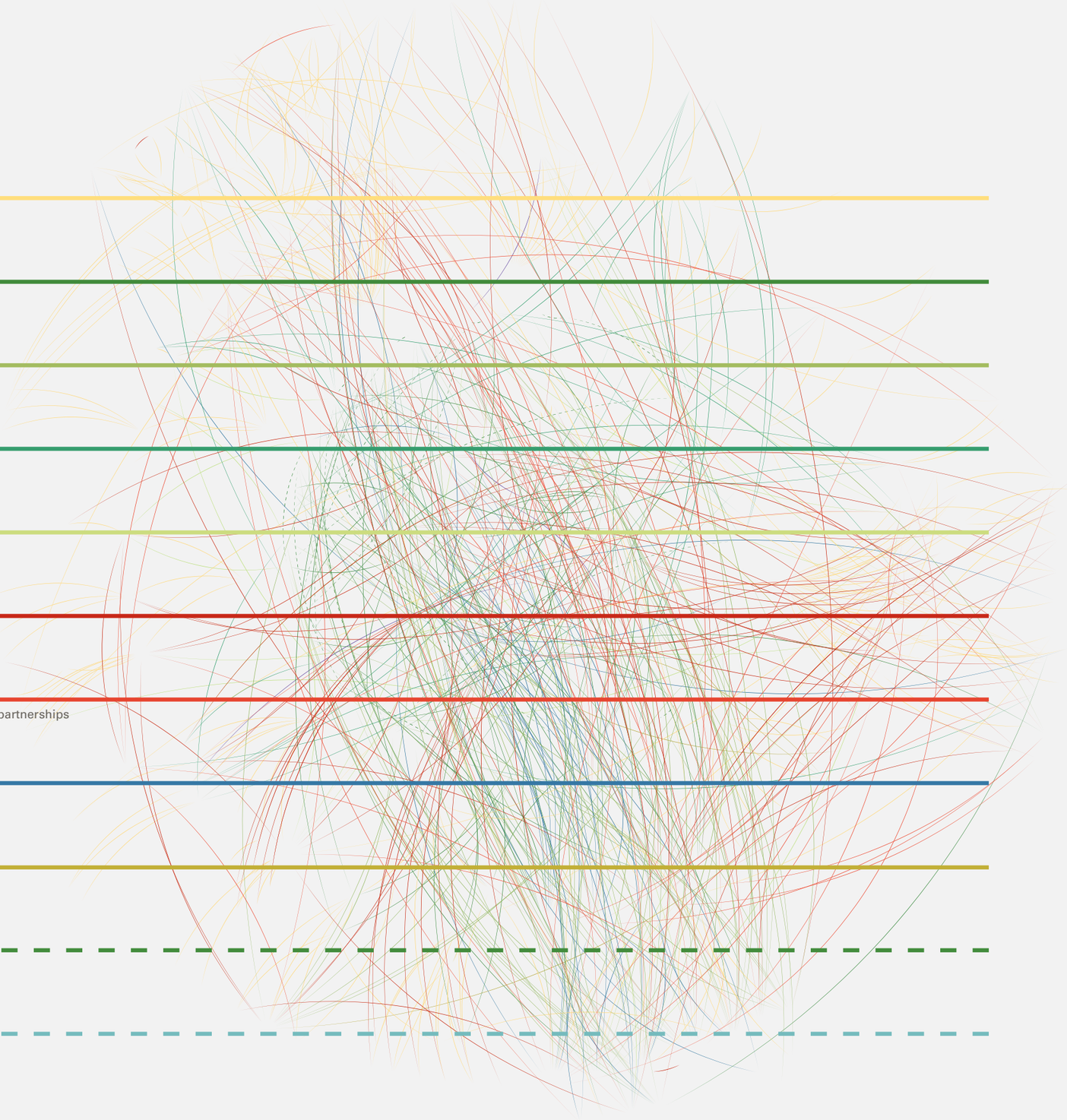
Shows where the funds are coming from

Topics

Connections between different topics and research areas

SDG

Connections with UN's Sustainable Development Goals



German collaboration has proven effective

The research project is inspired by the German initiative Architecture Research Incubator, ARI, a platform that connects and coordinates research and development in design, engineering, urban development and IT at TUM, Technical University of Munich. Via ARI, partnerships have been established, for example, between companies and municipal institutions in Munich. The development environment also makes facilities available for start-ups operated by current or former students; something that Aarhus School of Architecture has also been doing for several years in a variety of contexts. The most recent examples from Aarhus School of Architecture include the shared New Neighbour facilities for business clients and graduates as well as the innovation project LINKED in collaboration with the Royal Danish Academy and Design School Kolding.

The inspiration from TUM resulted in a collaboration between the founders of ARI and the researchers behind BASP, who have held a number of meetings aimed at exploring the opportunities for establishing a shared physical environment across professions in a Danish context.

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Communicating and pushing collaboration

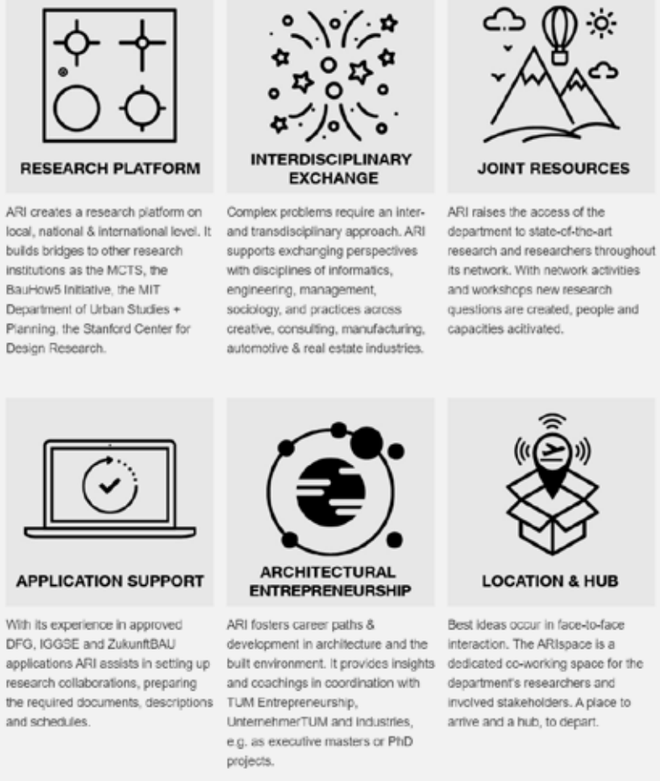
Since many of the pilot project's scheduled face-to-face meetings and other events had to be cancelled due to Covid, the researchers behind the project focused on promoting the usefulness of the map and the importance of green partnerships. As part of this project, the researchers behind BASP therefore showcased selected projects designed and carried out by students. In addition, they took part in workshops and seminars and developed a contribution to Klimafolkemødet (People's Climate Conference) in 2020. At this event, the researchers hosted a debate on how educational institutions and the practice field can collaborate more closely on sustainable architecture, with representatives from both camps.

The research project was also presented on a website with the interactive map as the focal element. The website also features student projects and selected research publications from researchers and educators at Aarhus School of Architecture.

The pilot project is far from complete but will require additional data analyses, which will be incorporated into the digital map. To be formalised, the map will require ongoing maintenance and expansion. For example, all the actors should be able to state their intentions in entering a collaboration when new projects are recorded and initiated. Furthermore, there is a research interest in carrying out subsequent qualitative evaluations of partnership processes facilitated by the map. Over time, it will be possible to compare past and current projects, develop evaluation parameters and create improvements for the future use of the platform and its projects. For example, one evaluation parameter could be how incorporating subgoals and predefined milestones into the project timeline can facilitate the collaboration and highlight the results of the joint efforts. Other criteria will vary due to the many and diverse project categories.

Scan QR to see the debate

Benefits for the Industry



Benefits for the Department

In 2020, the Danish Parliament approved a special research grant of two million kroner for the Aarhus School of Architecture dedicated to pilot projects on sustainable architecture aimed at promoting the green transition.

The seven pilot projects presented in this publication illustrate the wide range of efforts required to move architectural development in a more sustainable direction. The projects fall into the general areas of climate adaptation and biodiversity, rethinking resources and building technology and holistic architecture and partnerships for change.

AARHUS SCHOOL OF ARCHITECTURE