Master Thesis Sanne Keizer
Strategic Product Design
Delft University of Technology

THE FUTURE OF THE URBAN FOREST

exploring the systemic granularity of the urban green domain to navigate towards a new paradigm

The Future of the Urban Forest
Sanne Keizer

CLICK NL

NWO

PREFACE

My frame of nature changed in only six months.

My whole life I have been pulled by the outside, climbing trees, running my own flowershops-for-a-day, playing on sand mounds of construction sites. Sea, forest, mountains, and the polder landscape, where I grew up. One context more man-shaped than the other, but my attraction to and interest in nature has always been present. Something changed when I started reading the adventures of Humboldt parallel to the Hidden Life of Trees over the summer. Attraction and interest were amplified with deep respect, enchantment, and urgency. A new world of conscious interdependency opened up.

A way too broad and unscoped discovery began within the domain of nature, in particular trees, and their relation with our cities. I hope I can fuel these sentences with the enthusiasm, energy, and potential generated by this topic and the exceptional people working within it to change your frame of the urban forest too.

Anthropocentric note to trees

My apologies, it's about us again. I hope you can see this as a tribute, an ode, a lovesong if you like. This one's for you and about making your life more comfortable, your existence more social and your gifts more consciously received. We cannot do it without you, and unfortunately, you have to do it with us. But it will be better, I promise. Let me show you.

Have a good read!

Sanne Keizer

ACKNOWLEDGEMENTS

I feel fortunate to be able to conclude my time as an Industrial Design Engineering student with a project that has become a passion, summarising my educational career in a mix of architecture, urban environments, nature, sustainability, complex systems, future visions and, above all, a lot of great people. A 'thank you' is not enough for making this possible, but at least something I can capture in this written form.

First of all, I would like to express my gratitude to my supervisory team, my chair Rebecca Price, and my mentor René van der Velde, for guiding me along the way. I would like to thank Rebecca for giving me the freedom to make this project my own. My final academic journey would not have been the same without your dedicated time and sincere attention. You challenged my structured way of thinking, dared me to be bold, and taught me some valuable lessons, both professionally and in life. Fortunately, we will continue to work together. I am excited.

I want to thank René for our conversations and for offering me your perspective and expertise in the field of landscape architecture and urban forestry (or forest urbanism). Our talks in the quiet afternoons at the Landscape Department were very precious to me and truly challenged my process.

Besides my graduation advisors, I want to thank Gül Aktürk for working together over the last months and combining our efforts to organise the co-design sessions. A big thank you to the members of the i-Tree 2.0-NL consortium and the external people I interviewed, without your practical knowledge and insights I could never have gone this deep. You welcomed me with open arms, always found time for me, and made this project worthwhile.

Finally, to my parents, friends, and fellow designers, thank you for supporting me along the way and knowing that you were there for me to reach out to. Ruby, for listening to my endless pleas for paradigm shifts and thinking along. Ties and Jesse, for reflecting together, asking the hard questions, and taking it to the next level, as you always do. I cannot wait to continue our adventure together. Komovo passed by during the conversations, so I am optimistic that we will be able to stay in this domain one way or another.

EXECUTIVE SUMMARY

With nearly 70% of people living in cities by 2050 (United Nations, 2018), our urban environments are being put to the test, with more severe and frequent heat waves, droughts, floods, ongoing biodiversity loss, air pollution, and land subsidence. To sustain and increase the liveability and climate resilience of cities, the design and implementation of urban green infrastructure, with the urban forest as its backbone, is one of the most critical solutions (Spronken-Smith & Oke, 1998; Rosenzweig et al., 2015; Norton et al., 2015). However, the current indifference that runs through the veins of the anthropocentric political, economic, and socio-technical systems limits the urban forest from being a central part of the built environment.

As an attempt to put urban trees on the political agenda, the USDA Forest Service developed and launched the i-Tree software in 2006 to quantify the ecosystem services provided by urban trees (Nowak, 2020). In 2019, the first version became applicable to the Netherlands. This project is part of the three-year-long follow-up, i-Tree 2.0-NL, consisting of a consortium of 28 stakeholders to further elaborate the cooling performance, model growth curves, and synchronise the potential of the software for the stakeholders. This thesis concerns the latter.

The project starts with an understanding of the overarching transitions, exploring the direction in which the urban green domain should (and currently is) heading to calibrate the compass for change (see Figure 1). The newly proposed paradigm illustrates five societal shifts in how we relate to, integrate, account for, collaborate for and provide access to the urban forest. The ideal is to reposition the urban forest as critical infrastructure. The project is moving towards mapping the current system and processes of the consortium stakeholders, localising the role of the public green sector in urbanisation and discovering interrelationships. The different domains are strategically separated and examined in isolation to explore opportunities for integrating i-Tree into architectural, municipal and nursery processes. From this set of five opportunity areas, the concept of a management dashboard was selected for further development with the aim of linking municipal green space policy and green space management.

The 'Urban Forest Portfolio' is created, evolving the use of i-Tree from static assessments to a dynamic portfolio. The dashboard aims to integrate the urban forest lifecycle into planning, management and design, to track progress towards the realisation of long-term quantified targets, and to enable scenario evaluation for just compensation.

The integration of the proposition into the system is discussed, leading to eight concrete new practices and six speculations on a system scale, one of which is the establishment of the 'Rijksgroenstaat'. Finally, the principles behind these new practices helped to make the new paradigm tangible, operationalise the transitions and bring into focus the parts specific to the domain of this project.

The project aims to discover the systemic granularity of the urban green domain, oscillating between abstract paradigms, concrete practice, and levels in between. A systemic strategy developed side by side with the stakeholders in the green sector.

PART 1

the paradigm

understanding the transitions

PART 2

the system

mapping the current processes

PART 3

the opportunities

exploring possibilities for (re)connection

PART 4

the proposition

iterating speculative intervention

PART 5

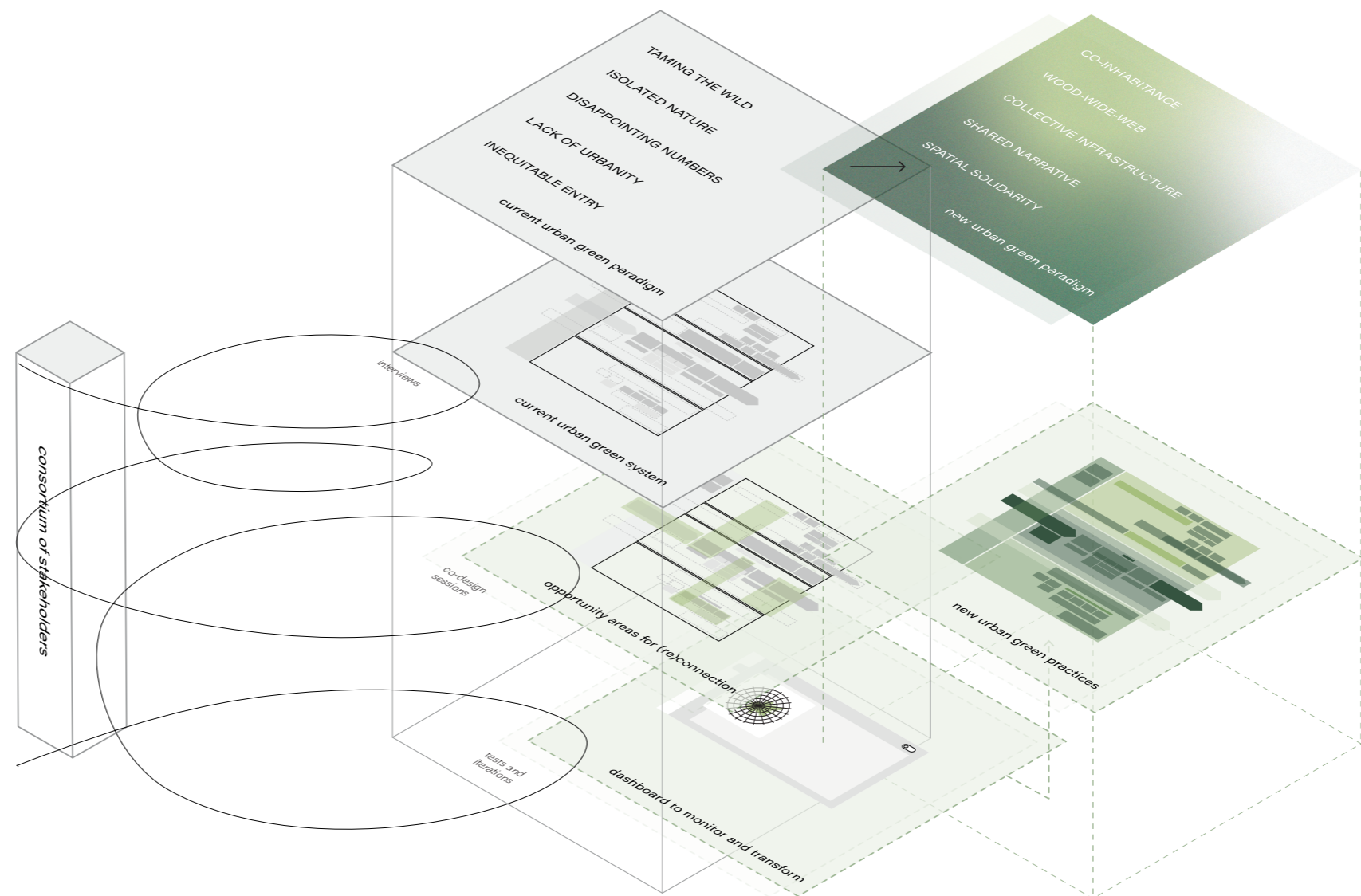### the integration

operationalising the transitions

Figure 1. Project overview

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INTRODUCTION

By 2050, 68% of the world's population is expected to live in cities due to population growth and migration (United Nations, 2018). The pace of climate change in relation to the activities of this growing global population is more urgent than ever before. Urban areas are facing a climate emergency and are experiencing a range of negative impacts such as more severe and frequent heat waves, flooding, loss of biodiversity, and air pollution (van der Velde, 2021). These impacts have a detrimental effect on the liveability and resilience of cities, putting human health and well-being at risk. One potential solution to mitigate these effects is through the design and implementation of urban green infrastructure. However, the current anthropocentric way of shaping the environment pushes green to the periphery and prevents it from being at the centre of the built environment.

PROJECT CONTEXT

Urban green infrastructure can be defined as a network of green spaces, both within the public and private domain, such as parks, gardens, green roofs and walls, and other vegetation (European Environment Agency, 2018). The urban forest understood as a mosaic of trees is the backbone of urban green infrastructure and one of the most important components in the adaption of cities to rising temperatures and heat stress, with multiple co-benefits, including enhanced biodiversity, improved quality of life, human health and (social) wellbeing (Spronken-Smith & Oke, 1998; Rosenzweig et al., 2015; Norton et al., 2015). As the focus of this thesis, the term 'urban forest' will be used throughout to refer to the network of trees and other vegetation that provide these ecological, social, and economic benefits in cities (Safford et al., 2013).

Despite its enormous potential and indispensability, the urban forest is fighting an uphill battle against human-induced circumstances. Indirectly, by having to face an increasingly demanding climate situation, and directly by facing anthropocentric indifference, lack of political priority, and being embedded in outdated accounting and management patterns (Dark Matter Labs, 2020). In order for cities to achieve resilience and sustain liveability, it is crucial to break free from the current paradigm and its related practices and embrace a new, future-proof narrative. This thesis aims to unravel part of this necessary paradigm shift needed to reposition the urban forest as critical infrastructure. The systemic granularity of the urban green domain will be explored to eventually find propositions that can operationalise these transitions.

i-Tree 2.0-NL

There is a growing debate about the need to redefine the relationship between cities and trees. A great advance in technology and methodology can be seen in order to secure their position within the urban environment. One of these developments is the i-Tree software, a model for quantifying the ecosystem services provided by trees (Nowak, 2020). Ecosystem services can be defined as the benefits that trees provide to human society and the environment through the ecological processes they support, such as carbon sequestration and heat island effect reduction. The i-Tree suite originated from the USDA Forest Service and is made applicable to Europe in 2019 (Nowak, 2020), leading to the launch of i-Tree NL version 1.0. Following these efforts, a consortium of knowledge institutes, municipalities, tree nurseries, tree consultants, architects, and engineers joined forces in the i-Tree 2.0-NL project, a three-year project funded by CLICKNL. The project centres around three work packages (WP): developing a tree architecture typology and investigating the cooling performance of selected tree species (WP1), modelling growth curves for a number of species up to their adult stage (WP2), and synchronising the technical

potential of the tool with the needs and values of the stakeholders within the consortium (van der Velde, 2021). This thesis is part of WP3 and the team working on this work package consisted of Dr Rebecca Price and Dr Gül Aktürk. The Project Brief can be found in Appendix A.

Project approach

This project could look like an interface development, exploring the adoption possibilities of the i-Tree software and its quantification potential to extend its use beyond the early adopters and embed it in the stakeholder processes. However, if only this technology were to be pushed, long-term change would not be seen, and only incremental improvements in specific processes would be achievable. In order to manifest the urban forest as critical infrastructure, new behaviours, industrial relations, policies, and socio-cultural narratives are required in addition to new technologies. All of this must somehow happen together for a radical transition to take place.

Therefore, this project attempts to articulate how this might occur, navigating different scale levels of the urban green domain using the technological proposition as a vehicle to speculate on a new paradigm together with the green sector. The consortium did not define a specific shared vision upfront but during the diverse conversations, a common urge could be felt. There was a very strong desire to better understand and express the value of the urban forest to make its position in the urban domain indisputable. The data of i-Tree, and the model in general, are considered as a potential means of facilitating this transition. In order for the next generation of software to contribute, the overarching transition must first be understood to define a clear direction of change and calibrate the compass for concept development. The combined forces of the stakeholders serve a greater purpose and this narrative must first be explored to direct found opportunities within their working processes towards this desirable new paradigm.

Paradigm shift

This thesis is triggered by the need for a paradigm shift in urban design and green space planning. A paradigm shift refers to a fundamental change in the way a particular issue is valued and approached. A paradigm shift requires a multi-faceted approach that addresses both the technical and social aspects of the issue. It requires the development of new knowledge, tools, methods, design strategies, and technologies, but it also involves changing the way people think about and relate to the topic. For such a shift to take place, innovation needs to happen in different places at different scale levels in an overlapping timeframe (Concilio & Tosoni, 2018). Only when enough

momentum is built simultaneously can 'the new' outweigh 'the old.'

The urban innovation process defined by Murray et al. distinguishes three different levels at which innovation must take place: niche, regime, and scape (see Figure 2), which increase in scale and stability. Niches are the local networks that facilitate an opportunity space for ideas to emerge and potentially be transformed into innovations. 'The regime represents the so-called 'grammar' of a socio-technical system' (Fuenfschilling & Truffer, 2014). It is at this level that the institutional rules by which a system operates are located. They provide the framework for the actions and behaviours of actors within the system, guide their decision-making and shape the overall functioning of the system. These rules can be formal, such as laws and regulations, or informal, such as norms and values. The largest and most stable level is the scape. Paradigms reside at this level and are identified as slowly changing.

The process of urban innovation not only takes place at different levels of scale but also passes through several stages of maturity. Inception, development, transition, and systemic change are the four distinct phases (Concilio & Tosoni, 2018; Murray et al., 2010). In the inception phase, unmet needs are defined, the problem is articulated, and the first ideas are generated, which are further developed into products and services ready for testing in the next phase of development. Both phases take place at the niche

scale of the innovation process, usually within the actual boundaries of a city. In the transition phase, the innovation begins to change and reshape the current regime after being scaled up, integrated, and combined with other innovation efforts at the niche level. The final stage of innovation, referred to as systemic change or paradigm shift, takes place at the scape level. However, unlike the other stages, it cannot be deliberately orchestrated. Instead, this type of change emerges suddenly as scattered local innovations come together, connect and establish themselves as the new norm (Wheatley & Frieze, 2006).

Counting on a paradigm shift as a logical outcome at the end of an innovation process is not realistic. However, the envisioned change can and should fuel the design process from the outset to increase its chances of adoption later on. In this way, it is more likely that the newly designed piece will fit into the 'future puzzle.' In the context of this thesis, the next generation of the i-Tree software could be a piece of the new puzzle of the urban green domain. Starting with implementation on a small scale, beyond the current efforts and potentially influencing regulations and thus the existing regime. However, the shape of this piece will depend on what this puzzle will look like; in which direction the new paradigm will be oriented. At the same time, the concrete nature of the piece is likely to influence the abstract puzzle, co-evolving together. A design approach that oscillates between paradigm and practice is therefore required.
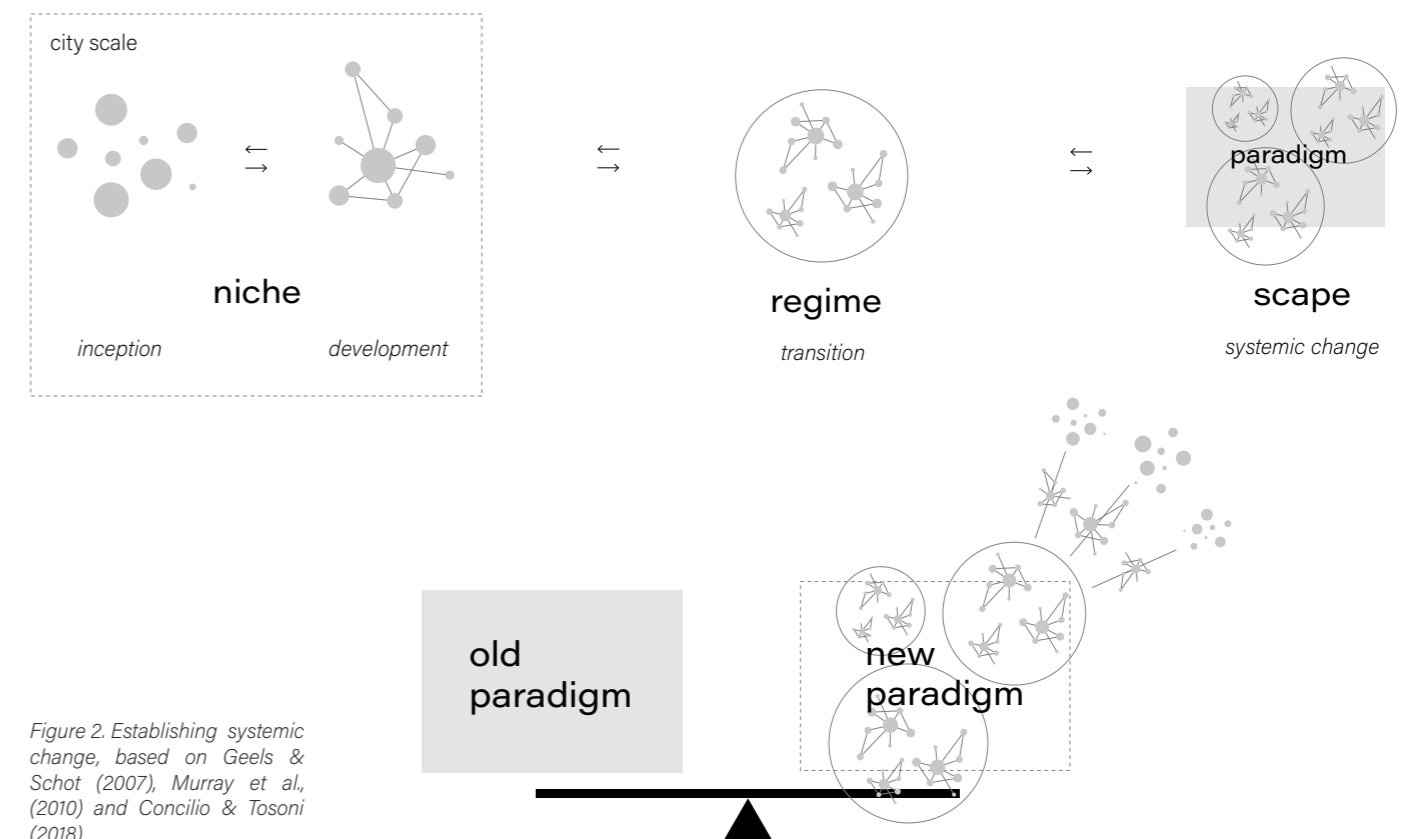

Figure 2. Establishing systemic change, based on Geels & Schot (2007), Murray et al. (2010) and Concilio & Tosoni (2018)

Project aim

Based on this paradigm perspective, the aim of the project is to describe the desired transitions, map the current system and decision-making processes around urban green, and define opportunities for the next generation of i-Tree in order to change practices in line with the intended future direction.

Research questions

This resulted in the following research questions for the project:

- How can the planning, design, implementation and management of public urban green be strengthened by infusing quantified urban forest data?

  - What is the desired future direction for the urban green domain? What does the new paradigm look like?
  - What are the current planning, design, implementation, and management processes and how are decisions made? Who are the different stakeholders and how do they relate to each other?
  - How could these processes be empowered by the infusion of quantified urban forest data?
  - What tangible proposition would be needed to embody part of these opportunities?
  - How could the integration of this proposition enhance current processes and operationalise the transitions towards the new paradigm?

Project scope

The scope of this project concerns the public part of the urban forest, which is the responsibility of the eight municipalities in the consortium. In contrast, private green spaces are currently governed by different regulations, have fragmented ownership, and less available data. However, as the urban forest is both private and public, the final part of the thesis explores this division. Secondly, most of the thesis is situated in the Dutch context, based on the Dutch socio-technical regime. However, the paradigm shifts draw from international developments and the i-Tree software originates from the United States. Therefore, transferability is an important issue and attention should be paid to the transfer of developments, ideas, and technologies across borders because for example the history, current perception, and relevance of a certain issue may be different. Finally, the project will present a preferred future perspective and a proposition as a building block geared to this new direction. This new future is deliberately further away than a four-year political term, as the urban forest should be freed from political winds in order to be positioned, implemented and managed as critical infrastructure.

This project is situated within the dynamics of a consortium with 28 different stakeholders and a pre-defined list of objectives and outcomes set out in a grant application. In order to fit the unique circumstances of this project and allow for adapting strategy during the course of the project, different aspects of certain methodologies are interwoven. Rather than a standard approach, a 'melange of methods' is used, exploring new practices. Firstly, the different ingredients of this melange are touched upon one by one. Secondly, the process and structure of the thesis are presented.

Frame innovation

The challenges facing society are becoming increasingly ill-defined and multifaceted, involving multiple organisations, disciplines, and social systems. Public sector organisations, such as the municipalities in the consortium, are increasingly called upon to collaborate and work across multiple domains in order to effectively address these challenges (Schaminée, 2019). The problems dealt with in this project can be labelled as 'wicked' (Buchanan, 1992) as they are open, complex, dynamic, and networked (Dorst, 2015). These challenges require a new approach to problem-solving, as traditional, reductionist methods have been shown to be ineffective in addressing them (Dorst, 2011). Frame innovation, as proposed by Kees Dorst, is a design approach that focuses on how problems are framed and understood by different stakeholders (Dorst, 2015). The 'frame' of a problem, a term first introduced by Bateson (1972) in the field of sociology and later adopted by Schön (1991) in the field of design, can have a significant impact on the proposed design solution. It is important to consider the different perspectives and frames that stakeholders hold in relation to the problems.

The revaluation of the urban forest within cities is one such problem as described above. The concept of framing is used throughout the project to identify the current understanding of the problems at hand and reframing is used within the process of identifying opportunity areas in the current system.

Systemic design

The field of design is evolving, moving up along the four orders of design as coined by Buchanan (1992). From 'symbolic and visual communications', which includes the traditional practice of graphic design, to 'material objects', the design of everyday products, and the relationship between products and people. The third order concerns 'activities and organised services' and relates to decision-making, experience flows, interactions, and strategic planning. The final order is the design of 'complex systems or environments for living, working, playing, and learning' and concerns the engineering and architecture of systems, such as educational or governmental contexts. As stated by van der Bijl-Brouwer and Malcolm (2020), design has evolved from a concrete, purely object-oriented practice to one that aims to address more abstract, complex societal issues. This shift has given rise to the field of systemic design, which combines the principles of systems thinking with design methodologies. Systemic design is better able to deal with the interconnectedness of complex problems and works with an evolutionary design approach of 'probe, sense, and respond' (Snowden & Boone, 2007) to bring about systemic change (Bijl-Brouwer & Malcolm, 2020). As systemic design is the process of identifying the connections between different elements to gain a better understanding of the system as a whole and to identify 'leverage points' to influence and steer the system in an intended new direction (Meadows, 2008). In the context of systems and an evolutionary design approach, the term 'solution' is not appropriate. Rather, Meadows (2008) works towards (re)creating balance.

Because the processes surrounding the urban forest involve a wide variety of stakeholders and cross domain boundaries, a systemic approach is taken to map this system and its relationships and to identify leverage points or opportunity areas to intervene in an evolutionary way.

Participatory design

Participatory design is an approach to design that emphasises the active participation of stakeholders in the design process. It is based on the belief that the perspectives, needs, and experiences of stakeholders are essential to the development of successful and sustainable design solutions. Participatory design differs from the established field of user-centred design in the role assigned to the user. In user-centred design, the user is seen as a passive subject of the study, whereas in participatory design, the user is seen as an active participant in the design process (Stappers & Visser, 2007).

Given the complex context of urban green and the consortium at hand, participatory design is a valuable approach, as it allows for a more comprehensive and inclusive understanding of the challenges and potential solutions, and ensures that the outcomes are aligned with their goals and objectives. It can help to develop ownership of the results and brings the lens of practice to the project. Co-design sessions are used to bring together the perspectives of a diverse group of stakeholders (Sanders & Stappers, 2008). The combinations of stakeholders are strategically configured to fit the intended outcomes.

Speculative design

Designers have the power, and one could argue the duty, to imagine and show what could be possible. The societal role of designers could be seen as visualising a perspective of change and offering the first steps towards its manifestation. When thinking about futures, Voros (2001) distinguishes four different potential futures, adapted by Dunne & Raby (2013): the 'probable, preferable, plausible and possible' future, decreasing in likelihood. Dunne & Raby use these futures in speculative design, a design approach that uses fictional scenarios and prototypes to explore the potential implications and consequences of current and future technologies, social trends, and policy decisions. It can be used to spark conversations and debates about the future and to provoke reflection on the values and assumptions that underpin our current design practices.

Within this project, the rationale behind speculative design is used to engage stakeholders in conversations about the future by aiming to intentionally disconnect for a moment from current challenges and collectively speculate about what might be. By placing the eventual proposition in a future context, space is created to detach from certain limitations and shortcomings and focus on questioning whether this potential scenario would be preferable.

Vision in Design (ViP)

Another design method, or philosophy, that helps to design and innovate in a future-oriented way is Vision in Design (ViP), developed by Hekkert and van Dijk (2016). Through a thorough and carefully designed process, a perspective on a future world is created in order to eventually

construct a personal future vision within this domain, the 'raison d'être' of the final proposition. The first steps of the method involve collecting future factors, which are the building blocks of possible futures. Factors are 'value-free observations, thoughts, theories, laws, considerations, beliefs or opinions' within a variety of viewpoints and domains. Factors are either stable (states and principles) or dynamic (developments and trends) over time and, when clustered, distilled, and combined can shape future worlds that allow a subjective point of view to be taken.

From this method, the quest is picked to navigate within a wide variety of search fields (psychological, cultural, sociological, biological, etc.) in order to infuse the constellation of the paradigm shift through a multidisciplinary widening of the frame of the domain. Together with the deliberate disconnection from the 'now' in order to design a proposition fit for the 'next.'

Strategic design

Strategic design concerns aligning limited resources with unlimited ambitions and is used as an overarching rationale that has allowed methodological selectivity throughout the project. To be able to adapt when and where appropriate based on the inputs and results, weaving together elements of methodologies appropriate to scale and phase (see Figure 3). This allowed a process of oscillation for the co-evolution of the puzzle and the piece, navigating between paradigm and practice, between system and proposition. Moving away from a binary perspective to explore tensions, interrelated perspectives, and gradual transitions. Enabling different styles of design leadership, balancing provocation and listening, abstract and practical.

Research approach

The research approach is built around the different aspects of the methods addressed. The objective is to achieve a high level of proficiency in the field of urban green, which will ultimately enable a desired new direction to be envisioned. It aims to explore the transitions underway, the current system, its context, and the interrelationships, and to identify validated challenges and opportunities. Therefore, this research consists of three approaches to data generation and collection.

Literature research

The initial stage of the research seeks to understand the current ongoing paradigm shift within the urban green domain. This is done by consulting the literature, exploring different disciplines and perspectives, and moving from the past to present to (potential) future contexts. The objective is to grasp the overarching movements that are driving, motivating, and challenging the system. This literature review has been an ongoing activity, involving a wide range of media such as books, articles, newspapers, magazines, films, and documentaries that have a strong, and in some cases, tenuous, connection to the urban green domain. The history and rationale of the i-Tree software are also investigated and mapped.

Qualitative research (interviews)

The second part of the research aims to empathise with and understand the current system of the public urban

green domain by conducting nearly forty interviews with almost all the stakeholders of the consortium and some external perspectives including urban forestry, (landscape) architecture, citizen participation, spatial planning, urban mobility, and municipal procurement. Most of the conversations were semi-structured one-on-one interviews of about one hour. Insights were captured in either analogue or digital form, summarised, and shared with the team. The data from the interviews is interpreted into the system map and into associated tensions per investigated domain, highlighting conflicting concepts and visualising the journey of the public urban green decisions. The insights gained were used to prepare for the co-design sessions. A longer-term relationship was established with some of the stakeholders and they were approached several times to identify opportunities, verify assumptions and test the proposition in a more unstructured way.

Research by design (co-design sessions)

The third and last part of the research aims to move from challenges to opportunities together with selected stakeholder groups. The sessions were carefully designed to first demonstrate an understanding of the current situation and concerns in order to build trust for a collaborative move towards exploring potential opportunities for the software within their current processes, following the 'path of expression' (Sanders & Stappers, 2013). In addition, a number of events and roundtables were attended and field visits were made to the five nurseries in the consortium and the municipality of Groningen in an attempt to learn more, create visibility within the field and expand the sphere of influence.

frame innovation   systemic design   participatory design

speculative design   vision in design   strategic design

paradigm

system

practice

proposition

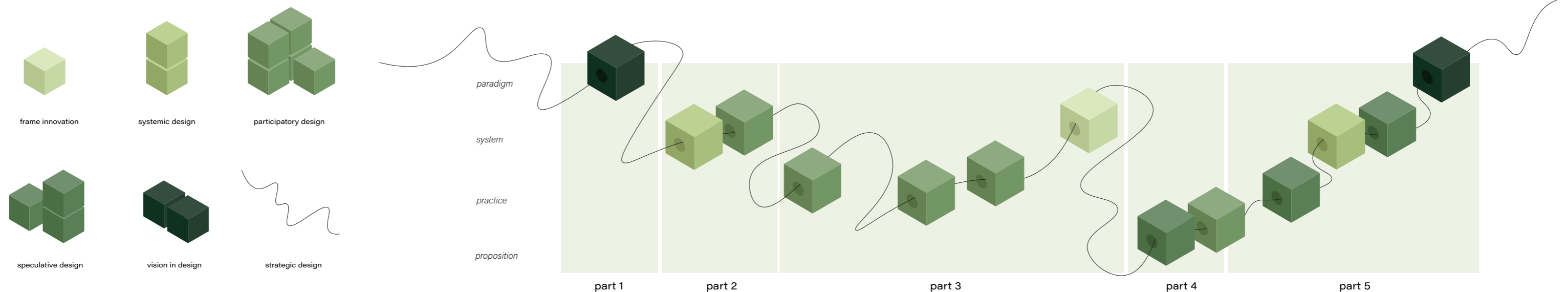part 1   part 2   part 3   part 4   part 5

Figure 3. Melange of methodologies, oscillating between paradigm and proposition

PROCESS - A READER'S GUIDE

This thesis is divided into five parts, an introduction and a conclusion. The five parts differ in terms of scale, abstraction, interaction with stakeholders, and moment in time, as shown in Figure 4.

Part 1 - the paradigm

Part 1 elaborates on the paradigm shift within the urban green domain, demanded by the climate challenge and potentially facilitated by technology, summarised in five transitions. Developments, ideas, signals, and theories from different fields are brought together to illustrate how urban green has arrived at its current undervalued position and how this should change in the future.

Part 2 - the system

Part 2 zooms in on the members of the i-Tree 2.0-NL consortium and, based on the interviews, maps the current system of public urban green decision-making processes and the relationships between the domains of the different stakeholder groups. The dynamics within these domains are further illuminated by highlighting the most prominent tensions that were distilled from the conversations.

Part 3 - the opportunities

The understanding of the existing system, the challenges, and the connections within the domains serve as a basis for identifying opportunity areas for the potential integration of i-Tree in Part 3. This is done in co-design sessions together with stakeholders.

Part 4 - the proposition

In the most concrete and scoped Part 4, one of the opportunity areas is selected and developed into a future proposition. The proposition is tested and iterated together with the relevant stakeholders and a timeline for further development is proposed.

Part 5 - the integration

The final Part 5 explores the integration of the proposition into the current system, presenting concrete practices that enhance the status quo and system scale speculations that provide a first outlook of a potential new system. The part concludes with the relationship between the proposition and its navigation to the new paradigm, illustrating how the piece makes the puzzle more focused.

PART 1
the paradigm
understanding the transitions

PART 2
the system
mapping the current processes

PART 3
the opportunities
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PART 4
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the integration
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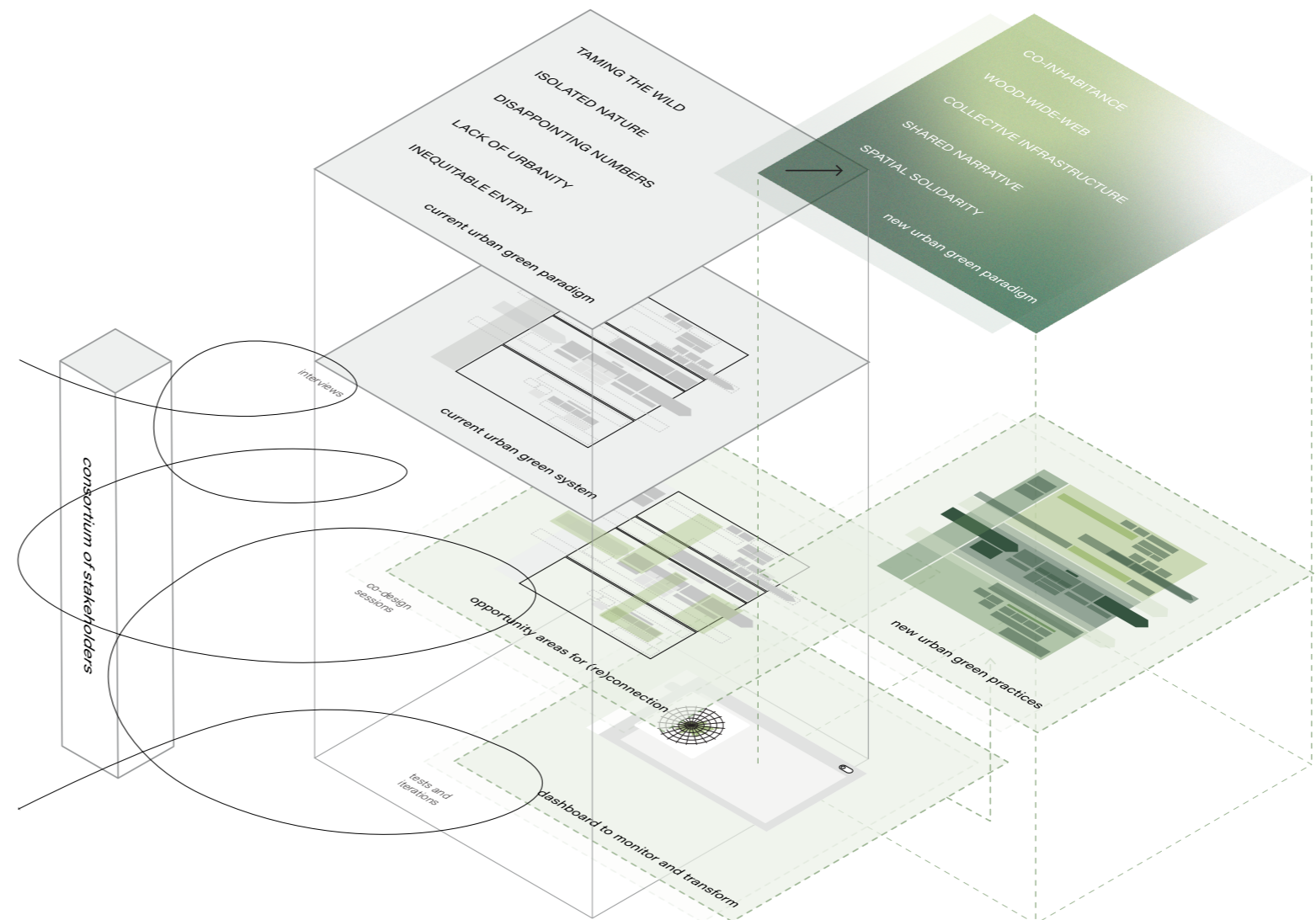
Figure 4. Project overview - relation between different parts

part 1
THE PARADIGM

This part explores the undeniable paradigm shift within the urban green domain. It is my own personal interpretation of the past and vision for the future, based on what is happening globally. In illustrating the historical foundations, current beliefs and potential developments of this chapter the pronoun 'we' is used throughout in a spirit of collectivism. It should be noted that while not all individuals have literally been part of these things, as a collective group of people over thousands of years, we have collectively made certain decisions and taken certain actions. While we may not be individually responsible for certain issues, the extenuating circumstances of climate change make it imperative that we now take collective action to address them.

FROM ANTHROPOCENE TO SYMBIOCENE

The urban green domain finds itself in an approximating paradigm shift. Society is rediscovering and reorienting its relationship with nature in an urban context, as demanded by today's challenges. The old paradigm is a co-contributor to this urgent position we find ourselves in by shaping our environment, our spatial planning, towards an anthropocentric one focused on domination and grid-like grey infrastructure. We still have to come a long way in establishing co-inhabitance, exchanging our pavement party for an equal green gathering, but the change has begun. From the Anthropocene to the Symbiocene, as proposed by Glenn Albrecht (VPRO, 2022). The far-from-complete outline in this chapter is intended to give a sense of this momentum, a cross-section, travelling towards what I believe is the desired public destination where we must arrive in time. Understanding and embracing the overarching transitions to secure the urban forests as critical infrastructure to keep our cities liveable and resilient. To manifest this repositioning, we as a society have to change. We have to change the way we relate to the urban forest, the way we integrate it, account for it, collaborate for it, and provide access to it. Five transitions in order to anchor the green infrastructure in time and space.

OLD PARADIGM

taming the wild

The way we relate to the urban forest

The process of 'taming the wild' is one that has been ongoing since the dawn of human civilisation. Agriculture was one of the first irreversible steps in this process, as Alexander von Humboldt remarked during his explorations in South America, forever changing our relationship with the natural environment (Wulf, 2016). Observing the production of indigo in the valley of Aragua at Lake Valencia he noted that 'the soil was being exploited 'like a mine'' (Wulf, 2016). Agriculture brought order to what was once considered a chaotic environment, allowing humans to exploit it for their own benefit. This shift from nomads to farmers, from travelling over land to cultivating it, marked a turning point in human history. The beginning of the creation of permanent settlements, the ancestors of our modern cities and the gateway to a population explosion and subsequent loss of biodiversity.

This dominating attitude is also addressed by the philosopher Bruno Latour, who argues that the division between humans and non-humans is a crucial aspect of this process (Verbeek, 2021). Humans, as subjects, study objects through science, and by establishing this separation we can dominate and rule over these objects. This perspective highlights the power dynamics at play in the relationship between humans and the natural world.
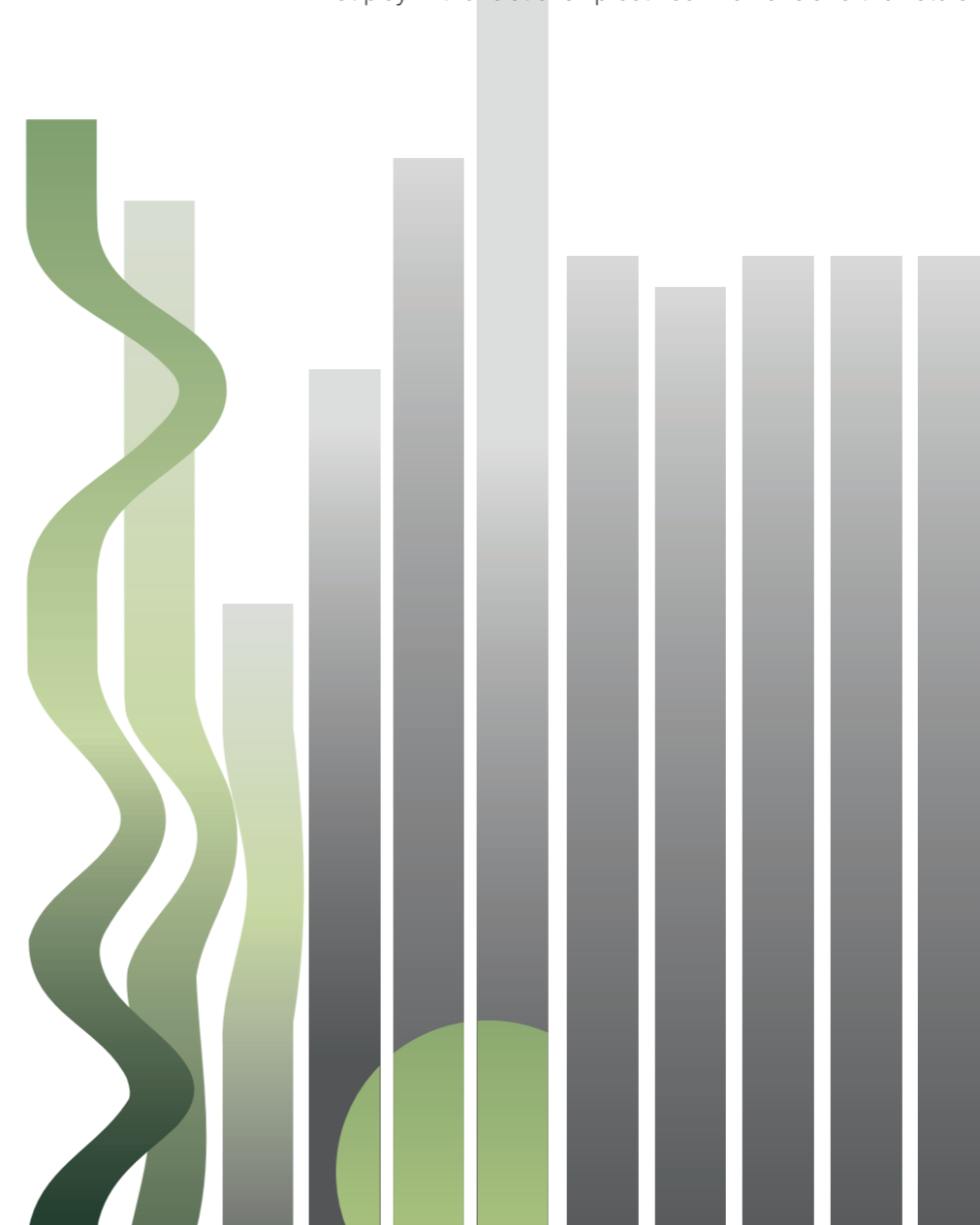
isolated nature

The way we integrate the urban forest

Massachusetts (US) was the first to pass a Tree Warden Law in 1896, which required a municipality to appoint tree wardens to ensure that public trees were safe and behaved decently, not interfering with our constructed, man-made world (Dark Matter Labs, 2020). Trees were portrayed as isolated entities, disconnected from their surroundings. This mental model dominates our urban green design and thinking to date.

There is an unnatural distance between humans and nature (IACA & Konijnendijk, 2020). We talk about and design within the division of city and nature, with a clear boundary between the two. The default is to contrast the two landscapes rather than being kin. Green spaces in cities are often ordered into predefined 'boxes' within our grid-like environments (Stuiver, 2022b). We force-fit organic matter into a geometric frame and design, plan, and talk in terms of discrete greys, reds, blues, and greens rather than gradients. Our urban environment has inherited a grey legacy, with hard surfaces from façade to façade, as a remnant of our pavement parties, when we focused on human mobility and took any form of non-human mobility for granted.

Our green structure plans and visions suggest a coherent system of urban green space but in reality, we should be talking about island biogeography, as the word 'system' in urban green system has lost its meaning (Meyer & Meyer, 2008). "The fact that we, humans, are built with a brain in charge of the functions of the various specialised organs has influenced just about every type of organisation or structure that humans have ever devised" (Mancuso, 2020, p. 50). Our world consists of siloed, centralised systems based on specialisation and hierarchy.

From a time perspective, we have also isolated nature. With our ever-expanding reach and influence, we have lost touch with the long-term cycles of nature (Krznaric, 2021). In the fourteenth century, church bells rang once an hour, now we change stocks based on nanoseconds. Politics is based on the alternation of building and dismantling every four years, while some trees only mature at the age of a hundred years. How can we regain the patience to take proper account of natural processes when we have become an efficient hyper-society?
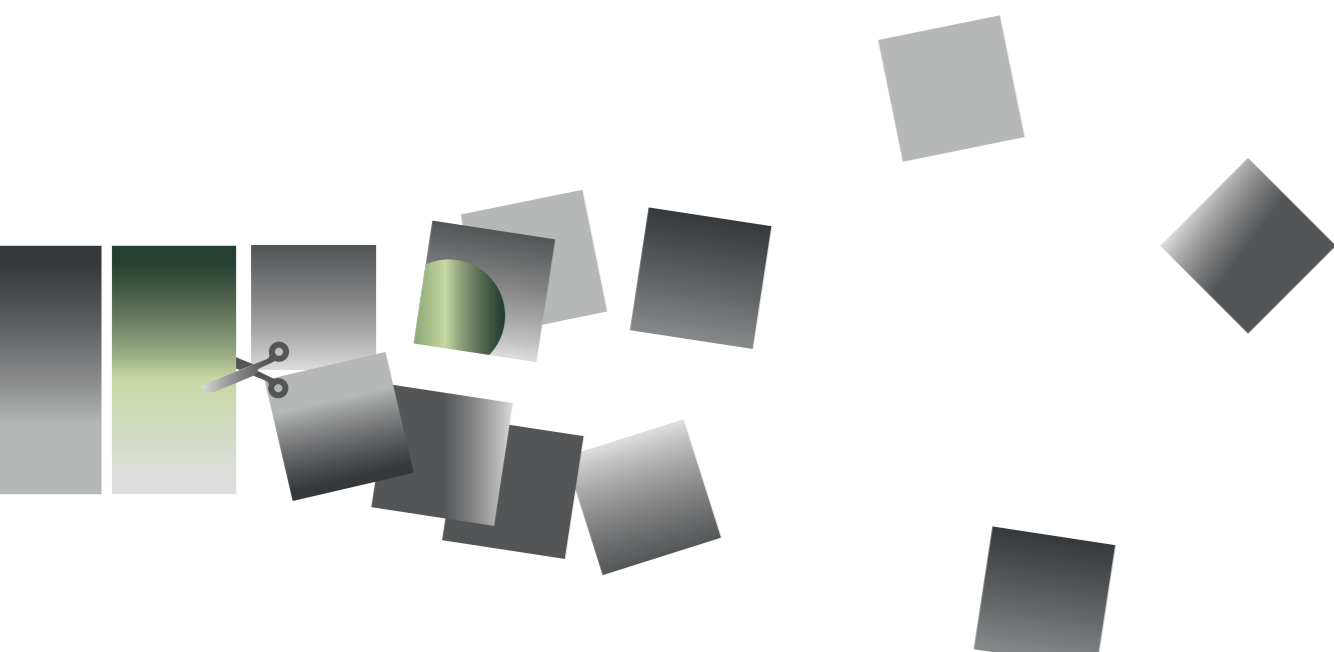
disappointing numbers

The way we account for the urban forest

Our enduring mental models of urban nature, and the way we perceive and approach it, have greatly influenced the way we have shaped our policies, funding structures, financial accounting, and management (Dark Matter Labs, 2020). An example of this is the use of the optimum rotation length of trees (+/- 50 years old), which is taken from the timber industry and applied to urban tree management. This is despite the fact that urban trees actually reach the start of their peak benefit provision at this age (Barrell, 2018). Furthermore, current local authority accounting practices do not consider trees as assets, but rather as a cost on the balance sheet. This has led to ongoing cost-cutting strategies that favour planting small trees and counting stems over increasing canopy cover and crown volume (Dark Matter Labs, 2020).

We focus on maintaining centralised grey infrastructure, which depreciates over time. In contrast to green infrastructure, where management actually leads to an exponential increase in benefits (Dark Matter Labs, 2020).

Furthermore, beneficiaries of tree services do not always cover their costs, as illustrated by the example of New York's Central Park, which is responsible for 18% of all real estate property values surrounding the park, yet this money does not flow back to the New York City Parks Department (IACA & Konijnendijk, 2020). This imbalance in green accounting is partly due to the current cumulative figures for tree benefits, which prevent the designation of multiple co-beneficiaries within the siloed public sector funding system.

lack of urbanity

The way we collaborate for the urban forest

The use of public space in cities has changed over time, with a significant shift occurring since the 1960s. Historically, the street was seen as a central hub for social interaction and activity, with a variety of modes of transport coexisting. It was the domain of cars, horses and carriages, cyclists, pedestrians, and traders. The road was narrow, the sidewalk wide. However, with increasing traffic and urbanisation, public space was transformed from a social meeting place into a paved transport artery, with limited interaction and less space for green (Bosch Slabbers landschapsarchitecten et al., 2016).

Public space as the ultimate equaliser has become a concept from the past (Sennett, 2017). Our social interactions which used to primarily take place on public decor turned inward to our private homes and screens. This has led to the erosion of the civil code, the decline of informal rules, and the lost meaning of public space (Achterhuis, 2019). Anton Zijderveld speaks of a 'lack of urbanity' (Konijnendijk, 2018) as a crucial problem of contemporary cities, where the community has given way to a group of loosely bound individuals accidentally living in the same area. Social cohesion and social capital are under pressure.

Public space is part of the 'language' of the urban environment that makes it understandable and legible (Meyer & Meyer, 2008). The decay of public space threatens the extinction of our common language, which asks for expansion with new words. This language can only continue to exist in a collective effort, as illustrated by Jane Jacobs (1961): "Cities have the capability of providing something for everybody, only because, and only when, they are created by everybody." Her influential work in the field of urban planning and public space critiqued the prevailing urban planning wisdom which emphasised large-scale, top-down approaches to planning cities based on separate functions (living, working, recreation) that were patched together.

inequitable entry

The way we provide access to the urban forest

From an environmental justice perspective, access to urban tree cover is not evenly distributed and is inequitable. A strong correlation is found between tree canopy coverage and household income in American neighbourhoods (Schwarz et al., 2015).

There is a power dimension to the implementation and management of urban trees (Konijnendijk, 2018). Historically, privileged groups have been able to claim (parts of) the city forest as a means of escaping the demanding urban pressure, or to use it for certain activities such as hunting. Paradoxically, the attempt to increase access to green spaces in low-income areas can in turn lead to gentrification. The documentary 'Racist Trees', part of IDFA 2022, shows a row of tamarisk trees at the edge of a golf course in Palm Springs, 'screening off' the originally black Crossley Tract neighbourhood (Newens & Son, 2019). Dense, mature trees become a means of facilitating segregation.

From dominated, isolated, consistently undervalued nature in an eroded and inequitable public space ...

Climate change

Urgent and undeniable truth

Are we able to limit our global temperature rise to 1.5 degrees (Pörtner et al., 2022)? Even the foundations of this ambition are fragile as we look at the climate summit COP27 in Egypt (Raaij, 2022). The rate of climate change in relation to human activity is more urgent than ever before. With almost 70% of people living in cities by 2050 (United Nations, 2018), our urban environment is put to the test. Anthropogenic climate change has a direct impact on extreme weather events, as measured by the attribution science developed by Frederieke Otto. This relatively new field of study aims to understand the causes of extreme weather events and how they are affected by climate change (Otto et al., 2018). Our cities are particularly vulnerable to rising temperatures due to the heat-island effect which causes more frequent and severe periods of heat stress. This natural phenomenon is a silent killer, becoming increasingly fatal as human (and non-human) physiological systems are unable to cope with these temperatures. In addition to heat stress, cities also have to deal with droughts, floods, loss of biodiversity, air pollution, and land subsidence.

The need to develop thriving, resilient urban environments is increasingly recognised by policy makers. Examples at the global level include the United Nations Sustainable Development Goals, in particular Goal 11, and the United Nations Decade of Restoration (United Nations Decade on Ecosystem Restoration, 2018). The European Commission has defined a Biodiversity Strategy, a Forestry Strategy, and a European Green Deal, linked to the urban environment through the New European Bauhaus (European Union, 2020).

Power and potential of green

In mitigating and adapting to climate change, the urban forest provides an answer. Shade, evapotranspiration, carbon sequestration, water retention, and pollution filtering are just a selection of the services that urban trees can provide simultaneously. Trees in the urban environment are also essential in our fight against biodiversity loss. Conservation International appointed 34 biodiversity hotspots around the world, all of which include urban areas (Stockholm Resilience Centre, 2012). We are currently part of the sixth extinction wave (Kolbert, 2014). A crisis that is linked to our climate crisis, but has not been treated as such to date, pointing again to COP27, where the 'Nature Zone Pavilion' is tucked away in a corner:

"The climate crisis and the biodiversity crisis are two sides of the same coin," said Lucy Almond of Nature4Climate, a coalition of 340 nature organizations, on Wednesday at the kick-off of the "biodiversity day" at the COP. "And they must be tackled together." Because achieving the Paris targets (a maximum of 1.5 degrees of warming in 2100 and climate neutrality in 2050) depends on nature's ability to absorb our CO2 emissions. "It is our cheapest climate solution" (Raaij, 2022).

Urgent and undeniable reasons to move away from the old paradigm that has led to the undervalued position of urban green.

To the outline of a new paradigm, a cross-section of apparent momentum for change combined with a little bit of wishful thinking. Exploring initiatives, projects, movements, scientific advances, revived ideas, and new mental models that indicate a transition. Not to strictly frame what 'the' new paradigm should look like, but to contextualise the direction.

taming the co-inhabitance

The way we relate to the urban forest

The dominating character of society and the tendency towards centralisation should make way for co-inhabitance by restoring the uneven balance between humans and non-humans (Verbeek, 2021). Going back to our roots and allowing our ancient evolutionary canopy preferences to prevail again (Townsend & Barton, 2018). We are moving towards a post-anthropocentric, more-than-human way of thinking in a wide range of disciplines, captured in the 'More-than-Human' reader of Het Nieuwe Instituut (Jaque et al., 2020). On 22 April 2022, they became the first 'Zoöp' in the world, an organisational model that safeguards all 'zoë', which is Greek for 'life'. This form of organisation depends on governance that allows cooperation between humans and non-humans, thereby involving them in the decision-making process (Het Nieuwe Instituut, 2022). Giving a voice to non-humans, offering them a seat at the table, and ensuring their protection.

For the Venice Architecture Biennale, Superlux imagined a dinner with all life forms on earth, a 'multi-species banquet' (Hahn, 2022). The International Architecture Biennale of Rotterdam 2022 hosted a discussion on the topic of nature as a political participant. Similar ambitions can be seen in 'de stem van de Noordzee' (Burgers & Meijer, 2020), which follows Bruno Latour's ideas of giving animals and things a voice. Stefano Mancuso speculates on new forms of representation in politics, law, ethics, and language with his 'Universal Rights of Plants' (Mancuso, 2020). In seven articles he applies the 1948 Universal Declaration of Human Rights to the plant kingdom. One of his most inspiring findings relates to regeneration. The plant world, like other natural systems, follows a simple rule: grow as long as you can, according to the resources available. This adaptation to finite resources is called phenotypic plasticity. It is a principle that human society should adopt if we are to co-inhabit our environment in a sustainable way.

In an attempt to repair the damage done, municipal ambitions focus on 'renaturing' the city (Galle et al., 2019). But to 'renature' means 'to restore to an original or normal state (Merriam-Webster's Collegiate Dictionary, 2019). In the case of our cities, this would require the removal of all people and man-made infrastructure in order to restore the land to its original landscape. This is neither a plausible nor a desirable scenario. Instead, we should embrace and live together in new urban ecosystems (Schilthuizen, 2022). While our attention is focused on preserving the last remnants of natural areas outside of urban environments, nature is adapting to our cities behind our backs, driven by evolutionary forces. For example, snails in urban areas exposed to heat stress have developed shells of lighter colour, the London 'subway-mosquito' has adapted its mating ritual to underground conditions, and a certain type of tree produces heavier seeds to increase its chances of landing in the small square space beneath its mother.

The European Forest Institute has recently published a research agenda on 'biocities' of the future (Wilkes-Allemann et al., 2022). A biocity is a concept that emphasises the integration of living systems and natural processes into the design and management of urban areas. It aims to create sustainable and resilient cities that are in harmony with the natural environment and support the well-being of both human and non-human inhabitants. This can include features such as green roofs, urban agriculture, rainwater harvesting, and biodiversity corridors, as well as policies and regulations that support the integration of nature into the built environment. It advocates urban planning that develops different levels of the city mutually reinforcing each other's functions. The goal of a biocity is to create a symbiotic relationship between the urban environment and the natural world, promoting healthy and liveable communities for all.

isolated n **wood-wide-web**

The way we integrate the urban forest

Alexander von Humboldt was the first to see nature as a 'living whole', a 'wonderful web of organic life', and brought this together in a visual representation, the 'Naturgemälde' (Wulf, 2016). His vision and extraordinary ideas inspired Darwin to board the Beagle and his books were one of the foundations of modern evolutionary biology. In The Origin of Species, Darwin writes about the elusive and complex ecological ecosystems where the consequences of intervention are in no way predictable. Chopping our urban nature into our constructed lines, square metres, districts, and time boxes interferes with this natural system. It takes an enormous amount of courage and strength to disconnect from our grid and the short-term cycles driven by modernity and humanity at the centre of the world. To infuse the decentralised nature of the plant kingdom into our specialised, siloed systems (Mancuso, 2020).

Our understanding of symbiotic forest systems was raised to a higher level with the doctoral research of ecologist Suzanne Simard in 1997 (Simard, 2022). Scientists already knew that trees and fungi had a trading relationship, exchanging carbon and nutrients with each other, but Simard showed that they also exchanged these materials with other trees through mycorrhizal networks. This 'wood-wide web', coined by Simard, is able to communicate, interact and share a kind of 'wisdom' (Beiler et al., 2009). In this light, a row of avenue trees torn apart by roads and car parks could be seen as orphans. We could broaden the human-centred perspective on 'urban mobility' and provide interconnected natural ecosystems that allow animals to move and plants to communicate. Unchain our urban green and let the emergent properties of nature flourish towards a symbiotic city (Stuiver, 2022a).

disappoint **collective benefits**

The way we account for the urban forest

An forthcoming development is the valuation of nature and its ecosystem services, in an attempt to gain recognition and decision-making power for our natural resources. According to Kate Raworth, this valuation can be expressed and developed in different metrics, the metrics of money and nature's own metrics:

"For the first time we can describe and measure nature's generosity and life systems in nature's own metrics [...] we can measure the depletion of ecosystems, we can measure the quality of the soil, the health of humans, our nutrition, our educational level, our self-reported levels of happiness. We can actually measure the well-being of people and the planet in natural and social metrics, in terms of life itself" (Dark Matter Labs, 2019).

Both metrics are needed because we need to speak the 'language of power' in order to change policies and decisions today. But this language of power is up for debate and its foundations are being shaken, because "life does not happen in money. Life happens in nature's values, in human values." Raworth asks society: "How can we create the full stack of regulations, and prices, and markets, and understanding, and language, and metaphor, and relationship that we need to do justice, to what I think will actually be the dashboard of metrics we are going to create in the 21st century" (Dark Matter Labs, 2019).

We are becoming increasingly aware of the importance of our 'civic capital' and the revaluation of our commons, the structures and systems that together create public value in our collective ownership (Dark Matter Labs et al, 2018). Urban trees are civic assets too. Current financial models are unable to successfully fund the necessary investment in the urban forest. While all the different stakeholders in a city reap the benefits, the costs of green infrastructure are not pooled. Dark Matter Labs' Trees as Infrastructure proposition connects different city stakeholders to co-finance, co-own and co-maintain urban trees using smart contracts, Natural Tree Understanding algorithms and the Internet of Trees for management and evaluation (Dark Matter Labs, 2020). In their proposal, beneficiaries could be real estate developers, general practitioners, and water management companies, for example, allowing us to work together towards a mature urban forest, secured and enabled by shared responsibility.

lack of urban shared narrative

The way we collaborate for the urban forest

In addition to a new position within our bureaucratic regimes, we as a society need to construct a new socio-cultural urban forest narrative. Civilisations and societies are based on shared narratives and it is only because of their existence that we are able to work together with large groups of people unfamiliar with each other (Harari, 2019). Shared stories connect rather than fragment, and this is exactly what our current anonymous cities need. As Cecil Konijnendijk (2018) states, 'People need a real home, a place that roots them in a hectic, rapidly changing world.' Local identity is in demand, as are 'places that balance the hard, standardized, and cost-efficient with the natural, personal and healthful.' Our urban trees lend themselves to being these beacons of trust and can act as identity carriers, the foundation of our social contract with place.

Cities hold great promise for tackling global challenges, as they are the places that deal with unruly realities on a daily basis. Citizens feel more involved and connected to their city than to their country; mayors are more popular than country administrators (Biezen, 2013). Recognition, confrontation, and common interest: the pragmatic potential and power of the city to restore urbanity and a sense of public progress. As early as the 1960s, Jane Jacobs argued for 'a more organic, bottom-up approach that emphasises the importance of diverse, mixed-use neighbourhoods and the role of residents in shaping the development of their communities' (Jacobs, 1961).

The emergence of citizen science and other participatory approaches to shaping and sustaining our natural ecosystems is promising. Citizen science is already helping to track progress towards the UN Sustainable Development Goals (Fritz et al., 2019). This non-traditional way of obtaining data could potentially play an important role in maintaining our urban forests and creating widespread ownership.

inequitable spatial solidarity

The way we provide access to the urban forest

We are as strong as the way we treat our weakest link, and therefore we must advocate spatial planning based on solidarity (Alkemade, 2020). The French philosopher and feminist Simone de Beauvoir argues in her book 'La Vieillesse' that the way we treat our elderly exposes our true intentions as a society. The way we work with minorities reveals the values we stand for. We can extend this framework to the way we treat nature, which is becoming increasingly fragile as a result of human carelessness. The former government architect of the Netherlands, Floris Alkemade, proposes decision-making and spatial planning based on interdependence, a call for solidarity.

Examples of concepts that aim to develop more accessible and inclusive urban landscapes are the x-minute city concept (Hobbs et al., 2022) and the 3-30-300 rule (Konijnendijk, 2021). The idea behind the x-minute city is that all residents should be able to reach essential amenities within a certain time frame, such as 5, 10, or 15 minutes, by either cycling or walking. The 3-30-300 rule in urban forestry aims for '3 trees from every home, 30 per cent tree canopy cover in every neighbourhood, 300 metres from the nearest public park or green space' (Konijnendijk, 2021). These guidelines are promising in that they present clear targets to guide decision-making for a more equitable urban environment. However, it is important to set goals and focus first on marginalised citizens and under-represented areas.
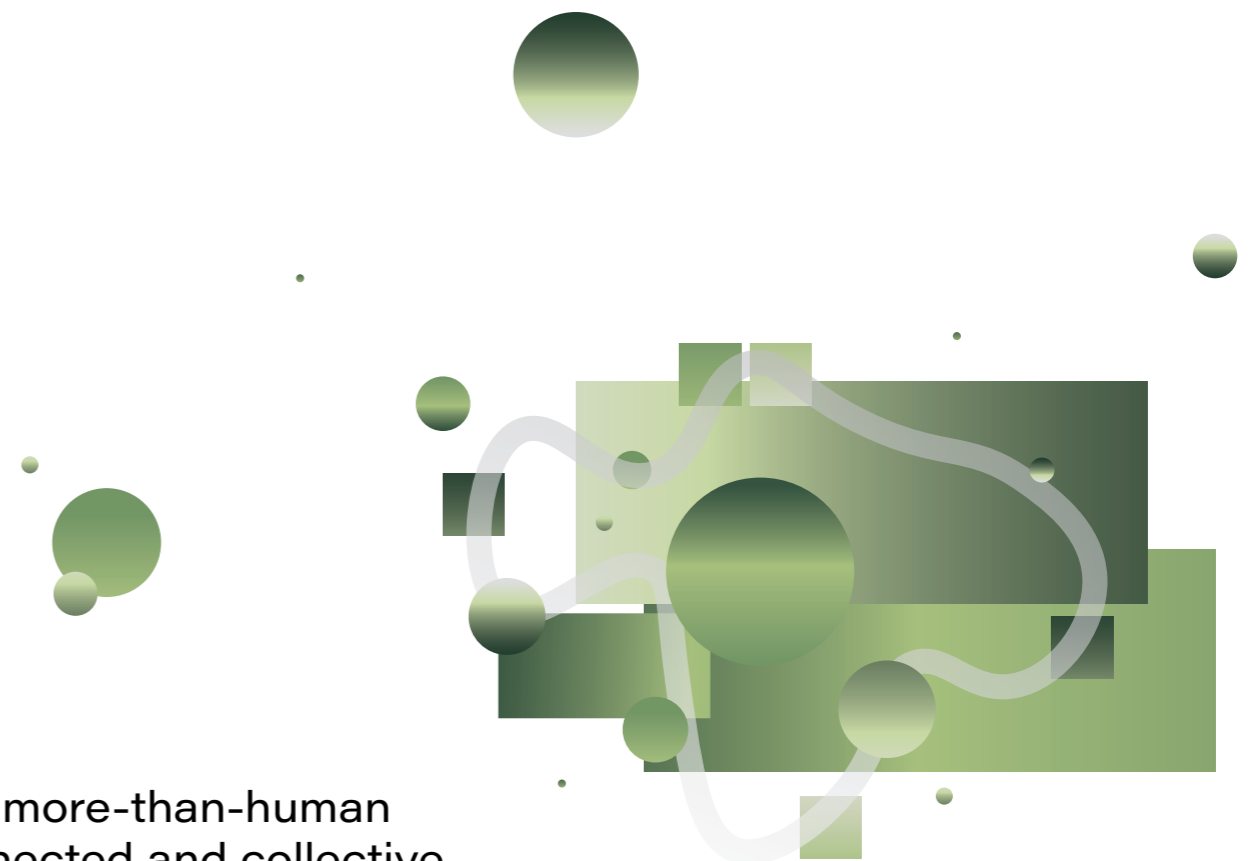
... to more-than-human connected and collective co-inhabitance driven by a shared urban narrative and spatial solidarity

Potential of technology

How can we facilitate this shift? The field of urban forestry is not as intelligent as it would like to be, and not very good at using modern technology (IACA & Konijnendijk, 2020). So far, it has been a discipline of generalists and 'circa-science', while the rest of the city uses quantified strong arguments (van der Velde & Pakhuis de Zwijger, 2022). There is a promising potential for technology to be one of the vehicles for transition, by smartening up the position of nature in the urban realm, 'not just human smart, but smart in its own right' (IACA & Konijnendijk, 2020).

Nature-smart

Our cities are becoming more 'smart' every day, using 'Internet of Things' devices to collect and analyse diverse data streams. Paradoxically, if you look at the IoT system of interconnected communication and decentralised self-management, there is a clear resemblance to the biological information network of a forest (Galle et al., 2019). We have plundered nature for inspiration, only to leave it behind disconnected. Could technology, in turn, be used to reinforce the natural ecosystem and secure its position in the harsh urban environment? A concept called the 'Internet of Nature', coined by ecological engineer Nadina Galle, could be one answer. An article in the journal Anthropocene Review discusses various examples of the Internet of Nature and its application in urban forestry. From LiDAR and remote sensing to monitor canopy cover, to biosensors, blockchain for green initiatives, and street-view imaginary to manage green quality.

Copenhagen-based research and design lab SPACE10 has published the Future Forest report, which explores how new technologies can support, protect and hold us accountable for our future forests (SPACE10, 2022). If society continues to increase current rates of deforestation and timber production, we risk losing up to 90 per cent of our original forests worldwide by 2030 (The World Counts, 2022). In an attempt to save 'the lungs of our planet' and 'home to 80 per cent of the world's animal, plant and insect species' they look at satellite mapping and LiDAR, isotope reference testing and eDNA, drone technologies and Web3 (blockchain, smart contracts, cryptocurrencies, NFTs and DAOs). The report does not have a primary focus on urban forestry, but the technologies discussed have application potential in the urban sector.

Another technology-driven example is the aforementioned Trees As Infrastructure proposal from Dark Matter Labs, which, in addition to its co-funding model, presents an agent-based digital twin of the urban forest in collaboration with Lucidminds in order to maintain and forecast urban trees (Dark Matter Labs & Lucidminds, 2021). TreesAI launched its first pilot in Glasgow to manage its urban forest inventory and help meet its climate targets (Dark Matter Labs et al., 2022).

Natural capital accounting

In order to recognise our environment as an asset, interest in the natural capital perspective has increased significantly since the 1970s among governments, businesses, society, and academia (United Nations, 2021). While it is easy to get lost in the plethora of acronyms, an attempt is made to provide a brief overview of these efforts.

A definition of natural capital, developed by the Natural Capital Coalition is as follows: "Natural capital is another term for the stock of renewable and non-renewable resources (e.g. plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people." (United Nations, 2021). Natural capital accounting (NCA) is the process of using an accounting framework to calculate stocks and flows of natural resources and their contributions in the form of ecosystem services. The United Nations has adopted the System of Environmental-Economic Accounting (SEEA) as the international standard framework. "SEEA Ecosystem Accounting is an integrated statistical framework for organizing biophysical data, measuring ecosystem services, tracking changes in ecosystem assets, and linking this information to economic and other human activity" (United Nations, 2021). The European Union's Integrated system of Natural Capital and ecosystem services Accounting (INCA) project has been testing the implementation of the framework. Natural capital accounting is seen as a key tool in the EU's nature recovery plan by mapping, monitoring and valuing the benefits of natural ecosystems (European Environment Agency & European Commission, 2021).

A nature capital accounting initiative that has also been adopted in the Netherlands is The Economics of Ecosystems and Biodiversity (TEEB), called 'TEEB-Stad' in Dutch. Its development started in 2011 as an initiative of the state and eleven municipalities (RIVM, 2016). To make the tool more location-specific, RIVM initiated the further development of TEEB-Stad into a more spatially explicit version: the 'Green Benefit Planner' (Groene Baten Planner) based on natural capital model maps realised by Atlas Natuurlijk Kapitaal (RIVM, 2017).

This natural capital accounting considers the assets of all blue and green ecosystem structures such as water, grass, shrubs, and trees. However, trees are modelled as a 'ball on a stick' and no distinction is made between the contribution variances of different species. These differences and nuances are large and crucial in the urban forestry practice (van der Velde & Pakhuis de Zwijger, 2022). Fortunately, there is a tool that is able to quantify species-specific ecosystem services of trees, specifically focused on the urban domain.

This tool is called i-Tree.

part 2
THE SYSTEM

Part 2 starts with an examination of i-Tree, including its historical background, rationale, functions, global distribution, and the eventual European release and formation of the i-Tree 2.0-NL consortium. Together with the stakeholders of the consortium the public urban green system and its processes are outlined. The findings from the interviews with the consortium members and external stakeholders are analysed in two ways. Firstly, the general process of each stakeholder is outlined, and secondly, the most prominent tensions within their field of work in relation to urban green are distilled from the conversations.

I-TREE

i-Tree US - history and goals

i-Tree is a freely available computer software suite developed through a public-private collaboration in America (USDA Forest Service, 2006). One million dollars is invested annually in its development. The i-Tree software was originally developed as a tool to support urban forest management and to help both urban and rural communities assess, quantify and manage the benefits and values provided by trees and forests. The vision of i-Tree is 'to improve forest and human health through user-friendly technology that engages people around the world in enhancing forest management and resilience' (Nowak, 2021). To achieve this vision, they have developed tools with the following objectives:

- Conduct an evaluation of the local urban forest conditions;
- Quantify the various ecosystem services and values that are generated from urban trees;
- Identify local hazards to the urban forest and human health;
- Calculate the impact of alterations in the urban forest structure on the provision of ecosystem services and values;
- Formulate best-practise urban forest management strategies that increase the desired ecosystem services and promote tree and human health;
- Determine the optimal tree species, placement, and planting methods to maximise ecosystem services and values over time and throughout space, enhancing human health and well-being (Nowak, 2021).

The models that preceded the US release of i-Tree in 2006 (see Figure 5) were the Urban Forest Effects model (UFORE) and the additional street tree assessment tool (STRATUM) which was added in 2004 (Nowak, 2021). Over the years, the suite of programmes has expanded and utilities have been added, with i-Tree Eco being the flagship tool. i-Tree Eco became functional for Canada, Australia, and the United Kingdom in 2015 and was released for Mexico and Europe in 2019.

Specifically, i-Tree Eco provides detailed information on the structure, function, and value of the urban forest, including the amount of tree canopy cover, diameter distribution and diversity of species, tree biomass, and data on ecosystem services such as carbon storage and sequestration, air pollution removal, stormwater retention, and building energy savings. It uses sample or inventory data for calculations. The programme can also perform a potential pest risk analysis and forecast future tree population numbers. The results also have a monetary component, expressing the ecosystem services in an estimated dollar value.

The i-Tree suite has expanded in several directions, but in defining future goals, Nowak (2021) highlights two other core programmes in addition to i-Tree Eco, five utilities that support these programmes, and the (potential) linkages (see Figure 6). The tools work at different scales, from individual trees to neighbourhoods, cities and landscapes.

The i-Tree team is continuously improving the suite on an incremental scale and aims to integrate more ecosystem services, such as links to human health and regulations, to expand species information, integrate functionalities on a national scale, and extend its reach globally in the coming years (Nowak, 2021).
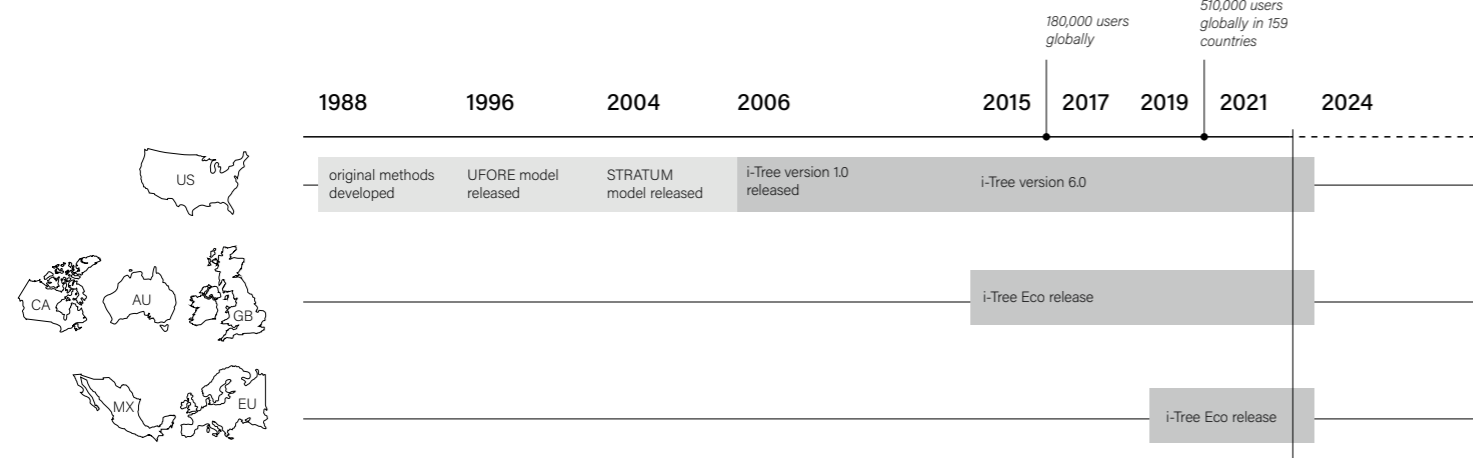
Figure 5. Timeline of i-Tree development, based on Nowak (2021)

i-Tree Eco walkthrough

Wendy Batenburg of Terra Nostra gave a demonstration of the i-Tree Eco programme, showing how they currently use the software. When a new project is created, the user must decide between using plot sample data or a complete inventory as input. If the plot sample is selected, outside measurements have to be made per plot. In the Netherlands the complete inventory is used more often as generally a lot of tree data is available. The population size is then filled in, which only affects the monetary value of the tree, as a tree provides more value in densely populated areas. However, this monetary feature is currently not used as the software defaults to American models and the limited amount of quantifiable services does not yield satisfactory results. Next, the user selects the parameters from the dataset, with tree species and stem diameter being mandatory. In the Netherlands, tree species are usually known, and stem diameters are categorised in classes such as 50-100 cm. The accuracy of the results can be improved by adding tree height, crown size, crown health, and crown light exposure. The Excel data is then uploaded into the programme, where the species in the dataset must be manually linked and compared with the species in the i-Tree database, which is currently a very time-consuming process. The species should be added with the exact correct Latin name. The model is not very user-friendly and can usually lead to some errors. Once the record is approved, a report request is made and the application joins a backlog in America. The report is usually delivered by email within an hour. Finally, tree consultants interpret the report and present their clients with a personalised version in their own style.
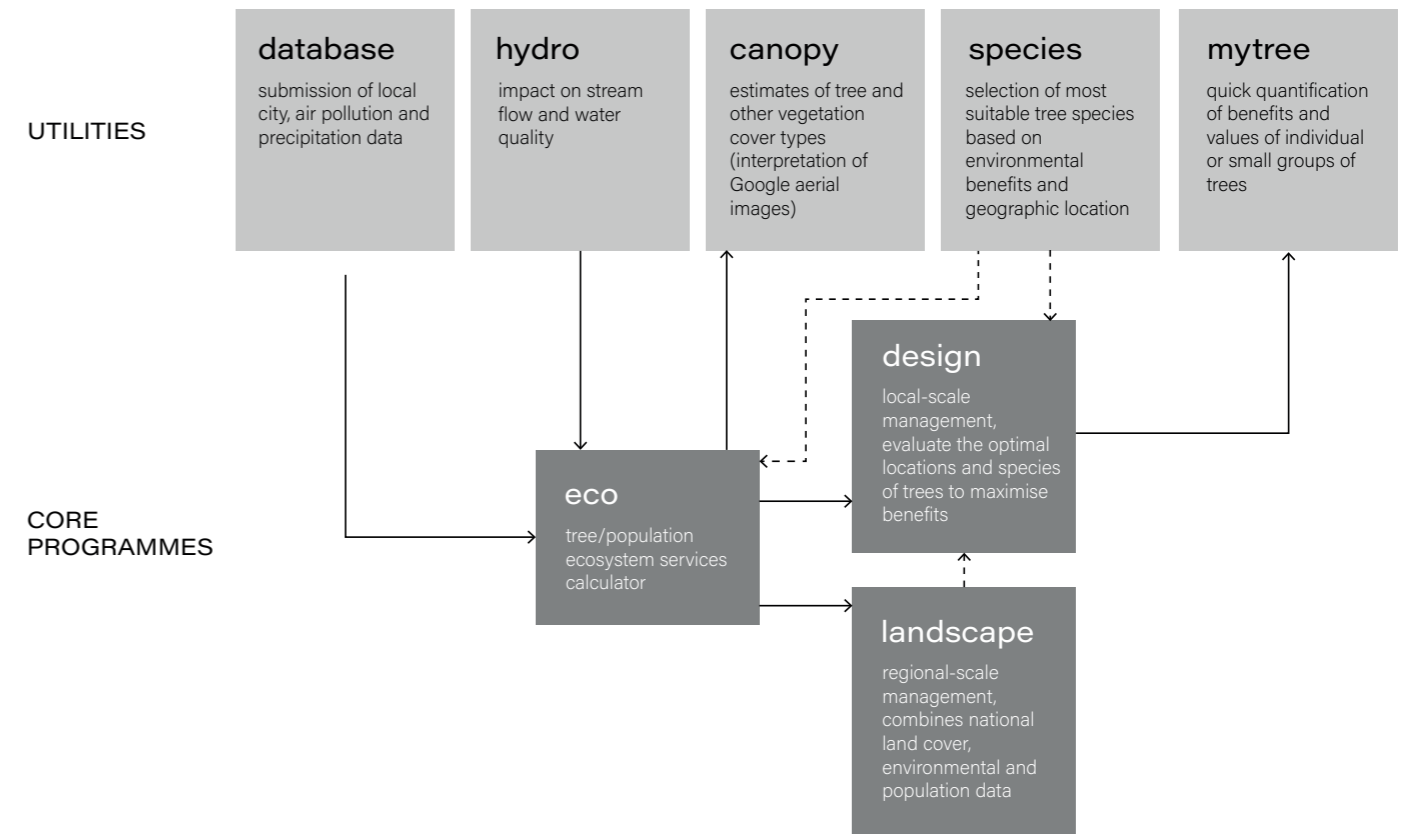
Figure 6. Core programs and utilities of i-Tree, adapted from Nowak (2021)

Essence - ecosystem services

Quantifying the ecosystem services provided by trees is the fundamental premise of the i-Tree software. Ecosystem services are 'the multitude of benefits that nature provides to society' (Millennium Ecosystem Assessment, 2005). The Millennium Ecosystem Assessment, a major initiative led by the United Nations, recognised four main categories of ecosystem services: supporting, provisioning, regulating, and cultural services.

In literature, the 'cascade model' has gained considerable traction (Potschin & Haines-Young, 2010), which elaborates on a flow from ecological structures to human benefits (Spangenberg et al., 2014), as shown in Figure 7. The relationship between the structural components of an ecosystem and the benefits people derive is important in this concept, as a particular function is only defined as a 'service' if it is something humans find useful and consider a benefit (Potschin & Haines-Young, 2010). This application of 'significance' creates a divide between the environmental capital and the anthropocentric social economic system. However, the scope of influence of tree managers is only within the structural domain of trees, while their targets and objectives are set in terms of benefits and values. It is therefore crucial to accurately measure forest structure, as inaccuracies in this measurement will lead to inaccurate values of ecosystem services and benefits. Tree management is not the only stakeholder that influences the structural components of the urban forest. In addition, the current forest and the environmental conditions, such as regeneration, growth, mortality, pests, and weather conditions, have a significant impact. Lastly, the human-induced effects such as the import of exotic plants, insects, pollution, and climate change must be taken into account (Nowak, 2021).

The i-Tree suite is able to support in accurate modelling and monitoring of the urban forest, a crucial element in the design, planning, and use of its ecosystem services, which are essential for the health and resilience of the urban environment.

Context: i-Tree NL

History i-Tree 1.0-NL

The potential of and interest in the tool has spread overseas. Matthew Wells, former director of Tree Preservation in New York and current public landscape manager of Santa Monica, calculated the financial benefits of New York City's 5.2 million trees using the predecessor programmes of i-Tree (UFORE and STRATUM). With his calculations, he convinced Mayor Bloomberg to make trees an essential part of his ambitious PlaNYC for a greener and greater New York (Stad en Groen, 2013).

Jan Willem de Groot, current manager of tree consultant Pius Floris, invited Matthew Wells to tell his story at the sixth 'Boominfodag' (Tree Info Day) in the Netherlands in October 2013. The reports from New York and London inspired the creation of the 'Platform i-Tree NL' with the aim of making i-Tree Eco available in the Netherlands (Batenburg & Kuijper, 2019). Starting in 2015, two pilot projects were initiated with Dutch municipalities to gain experience with the model and to investigate its applicability by calculating different tree stocks. In February 2019, i-Tree Eco was launched in the Netherlands. In June 2021, the i-Tree 2.0-NL project started to improve its effectiveness through further development (see Figure 8 for an extended version of the timeline).

Consortium i-Tree 2.0-NL

A consortium of 28 different public, private and academic stakeholders was formed to carry out the three-year i-Tree 2.0-NL project, which was funded by CLICKNL (see Figure 9). The figure divides the stakeholders into five groups and highlights three stakeholder groups of which a certain scoped part is represented (academics, architecture/engineering and municipalities). The activities of the tree consultants and tree nurseries are fully included in the domain of the project. This distinction is made explicit because the other perspectives and fields present in the stakeholder bodies on the left have an influence on their functioning. For example, the municipal green policy and management departments are closely related to and affected by the other municipal departments. It is important to be aware of the forces at work in these sub-groups. Additionally, citizens and trees were included as they are not directly part of the consortium group but represent the most important actors within the domain.

The i-Tree 2.0-NL project aims to increase the effectiveness of the i-Tree model by investigating the cooling mechanisms of urban trees, developing a tree architecture typology and adding the heat performance of different tree species (Work Package 1), modelling the growth curves of tree species up to the adult stage (Work Package 2), and synchronising the quantification possibilities of i-Tree with the interests of the consortium members (Work Package 3). The technical potential of the tool will only be successfully adopted and used if it resonates with the needs and values of the stakeholders. This graduation project is part of WP3 in collaboration with the efforts of Dr Rebecca Price and Dr Gül Aktürk.

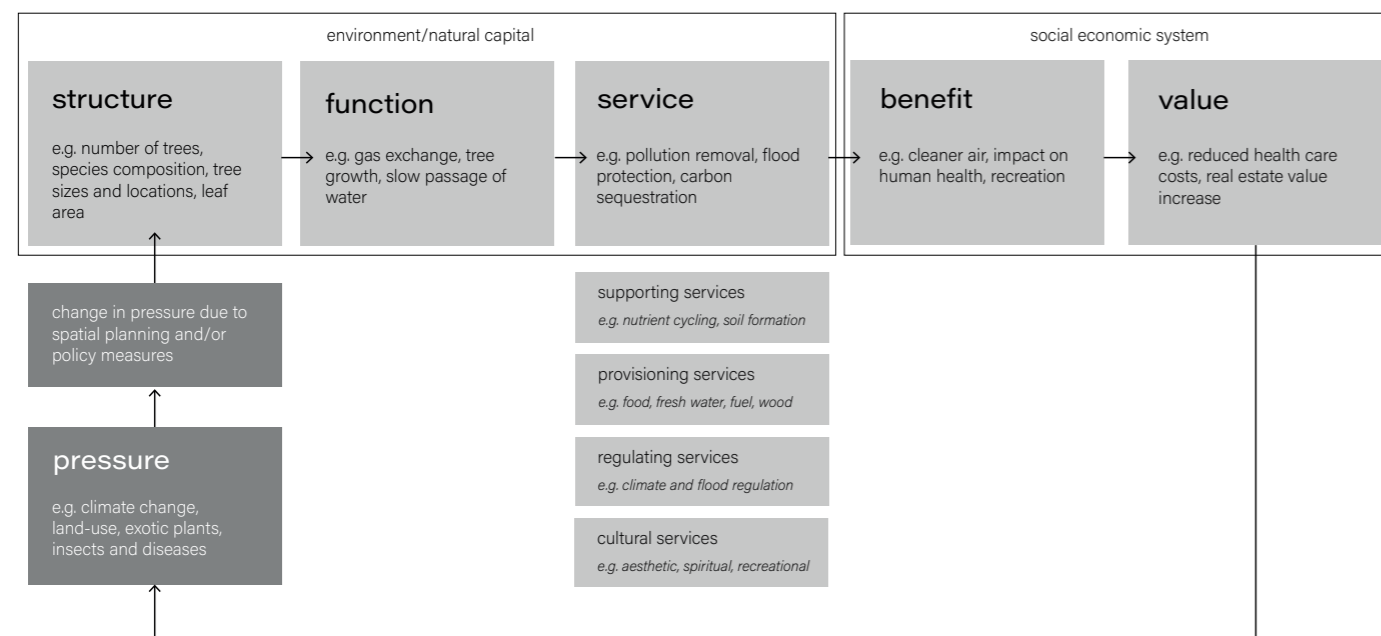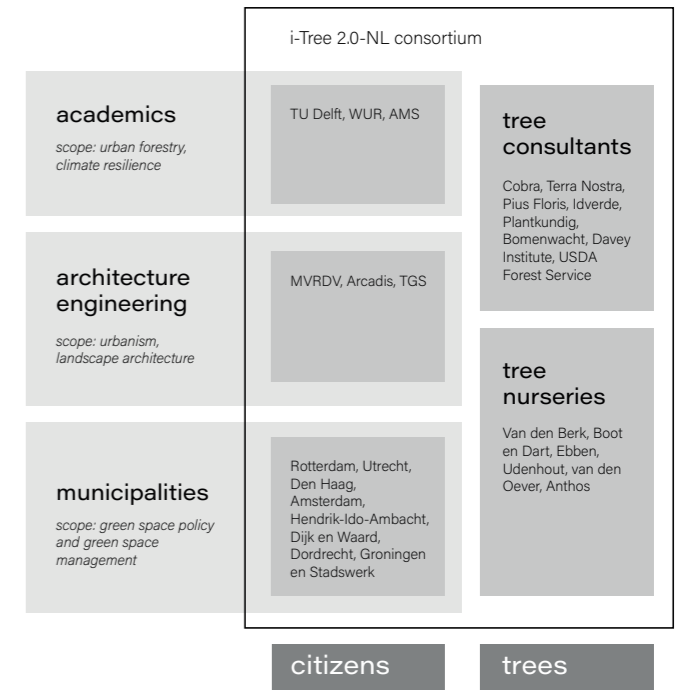*Figure 9. Stakeholders of the i-Tree 2.0-NL consortium, based on Van der Velde (2021)*

Figure 7. 'Cascade model' of ecosystem services, adapted from Millennium Ecosystem Assessment (2005), Potschin & Haines-Young (2010) and Nowak (2021)
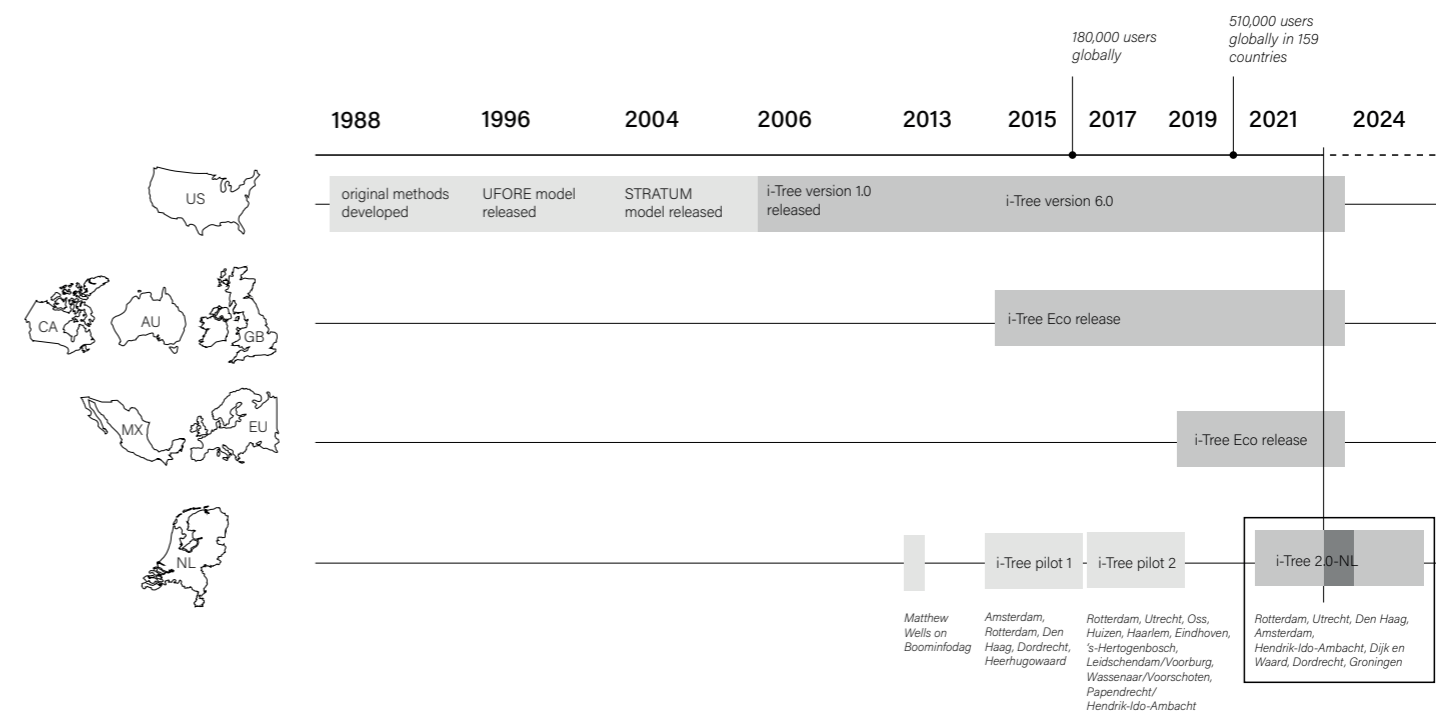
Figure 8. Timeline of i-Tree development (addition of the Netherlands), based on Nowak (2021) and Batenbrug & Kuijper (2019)

BUILDING THE SYSTEM

The opportunity to directly engage and gain knowledge from this diverse group of consortium members was a critical source of input. Most of the organisations were approached and spoken to, resulting in a broad understanding of the urban green domain, which will be explored in the remainder of this part.

Interview setup

An overview of the conducted interviews and attended events can be seen in Figure 10. This research phase is primarily focused on reaching out to the consortium members to develop a sense of the domain and start building relationships. During this process, a number of relevant external stakeholders were identified and the opportunity was taken to include their perspectives.

This research approach uses semi-structured and unstructured interview formats. 37 semi-structured interviews were conducted. Interview guides (Appendix B) were used during the interviews, which list the main issues to be explored, but allow room for steering and delving further into topics as the interview progresses. The general themes explored for all five stakeholder groups, except academics, are ways of working (current tools and place of green within processes), challenges in greening the city (and keeping it green), and opportunities, expectations, feelings, ideas and doubts about the i-Tree software. Most of the interviews were one-to-one and lasted between 30 and 90 minutes, with one exception of 2.5 hours. 17 of the interviews were conducted online and 20 were offline interviews. It was decided that not all would be recorded, but that notes would be taken during the interviews, edited immediately afterwards and translated into English where

necessary. The key findings were summarised at the end of each week and the composite findings were shared with the team on a weekly basis.

The data from the interviews are analysed and interpreted to create general process journeys for each stakeholder group. Together they form a systemic overview of the stakeholder process journey of public urban green. This journey is used to capture the relationships, dynamics, and leverage points of the system, to inform challenges and opportunities and to provide a broad canvas for further scoping. It is important to note that the processes outlined are generic and simplified in nature. Each project is unique and will follow its own context-specific path. The purpose of the system map is to provide an overview of the decision-making processes and grasp the interrelationships between stakeholders and the position of green, rather than to accurately represent the course of a specific case.

A thematic analysis of the interviews with the architects, municipalities, and nurseries was also performed in order to distill the most prominent themes, which are summarised in tensions within the three domains. The tensions and key findings of the other stakeholder groups are illustrated with anonymised quotes from the interviews, which were either reconstructed from the extensive notes taken or extracted from the recordings.

The unstructured format was used later in the final phase of the project for the follow-up conversations as a check-in to validate assumptions and test the proposition. Where a stakeholder was spoken to in this unstructured way, or where there was any other interaction beyond the initial one-on-one interview, this is indicated in the table of participants under N.B.

With reference to the paradigm shift described in Part 1, elements of the old paradigm were played out and experienced first-hand during the stakeholder interviews. Short anecdotes are used to illustrate these phenomena. They show how prevalent these transitions are and bring them to life in a more practical and relatable context. The connections to the old paradigm are indicated next to each tension title.

i-Tree 2.0-NL consortium - interviews

academics
scope: urban forestry, climate resilience

Ab Veldhuizen - WUR
Jelle Hiemstra - WUR
Henk Wolfert - AMS

tree consultants

Jan Willem de Groot - Pius Floris
Wendy Batenburg - Terra Nostra
Fons van Kuik - Cobra

architecture engineering
scope: urbanism, landscape architecture

Stijn Lanters - MVRDV landscape
Kristina Knauf - MVRDV climate
Nika Jazaei - MVRDV urban
Leo Stuckardt - MVRDV next
Erwin van Herwijnen - TGS
Stephan Boon - MVRDV urban
John Boon - Arcadis landscape

tree nurseries

Leon Smet - Anthos
Pieter van den Berk - van den Berk
Albert de Vries - Boot en Dart
Martin Houben - Udenhout
Jeroen van den Oever - van den Oever
Stef Janssen - Ebben
Dirk Ebben - Ebben
Thijs Dolders - Ebben

municipalities
scope: green policy and green management

Rob Zweekhorst - Dijk en Waard
Leendert Koudstaal - Den Haag
Ruud de Jong - Hendrik-Ido-Ambacht
Oege Oevering - Dordrecht
Jacco de Frel - Rotterdam
Henk Langeveld - Groningen
Wieteke de Boer - Groningen
Jeroen van Gaalen - Utrecht
Rob Hendriks - Utrecht
Hans Kaljee - Amsterdam

external - interviews/conversations

Seowoo Nam - MSc. IDE DfI (intern Lucidminds)
Jean-Francois Gauthier - SYLVA landscape architects
Jip Pijs - Kickstad
Lior Steinberg - Humankind
Anouk Jansen - MSc. Urbanism
Tamas Erkelens - Dutch Ministry of Health
Sytse Berends - de Groene Stad
Cecil Konijnendijk - urban forestry expert WUR
Bonne Keizer - purchaser green Municipality of Amsterdam
Willem de Feijter - city forester of Rotterdam
Djavan Braumuller - Rebel urban mobility consultant
Robbert Snep - green cities expert WUR

external - attended events/talks

Public space trade fair - Jaarbeurs Utrecht
Nature as political participant - IABR Rotterdam
Lecture series designing green cities - TU Delft Architecture
Donut deal day - Pakhuis de Zwijger Amsterdam
Together in the city - Pakhuis de Zwijger Amsterdam
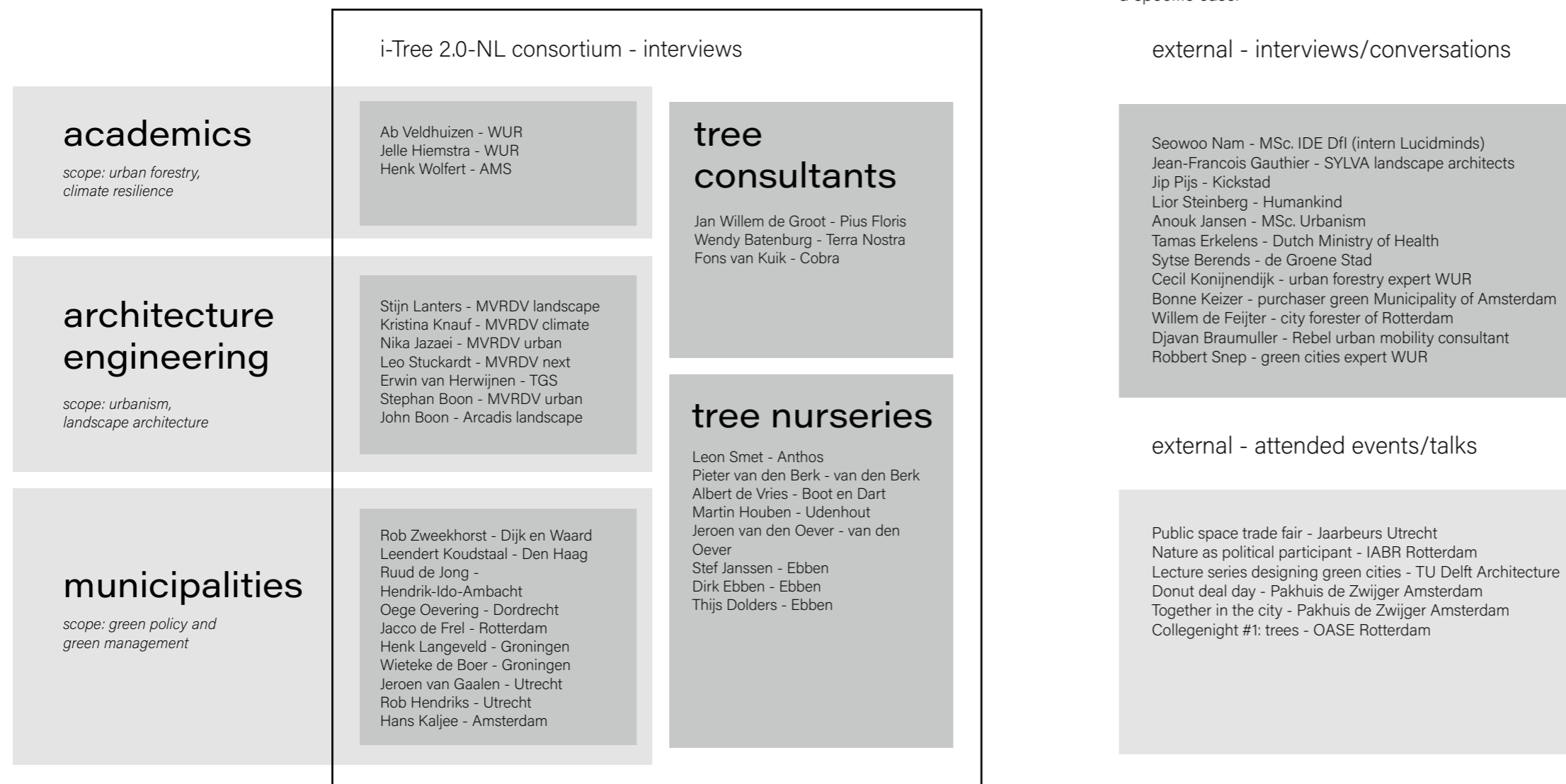Collegenight #1: trees - OASE Rotterdam

Figure 10. Overview of interview participants, external perspectives and attended events during the project

(Landscape) architecture/urbanism

Based on the interviews with the (landscape) architects and urbanists of MVRDV and Arcadis (see Table 1), the processes of the architects are mapped first, as shown in Figure 11. The processes of the project developers and executive organisations are included in the overview, but not detailed. The following section discusses the apparent tensions within their field of work, as distilled form the conversations. An overview is already presented in Figure 12.
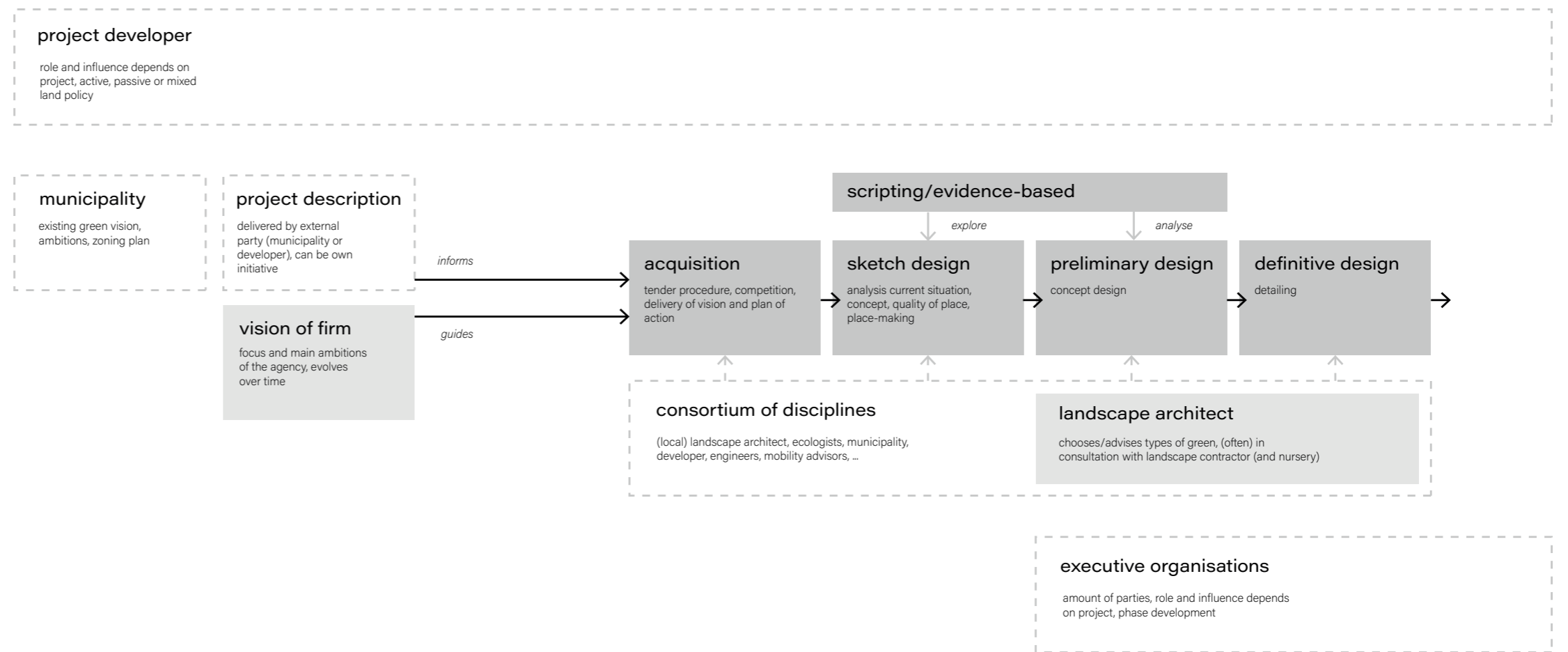
project developer

role and influence depends on project, active, passive or mixed land policy

municipality

existing green vision, ambitions, zoning plan

project description

delivered by external party (municipality or developer), can be own initiative

vision of firm

focus and main ambitions of the agency, evolves over time

informs

guides

scripting/evidence-based

explore → *analyse*

acquisition

tender procedure, competition, delivery of vision and plan of action

sketch design

analysis current situation, concept, quality of place, place-making

preliminary design

concept design

definitive design

detailing

consortium of disciplines

(local) landscape architect, ecologists, municipality, developer, engineers, mobility advisors, ...

landscape architect

chooses/advises types of green, (often) in consultation with landscape contractor (and nursery)

executive organisations

amount of parties, role and influence depends on project, phase development

Figure 11. General process overview within the domain of architects

Who	Role	When	Where	N.B.
Stijn Lanters	Landscape architect MVRDV	21 September 2022 (60 minutes)	MVRDV office, Rotterdam	
Kristina Knauf	Architect MVRDV Climate	21 September 2022 (80 minutes)	MVRDV office, Rotterdam	*Several conversations on discussing WP3*
Nika Jazaei	Urbanist MVRDV	23 September 2022 (45 minutes)	Online	
Leo Stuckardt	Architect MVRDV Next	30 September 2022 (90 minutes)	MVRDV office, Rotterdam	*Unstructured follow-up conversation together with Stephan Boon on 13 December 2022*
Erwin van Herwijnen	Senior Advisor New Urban Standard	30 September 2022 (90 minutes)	The Green Village, Delft	
Stephan Boon	Urbanist MVRDV	13 October 2022 (90 minutes)	MVRDV office, Rotterdam	*Several conversations on discussing WP3*
John Boon	Landscape architect Arcadis	19 October 2022 (60 minutes)	Online	

Table 1. Interview participants (landscape)architecture, urban and engineer perspective of i-Tree consortium

architecture vs. landscape

volume vs. void
green as support vs. green as starting point
short-term vs. long-term
small scale vs. large scale

intuitive vs. quantified

already able to quantify parameters such as energy and CO_2, using green in an unreflective and intuitive way based on knowledge and expertise

public vs. private space

iseparated in terms of responsibility, ownership, and distribution of green in the city

individual vs. collective concerns

classical paradox within spatial planning

visual vs. numerical

visual effect and quantified benefits should be connected but do not always speak the same language, need to understand performance and spatial requirements of trees

city vs. nature

the classic dichotomic division between city and nature, inherited grey legacy from the past, boundaries are increasingly blurring

man-made vs. nature-based

the battle between man-made grey infrastructure (decreasing in value over time) and green infrastructure (increasing in value over time)

opportunities vs. restrictions

architects are able to start open-minded in terms of opportunities and concepts, usually in contrast and frustrated with given tender constraints

continuity vs. diversity

continuity of the design of public space can conflict with the need for diversity for an optimal living environment

render vs. reality

beautiful renders are presented with big, healthy trees defining the place, however the conditions to reach these mature state are often not lived up to

spontaneous processes vs. static designs

succession of forests are spontaneous processes that are framed into static designs, snapshots and renders

Figure 12. Overview of tensions distilled from the interviews within the architectural domain

Tensions within architectural domain

Architecture vs. landscape perspective

"Some people in the studio ask 'how big is a tree?'"

Architecture, urbanism, and landscape architecture are all disciplines concerned with the design and planning of the built environment, but they have different emphases and specialisms. To put it bluntly, architecture versus landscape is akin to volume versus void, built environment versus natural environment, green as support versus green as starting point, short-term versus long-term, small scale versus large scale. These differences result in different spatial perspectives, priorities, and sequencing of green infrastructure decisions. The three disciplines work together to shape the built environment but integration can be challenging. Traditionally, the landscape perspective has been relatively subservient, being consulted too late and ending up filling in the remaining green blocks on the map rather than having the opportunity to make connections. However, this hierarchy seems to be changing.

Intuitive vs. quantified decision-making

disappointing numbers

"Green is currently decided on intuitively based on knowledge and experience. Where we do many quantitative studies for, for example, light incidence and energy, we are not currently doing that for the 'soft side'"

"Not a lot of people know how we can control this heat island effect, we know it happens but we do not have the knowledge to really measure it"

"In Porto we once had a long presentation to convince a big corporate of the needed size of a park, figures help in this discussion"

"Now it's very generic and we want it more specific, we just place a tree, but the values differ for tree species"

The design practices of MVRDV and Arcadis are evolving to focus increasingly on quantification and the construction of new narratives based on data. MVRDV calls this process of algorithmic design 'scripting', developed by the MVRDV Next division. Arcadis speaks of 'evidence-based' design. Scripting is used in two ways: to generate new scenarios and to analyse them accordingly. A few projects from MVRDV where this practice is applied are SolarScape, in modelling the volumetric impact of Rotterdam's high-rise vision, the Almere Floriade (MVRDV, 2022), in organising a dynamic database of plants from A-Z, and the Novio Tech Campus in Nijmegen, in optimising vegetation distances based on five selected animal ambassadors. In the same spirit of data-driven design, a CO_2 model and an energy model are used to accurately calculate the impact of their proposals. Green, however, is used in an unreflective way based on intuition. They use the Tree Ebb from tree nursery Ebben (Boomkwekerij Ebben B.V., 2022) and the tree catalogue of van den Berk (Boomkwekerij Gebr. van den Berk, 2015) for consultation. They also developed a strategy list for nature-inclusive design which belongs to the MVRDV Climate team. Both architecture firms expressed the need to better understand the (species-specific) performance of trees and the parameters that define this performance.

Public vs. private space

isolated nature

"The boundary between public and private is indeed interesting and important in this issue. Perhaps there is even more to be gained on a private level. A large part of the 'urban forest' is not on public land ... In Overschil, Groningen, is 80% of green on private property"

A city is currently divided into public and private space, but the real power of the urban forest lies in the combination of the two. The current strict division between both domains in terms of responsibility and ownership makes it difficult to see it and make decisions for it as an integrated whole. In particular, the activation of the rooftop landscape, an important focus of MVRDV, faces challenges in terms of ownership.

Individual vs. collective concerns

shared narrative

There is a classic paradox in spatial planning regarding individual versus collective concerns. People want to support collective interests as long as it does not encroach too much on their personal space. The offices are increasingly emphasising citizen participation and have found that it is easier to engage people if they can see a direct benefit from their involvement. For example, if they get a share of the profits or a reduction in their taxes.

Visual vs. numerical data

"You want to see the visual effect of trees and you want to measure the benefits, you want to marry the numerical and the visual because you need both"

In spatial planning, the visual quality of a particular design and its quantified benefits should be connected but they do not always speak the same language. The visual and numerical worlds should be married. In terms of green, the requirements and quantified performance need to be understood and have a spatial dimension to them in order to be suitable for design.

"Green is the most important theme right now, to contribute to the climate challenge ... becoming more urgent because of heat, drought, and water"

"Back in the days, pavement dominated, now green façades and roofs are taking the lead"

"Responsibility for city transformations and public space is with municipalities, in terms of wishes for green we are aligned but we differ in how we want to reach it. We want more green in a less traditional way. We always end up in a lot of discussions with traffic and management"

"The municipality is divided into several asset managers, one for pavement, one for green, they base their decisions on quick results and short-term thinking"

"Realising the project is not the problem, the developer will make it happen, maintaining it is the real problem"

"The way green is maintained is a very important parameter to success. It would be interesting to include a maintenance perspective as a landscape architect, as your landscape needs time and maintenance to evolve"

City vs. nature

isolated nature

There was a dichotomous division between city and nature. The urban environment inherited a grey legacy from past building periods, with pavement from façade to façade. Nature had to be moved out of the city and now has to be moved back in. The vision of architectural firms is to integrate green, to break the separation between the two worlds and to diffuse.

Man-made vs. nature-based infrastructure

isolated nature

The battle for space is intense and ongoing, putting pressure on the already largely forgiven square metres. The roots and mycorrhizal networks of trees and other vegetation have to compete with the pipes, cables, roads, and systems of man-made (grey) infrastructure. The shortage of housing, the accessibility of emergency services, people's allergies, and the obstruction of security cameras are just some of the many challenges that make it even more difficult to incorporate green into the built environment.

Opportunities vs. restrictions

Usually, the municipality and architecture firms agree on green ambitions but pursue different ways of manifesting them. The design process and the ability to start open-minded in terms of opportunities and guiding ideas may not always match the specific constraints imposed by the tender process, which can result in missed opportunities in collaboration.

Continuity vs. diversity

Architects want to create a certain level of uniformity and recognisability in their designs to create a relatable sense of place. This can be at odds with the diversity needed to provide an optimal living environment for all urban species.

Render vs. reality

Architectural renderings often show urban green spaces that are mature and well-established, but the management and maintenance required to achieve this level of maturity is often not considered during the design phase. Trees are planted in smaller sizes and there is no direct control or responsibility for living up to these intended green structures.

Spontaneous processes vs. static designs

taming the wild

Urban plans typically include a more static aspect of buildings and an organic aspect of green infrastructure. However, the growth and development of trees, also known as their succession, is a dynamic and spontaneous process that is merged and framed within a static design proposal.

Municipalities

For mapping the decision-making process of green infrastructure within municipalities, the area transformation process is studied and used as a basis (Bouwend Nederland et al., 2019; Rijkswaterstaat, n.d.), as shown in Figure 13. This process is chosen based on the assumption that most of the large-scale green decisions are made during these phases. When an area is being redesigned it is determined which green infrastructure will remain, which will be removed and which will be added, and how the current state (situation A) will be transformed into the new desired state (situation B). It is a comprehensive process with many variables and stakeholders involved. The trajectory, involvement of parties, and duration of the transformation are influenced by factors such as land policy, ownership, municipal objectives, and visions for the area. Additionally, the tendering phase is assessed, as procurement legislation applies to most area developments.

The new Environment and Planning Act is likely to have an impact on this process, as the government wants to simplify and merge the rules for spatial development (Ministerie van Infrastructuur en Waterstaat, 2022). The Act is expected to come into effect on 1 July 2023 but is not considered in this thesis.

The municipal green policy makers and managers who were interviewed are listed in Table 2 and the main tensions are summarised in Figure 14.
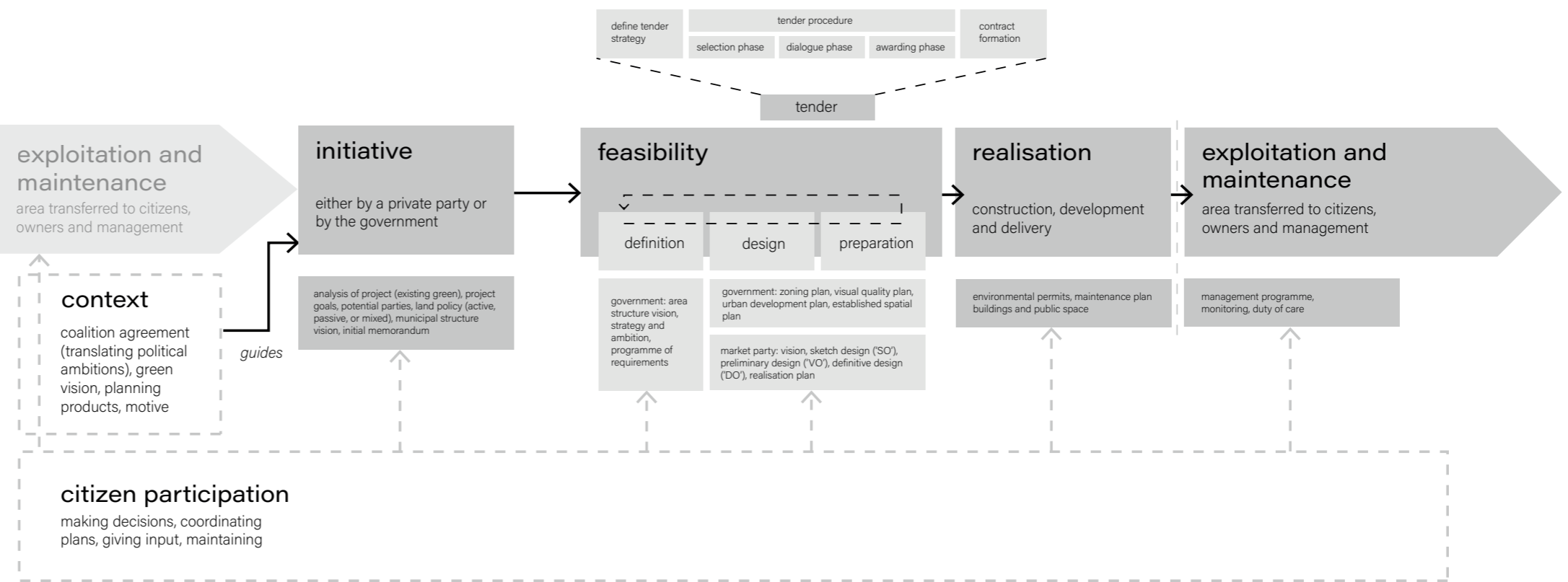

Figure 13. General process overview within the domain of municipalities, adapted from (Bouwend Nederland et al., 2019)

Who	Role	When	Where	N.B.
Rob Zweekhorst	Green management municipality of Dijk en Waard	3 October 2022 (30 minutes)	Online	
Leendert Koudstaal	Tree expert municipality of The Hague	3 October 2022 (30 minutes)	Online	
Ruud de Jong	Green management municipality of Hendrik-Ido-Ambacht	10 October 2022 (45 minutes)	Online	*Unstructured joined conversation together with Rebecca on 12 October 2022*
Oege Oevering	Advisor green municipality of Dordrecht	10 October 2022 (30 minutes)	Online	
Jacco de Frel	Green management municipality of Rotterdam	10 October 2022 (30 minutes)	Online	
Henk Langeveld	Advisor green municipality of Groningen	11 October 2022 (45 minutes)	Online	*Field visit to Groningen together with Rebecca on 26 October 2022, unstructured follow-up conversation to validate concept on 13 February 2023*
Wieteke de Boer	Green management municipality of Groningen	26 October 2022 (90 minutes)	Municipality of Groningen office, Groningen (together with Henk Langeveld)	*Field visit together with Rebecca, unstructured follow-up conversation to validate concept on 13 February 2023*
Jeroen van Gaalen	Green management municipality of Utrecht	24 October 2022 (60 minutes)	Online (together with Rob Hendriks)	*Unstructured follow-up conversation to validate concept on 15 February 2023*
Rob Hendriks	Green policy municipality of Utrecht	24 October 2022 (60 minutes)	Online (together with Jeroen van Gaalen)	
Hans Kaljee	Green management municipality of Amsterdam	12 December 2022 (90 minutes)	Municipality of Amsterdam office, Amsterdam (together with Emma Reeskamp)	*Unstructured follow-up conversation together with Emma Reeskamp to validate concept on 17 February 2023*

Table 2. Interview participants municipal perspective of i-Tree consortium

Figure 14. Overview of tensions distilled from the interviews within the green municipal domain

Tensions within green municipal domain

Housing vs. greening

Densification conflicts with space for green. Coming from a period in which cities have left a 'grey legacy' of concrete and asphalt, green spaces are seen as an afterthought. As a result, decisions about green spaces are not taken into account during the initial stages of area transformation but are integrated into plans that are already largely established. However, the importance of green spaces is being increasingly recognised and is rising on the priority list, shifting from decorative green to functional green. One of the biggest challenges remains how to manifest the urban forest in cities and how to create enough space for growth when the land is already largely developed and allocated to other uses, to have 'the right tree in the right place'.

Public vs. private green   lack of urbanity

The municipality is only responsible for public green, but the urban forest and its benefits encompass both public and private green. The ratio between public and private can vary greatly between cities and municipalities, as can the rules and regulations that apply to both domains.

Individual vs. collective concerns   lack of urbanity

The attitudes of citizens towards green are increasingly polarising, with activist tree huggers and shade-loving Tesla owners on either side of the spectrum. To create climate-resilient cities by increasing green infrastructure, there is an increased need for the public interest to outweigh individual concerns.

Policy vs. legal anchoring   disappointing numbers

Currently, green is secured in policy but these policies are not binding. Only the tree valuation of the Dutch Association of Tree Valuators (NVTB, 2023) stands in court. Boom Effect Analyses (BEA's), or 'Tree Effect Analyses' (Bomenstichting, n.d.) are used to determine the value of trees during area transformation, together with replating obligations, but there is a need for a uniform system and national standards. In contrast to carefully managed grey infrastructure and quantified parking norms, there is a lack of concrete green rules and regulations. It is a topic to be debated, to be participated in, and therefore a topic to be compromised on. It disappears first from the spatial scene when budgets are limited and currently depends on the personal green ambitions of decision-makers.

Citizens vs. developers

Municipal green managers and policy makers are caught between legitimising tree decisions to citizens and convincing developers of the value of trees. It is a recurring debate in need of hard numbers.

Indigenous vs. exotic species

There is an ongoing debate about the use of indigenous versus exotic tree species. Indigenous species are considered better for biodiversity, but it is being questioned whether these species are still suitable given the effects of climate change and more extreme weather conditions in urban areas. Much emphasis is placed on the choice of appropriate tree species and the selection of a climate-resilient tree inventory that can withstand future conditions. Furthermore, there is doubt whether the increasing demand for trees can be met with the capacity of nurseries.

Numbers vs. volume   disappointing numbers

Municipalities currently report on the number of trees, but talk in terms of canopy cover or crown volume, as these are the metrics that truly reflect a tree's value and contribution to ecosystem services. A transition from counting the number of individual stems to measuring crown volume is needed for a more accurate assessment of the urban forest.

Lifecycle vs. political cycle   isolated nature

The optimal life cycle of a tree is 80-100 years, as opposed to the 4-year political cycle. Political goals are often translated into short-term coalition agreements and implemented through ad-hoc management, but for green infrastructure to thrive, a long-term perspective is needed. The urban forest needs to be taken out of the political arena and become part of critical infrastructure.

Street vs. city scale   inequitable entry

The battle to integrate urban green is multifaceted and fought at multiple scales, from the individual tree to the entire municipal inventory. The question is which issues should be addressed at which level when considering for example green equity, tree canopy targets, and the provision of ecosystem services.

Above vs. below ground   isolated nature

The city is designed in silos and separated functions, below and above ground. Trees bridge both worlds but they are not considered and organised as one system. Public space should be organised in a different way, reconnecting its isolated parts.

Costs vs. benefits   disappointing numbers

Municipalities invest in public space, but a wide range of stakeholders benefit from it. Currently, the budgets for these spaces are not structured in a way that allows for a circular flow of funds.

Ecosystem services vs. controlled management   taming the wild

Green space management budgets are often limited and constrained by strict quality standards. As a result, management has traditionally focused on preventing complaints and reducing nuisance and disservices, resulting in limited growth and planting of small trees, which reduces the potential of the urban forest to provide ecosystem services. However, the management rationale is gradually shifting to focus less on weed control in ecologically designated areas and allow for more robust and diverse vegetation to flourish.

Tree consultants

Who	Role	When	Where	N.B.
Jan Willem de Groot	Franchise manager Pius Floris	5 October 2022 (90 minutes)	Public space trade fair, Jaarbeurs Utrecht	
Wendy Batenburg	Senior scientist ecosystem services Terra Nostra	6 October 2022 (60 minutes)	Terra Nostra office, Bleskensgraaf	*Unstructured follow-up conversation to validate concept on 12 January 2023 and 7 February 2023*
Fons van Kuik	Senior advisor ecosystem services Cobra Groeninzicht	12 January (60 minutes)	Online	

Table 3. Interview participants tree consultant perspective of i-Tree consortium

The interviewed tree consultants are listed in Table 3.

National platform

Cobra, Terra Nostra, Idverde, and Pius Floris have joined forces in the national 'Platform i-Tree Nederland' (Cobra Groeninzicht et al., 2021) to work together and develop guidelines and frameworks in order to standardise the use of i-Tree. The risk lies in the wrong interpretation of the model. For example, it is not really suitable for calculating the values of a single tree. Tree consultants are currently the only stakeholder group that has adopted the i-Tree software and is actively working with it. They offer i-Tree services to their clients, mostly municipalities, driven by supply rather than demand. As the firms could be seen as the early adopters of the software most of their clients do not directly see the value and therefore do not yet ask for it. The tree consultants express a need for expanding the application possibilities for i-Tree as the totality of the application potential is important for its potential impact.

There are still some difficulties in using the tool, as it is primarily for expert use only, requires a very precise dataset, and is based on American figures. However, i-Tree is the most specific tool available and is currently the only one capable of quantifying the ecosystem services provided by urban trees. The Dutch context is more than ten years behind the adoption in America, which can in some cases be challenging as it can lead to false expectations from clients about the potential of the tool and the availability of data as it is compared to the US and UK. In addition to the longer experience with the tool, the two countries also have very different and more extensive histories with urban forestry. For example, the Netherlands does not have an organisation like the USDA Forest Service, so the structures and concepts cannot be directly copied to other countries. Ambassadors and champions are needed to raise the necessary awareness, such as the American singer Bette Midler, who founded the New York Restoration Project in 1995 and helped to plant one million trees in the city (Peregoy, 2016).

Incomplete argument

disappointing numbers

"It should be about the function of the tree because it is never money that you get in your hands, it is avoided costs, and often even avoided costs of another party than the one who is paying for green"

Currently, the software is not able to provide a full quantified argument for urban trees as it can only accurately measure some of the ecosystem services (carbon sequestration, air pollution filtering, and water retention). This is an important disclaimer to the use of i-Tree that needs to be mentioned and therefore the software should never be the sole means of expressing the value of the urban forest. The firms started by including the monetary values in their analyses but decided to switch to functional values as the figures were not impressive and led to an intention to buy off rather than maintain green.

"We have a lot of "sidewalk vegetables" in our cities: trees that stand a maximum of 10 years. We should create the potential for trees to get old again"

"Same if I buy a Ferrari, if I can't afford gas and no maintenance it's just a nice view for the neighbour"

"Accountability of a municipality is very important, you must be able to monitor whether the goals that are set are being achieved. At the moment there is no dashboard of objectives and strategy and how far we are in the area. It could potentially be teamwork between the municipality and tree consultants to land the urban forest vision and support it with software. Policy and management and the feedback between them must be improved."

From decoration to functional performance

The balance between water, oxygen and organic matter determines the quality of the growing place and thus the success of the tree. It is only after 30 years that a tree begins to yield a return. The field is moving from green with aesthetic qualities to the functional aspects of trees. It is important to state what the intended results and function of green should be in a particular location. The urban forest can only thrive if it is managed properly.

Urban forestry masterplans

isolated nature

The feedback between municipal green policy and management needs to be improved. A long-term plan is needed that looks at the urban forest as a whole, breaking down the public/private divide. Following UK practice, the concept of an 'urban forestry masterplan' could be helpful (Birmingham City Council et al., 2021). This plan sets out the mission and vision for Birmingham's urban forest the period 2021 to 2050 and extensively elaborates on the specific targets needed to achieve these ambitions.

Tree nurseries

The five largest tree nurseries in the Netherlands are part of the i-Tree consortium. A generalised version of their process is shown in Figure 16. These nurseries focus on growing (semi) mature trees and they buy saplings from propagators. The two largest market segments are the institutional market (governments and public green spaces), and the private market (garden centres). Some nurseries specialise entirely in the institutional segment. In addition to trees, most nurseries offer a complete green package, including shrubs, roses, and perennials.

The interviewed members of the i-Tree consortium involved in tree growing are listed in Table 4 and a summary of the tensions they face can be found in Figure 15.
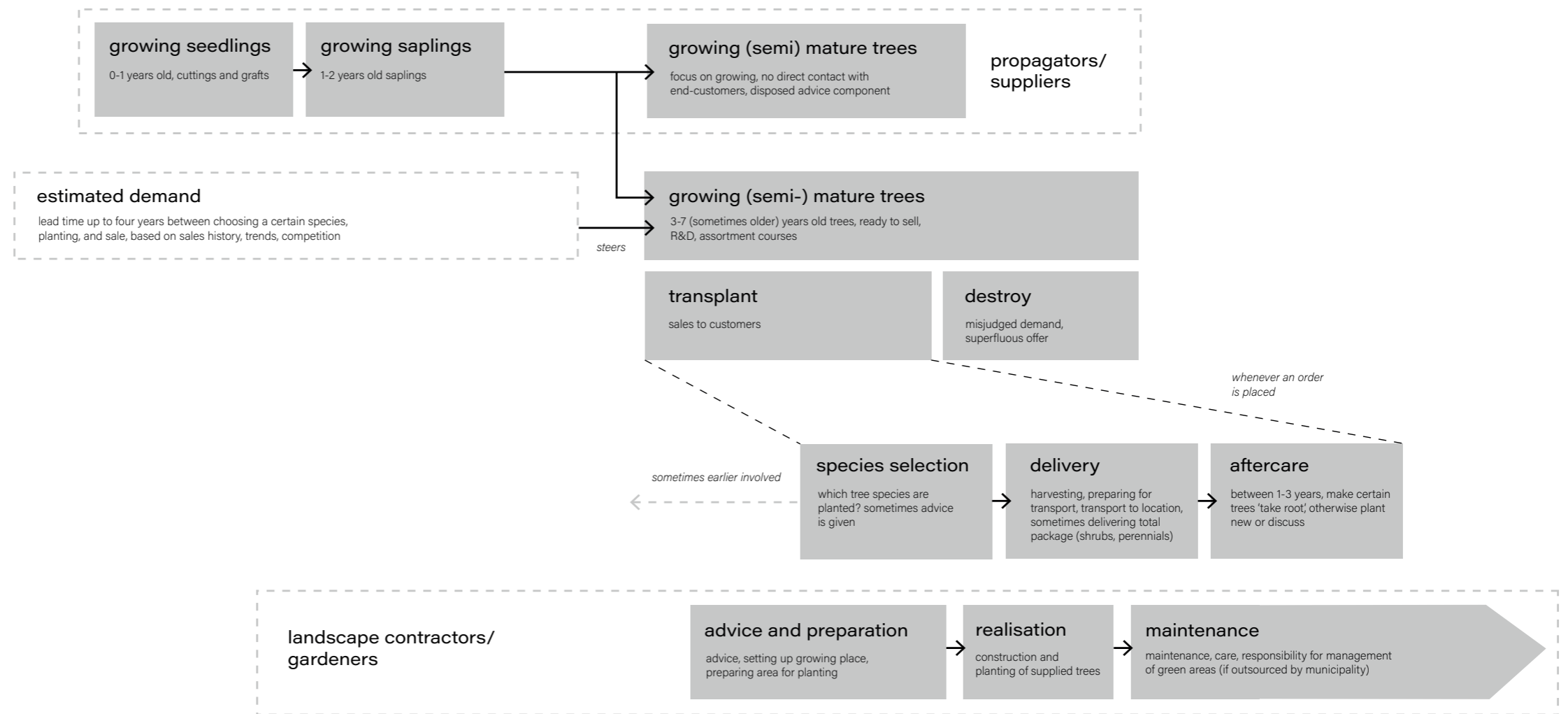
Figure 16. General process overview within the domain of tree nurseries

Who	Role	When	Where	N.B.
Leon Smet	Secretary Royal Anthos	4 October 2022 (60 minutes)	Café Bij Mauce The Hague	*Follow-up conversation on 10 January 2023 to validate findings*
Pieter van den Berk	Managing director nursery van den Berk	7 December 2022 (90 minutes)	Van den Berk office, Sint-Oedenrode	*Together with Gül and Rebecca*
Albert de Vries	Director nursery Boot & Dart	8 December 2022 (60 minutes)	Boot & Dart office, Boskoop	
Jeroen van den Oever	Deputy director nursery van den Oever	9 December 2022 (90 minutes)	Van den Oever office, Haaren	
Martin Houben	Director nursery Udenhout	9 December 2022 (60 minutes)	Udenhout office, Udenhout	
Dirk Ebben	Sales Netherlands and Central-Europe nursery Ebben	21 December 2022 (90 minutes)	Ebben office, Cuijk (together with Stef Janssen and Thijs Dolders)	*Together with Gül and Rebecca*
Thijs Dolders	Sales Netherlands nursery Ebben	21 December 2022 (90 minutes)	Ebben office, Cuijk (together with Dirk Ebben and Stef Janssen)	*Together with Gül and Rebecca*
Stef Janssen	Innovator nursery Ebben	21 December 2022 (90 minutes)	Ebben office, Cuijk (together with Dirk Ebben and Thijs Dolders)	*Together with Gül and Rebecca*

Table 4. Interview participants tree nursery perspective of i-Tree consortium

Figure 15. Overview of tensions distilled from the interviews within the tree nursery domain

Tensions within nursery domain

Market cycle vs. natural cycle

isolated nature

The nursery market is very sensitive to trends, which can conflict with the long lead times of around four years required for natural tree growth. Typically, seedlings are purchased at the age of three and are ready for sale at seven years old. The nurseries maintain a stock and rely on supplies from propagators and other nurseries in the supply chain. There is a "you ask, we deliver" mentality, but the nature of the product does not allow for rapid changes in supply, resulting in volatile prices.

Tradition vs. innovation

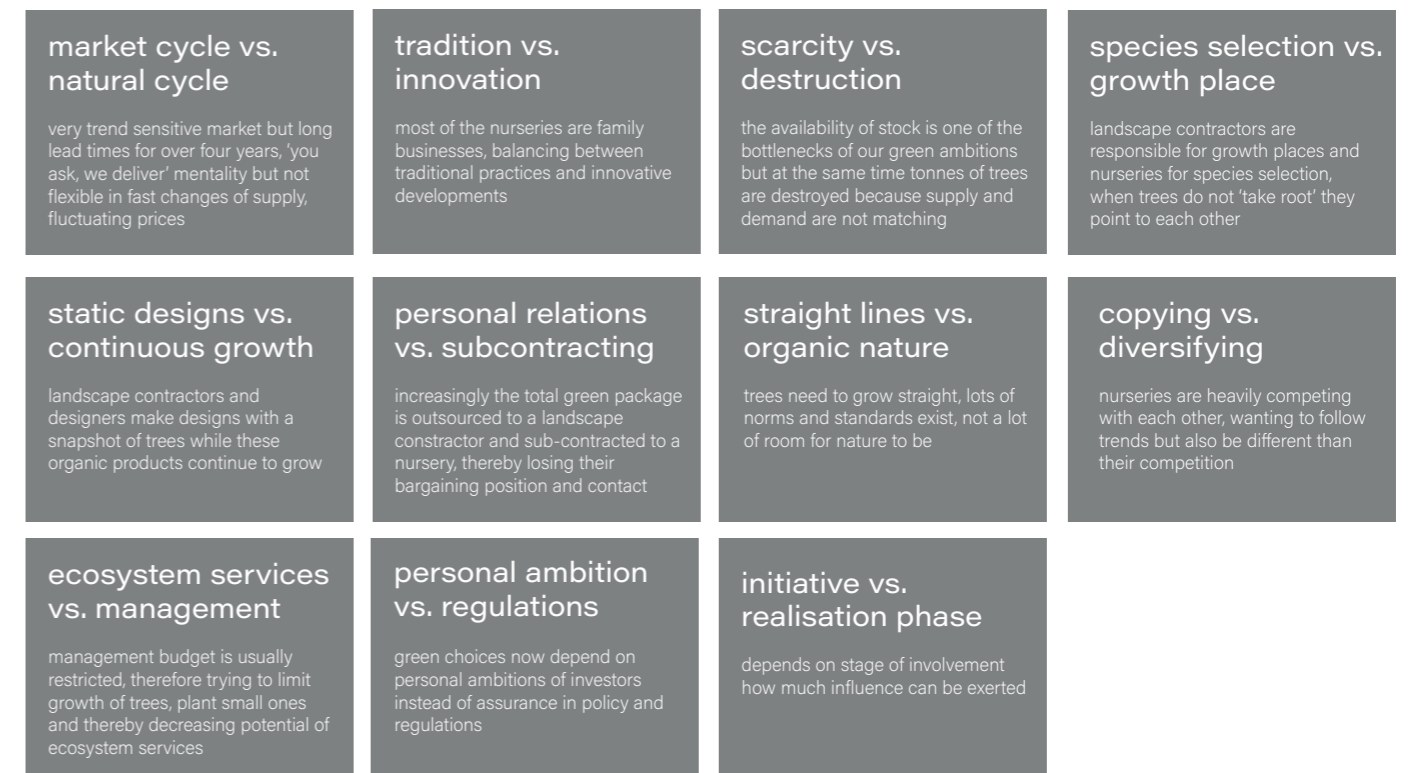Most of the nurseries are family-owned businesses that have been passed down through generations. They have a strong sense of tradition and rely on tried and tested methods. However, as the sector evolves and new technologies become available, they have to strike a balance between maintaining traditional practices and embracing innovation. Despite this, it is a fairly conservative industry in its approach to technology adoption.

Scarcity vs. destruction

The availability of stock is one of the bottlenecks of current urban green ambitions. At the same time, it has been described that nurseries end up destroying a part of their stock because supply and demand do not match and the nurseries are unable to sell them because the cost of transplanting increases exponentially with the age of the trees, making destruction the most financially attractive solution.

Species selection vs. growth space

A landscape contractor, such as Idverde, is responsible for growth places of trees. In some cases, a municipality will outsource the responsibility for tree management to this party. The nurseries are responsible for selecting appropriate species for a particular area. Their responsibility usually lasts for a maximum of three years. When trees fail to 'take root' both parties point to each other as there can be many reasons for this, such as incorrect species selection, inadequate growth conditions, or lack of watering. The need for a range of species that can withstand changing climates, known as "climate trees," is becoming increasingly important.

Static designs vs. continuous growth

taming the wild

Landscape contractors and designers create designs with trees that are framed at one point in time, not taking into account the fact that trees are living organisms that continue to grow. This growth process cannot be manipulated and there currently is a disconnect between the building and growing seasons as the construction process is not at all aligned with the planting season of green.

Personal relations vs. subcontracting

Traditionally, personal contact has been very important in this industry. However, the influence of landscape contractors has become more pronounced. More often the total green package of species selection, growth place design, and management is jointly outsourced to a landscaper and subcontracted to a nursery. As a result, nurseries are losing their bargaining power and direct contact with the end customer, even though they have deliberately chosen to retain an advisory role rather than focusing solely on growing, as some other nurseries in the Netherlands do. It is feared that the specific knowledge required is fading away and the number of qualified people is decreasing.

Straight lines vs. organic nature

taming the wild

The Dutch nursery industry has strict guidelines and regulations that dictate how trees should grow. These norms and constraints often limit the natural growth of trees and do not allow for much deviation from a certain standard. Trees must grow straight and there is not much room for nature to be.

Copying vs. diversifying

The sector is highly competitive, with nurseries constantly vying for business by following the latest trends and differentiating themselves from the competition by offering unique products and services. A high standard of quality is required from them in order to maintain their position in the industry.

Ecosystem services vs. controlled management

disappointing numbers

The ecosystem services provided by trees increase exponentially with age. For this reason, and because of commercial interest, nurseries are trying to steer towards selling more large trees from the outset. Their supply chain is directly linked to the position of green on the priority list of local authorities. When management budgets are restricted, this results in limiting growth and therefore planting smaller trees rather than mature ones.

Personal ambitions vs. regulations

Green decisions are currently driven more by investors' personal ambitions than by policy and regulatory certainty. Strict rules and a long-term vision are strongly desired.

Initiative vs. realisation phase

The stage of involvement in the transformation process determines how much influence can be exerted. The five nurseries differ in their need for involvement and the depth of advice they provide, with some seeking to be involved earlier in the process than others. This urge for involvement is related to the perceived impact that i-Tree can have on their business, with some nurseries seeking to shape the decision-making process for green, while others are only consulted after these decisions have already been made.

"It's like a 'cow market', prices are constantly changing. When you settle on a budget two years before, the market can be totally different when you deliver them"

"Many parties do not want to commit them early on and do not place an order yet, while our lead time takes a while. There is quite some risk involved in this process"

"After year 6 they are transplanted or destroyed, all growers deal with capital destruction, that's your margin changing/misjudged demand, is a very fashion trend sensitive industry"

"There are deadlines for construction developments and the fines for not meeting the deadline are often larger than the costs of replanting green. So what sometimes happens is that trees are planted anyway and are replanted during the season"

"Green is seen as a material, while function must be included in the design, as it has an effect on the size of the place, time dimension, growing location"

"If it's really bad, they outsource the project to a civil party who then subcontracts a landscaping company who then comes back to us. You're always at the back"

"40/50 years ago, municipalities still had park services, there was a lot of knowledge and those jobs had real prestige, everything was in-house and all green space was decided together with the nursery. BTL and Idverde were not there yet and green education was full"

"Someone at the municipality with no knowledge about trees put a level against the stem and compared it to the straightness of a window frame"

"Architects come to investors come to landscapers come to us, we are last. If the budget is not there they choose for smaller green thereby destroying the ambition. We need numbers to convince it's an investment, feel confident about the benefits of green"

"Architects make designs and go to municipalities, show them beautiful pictures but in the end, you get small trees, not what was intended, and they can get away with that"

"We need rules, a minimal amount of trees per building, a minimal amount of budget, maybe 10%, of development that should go to green"

"If you are only asked in the realisation phase it's all about offering the cheapest price, in the realisation phase you are a shop, when you are asked in the initiative phase, you can be a consultant and think along"

"We need involvement in an earlier phase, within cities, you have two types: you have people from green, and people from management. People from green have a lot of great ideas but when this is turned into practical plans a lot is lost, turning visions into practice is hard and not always well informed"

"For us, i-Tree is less relevant, because we deliver a tree and then the choice for the tree has already been made. We are not fighting the battle between a tree versus something else. It's kind of like going to the supermarket and wanting tiger bread, but they don't have that anymore so the baker gives you whole wheat. In this example, we are the baker"

Academics

Who	Role	When	Where
Ab Veldhuizen	Hydrologist Wageningen University & Research Soils, Water & Land Use Division	7 October 2022 (60 minutes)	Online
Jelle Hiemstra	Senior scientist Trees & Urban Green Wageningen University & Research Field Crops Division	19 October 2022 (60 minutes)	Online
Henk Wolfert	Program manager AMS Institute	12 December 2022 (60 minutes)	AMS Institute, Amsterdam

Table 5. Interview participants academic perspective of i-Tree consortium

The interviewed academics of the i-Tree consortium are listed in Table 5.

Long-term perspective

The academy tends to focus on the long-term, whereas area development trajectories are often relatively short-term. The area development process often is too fast for research institutions, which are more concerned with larger, overarching developments and knowledge generation. Despite this, research institutions have begun to develop more effective links with municipalities, but the same cannot be said of the business community, which tends to move at a much faster pace, making it challenging to engage in a meaningful way. However, academic research plays a crucial role in contributing to the available knowledge base, and ultimately in shaping and guiding the direction of organisations working in a particular field. For example, academic validation of the i-Tree software is critical to its development, adoption and relevance.

Collaboration

The i-Tree consortium is a triple helix collaboration (Etzkowitz & Leydesdorff, 1995), a partnership between academia, industry, and government. The role of academia is to bring the parties together, to connect the public and private sectors, and to examine the broader dynamics and interrelationships as the issues of the day tend to prevent the other organisations from stepping back and looking at the big picture.

Approximation of reality

Something like i-Tree makes it possible to quantify trees in terms of the ecosystem services they deliver, which is a model-like approach. A model has many limitations and it is important to learn what you can do with it. After all, it is only an approximation of reality.

Green as an afterthought

The biggest challenge for green is the multiple claims on limited space, cables, pipes, sewers, and traffic. Traditionally, these things take priority because green is an afterthought and the space is already largely occupied. In new districts, it should be technically easier to make room for green, but the costs are not properly distributed and concrete standards do not yet exist for green but do exist for drainage and pipes. Whoever has to secure green in such a plan has far fewer weapons and that makes the discussion very difficult. The question is how to ensure that green stays on the table from the start of the planning process to the realisation of the project. The Amsterdam Rainproof project succeeded in obliging certain requirements for rainwater storage (Amsterdam Rainproof & Waternet, 2014).

"Data and information come out of i-Tree, but that ultimately has to be included in a very subjective planning process. Awareness of this is very important as the meaning of a model should never be overestimated. All models are wrong, some are useful"

When looking at the different groups of parties in the consortium, 1. designers and engineers, 2. municipalities, and 3. greenspace management and nurseries, I think it should start with policy, guidelines, and national standards. You lose things along the way in a green-focused plan because there are currently no clear standards for green functions or benefits"

"Building regulations are interesting, they did this with water in the Amsterdam Rainproof project. Included in the building decree that you must be able to store so many cubic meters of water in your building, that you must be able to host so many hours of a certain heavy rain shower"

Process journey public urban green

The separate processes of the different stakeholder domains are combined to create the compound stakeholder process journey for public urban green (see Figure 18 on the next page). The system shows how the urban green sector currently participates in the urbanisation processes. It provides an overview of the general sequence and interrelationships within the public green stakeholder domains and is used in Part 3 to map the opportunity areas and act as a canvas for further scoping.

Lost connection between stakeholder domains

A general overarching finding, illustrated in Figure 17, is the lost connection between the actors who create the conditions for urban green in the transformation phase and the actors who have to live up to these conditions in the maintenance phase. Their targets, constraints, and language are not properly aligned even though they follow up on each other in the cyclical urban process. The municipal policy makers and planners, project developers, architects, and engineers have a spatial language and create visions for spatial quality, place-making, and conceptualisation. These stakeholders present enchanting green renders with mature trees to attract potential citizens-to-be and contribute to a liveable environment. Municipal green managers, on the other hand, argue from quality requirements, limiting complaints, limiting nuisance, and thus limiting green growth. Future visions and daily practice clash. Combined with a lack of green policies and regulations, transformations can get away with leaving greenspace management and tree nurseries an impossible job. The remainder of this project aims to find ways to restore these connections.
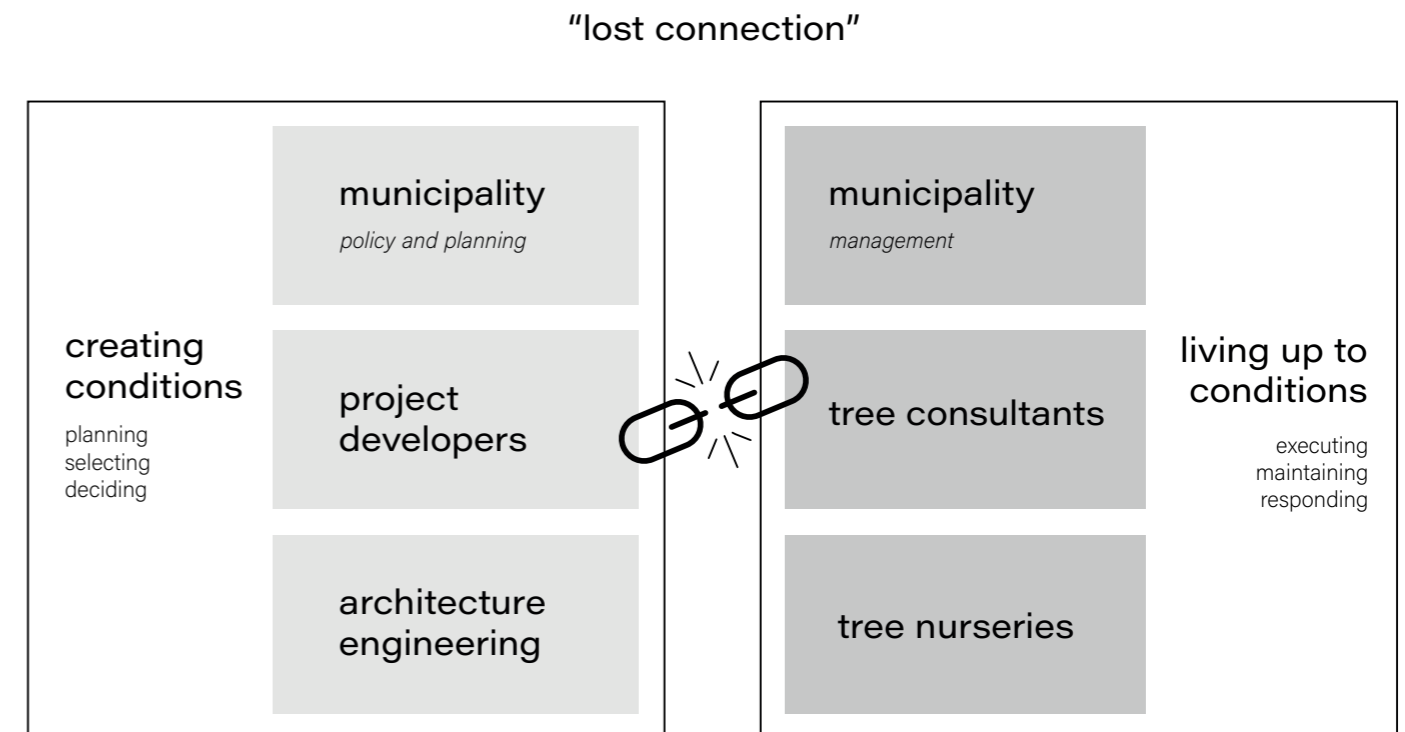
"lost connection"

Figure 17. Lost connection between condition creators and condition fulfilers

Stakeholder process journey public urban green

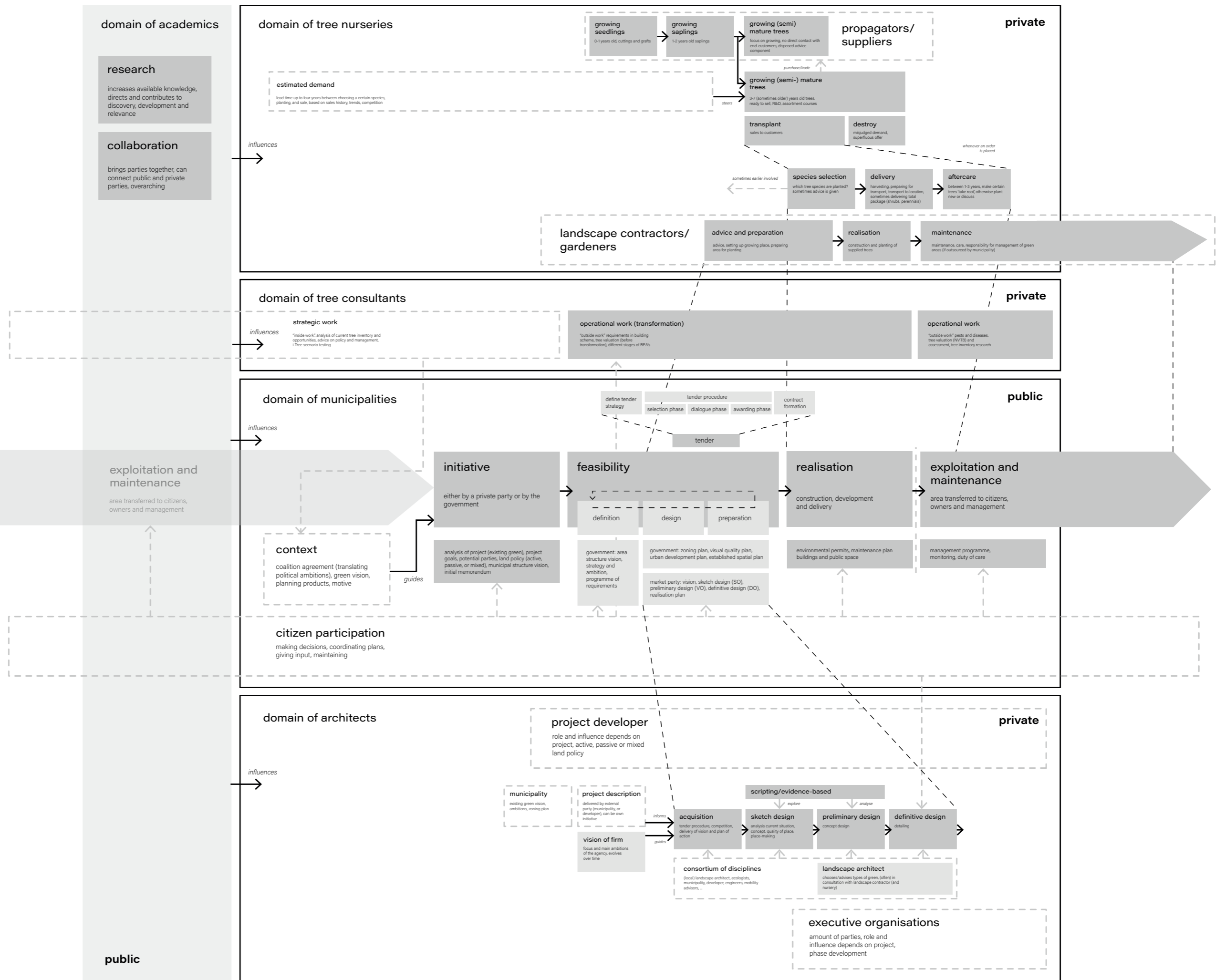Current role of the green sector in urbanisation

domain of academics

research

increases available knowledge, directs and contributes to discovery, development and relevance

collaboration

brings parties together, can connect public and private parties, overarching

influences

domain of tree nurseries   **private**

growing seedlings
0-1 years old, cuttings and grafts

growing saplings
1-2 years old saplings

growing (semi) mature trees
focus on growing, no direct contact with end-customers, disposed advice component

propagators/ suppliers

purchase/trade

estimated demand
lead time up to four years between choosing a certain species, planting, and sale, based on sales history, trends, competition

growing (semi-) mature trees
3-7 (sometimes older) years old trees, ready to sell, R&D, assortment courses

steers

transplant
sales to customers

destroy
misjudged demand, superfluous offer

whenever an order is placed

sometimes earlier involved

species selection
which tree species are planted? sometimes advice is given

delivery
harvesting, preparing for transport, transport to location, sometimes delivering total package (shrubs, perennials)

aftercare
between 1-3 years, make certain trees 'take root', otherwise plant new or discuss

landscape contractors/ gardeners

advice and preparation
advice, setting up growing place, preparing area for planting

realisation
construction and planting of supplied trees

maintenance
maintenance, care, responsibility for management of green areas (if outsourced by municipality)

domain of tree consultants   **private**

influences

strategic work
"inside work", analysis of current tree inventory and opportunities, advice on policy and management, i-Tree scenario testing

operational work (transformation)
"outside work" requirements in building scheme, tree valuation (before transformation), different stages of BEA's

operational work
"outside work" pests and diseases, tree valuation (NVTB) and assessment, tree inventory research

domain of municipalities   **public**

influences

define tender strategy

tender procedure
selection phase | dialogue phase | awarding phase

contract formation

tender

exploitation and maintenance

area transferred to citizens, owners and management

initiative
either by a private party or by the government

feasibility
definition | design | preparation

realisation
construction, development and delivery

exploitation and maintenance
area transferred to citizens, owners and management

context
coalition agreement (translating political ambitions), green vision, planning products, motive

guides

analysis of project (existing green), project goals, potential parties, land policy (active, passive, or mixed), municipal structure vision, initial memorandum

government: area structure vision, strategy and ambition, programme of requirements

government: zoning plan, visual quality plan, urban development plan, established spatial plan

market party: vision, sketch design (SO), preliminary design (VO), definitive design (DO), realisation plan

environmental permits, maintenance plan buildings and public space

management programme, monitoring, duty of care

citizen participation
making decisions, coordinating plans, giving input, maintaining

domain of architects   **private**

influences

project developer
role and influence depends on project, active, passive or mixed land policy

municipality
existing green vision, ambitions, zoning plan

project description
delivered by external party (municipality, or developer), can be own initiative

informs

scripting/evidence-based

acquisition
tender procedure, competition, delivery of vision and plan of action

explore

sketch design
analysis current situation, concept, quality of place, place-making

analyse

preliminary design
concept design

definitive design
detailing

vision of firm
focus and main ambitions of the agency, evolves over time

guides

consortium of disciplines
(local) landscape architect, ecologists, municipality, developer, engineers, mobility advisors, ...

landscape architect
chooses/advises types of green, (often) in consultation with landscape contractor (and nursery)

executive organisations
amount of parties, role and influence depends on project, phase development

public

Figure 18. Stakeholder process journey public urban green

External perspectives

Who	Role	When	Where	N.B.
Jean-Francois Gauthier	Landscape architect at SYLVA	7 October 2022 (90 minutes)	Cafe JORDYs, Rotterdam	*Unstructured follow-up conversation to discuss workshop set-up on 19 October 2022 in Rotterdam*
Jip Pijs	Participation strategist Kickstad	7 October 2022 (60 minutes)	Kickstad office, Rotterdam	
Sytse Berends	Communications at the Groene Stad	9 November 2022 (80 minutes)	Online	
Anouk Jansen	MSc. Urbanism Faculty of Architecture	16 November 2022 (60 minutes)	Essenburgsingel, Rotterdam	*Several conversations to check architectural assumptions and concepts*
Cecil Konijnendijk	Urban forestry expert WUR, founder of Nature Based Solutions Institute	21 November 2022 (60 minutes)	Online	*Unstructured follow-up conversation to validate concept and findings on 26 January 2022 in Zeist*
Willem de Feijter	City forester of Rotterdam	24 November 2022 (90 minutes)	Cafe Lebkov, Rotterdam	
Bonne Keizer	Procurer of green municipality of Amsterdam	25 November 2022 (60 minutes)	Online	
Djavan Braumuller	Urban mobility consultant at Rebel Group	1 December 2022 (30 minutes)	Online	
Robbert Snep	Senior scientist Green Cities Wageningen University & Research Regional Development and Land Use Division	23 January 2022 (150 minutes)	Online	

Table 6. Interview participants external perspectives

The interviewed external people are listed in Table 6.

Landscape architecture perspective

"We know we should not bring a crocodile to Rotterdam, but we do not know this about trees"

The current trend in spatial planning focuses on integrating green into cities, while the next one will likely focus on optimising underground conditions. However, this knowledge about vegetation is not new, it is just not widely used anymore. It has long been known that exotic species cannot exchange information and nutrients, which prevents them from connecting with their habitat. This practical knowledge is fading away.

Urban planning perspective

"I think the topic of trees in the city is quite siloed right now, you could replace the word 'tree' with 'playground', it's just another topic on the horizon of urban planners. Trees cost money and therefore they are planted small. It's all Excel right now."

"What do 37,000 km. of separated cycle lanes get the Dutch? 74 minutes of cycling per week per capita; preventing 6,500 premature deaths and €19 billion in healthcare costs each year. Ask not whether your country can afford to invest in cycling— ask whether it can afford not to." (Bruntlett, 2022)

Trees are on an urban planner's checklist. It all starts with rules and regulations, this i-Tree tool should be integrated into the redevelopment of an area and be forced to use and meet a predetermined standard. At present, there is no set minimum requirement for green spaces, as there is for parking spaces.

Public transport in the Netherlands is a very interesting concept because it does not pay. The bicycle parking lot underneath Rotterdam Central Station is free.

This social cost-benefit analysis is a compelling example in the context of urban forest valuation. Decisio is an economic research consultancy in the fields of energy, water, economics, infrastructure and mobility that carries out this type of analysis. They performed an interesting business case within the urban green domain for Dordrecht (Decisio, 2022). Within this project, they identified the blue-green infrastructure of the Dordwijkzone as a prerequisite for the densification of the Spoorzone. Theoretically and mathematically, the projects and the social business cases are independent but in practice, they are interrelated and need each other.

Furthermore, there is an obvious parallel between green and walking as it belongs to everyone and therefore to no one, transcends a domain and fits into the remaining space.

There is a need for integrated sustainable urban planning and design. Currently, challenges are being addressed in silos, with different, separate policy documents, budgets and accounts. A transition is needed to more holistic, systemic solutions.

"We often work in inner cities, where transformations are often at the expense of green. It is a difficult subject, involves a lot of emotion, as it is really a direct intervention in the living environment, green is often eaten up by urban planning."

"Just like we do with sewers and roads, but then also with green. Municipalities know exactly how the road network works, and how the sewage system works, green must be on the same list of critical infrastructure. Making it an asset."

"Biggest shortcoming with i-Tree is the user interface, some apps do work on this, PlanetGeo and Davey incorporated it into their tree inventory software which makes it a bit more user-friendly, but you actually want a residents interface. i-Tree canopy is simple but still too difficult, must be intuitive, but is very scientifically oriented right now. They consistently underinvested in the interface"

"I wanted to see if ecosystem services could be realised as a revenue model. To put trees in the blockchain, integrate ecosystem services in a value passport and connect with a digital twin model. Management systems are now flat cards and poorly monitored. You would like to steer on crown volume and monitor that, know what you have and then record that first. Those systems must go to 3D in order to accurately monitor growth"

"I don't think the alderman will be happy with the tool. Right now, you are not being judged on those criteria here, I think the momentum is not yet there, but the urgency is becoming clearer and BEAs are now mandatory"

"Within the public space we work with image quality levels. We recently adjusted everything to quality level B, which means x number of cans per square meter, grass length of a certain height, bushes x number of centimetres overhang. Certain green is also ecologically framed, other standards apply for this in the context of biodiversity. I can see it happening that at some point the entire city will become an ecological area. Keeping ecosystem values intact could be possibly integrated into green Puccini"

Participatory perspective

Green and the use of public space is fundamentally a participatory issue because there is a strong sense that public space belongs to everyone. The spatial and social sides of an area transformation are often not well united. There are several levels of participation being informed to being involved to being able to decide, and it is important to determine the intended goal of participation. The participation process needs to be well designed according to the needs of the participants. The deeper and broader the participation, the more expensive it will be, as more and more specific means have to be developed to reach these people.

Urban forestry perspective

The role of municipalities is very important in relation to urban green. A long-term plan, vision, and objectives need to be developed in terms of the canopy and functional targets that should come from a master plan. If the municipalities do not state what they actually want it becomes difficult because the architects have to think for themselves what is realistic and popular. They should only have to fill in the framework. The biggest pain point in urban forestry is the 100-year tree cycle and the 4-year political cycle. It should be ensured that tree policy is not tied to a particular party manifesto, regardless of political colour, but is to be part of critical infrastructure just like roads and bridges.

The tree consultants are performing excellent analysis and are very strong within this field. However, they currently do little in terms of policy development and monitoring which needs to be a future focus of their services. It would be interesting to discover how i-Tree could be integrated into the governance of municipalities and how it could support policy development, target setting, monitoring, and steering towards ecosystem services.

Tree nurseries sell what they grow and are very demand-driven. Their strategy is based on stem diameter rather than age, and they focus primarily on fast-growing species. However, this does not necessarily mean that these species are beneficial for all ecosystem services. There are great opportunities for technological advances in this sector.

The focus of research in today's green sector has shifted from technical tree knowledge to a more strategic focus in recent years, prompting much industry comment.

Municipal procurement perspective

A climate-adaptive quick scan is currently being developed in Amsterdam to check the current situation of an area and what the impact of the new design will be. The intention is to make this a mandatory part of the tendering process. The 'Handboek Groen' (Gemeente Amsterdam, 2019) does not yet include requirements for canopy cover or ecosystem services.

Summary of key insights

Green is rising on the agenda, becoming increasingly important within all domains. However, it still lags behind other urban functions and there is a need to catch up and reconnect the condition creators with the condition fulfilers. The shift in focus from aesthetics to functionality accompanied by new knowledge on ecosystem services demands new methods and processes to rightfully integrate the urban forest into current spatial planning practice, municipal policy, and management procedures in order to establish it as critical infrastructure. From the rich and diverse stakeholder conversations, five prominent cross-domain needs have been distilled.

1. The need to monitor a long-term plan

There is a need for a long-term plan with monitored concrete targets to remove political colour from the priority of managing the urban forest and to secure its position as critical infrastructure. Objectives should be based on maintaining the current structure, respecting its natural cycle and creating realistic targets for future ambitions. From management for limitation to management for growth, incorporating the dimension of time.

2. The need for a matched future-proof inventory

The implementation of policy ambitions to increase the inventory of sustainable urban trees can only be achieved if the right stock of trees is available. A more stable and mutually supportive relationship is needed to match climate-resilient functional demand with a more secure supply that is guaranteed to be taken.

3. The need for specific green rules and targets

The urban forest loses out in the force field of urban interests by being a topic to compromise on that is not backed up by strong standards and policies. Depending on the personal green ambitions of decision-makers facing pressure from underground and above, the green disappears first from the spatial scene when budgets are tight. Discussions need to be bound, firm rules need to be manifested and accountability needs to be pursued.

4. The need for green integration in spatial design at all levels

Spanning across multiple siloed assets within a city, the urban forest needs to be taken into account at all levels of the decision-making process, not just at the end. To be considered, the right information and knowledge must be available and integrated into the different stages of transformation. Quantified performance should marry spatial requirements.

5. The need to justify decisions to all stakeholders

The urban forest cannot thrive without the care, respect, and involvement of its inhabitants. They should be empowered by explaining decisions, educating about impacts, striving for equity, and providing structures for participation. To blur public and private, human and non-human, individual and collective into shared social narratives.

part 3
THE OPPORTUNITIES

By empathising with the system and developing an understanding of the tensions and interrelationships, a foundation has been laid for exploring opportunities. In Part 3, the focus is shifted from entangling the present to investigating potential futures with strategically selected groups of stakeholders. Two co-design sessions were organised, one focusing on spatial planning including (landscape) architects, urbanists, and two tree consultants and the other bringing together the different municipalities. A week of field trips was planned to gather the nursery perspective and to collaboratively speculate on possibilities. The set-up, visualised results, and reflections are elaborated on in this part. Some of the key insights have a more methodological aspect to them, helping to determine how to proceed and strategically intervene within the project. Others are more solution-oriented, inspiring genuine design opportunities.

Combined with the needs identified in the previous part, the discovered potential for the different stakeholders ends up in five defined opportunity areas. They either vertically connect two stakeholder domains within the system or horizontally link together different perspectives within a specific domain. The opportunity areas are discussed after which a choice is made for further investigation of one of them.

In the structure of this thesis, the diagnosis of needs seems to precede the identification of opportunities. In reality, however, these processes occurred in parallel, also known as the co-evolution of problem and solution (Dorst & Cross, 2001). As the problem space is explored, certain processes within the solution space are excited and vice versa, continually influencing the understanding at both ends.

CO-DESIGN SESSIONS

The co-design sessions were prepared through a thematic analysis of the interviews with the stakeholders of concern. By first demonstrating an understanding of their current challenges and ways of working, space was created to move towards speculation about the potential integration of i-Tree into their current processes. Both sessions were fully transcribed and analysed. These results are clustered and summarised in a process visual.

Co-design session 1: spatial transformation

Preparation and setup

During the first co-design session (for setup see Figure 22) together with the architects, it was initially determined to aim for a workshop structure that would harness their design power. Through several iterations of the design task and format, the team progressed from an initial focus on the redesign of a specific street to eventually deciding to concentrate the efforts of the participants on the redesign of the current Marineterrein plan. This decision was made because the Marineterrein was already established as a potential case for the i-Tree project, and the scale of a district is better suited to the i-Tree functionality.

The session started with a short introduction on the current status of Work Package 3, explaining how the stakeholder participation was proceeding and who had been spoken to. In order to get everyone on the same level of knowledge about the current i-Tree software, it was decided to ask Wendy Batenburg (Terra Nostra) to give a presentation on its functionalities and potential. The central question for the session was then proposed and the current workflow of the architects was discussed briefly. The current, developing and potential quantified ecosystem services of the tool were shown before the hands-on part of the workshop started. The group was split up into two 'design studios' to work on a new proposal for the Marineterrein in Amsterdam after showing the current proposed plan (Marineterrein Amsterdam, 2021) and the resulting removal of trees (see Figure 19). The teams were provided with several maps of the terrain, such as land use, current green infrastructure, monumental building status, sight lines, accessibility, envisioned programme, density, and underground infrastructure. Also, a table of relative ecosystem service data for six different tree species was provided (see Figure 20).

The task of the two design studios was to create a plan that adhered to the initial programme split between green and building, reasoning from the perspective of green (see Figure 21). After one hour, the two teams presented their plans in a plenary discussion (see Figure 23).

Figure 19. Saved and removed trees after transformation of Marineterrein

Figure 20. Provided table of ecosystem services of six tree species, courtesy of Gül Aktürk

SPATIAL DISCUSSION 11:00 12:30
function as a design studio - landscape | urban | tree

Figure 21. Two slides of session 1 on the redevelopment of Marineterrein

co-design session 1   MVRDV office, Rotterdam
1 november

academics
scope: urban forestry, climate resilience

Rebecca Price - Assistant Professor TU Delft IDE
Gül Aktürk - Postdoc TU Delft IDE
Sanne Keizer - MSc. Graduate TU Delft IDE

tree consultants
Jarren Verbeek - Specialist GIS & remote sensing Cobra Groeninzicht
Wendy Batenburg - Senior scientist ecosystem services Terra Nostra

architecture engineering
scope: urbanist, landscape architecture

Kristina Knauf - Architect MVRDV Climate
Leo Stuckardt - Architect MVRDV Next
Stephan Boon - Urbanist MVRDV
John Boon - Landscape architect Arcadis
Jean-Francois Gauthier - Landscape architect SYLVA (external)

how can i-Tree play a central role in making green more leading in spatial transformation design processes?

language spoken during session: English

walk-in
getting familiar - introduction and workflow - wendy | sanne   10:00 - 10:30
hands-on - spatial discussion + *break*   10:30 - 12:30
wrap-up   12:30 - 13:00

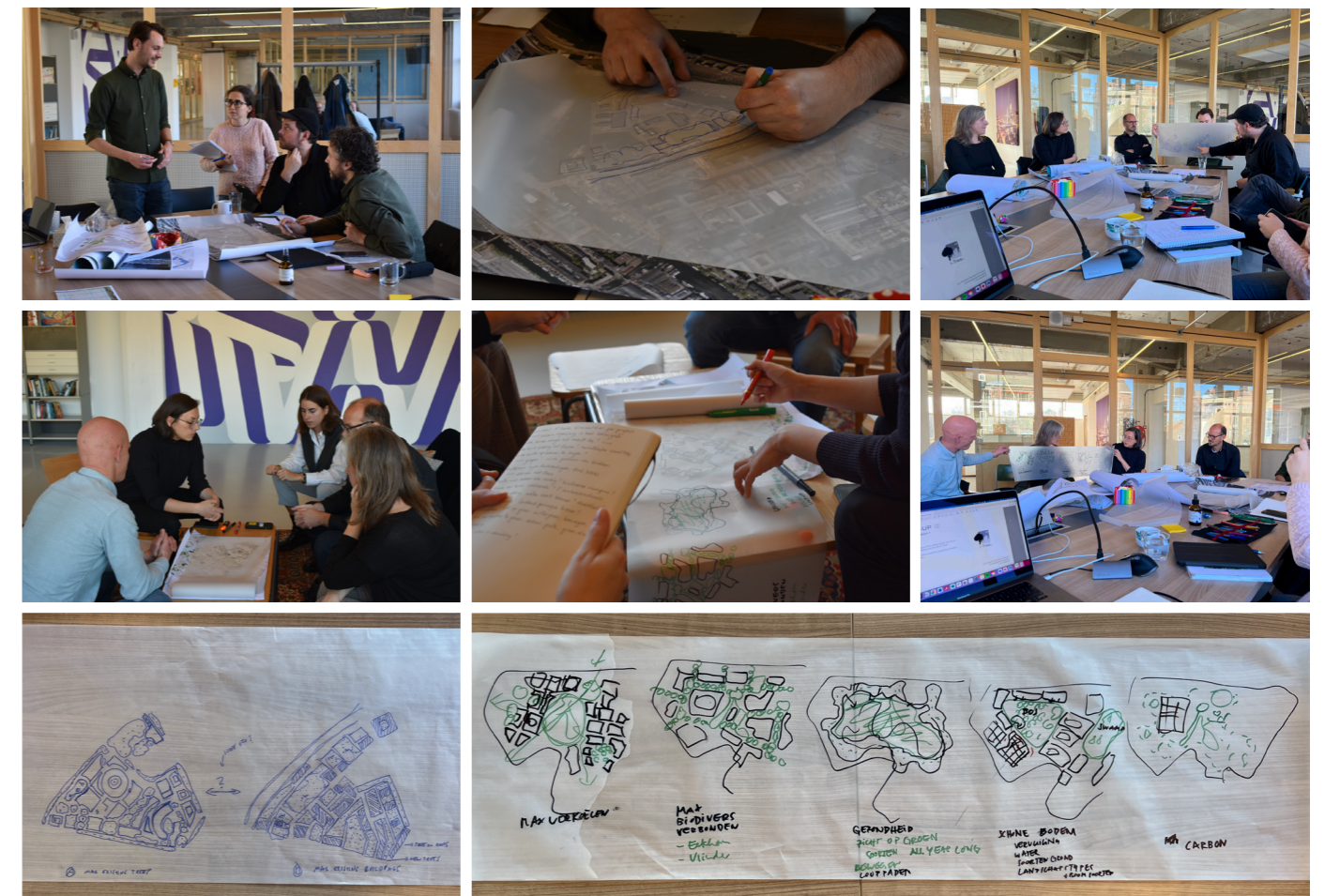Figure 22. Participants and setup of co-design session 1

Figure 23. Pictures of co-design session 1 workshop and outcomes

Results

Way of working

The work of architects is about 'place-making', about creating a certain identity, experience, and feeling of a certain place. They define a concept, or leading principle, at the initial phase of a project in order to guide the process. Based on this concept they develop multiple scenarios. Space for creativity and design is created by not having a single focus and not taking everything into account from the beginning.

Spatial requirements - input for trees

In order to properly consider trees in the design phase, the spatial requirements need to be known. The inventory of existing trees needs to be specific. Currently, they receive BEA's (Tree Impact Assessments) within the analysis phase when performing them is initiated by the municipality or project developer. However, life expectancy and contribution to ecosystem services in the form of baseline maps are missing. The tree is treated as an object rather than a 'service provider'. Other sources of spatial requirements would be the relationship between soil and tree health, the effect of heat stress in the existing situation, the impact of buildings on tree performance, the amount of daylight exposure required by certain trees, the diversity and position of trees with regard to pest and disease risk, and the ecosystem of the tree itself and its relationship to other trees. Also, they want to know how to ensure their survival during the actual construction process as this is currently not taken into account during the early stages of the design process.

Green performance - output of trees

It is important to define the goals of green performance from the outset. What are the ecosystem services to be optimised, which common qualities should be generated and what is the main objective? The way in which green is positioned depends on the goal. Taking everything into account from the beginning results in a superficial design that is too complex. One of the teams developed five scenarios, each based on a specific ecosystem service as a starting point which resulted in five different designs based on maximum cooling, maximum biodiversity, maximum health benefits, maximum soil restoration, and maximum carbon storage (see Figure Figure 23).

Each perspective demanded different design decisions. In the first scenario on cooling, the focus was on optimising the placement of trees, including grouping, creating shade, increasing evapotranspiration, using shading from buildings, and creating a porous pattern of building blocks to facilitate the flow of water and wind. In the biodiversity scenario, they considered the idea of 'animal ambassadors', the use of native versus exotic species, the establishment of ecological corridors, and the use of high-rise to minimise the required ground space. In the third scenario on maximising health benefits, they debated views on green, subjective feelings of happiness, evergreen species, space for recreation and social cohesion. During

the creation of the soil-centred plan, opportunities for restoring the natural landscape, current contamination, soil life, succession stages, water retention, reuse of excavated soil, and transitions between different soil types were mentioned. They identified the final carbon storage scenario to be less site-specific and geared towards keeping existing trees, allowing trees to grow old and providing proper compensation. The variations in these discussions highlight the finding that each ecosystem service involves specific design decisions.

Potential of i-Tree within spatial domain

The architects showed a genuine interest and need to incorporate quantified data on urban green. During the discussions several opportunities for the integration of i-Tree passed by:

- **Spatialised parameters**. The different data sources presented during the workshop (table of ecosystem service data of trees and multiple maps of the Marineterrein) do not speak the same language. It is hard to translate relative scaling into computer modelling as it has to be converted into numerical values to be able to use in the process of scripting. The data on ecosystem services should be spatialised as a starting point for design, creating heat maps that can be laid on top of each other to look for correlations. Also, the required space should be shown as 'blocks' around it, certain invisible envelopes for current and future conditions. To take into account the spatial conditions and values that need to be considered when making choices about positioning on site. Currently, they use a certain 'offset' around trees, this 'void of development' should be made more specific. A connection with GIS or a plug-in should be provided in order to integrate it into the current workflow. The interpretation of the database should be left to the firms themselves.

- **Site-specific conditions**. It is important to be specific on conditions at a certain site and understand its challenges. Some of the ecosystem services appear to be more location-specific than others and this should be taken into account when prioritising in the design process. It could be seen as a scale where a particular ecosystem service might be 15% location-specific. For example, carbon sequestration is less site-specific than biodiversity or the property value of the buildings on the site. The involvement, dynamics, and resistance of citizens in development processes also vary from place to place, as does the relevance of social returns. They should be involved and included in public spaces by giving them proper information and showing how they can contribute to their living environment. i-Tree is too abstract right now and more designed ways of engagement are needed in the form of narratives. People are passionate about plants, but they need to see them in a more systematic way.

- **Dimension of time.** How does a tree grow over time? What is the life expectancy of a tree? How does the ecosystem around a tree function? How do pioneer species pave the way for other species in the successional stages? It takes time and different

stages for a healthy forest to grow. Incorporating the time aspect and considering time spans of 2100 or 2200 opens up opportunities to rethink urban development on certain horizons and build flexibility into a plan. Taking into account the maintenance perspective to allow it to grow and reach its full potential, to define open space, to show the benefits and to provide a connection between choices and management. Also, concessions can be made based on the future potential of a tree. If it is unlikely to grow old and reach its mature age due to disease or unsuitable growing conditions the decision to remove it could be justified.

- **Scenario evaluation.** Architects design in extremes and think in radical scenarios. i-Tree could help make decisions for specific plans from an urban forest perspective, comparing them on different aspects such as ecosystem services and facilitating in making combinations. The software could potentially balance the extremes, provide insight into how the scenarios differ, add nuance, localise, and make it more granular. Both an analytical and generative path was envisaged, either to compare scenarios and select the best one or to generate and explore new scenarios based on data.

- **Response of buildings to green**. If a plan is dependent on trees, the more information you have about trees, the more sophisticated your buildings can respond to it. Volumes should follow green, not buildings defining poor conditions for green. From a decorative, beautifying function of green to an understanding of the urban forest as an ecosystem service provider and a post-modern city with a symbiosis between green and buildings. For this to manifest, a better understanding is needed of the performance of trees and the parameters that define them. To demonstrate the power of green, to add it to balance the impact of buildings and to create a resilient urban fabric.

Limitations of the session

The scope of the session was quite narrow as there are many other aspects to consider such as mobility, social relationships, cables, and other infrastructure. Once this knowledge is available, it brings about a whole set of constraints and restrictions that make an actual design project much more complex than this exercise. By looking at the Marineterrein a relatively green and qualitative area is chosen and the effect of improvement could potentially be greater in other more problematic areas. Next to trees, there are other forms of green that should be taken into account and have been neglected in this discussion.

A personal reflection on co-design session 1 and dealing with the responsibility of occupying someone's time, a valuable first step into the unknown which led to valuable insights. I found it difficult to get the most out of a session when I was not well-versed in both areas of concern (green and architecture). In trying to give shape to this urban design challenge, I felt that my lack of familiarity with architectural practices prevented me from unleashing and offering a fully fruitful canvas. For the next workshop, I plan to work more closely together with the participants and immerse myself more deeply in their processes and challenges. I also plan to be more humble upfront about the attempt to learn and to ask for guidance on parts that do not flow and do not turn out as expected.

Key insights

As well as considering and speculating about different ways of redesigning or reimagining i-Tree, the workshop provided strategic insight into how to take the project forward. It was established that certain parts of the system map can be investigated in isolation. Domains can be separated strategically to allow for targeted intervention and value creation in each section. This ensures depth and width in defining the different opportunity areas within the processes, as bringing all stakeholders together at once would potentially lead to an infinite and entangled discussion. This line of thinking will be used throughout the rest of the project to determine where to intervene and focus efforts across the system map.

The key insights from the session in terms of genuine design opportunities are summarised and visually presented in Figure 24 in relation to the existing architecture process.
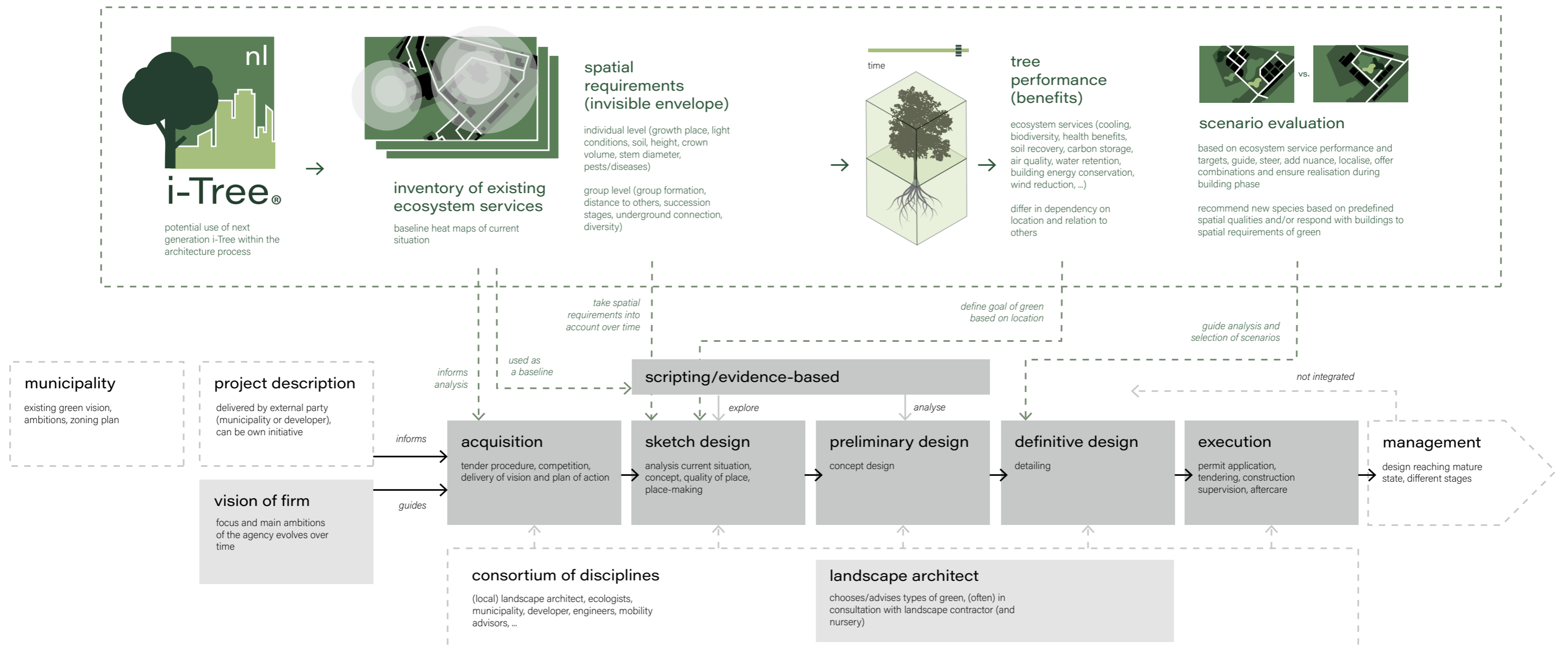

Figure 24. Potential use of next-generation i-Tree within the architecture process

Co-design session 2: the future of the urban forest

Preparation and setup

The second co-design session was planned for the participation of the eight municipalities of the consortium (see Figure 25 for an impression and Figure 27 for the setup). Unfortunately, four participants cancelled on the day of the session due to health issues. Additionally, Daniela Maiullari (TU Delft, BK) and Fons van Kuik (Cobra) attended the workshop to share updates on the other two related work packages and to request specific data and measurement assistance from the municipalities.

Based on the insights gained from the previous workshop, the expectations for the upcoming session were discussed with the municipalities during the interviews, and the set-up was refined through multiple iterations with the help of Gül, Daniela, and Rebecca, and prior consultation with Henk Langeveld and René van der Velde. To further prepare for the session, the process of area transformation was thoroughly investigated (Bouwend Nederland et al., 2019; Rijkswaterstaat, n.d.) and copies were distributed during the workshop. In addition, the attendees were requested to provide their current goals for green in advance of the session.

The session started with everyone sharing the green targets of their municipality to establish a shared understanding of everyone's current situation, challenges, and way of working. Then, a conscious decision was made to start by introducing the paradigm shift to set the tone for transition and facilitate a shared narrative. Afterwards, Wendy's presentation on i-Tree was shown, along with London's urban forest statistics, and the Urban Forestry Master Plan of Birmingham, all with the aim of building towards a mode of exploring possibilities. During the hands-on part, the process of area transformation was handed out to identify potential integrations for i-Tree to facilitate this new paradigm (see Figure 26 for one of the examples and Appendix C for all seven). They worked individually before presenting the opportunities in a group discussion. Questions such as "What is required to set targets for ecosystem services and how can i-Tree facilitate this?" and "At what stage of the process can interventions be made and in what ways?" were displayed on the screen to stimulate debate. The session ended with a presentation by Daniela and Fons.

Figure 25. Impression of co-design session 2

Figure 26. One of the seven municipal process journeys from co-design session 2, courtesy of Henk Langeveld

co-design session 2
28 november

academics

scope: urban forestry, climate resilience

Rebecca Price - Assistant Professor TU Delft IDE
Gül Aktürk - Postdoctoral Researcher TU Delft IDE
Sanne Keizer - MSc. Graduate TU Delft IDE
Daniela Maiullari - Postdoctoral Researcher TU Delft BK

tree consultants

Fons van Kuik - Senior advisor ecosystem services Cobra Groeninzicht

municipalities

scope: green policy and green management

Rob Zweekhorst - Green management municipality of Dijk en Waard
Leendert Koudstaal - Tree expert municipality of The Hague
Ruud de Jong - Green management municipality of Hendrik-Ido-Ambacht
Oege Oevering - Advisor green municipality of Dordrecht
Jacco de Frel - Green management municipality of Rotterdam
Henk Langeveld - Advisor green municipality of Groningen
Jeroen van Gaalen - Green management municipality of Utrecht
Rob Hendriks - Green policy municipality of Utrecht
Wieteke de Boer - Green management municipality of Groningen
Hans Kaljee - Green management municipality of Amsterdam

TU Delft IDE Faculty, Delft

how can i-Tree 2.0 play a central role to make green more leading in cities?

language spoken during session: Dutch

walk-in	13:30 - 14:00
getting familiar | current targets and strategy	14:00 - 14:45
getting familiar | i-tree and the future of the urban forest	14:45 - 15:00
break	15:00 - 15:45
hands-on | green in the lead	15:45 - 16:00
presentation daniela | wp1 en wp2	16:00 - 16:30
wrap-up	

Figure 27. Participants and setup of co-design session 2

Results

Expanding the area of influence

There is a need to broaden the scope of influence beyond green policy and management to higher levels of decision-making. For example, within climate adaptation strategies, which are increasingly looking at green for evapotranspiration, cooling, and collecting rainwater. This is an important perspective as the budgets in these areas are increasingly more adequate. Additionally, green should piggyback on other developments within the existing city to ensure that when there is a transformation and the street is open, several projects are tackled in an integrated manner. Over the past few decades, the position of green has evolved, from one of inferiority and last resort to one of general prominence, from being a follower to being in the lead. However, the connotation of 'leading' has provoked some discussion and an 'integral' position has been preferred.

Long-term plan

The field lacks a long-term plan to strategically steer policy. There is an urge for indicators that last a minimum of twenty years in order to be able to track progress rather than shifting ambitions every four years. Trees need to be able to reach an age of 70/80 years but currently, the average age is 30. A large percentage of growth places are rejected within the municipality, yet this is one of the most important determinants of longevity. Strict quality regulations and a lasting strategy are needed to make the right investments for a future-proof city.

Connection policy and management

The targets set in policy should be aligned with management. In Hendrik-Ido-Ambacht, for example, the ambition was set to plant 500 new trees, however, it is not even certain that this number of sites still exists within the municipality.

Potential of i-Tree within municipal domain

Possibilities for integrating i-Tree were identified at different phases of the area development process:

- **Establish the baseline.** The initial step should be to catalogue the existing inventory of trees and their values. Preserving what is currently there and living up to the future potential of this green should be the priority and built into the programme of requirements during the initiative phase. Green decision-making should be integrated throughout the entire process and everyone in the chain should be aware of the performance and needed spatial requirements.

- **Determine concrete ambitions.** Once the current baseline of the site has been determined, goals for future improvement should be set. The time dimension and natural growth of the current inventory should be considered. It is important to understand the potential of the existing green spaces and how tree felling and planting may affect them over time. Knowing where a specific tree population is in its lifecycle can be beneficial in making informed decisions. These decisions should be based on crown volume rather than numbers. The indicators, guidelines, and ambitions should be specific and stringent. The municipality of Utrecht showed some concrete examples of aiming for 40% green cover per district, a maximum distance to greenspace of maximum 200 meters, an addition of 12.000 trees in four years, and an increase of the total area of green space within the city by 440 hectares. These targets could be included in tenders and direct claims for green space above and below ground could be made. The position of green in the decision-making processes of transformation could be increasingly secured by obligating the integration of a green expert perspective, such as an urban forester or ecologist. Additionally, emphasis should be placed on biodiversity and the establishment of species in urban ecosystems. Utrecht aims to create space for 30 target species.

- **Manage and monitor for realisation**. These specific targets for crown volume and ecosystem services of the urban forest should be monitored. The management plan should be geared towards achieving these determined values. It would be helpful if i-Tree could facilitate some kind of dashboard to measure progress and provide a way to correctly compensate for lost current inventory. Both should be considered, as 'the majority of the city (90%) is in the maintenance phase and only a small management projects and large transformations portion (10%) is in development.' The software should be fully integrated into municipal asset management to track developments and facilitate communication with citizens. To be able to argue and justify certain decisions with the support of quantifiable data.

Personal reflection on co-design session 2. I succeeded in immersing myself in the challenges and processes of the participants prior to the workshop and felt more comfortable presenting. Supported by the conversations with Rebecca, I better understand that a co-design session is not a transactional matter waiting for participants to open their treasure trove of insights. It is rather about facilitating a collaborative process of discovering opportunities than it is about expecting to find answers. For this discovery to be mutually pleasant and beneficial, it is crucial to develop a proper understanding and level of empathy beforehand in order to unlock a deeper level of knowledge creation.

Key insights

Discussing the natural growth and potential of the existing tree population, and the need to monitor what's already there, sparked an idea. What if the lifecycle of an inventory was visualised, showing its growth at specific timeframes? By comparing these figures with the intended new situation of the tree inventory after transformation, it would be possible to calculate if and how much compensation is demanded. In this way, the influx and efflux of a tree inventory could be monitored over time. It is worth noting that this thinking aligns with the findings of the architecture session, which also emphasised the importance of scenario evaluation and the integration of the time dimension. This approach is visualised in Figure 28 along with the other key insights of the session. Additionally, the aforementioned management transformation cycle is being carried forward as a concept for further exploration.
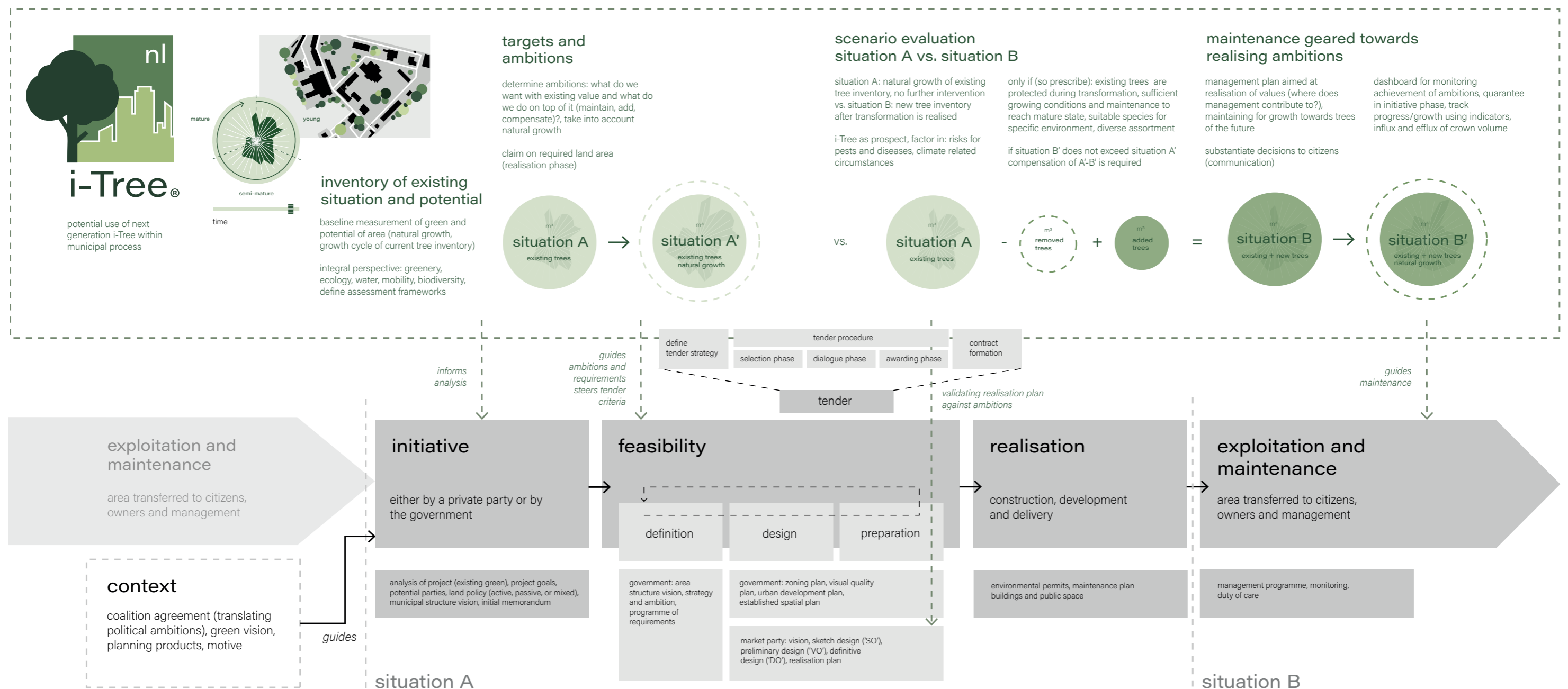

Figure 28. Potential use of next-generation i-Tree within the municipal area transformation process

Iterative week of field trips: tree nurseries

The original plan was to organise a third co-design session together with the tree nurseries and tree consultants. However, December turned out to be a very busy month for the nurseries as it is in the middle of the planting season. For once, the cycle of nature was respected and it was decided to visit each of them individually (see Figure 30). This approach also allowed for developing a sense of the diverse companies and their differences. These field trips were used as iterative sessions to build their process and investigate opportunities for i-Tree together. The insights gained from the interviews have already been discussed in Part 2, and this section will focus on the identified opportunities.

Potential of i-Tree within nursery domain

Opportunities to integrate i-Tree were identified at various stages of the nursery process and visualised in Figure 29:

- **Track and trace.** It could be possible to track the different locations a tree comes from, to trace its origin. Municipalities are increasingly demanding this kind of information as they want to know the origin of their trees. For example, if they ask for organic trees but they are currently out of stock at a particular nursery it can happen that they may be supplied with non-organic trees that cannot be traced back to the original source.
- **Integrating time dimension.** The time aspect should be integrated into the whole process as the nurseries deliver an organic product that continues to grow during the course of the projects. Green is currently seen as a material, whereas its function needs to be included in the design and has an impact on the size of the place, the time dimension, and the growing site. There are many opportunities in the longest phase of the process, which is management.
- **Long-term contracts.** Part of the stock of the nurseries is destroyed because they are not able to sell it because demand does not match supply. Long-term contracts could increase interdependence and tune the inventory to municipal targets ahead of time.

- **Carbon credits.** Offer green certificates for urban trees as they already sequester CO2 for several years on the nursing site.
- **Ecosystem services per circumference.** The provision of ecosystem services increases exponentially with age. This should be shown per tree size, like washing labels. i-Tree could potentially also be used in reverse to calculate the amount of energy and CO2 used to produce the products. How 'green' is this green?
- **Connected datasets.** Municipalities already measure stem width but so do nurseries. There is potential for collaboration and sharing datasets. Additionally, the crown volume could be measured on the nursery site.

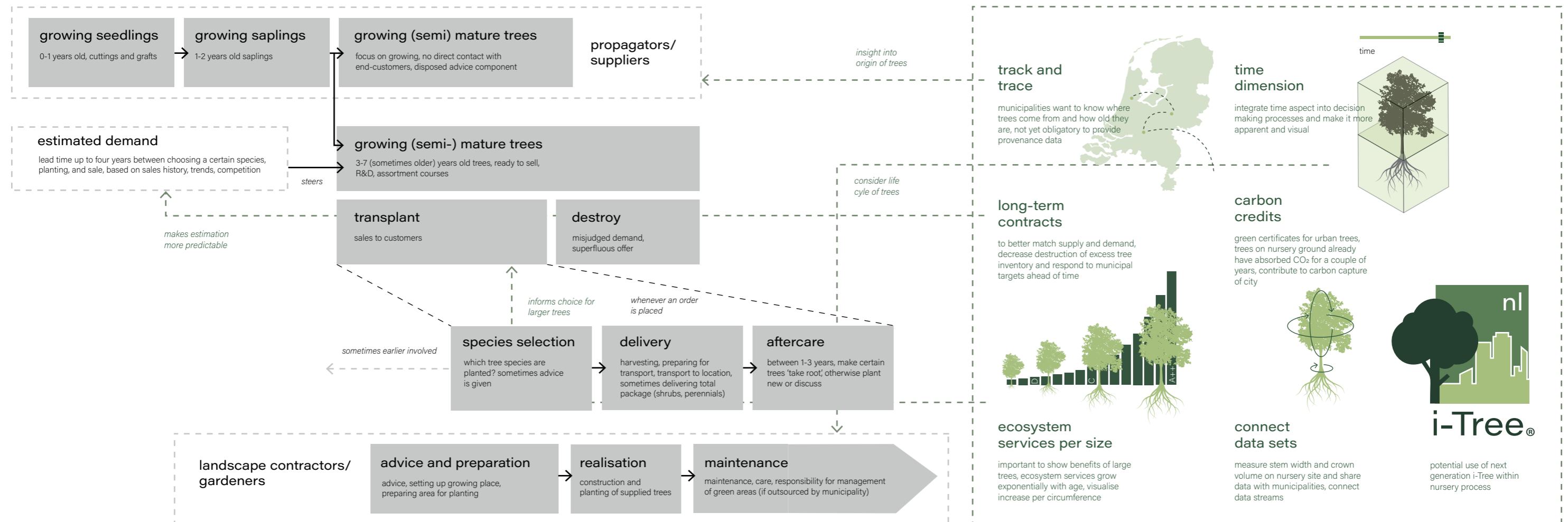Figure 30. Pictures of tree nursery field trips

Figure 29. Potential use of next-generation i-Tree within the process of tree nurseries

Key reframes

The conversations and sessions led to two key reframes of the central concepts of this project, ecosystem services and urban transformation. These are elaborated on below before moving on to the identified opportunity areas.

Reframe - ecosystem services

The project started with a clear focus on design for ecosystem services. During the first few months, early ideas emerged about ecosystem service parameters that could be upscaled or downscaled resulting in a spatial map with a responsive tree inventory. However, as the conversations progressed, this understanding became more nuanced. Not all ecosystem services are equally important and there is much debate about some of the services that can be quantified with i-Tree. The contribution of the urban forest to carbon sequestration is relatively small compared to other natural ecosystems, the filtering of air pollution is discussed because of the possible 'canyoning effects' within streets, and stormwater regulation also has to be treated with caution based on recent publications.

On the other hand, the positive effects on health, biodiversity, and cooling are significant and undisputed. Unfortunately, these three services cannot yet be measured with i-Tree. However, Work Package 1 is working on specifying the cooling performance of certain tree species. This refinement within the relevance of ecosystem services to the urban environment should be taken into account as designing for maximum carbon sequestration implies other decisions than transforming based on maximum cooling. Additionally, a focus should be defined as designing based on all ecosystem services would, exaggeratedly, result in a single species. Therefore, Hans Kaljee focuses his arguments towards heat stress as it is a concept that is crucial, substantial, and easy to understand and Cecil Konijnendijk emphasises the contribution to human health.

Furthermore, ecosystem services are a subjective label put on environmental functions that humans find useful and consider as benefits, as explained in Part 2. By moving to the first step of this cascade and looking at the structural components, 'objective' parameters can be found. Based on the conversations it became clear that it is important to look at crown volume or leaf area rather than the number of trees. Crown volume is directly related to the provided ecosystem services so an addition results in an increase of all of them. Crown volume is an indicator, while the resulting ecosystem services can be seen as different impacts.

In conclusion, it is important to highlight the wide range of ecosystem services provided by trees in order to advocate for their detrimental multifunctional role in cities. However, the data should be handled with care as presenting disappointing numbers risks doing even more damage than not presenting numbers at all. Heat stress, human health, and biodiversity are urgent and high on the national agenda so they should absolutely be used in the debate even if the numbers are not yet quantified. Crown volume is a value-free parameter that can be used to set targets, whereas the contribution of ecosystem services should be treated in a more context-specific way.

Reframe - transformation process

The process of decision making for public urban green spaces centres around the steps of municipal area transformation. However, during the session with the municipalities, it was noted that the majority of the city is in the maintenance phase, with only a small part in development. Similarly, in the interviews with nurseries and architects, attention was drawn to 'the longest phase of the process' and 'the perspective through which a landscape is able to evolve'. Based on this, another zoomed-out snapshot of the same system became evident (see Figure 31). Looking at a particular urban area over time, the process is circular, with transformation followed by a period of maintenance. This sequence simultaneously repeats itself in different timescales and orders of magnitude throughout the city. The different types of transformation could be categorised as 'newly built', 'redevelopment', and 'existing city', increasing in size of the operation and decreasing in solution space.
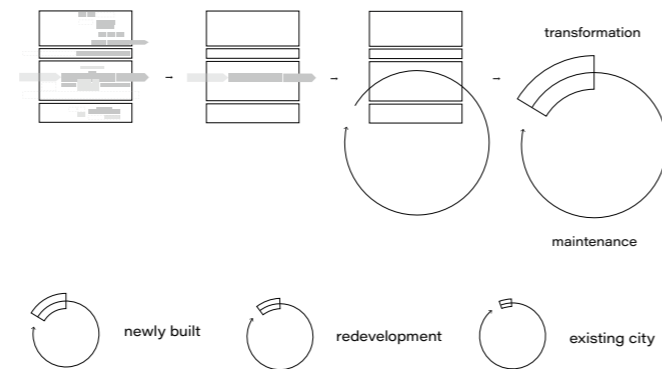

Figure 31. Zoomed out snapshot of transformation process as a cyclic process followed by maintenance

The interviews and co-design sessions shaped an understanding of the urban green system and its stakeholders. The pressure on green space requires this system to act as a collective front working towards the common goal of creating climate-resilient cities led by green. However, as noted above, there is a lost connection between the stakeholders creating conditions and those who are expected to meet them. There is an opportunity to (re)connect the chain by making the process and interdependencies transparent, negotiable, and more promising. However, it is important to identify for whom value is created, what i-Tree wants to be, and what the limits are. This chapter aims to explore possible connections through the integration of i-Tree, either horizontally within the domain of a particular stakeholder or vertically between the relation of two stakeholders. Five opportunity areas are proposed based on the previously identified needs, discovered opportunities, and reframing. Finally, one of them is selected for further investigation and prototyping.

Some of the opportunity areas are more resolved than others as the resources within this project are limited and need to be strategically directed towards the most promising ones. For all areas, the ambition was to validate the findings together with the appropriate stakeholders (see Table 7). Figure 32 on the next page shows an overview of the opportunity areas.

	Connection	Validated by
Opportunity area 1 - management dashboard	Municipal management and policy in collaboration with tree consultants	René van der Velde, Wendy Batenburg, Fons van Kuik, Hans Kaljee, Cecil Konijnendijk
Opportunity area 2 - inventory match	Municipalities and tree nurseries	René van der Velde, Leon Smet, Hans Kaljee, Cecil Konijnendijk
Opportunity area 3 - urban rules by design	Municipalities and architects (through tender targets)	René van der Velde, Stephan Boon, Leo Stuckardt, Cecil Konijnendijk
Opportunity area 4 - abstraction levels	Urban and landscape architecture	René van der Velde, Cecil Konijnendijk
Opportunity area 5 - choice justification	Municipalities and citizens	René van der Velde, Hans Kaljee, Cecil Konijnendijk

Table 7. Stakeholders asked to validate findings within opportunity areas

Opportunity areas for intervention

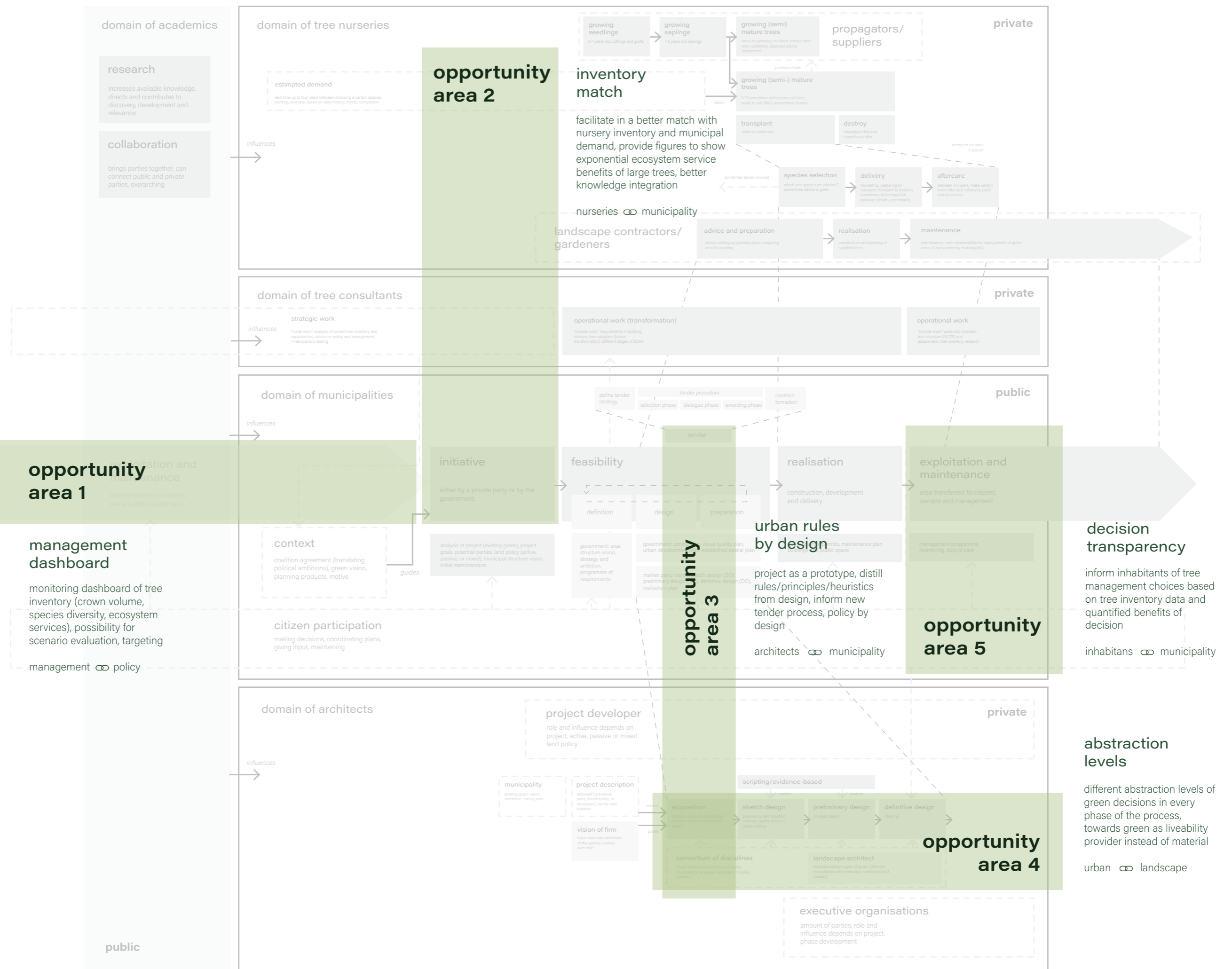Exploring possible (re)connections of stakeholder domains

domain of academics

research

increases available knowledge, directs and contributes to discovery, development and relevance

collaboration

brings parties together, can connect public and private parties, overarching

influences

domain of tree nurseries

private

growing seedlings
2-3 years old, cuttings and grafts

growing saplings
-2 years old saplings

growing (semi) mature trees

propagators/ suppliers

estimated demand
lead time up to four years between choosing a certain species, planting, and sale, based on sales history, trends, competition

opportunity area 2

inventory match

facilitate in a better match with nursery inventory and municipal demand, provide figures to show exponential ecosystem service benefits of large trees, better knowledge integration

nurseries ∞ municipality

growing (semi-) mature trees

transplant
sale to customers

destroy
expected demand, superfluous offer

species selection

delivery

aftercare

landscape contractors/ gardeners

advice and preparation

realisation

maintenance

domain of tree consultants

private

influences

strategic work

operational work (transformation)

operational work

domain of municipalities

public

influences

define tender strategy

tender procedure
selection phase dialogue phase awarding phase

contract formation

tender

opportunity area 1

initiative
either by a private party or by the government

feasibility

realisation
construction, development and delivery

exploitation and maintenance
area transferred to citizens, owners and management

management dashboard

monitoring dashboard of tree inventory (crown volume, species diversity, ecosystem services), possibility for scenario evaluation, targeting

management ∞ policy

context
coalition agreement (translating political ambitions), green vision, planning products, motive

guides

definition

design

preparation

analysis of project (existing green), project goals, potential parties, land policy (active, passive, or mixed), municipal structure vision, initial memorandum

government: area structure vision, strategy and ambition, programme of requirements

market party

opportunity area 3

urban rules by design

project as a prototype, distill rules/principles/heuristics from design, inform new tender process, policy by design

architects ∞ municipality

opportunity area 5

citizen participation
making decisions, coordinating plans, giving input, maintaining

decision transparency

inform inhabitants of tree management choices based on tree inventory data and quantified benefits of decision

inhabitans ∞ municipality

domain of architects

private

influences

project developer
role and influence depends on project, active, passive or mixed land policy

scripting/evidence-based

municipality
existing green vision, ambitions, zoning plan

project description
delivered by external party (municipality or developer), can be own initiative

vision of firm
focus and main ambitions of the agency, evolves over time

acquisition

sketch design

preliminary design

definitive design

consortium of disciplines

landscape architect

opportunity area 4

abstraction levels

different abstraction levels of green decisions in every phase of the process, towards green as liveability provider instead of material

urban ∞ landscape

executive organisations
amount of parties, role and influence depends on project, phase development

public

Figure 32. Opportunity areas mapped on public urban green process journey

Opportunity area 1 - management dashboard

The need to monitor a long-term plan

There is a need for a long-term plan with monitored concrete targets to remove political colour from the priority of managing the urban forest and to secure its position as critical infrastructure. Objectives should be based on maintaining the current structure, respecting its natural cycle and creating realistic targets for future ambitions. From management for limitation to management for growth; incorporating the dimension of time.

Without knowing the current state, it is impossible to set goals for the desired future state. To better link green space management and policy, the urban forest and the progress towards realising objectives need to be monitored over time. In this way, management can be geared towards achieving set values and green policy can establish realistic, context-specific targets. The current attitude, budgets, and strict quality requirements around tree management are inhibiting the urban forest from thriving. To move from management based on limiting constraints and maintaining a static situation to management for growth and reaching maturity. Crown volume could be taken as the main parameter to monitor, and the life cycle of the tree inventory has to be considered as natural growth can be accounted for. Next to crown volume, the diversity of tree species is crucial to creating a resilient urban forest in terms of disease resistance, successional stages, and biodiversity. This data can be interpreted and visualised as shown in Figure 33, which can serve as the basis for a management dashboard. In addition to monitoring, different tree inventory situations could be compared, for example before and after an area transformation. These calculations could indicate justified compensation and could also facilitate target setting. In this way, the transformation-management cycles build on and reinforce each other.

As the tree consultants are very strong in urban forest analysis but could take a more prominent position in terms of green policy development and monitoring, this dashboard, accompanied by the interpretation and target setting could be a promising collaboration. This assumption was in line with the future ambitions of the spoken tree consultants.
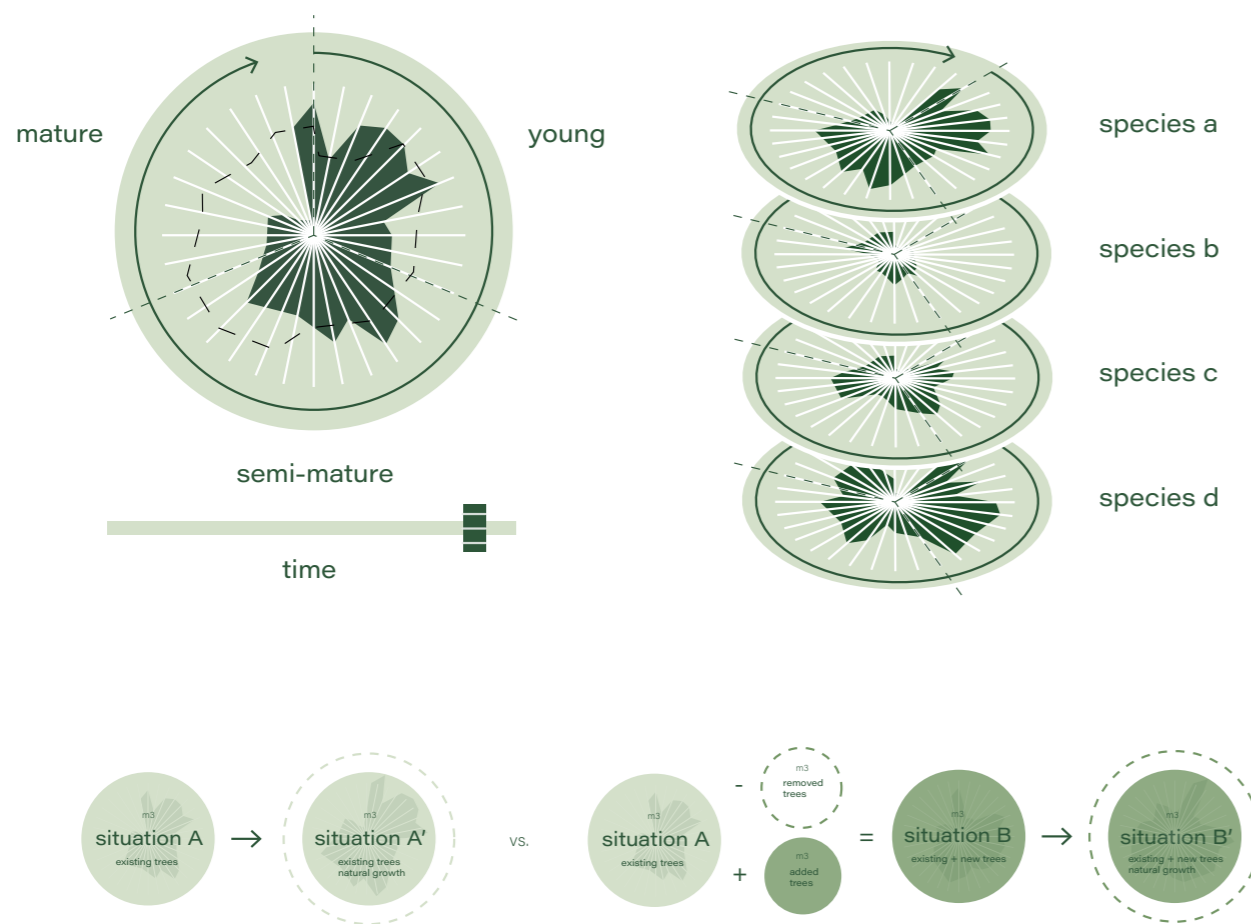
Figure 33. Visualisation of opportunity area 1 - management dashboard infographics

Opportunity area 2 - inventory match

The need for a matched future-proof inventory

The implementation of policy ambitions to increase the inventory of sustainable urban trees can only be achieved if the right stock of trees is available. A more stable and mutually supportive relationship is needed to match climate-resilient functional demand with a more secure supply that is guaranteed to be taken.

The need for better coordination between tree nurseries and municipalities is not a new discussion. It concerns a tough sector, different mentalities, and ingrained patterns. Within the scope of this graduation project, it has been decided not to pursue this opportunity area for further concept development. It is assumed that significant results can be achieved in other areas in a shorter period of time. However, the found opportunities were "spot-on", as Leon Smet put it, and are elaborated on further by adding his knowledge. No single proposal is picked but several directions are complemented.

- **Connected data sets.** The opportunity for greater continuity and connection is an overarching one. It concerns something systemic, more like a shell. This is a process-oriented intervention, whereas the other opportunities are all specific issues that could be zoomed in on.
- **Track and trace**. Municipalities want to have more insight into the provenance of trees and are increasingly asking for track and trace data. This data includes phytosanitary information, for example, which indicates the resilience and disease resistance of plants. Trees grow up in different locations, pass from different propagators to nurseries and may be transplanted multiple times at the same nursery site. The horticultural technique of crafting is when a scion and a rootstock are joined. Cities are concerned about non-native species and are therefore increasingly interested in obtaining this data on the path from seed to rootstock to tree (see Figure 34). However, providing this data is currently not obligatory. Developments are underway in DNA research and the potential chipping of trees. Trees stored in blockchain might not be far off.
- **Long-term contracts.** The need for this type of contract is evident in the nursery sector. Municipalities used to have city nurseries with which they had a strong relationship, but they gradually disappeared. The current debate is rising on whether they need to come back. A reliable contract between the supplier and the end user is essential for keeping parties together, exchanging knowledge, and matching supply and demand.
- **Integrating time dimension.** i-Tree is going to facilitate the decision-making of public parties regarding the implementation, size, and performance of trees. The dimension of time is insufficiently incorporated in the process right now but if the tool can advocate for the advantages of larger trees in terms of ecosystem service provision this will be of significant importance as it directly affects the nurseries' businesses.
- **Carbon credits.** The sector has been too modest to capitalise on this. This is a sensitive opportunity as it is unexplored territory yet but definitely a missed commercial opportunity at the moment. This could be financially incorporated into the decision-making procedure and delivery times, from seed to maintenance. The question remains, who will claim and trade this? How will this affect prices?
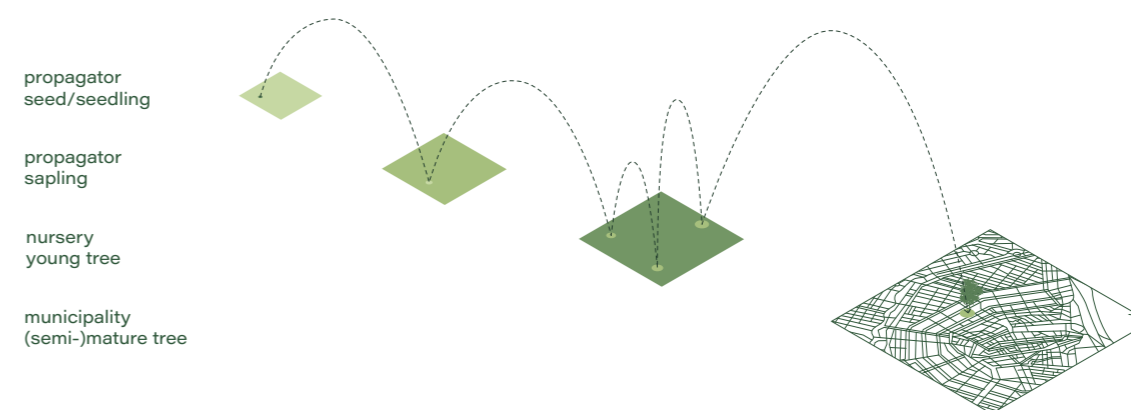

Figure 34. Visualisation of opportunity area 2 - track and trace

Opportunity area 3 -
urban rules by design

**The need for specific green
rules and targets**

The urban forest loses out in
the force field of urban interests
by being a topic to compromise
on that is not backed up by
strong standards and policies.
Depending on the personal
green ambitions of decision-
makers facing pressure from
underground and above, the
green disappears first from the
spatial scene when budgets
are tight. Discussions need to
be bound, firm rules need to be
manifested and accountability
needs to be pursued.

The urban green domain is in need of concrete rules and regulations to ensure that its
position is rightfully considered from the start of a transformation. However, for these
rules to be effective and generate the greatest value, the innovative power of design
professionals should be harnessed by developing them together. Municipalities should
put up a realistic framework that allows for the creativity of the market to flourish.

With this in mind, it was decided to examine the architectural tendering process for an
area transformation as the requirements outlined in this document will steer the final
plan that will eventually be executed. The initial concept idea was to design a new urban
tender with speculative green targets and have one of the architects in the consortium
create a plan based on this. This approach would make it possible to spatially evaluate
the feasibility of the new targets in a specific location and to understand the potential
impact of different design choices.

This concept was discussed with Stephan Boon and Leo Stuckardt of MVRDV. They
recognised the potential to intervene in the early phase of tendering and to state the
importance pre-stage. However, they challenged the sequence of the approach which
they felt was too close to the real world. Providing them with a redesigned tender will
impose the same challenges on the designers and they will again end up frustrated
wishing the tender process was different. They proposed to turn it around and use a
'project as a prototype'. Make a design first, have a sharp evaluation of the project, and
then distil future urban rules from it. To start approaching it from the design side and
use a new urban plan as a speculative probe. When a concrete site is selected, specific
urgencies can be taken into account and examples given of how design strategies can
help.

They mentioned one of their finished projects regarding rooftops in Rotterdam. The
city already had a developed vision for rooftop use that included various themes and
activations. They built on this framework and started by creating a tool to increase literacy
about the rooftops in each district, to show for example the rooftops built before 1950 or
those with a high energy production potential. A similar approach could be applied to
trees in urban areas. The next step would be to translate this information into capacities
and connect it to needs for a certain specific area. It could for example be interesting to
know if a particular district has a lot of old trees as they would have to renew them at a
certain moment or if there are only one or two dominant tree species present in relation
to a biodiversity ambition. By having the data first, some objectives can be extracted from
it, such as a ratio of new to old trees.

Starting with design by research, moving to research by design, and ending up with a co-
evolutionary approach working from both ends towards the middle. Designers are driven
by visual quality and policy-makers by textual requirements. A shared language can
lead to the joint development of spatial rules for functional green. The aim is to think in
terms of quality-of-life requirements to which the distribution and quality of green should
respond. The general steps in carrying out this approach are proposed in Figure 35.
Start with selecting a specific location and investigate current policy documents on heat
stress, generate a design, iterate it together with the green consultants and municipalities,
translate it to urban heuristics or guidelines, and evaluate how it could help to produce
better tender documents. A further step towards 'policy by design', as stated for example
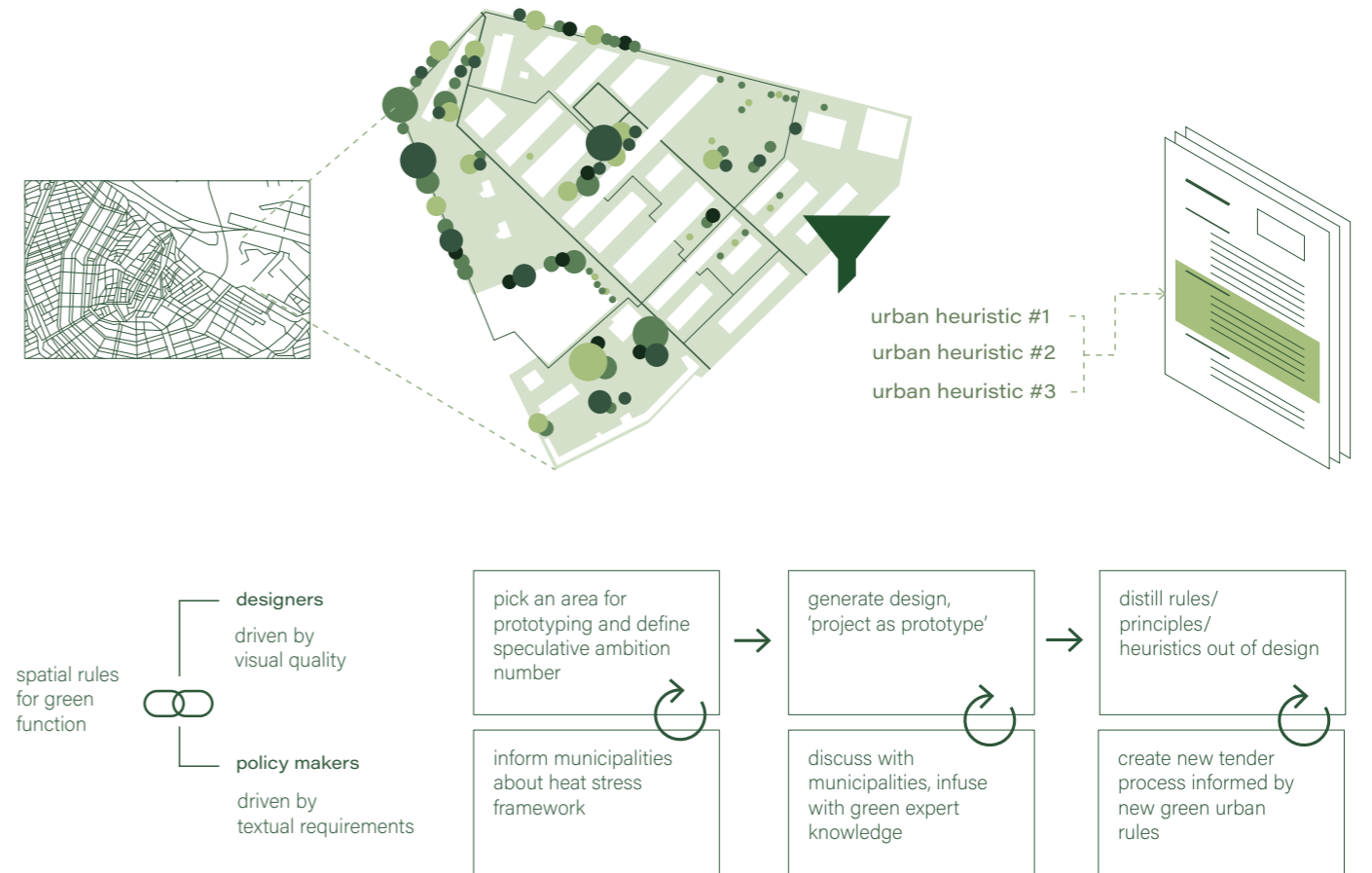in van Kuijk's column (van Kuijk, 2022).

urban heuristic #1
urban heuristic #2
urban heuristic #3

*Figure 35. Visualisation of opportunity area 3 - process proposal urban
rules by design*

spatial rules
for green
function

designers

driven by
visual quality

policy makers

driven by
textual requirements

pick an area for
prototyping and define
speculative ambition
number

inform municipalities
about heat stress
framework

generate design,
'project as prototype'

discuss with
municipalities, infuse
with green expert
knowledge

distill rules/
principles/
heuristics out of design

create new tender
process informed by
new green urban
rules

Opportunity area 4 - abstraction levels

The need for green integration in spatial design at all levels

Spanning across multiple siloed assets within a city, the urban forest needs to be taken into account at all levels of the decision-making process, not just at the end. To be considered, the right information and knowledge must be available and integrated into the different stages of transformation. Quantified performance should marry spatial requirements.

Architecture is in principle a human-centred discipline, providing sheltered divisions between humans and the outside world (Weisser et al., 2022). Within the scope of this project, it was noticed that this anthropocentric perspective inherent to the practice leads to an uneven distribution of attention and detail when it comes to design choices for buildings versus green. In examining the architectural decision-making process it was observed that green space is absent on certain detail levels and falls behind on the granularity of the process for creating urban volumes. The interviews made it clear that this is not necessarily a matter of unwillingness, but rather a lack of necessary information which causes green to be underrepresented in certain stages of design. Among the inevitable compromises that are made within the limited space of the city, the inclusion of green should at least be present in the options. Figure 36 attempts to illustrate this finding in a far from complete way, as it must be noted that it is based on the limited knowledge of the architectural field and is thereby likely to ignore valuable developments and exceptional practice. However, within this limited view, it was seen that green was taken into account in the initial stages of design when determining the number of square metres of public space. To be brought back to the table by landscape architects at the detailing stage to fill the remaining (often reduced) green spaces with specific tree species, similar to the choice of materials for a façade. This was also noticed when green space management was consulted for approval of the design plan in the final stage of the process. They operate at different levels of detail and it is therefore very difficult to integrate their perspective earlier on, as it is seen as limiting creativity and conceptual freedom.

Trees are seen as a material, not as living organisms providing habitat to non-humans and ensuring the human environment is liveable. Given the critical role that urban forests play, they should be entitled to at least as much granular thinking as our man-made infrastructures. To effectively integrate green spaces into the design process, design principles and methodologies should be developed that take into account functionality, adequate space for growth, the dimension of time, and optimal conditions for ecosystem services. To be included in the design process from the outset, not as an afterthought. To be the centre of architectural concepts, just as the animal ambassadors and the alphabetically arranged arboretum were in MVRDV's projects. To intertwine and connect the urban and landscape perspectives, to abolish the division between man and nature, and to take all urban dwellers into account.

A promising example that could extend the current granularity is the development of the new design approach by Weisser et al. (2022). The concept of an 'Ecolope' is proposed, 'a multi-criteria designed building envelope that takes into account the needs of diverse organisms' (ibid.). A way of multi-species design that draws from, but goes beyond current knowledge in architecture, ecology, and computational design.
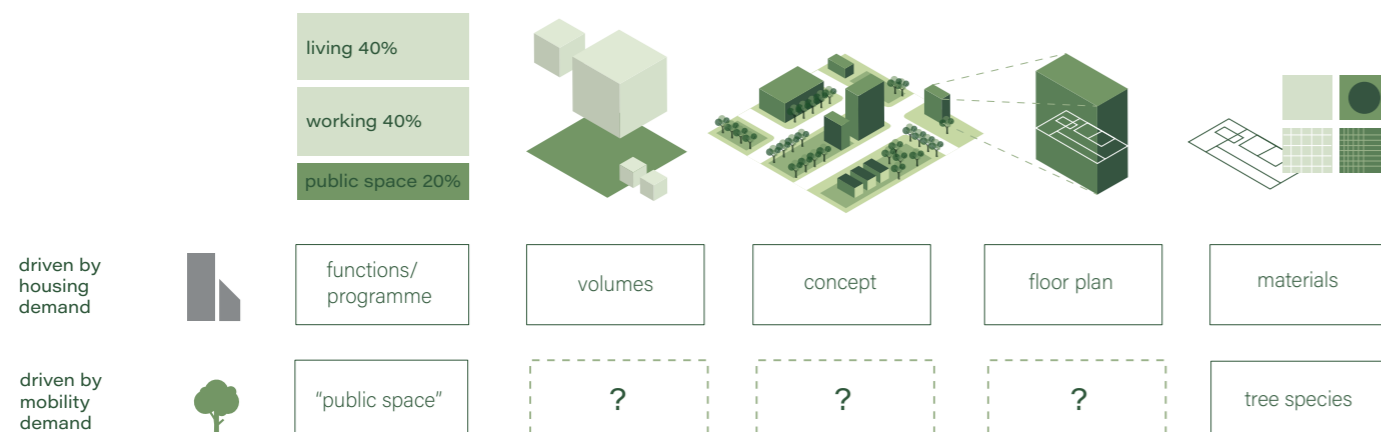

Figure 36. Visualisation of opportunity area 4 - abstraction levels buildings versus green

Opportunity area 5 - decision transparancy

The need to justify decisions to all stakeholders

The urban forest cannot thrive without the care, respect, and involvement of its inhabitants. They should be empowered by explaining decisions, educating about impacts, striving for equity, and providing structures for participation. To blur public and private, human and non-human, individual and collective into shared social narratives.

The i-Tree project is driven by a 'triple helix' consortium (Etzkowitz & Leydesdorff, 1995), consisting of academic, public, and private parties. When initially listing the stakeholders in Part 2, the group did not feel complete. 'Citizens' and 'trees' were added instinctively. Now, towards the end of the project, animals and microbiota would be added on purpose too. Since the urban forest is a multi-species domain, it should be solved from a multi-species perspective. The collaboration should move to a quadruple helix and collectively provide a voice for the environment, making it a quintuple innovation narrative (Carayannis & Campbell, 2009).

Citizens should be allowed to the domain by first of all providing them with information, to justify certain decisions in a quantified way. An example of this could be showing the people of Amsterdam that the elms on the 'Oranjeloper' do not significantly contribute to the ecosystem service provision as the growth places are unsuitable (see Figure 37). Redesigning the site and replanting would allow for a better life for the trees and more substantial benefits.

Another opportunity for a more bottom-up approach to forest management would be to create a kind of 'Wikipedia model' of mapping the private part of the forest and developing a shared narrative with the help of citizen science (Fritz et al., 2019). This could even be supported by a municipal campaign, for example, stressing the shared responsibility for keeping the city breathing.
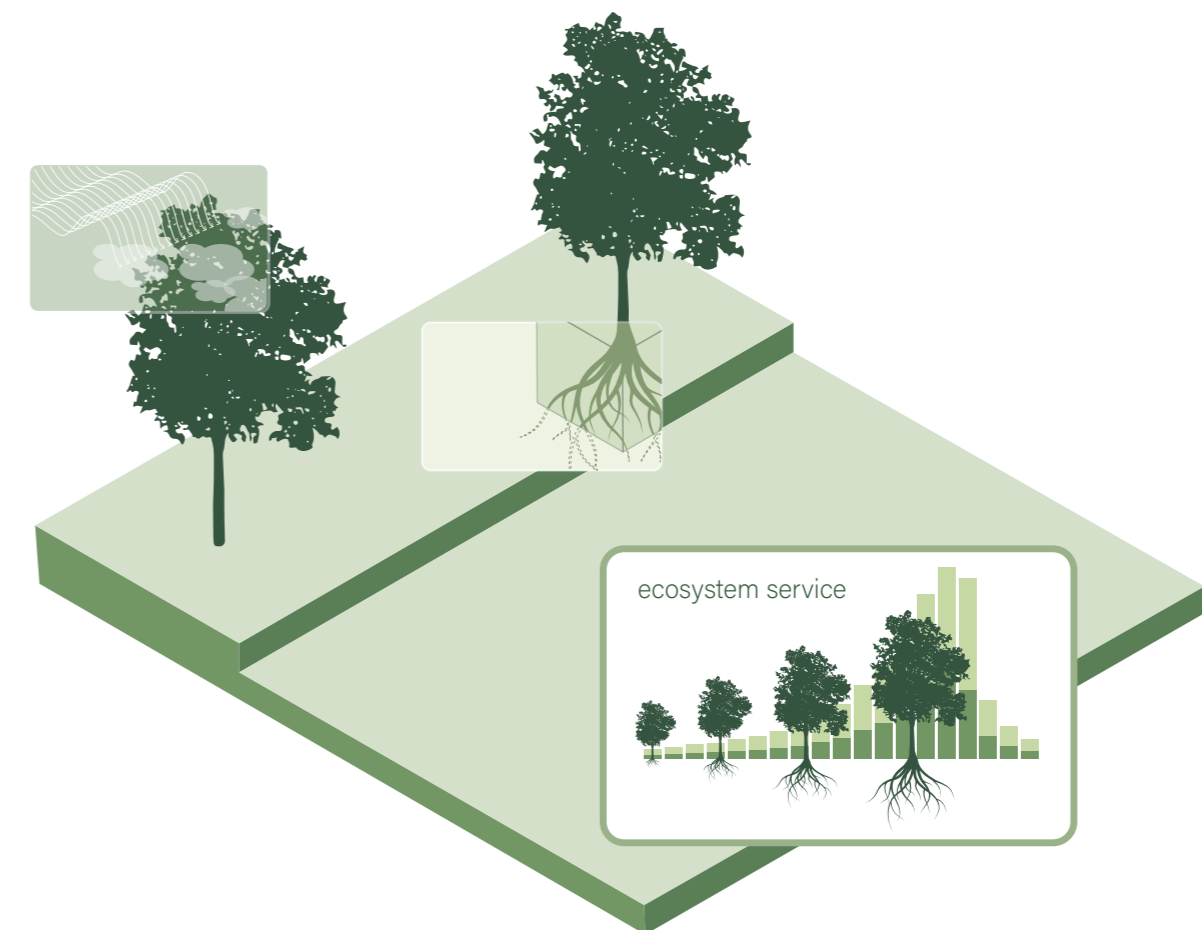

Figure 37. Visualisation of opportunity area 5 - decision transparancy

Concluding summary - choice justification

The first opportunity area of the management dashboard is chosen for further elaboration and concept development based on the following arguments:

- The need for monitoring can be seen as the starting point of a cascade of needs and the dashboard could serve as an input base as concrete rules and guidelines can only be established once the current situation is known in order to set ambitions for improvement;
- The current inappropriate way of incorporating the time dimension of the urban forest is mentioned across domains from the perspective of architects, municipalities and tree nurseries;
- The majority of the city is in the maintenance phase, with only a small proportion in development. Aligning the ambitions of policy and management could potentially generate a large impact;
- Next to reinforcing the connection between green policy and management in collaboration with the tree consultants, there could be opportunities to link other stakeholders such as citizens, by providing insight into the urban forest in their immediate vicinity, tree nurseries, by linking the evolving life cycle of the municipal tree inventory to future supply, and lastly planners and architects, by providing them with new layers of information to incorporate into their design process;
- The current i-Tree tool is for expert-use only and quite hard to interpret due to structural under-investment in the user interface;
- The 'urban rules by design' concept is being advanced within the Marineterrein context by Dr Gül Aktürk, whose expertise is in the architectural domain, in collaboration with MVRDV and other relevant stakeholders. Currently, a mock tender is being prepared, stakeholders in the green domain are providing input, and MVRDV is working on an alternative urban plan. Within the coming months the urban plan and distilled heuristics will co-evolve together in a series of workshops and design sprints;
- Delving into the nursery business would probably not yield the most significant results, and citizen participation will be investigated in the follow-up grant project called 'Roffalab';
- *On a personal note, my hands were itching to start designing and prototyping the management dashboard and wanted to provide the sector with a visual boost.*

In Part 4, the management dashboard will be further explored and developed into a first prototype ready to be tested and iterated together with the stakeholders.
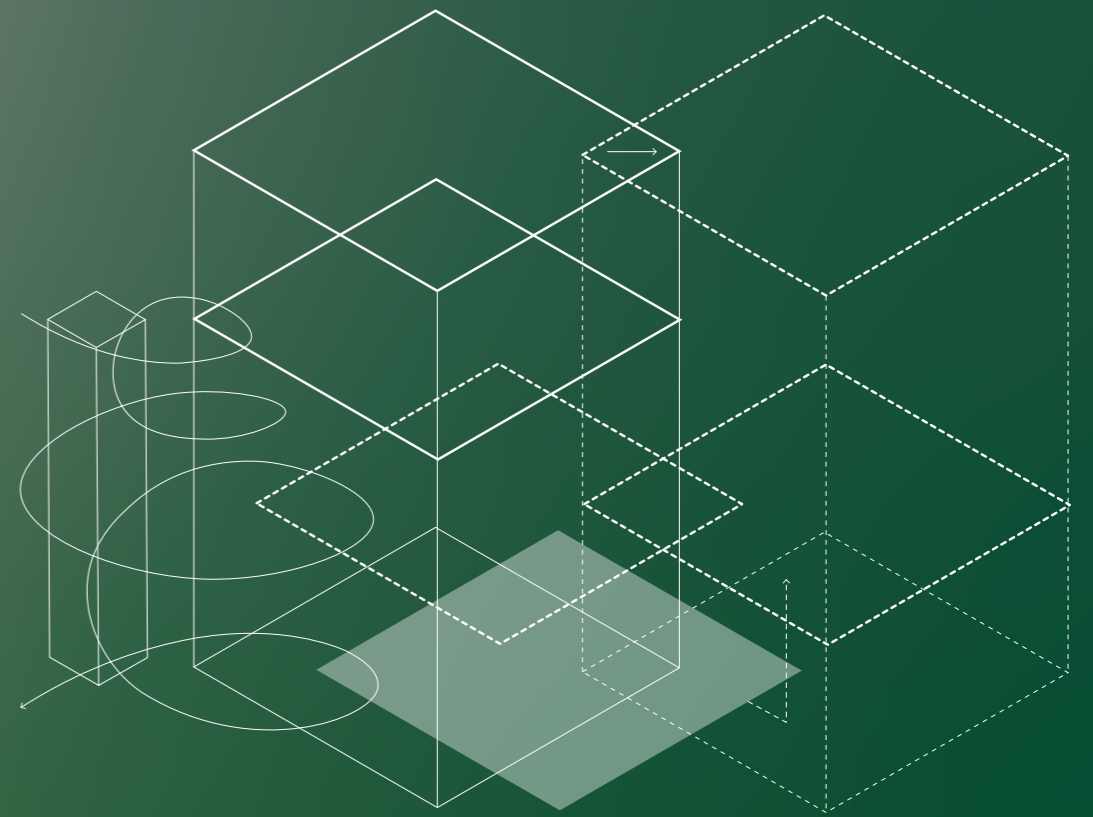
part 4
THE PROPOSITION

The management dashboard created in Opportunity Area 1 is chosen as the final proposition to elaborate on further in Part 4. The rationale behind the dashboard is stated, together with the envisioned users and key elements. The first version of the dashboard is tested with a selected group of stakeholders and the iterated final version is explained in detail by using annotations and presenting the flow of interaction. The part concludes with a timeline of proposition development, illustrating the future potential advancements.

The proposition presented is speculative in nature. It is based on fictional data, optimal growth curves, and independent of morphology, and can be seen as an initial exploration of visualisation and functionality. It is a vehicle for facilitating conversations about the potential format and role of i-Tree, speculating on lines of development and available data. It is a synthesis of the opportunities explored, a stakeholder wish list resolved in a tangible proposal. A first attempt at monitoring that does honour to green critical infrastructure; a proposition in tune with the arborescent rhythm.

As mentioned in the introduction, this thesis started with the elaboration of a paradigm shift in order to define a clear direction of change and calibrate the compass for concept development. While the interviews and stakeholder anecdotes illustrated the mechanisms within the old paradigm, the transitions to the new paradigm are used as an inspiration for the new proposition. The small label next to a title highlights the corresponding transition to show its influence.

Rationale - from static assessment to dynamic portfolio

Currently, i-Tree is used as an instantaneous photograph, a flash of some of the functionality of the tree inventory at that particular moment, presented in a static report whose figures are out of date as soon as the save button is pressed. Trees are dynamic, living organisms and their life cycle must be taken into account. They do not fit into a four-year political cycle, as it takes up to thirty years for their root systems to ground, grow and begin to optimally provide the ecosystem services our urban environments so desperately need. To anchor the urban forest as part of the city's critical infrastructure, it should be mapped, monitored and forecast as such. One proposition to facilitate this repositioning is the Urban Forest Portfolio.

Key users

Recognizing the broken connection between condition creators and condition fulfilers, the Urban Forest Portfolio aims to reunite and bring green space policy and green space management closer together by providing a platform for the creation and monitoring of common targets. This would provide green policy makers with a real-time view of their inventory as a basis for preservation, compensation, and the setting of measurable targets that can be tracked over time. It would shift the logic of tactical green space management from a focus on maintaining visual quality and minimising complaints and disservices to management that prioritises the realisation of functional performance targets and maturity. To facilitate overarching guidance of day-to-day management activities.

The tree consultants could assist in setting up the dashboard based on the available data of a particular municipality and in interpreting the results in policy and management plans.

Key elements of proposition

Based on the conversations, workshop input, and reframing it was decided to present the portfolio of the urban forest in two ways, providing insight into crown volume (indicator) and associated ecosystem services (impact). Crown volume is the foundation for all services, as all performance is related to this metric. Currently, the green sector reports on the number of trees and speaks in terms of square metres of canopy cover. The Urban Forest Portfolio deliberately shifts to a three-dimensional crown volume, which is in line with the current aspirations of the sector but not yet applicable. If the space of the urban forest is to be properly claimed, this third spatial axis is essential.

Looking only at crown volume would be too limited as it does not tell us anything about the resilience, health, and contextuality of the urban forest. Other important factors that influence its performance are species diversity, equitable distribution, connectivity between networks, adequate growth conditions, and proper management. All these parameters will be considered in the proposition, either within the concept or as part of the development timeline.

During the co-design sessions, three crucial functionalities for the dashboard were identified: integrating the time dimension related to the life cycle of the urban forest, incorporating the spatial aspect of the data, and evaluating scenarios. These themes were prominent in all sessions and their application forms the foundation of the Urban Forest Portfolio.

Integrate time dimension   *wood-wide-web*

The basis of the dashboard is a circular graph showing an indicator (crown volume) or impact (ecosystem service) in relation to the age classes of the urban forest. A 100-year cycle was selected and divided into 10 classes, according to Pretzsch et al. (2021). Currently, half of all urban trees do not reach 10 years of age (Dark Matter Labs, 2020), and the average age of trees in the consortium's municipalities is around 30 years. While a target of 100 years may not yet be achievable (except for monumental trees), this should be the new ambition, looking at the optimum of functional performance in the 70-80 age range.

By linking crown volume to age, the dashboard is able to take into account the natural growth and life cycle of trees to forecast the future of the portfolio (see Figure 38). By incorporating specific growth curves, replanting and mortality rates, and considering risks from pests, diseases, and other environmental factors, the dashboard can provide a more accurate understanding of the influx and efflux of the inventory.

For ecosystem services, this representation can visually emphasise the exponential increase in performance with age, showing that the majority of an ecosystem service is provided by the mature part of the inventory.

Spatialise data   *wood-wide-web*

Currently, the ecosystem service data presented in an i-Tree assessment is not spatialised. The service tables do not speak the same language as the planning maps. Figures are provided on how many kilograms of carbon are sequestered and stored, how many pollutants are filtered, and how many cubic metres of water are retained, but this data is not visualised in relation to the spatial context. In order to design and plan for functional performance, services need a spatial component that indicates the location of cooling, retention and filtering.

Also, in terms of claiming space for green, the invisible envelope above and below ground should be considered over time to define the boundaries that cannot be touched based on current and future conditions. The three-dimensional metric of crown volume is therefore used as a first step in this direction.

Evaluate scenarios   *collective benefits*

So far, the focus has been on how the dashboard can track the progress of the urban forest portfolio in terms of crown volume and ecosystem services over time and in relation to space. However, the inventory is in constant flux, not only due to relatively incremental mortality and replanting rates, but more significantly, during transformations. The green sector needs a tool to compare the pre-transformation baseline with the post-transformation scenario in terms of crown volume and ecosystem services. Both scenarios should be evaluated against each other to determine the consequences of the intervention and the time needed to either return to or exceed the baseline. These evaluations can provide a concrete argument for decision-makers to continue or halt interventions in the existing urban forest, and help to communicate about it.

The dashboard therefore has a monitor side to examine the existing portfolio and potential for growth and to track progress towards targets, and a transform side to evaluate and compare different scenarios for transformation, but potentially also for proposed new targets or climate models.
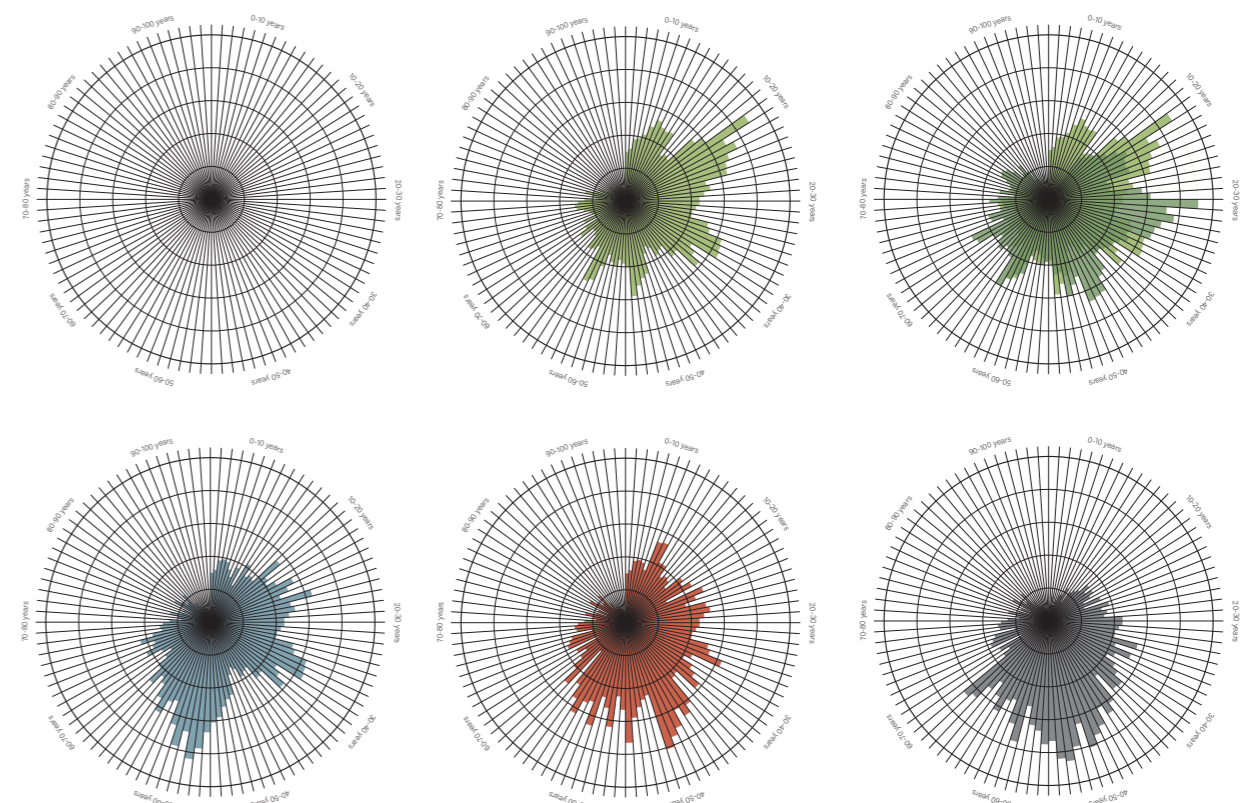

Figure 38. Crown volume growth over ten years time, water retention, pollutants filtering, and carbon sequestration related to age
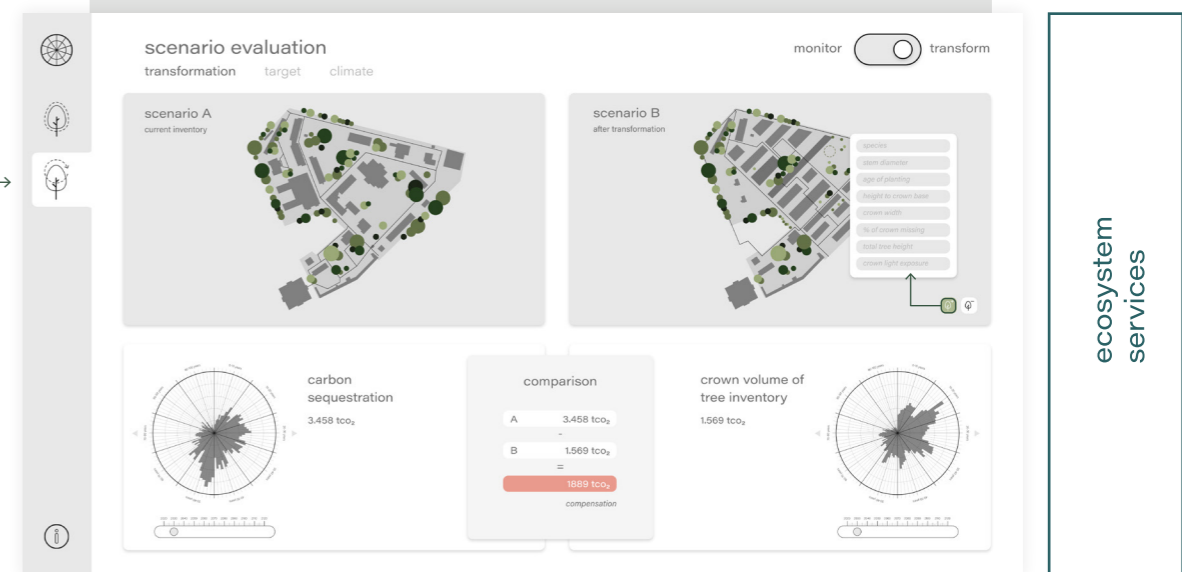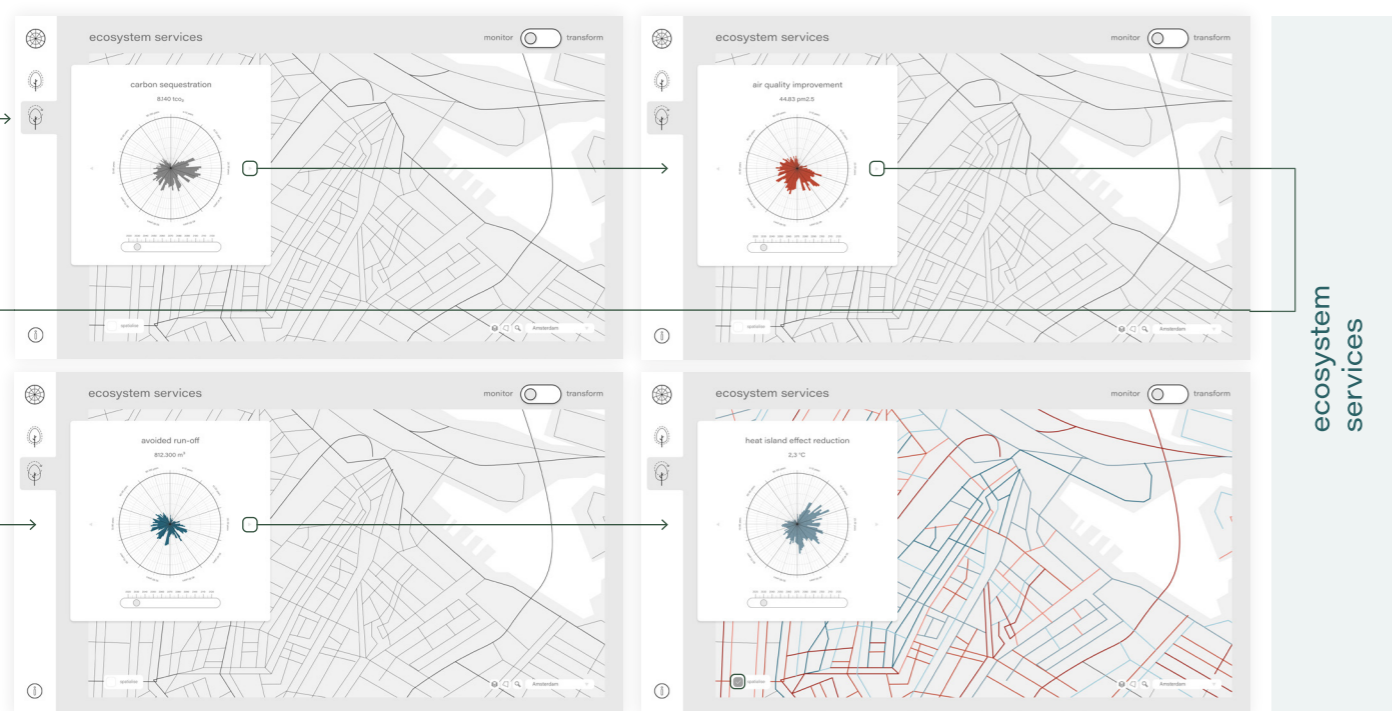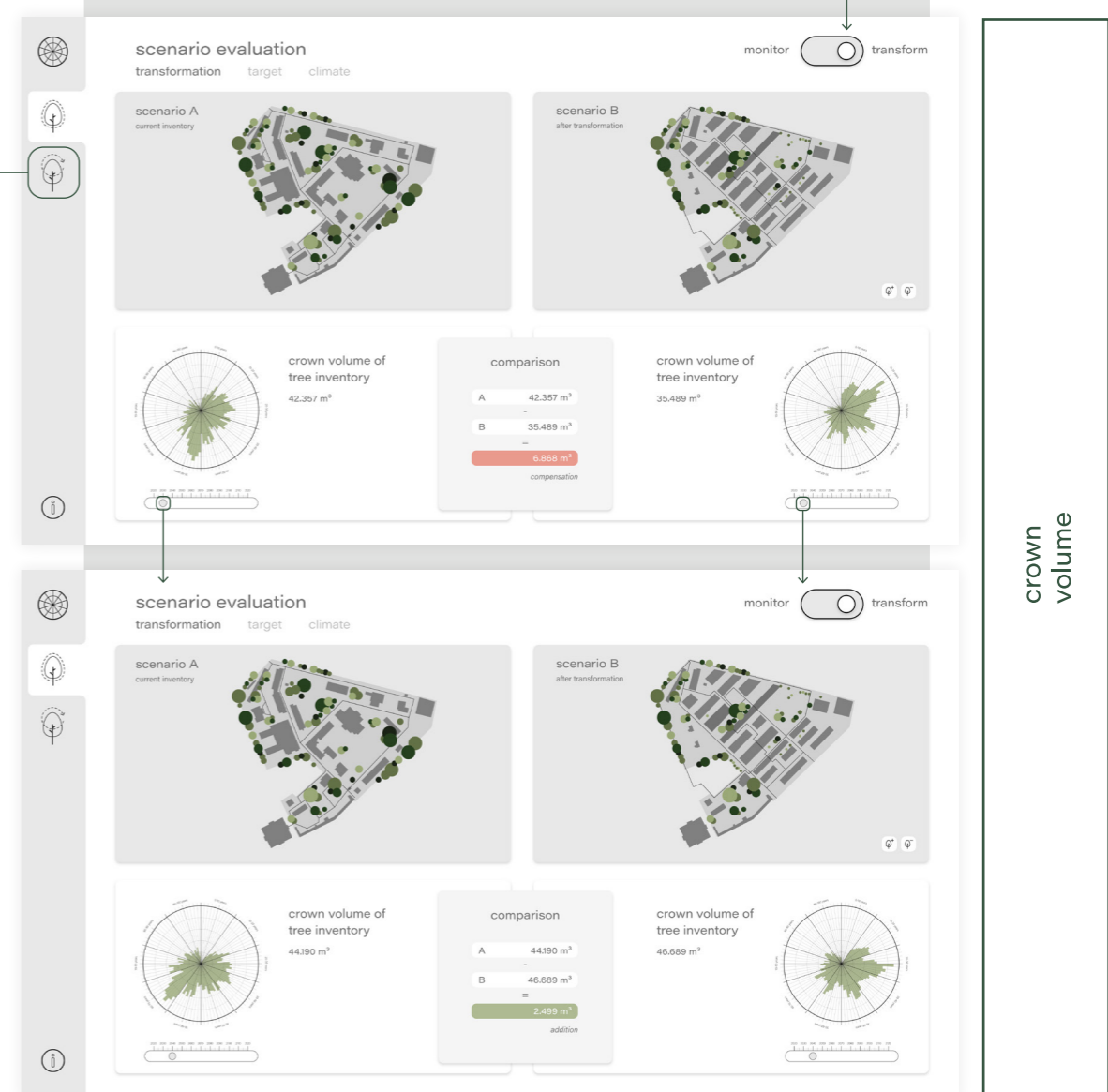
Urban Forest Portfolio - first prototype

The following section presents the first version of the dashboard with fictional data, highlighting both the monitoring and transformation functionality and the flow between the wireframes . The diversity of the inventory and the spatial distribution of the 16-year-old crown volume are visualised (Gemeente Amsterdam, 2020). The ecosystem services shown are limited to those that can be quantified with i-Tree, supplemented by the reduction of the heat island effect, as this service is the main focus and is currently being developed as part of the i-Tree 2.0-NL project.

The scenario evaluation uses the transformation of the Marineterrein Amsterdam (2021) as a case study, comparing the relatively mature crown volume before the intervention to the younger stock after the intervention in 2030 and 2040. A comparison between the two scenarios is shown, highlighting the need for compensation or supplementation. The same approach is used to assess ecosystem services, specifically comparing the carbon sequestration between the two scenarios. The input parameters of i-Tree can be used to add or remove trees from the plan.

Figure 39 gives an impression of the design process of the Portfolio, followed by an overview of the wireframes and interaction flow of the first version of the dashboard on the next page in Figure 40.

Figure 39. A look into the design process of the first version of the dashboard

Figure 40. Overview of wireframes and flow Urban Forest Portfolio - first prototype

Proposition testing - first prototype

Discussed with	When
Wendy Batenburg (Terra Nostra)	12 January 2023 and 7 February 2023
Fons van Kuik (Cobra)	12 January 2023
Robbert Snep (WUR)	23 January 2023
Cecil Konijnendijk (WUR)	26 January 2023
Henk Langeveld + Wieteke de Boer (municipality of Groningen)	13 February 2023
Jeroen van Gaalen (municipality of Utrecht)	15 February 2023
Hans Kaljee + Emma Reeskamp (municipality of Amsterdam)	17 February 2023

Table 8. Stakeholders asked to test proposition

The proposition was tested with a selected group of stakeholders (as listed in Table 8). For most of these stakeholders, the test was a follow-up to previous interviews and interactions, so only a brief update was required as they were already familiar with the project. The first round of testing was deliberately scheduled with tree consultants and urban forestry experts as they already had some level of experience with the i-Tree software. It was felt that this would make it easier for them to suggest improvements and fill in any gaps. Based on their feedback, the dashboard was iterated and presented to the municipal officers.

During the tests, the dashboard and its various functionalities were demonstrated and feedback was asked for. This feedback is divided into signals of traction and signals for improvement. The selected traction signals are used to assess whether the dashboard meets the needs of the stakeholders, can be produced using (the next generation of) the i-Tree software, is ultimately capable of generating change in the system and has long-term potential. The signals for improvement were taken into account and either incorporated into the next iteration of the dashboard, added to the development timeline, or deliberately excluded due to their level of importance and limited resources.

Signals of traction

Confirmed need

The decision to continue with the dashboard was confirmed. The tree experts and consultants recognised an urgent need for monitoring when talking to municipalities about their green policies and management.

"I have been to many municipalities to talk about urban forest masterplans and there is a real need to have easily interpretable, real-time information, and relate ecosystem services to the future. To see if we are going to do an intervention, what are the consequences? And how long will it take us to get back to our initial level? In doing that, this is very, very helpful"

"I recognise a lot of questions from councils that I could answer with this and the way it is visualised, great if we could use something like this in the future"

"The transform side, the scenario concept of the dashboard, is very good. This is what Alphen aan de Rijn wants to see, I think this is a useful approach and very intuitive for people to use"

"Very useful for green policy-makers and green planners, but also for strategic green space managers as an overarching guidance on daily management. Maybe even people that have to do with social inequality."

"Tree managers are working on a practical level, but often want something visual, something that summarizes and is easily conveyed to policy makers and aldermen, especially visual"

The chosen functionalities and metrics also resonate with the future ambitions of the tree consultants in relation to the use of i-Tree.

In one of the discussions, the Oranjeloper project in Amsterdam was mentioned as a good opportunity to apply the dashboard directly, demonstrating the first signs of feasibility of the proposed functions.

Finally, signals for the proposition's longevity were found in suggestions to embed the dashboard in urban forestry master plans and eventually in municipal planning systems.

Potential advancements focused either on adding more information about the urban forest that was not already included in the dashboard, or on suggesting improvements to certain aspects of the visualisations.

They asked about how the growth location and specific positioning of trees were taken into account, and what the location-specific contribution of the ecosystem services was, as spatial pattern plays a significant role in determining benefits.

One stakeholder also raised the issue of the ambitious one hundred year lifespan and expressed concern about the simplified nature of the inventory visualisation. Some were also afraid the graph would be hard to interpret without context.

Only the quantified ecosystem services were currently considered and it was suggested that the qualitative aspect of the story be included to provide a broader perspective beyond the monetary side.

Lastly, it was suggested to incorporate different scales into the maps and to consider how the dashboard would appear at the municipal, area, and asset levels, as they represent the different types of transformations mentioned earlier.

Resonating functionalities

"The dashboard is the right choice, if we could really compare scenarios based on indicators, climate models, and ambitions that would be great as an end result"

"We want to introduce i-Tree to reach targets, use it as a monitoring instrument, as a scenario instrument"

"We definitely want to move to crown volume, we discussed this with platform i-Tree, we all agreed that it is a pity it is not yet in i-Tree"

Concrete opportunity for application

"I think it perfectly fits within the Oranjeloper project in Amsterdam, but we will certainly not have the data ready for the end of February. Would be a good next step to replace the fictional data with the data of the Oranjeloper project"

Connection to broader ecosystem

"This dashboard could facilitate a connection between policy and management and could be part of the urban forestry masterplans, steering on KPIs"

"Focusing on collaboration with tree consultants is a good idea, they are perhaps the ones who will develop it further as they have a lot of capacity. They could add for example the 3-30-300 rule as layers, and suddenly you have everything linked in a system, even more so if you would link it to other municipal systems such as the planning system"
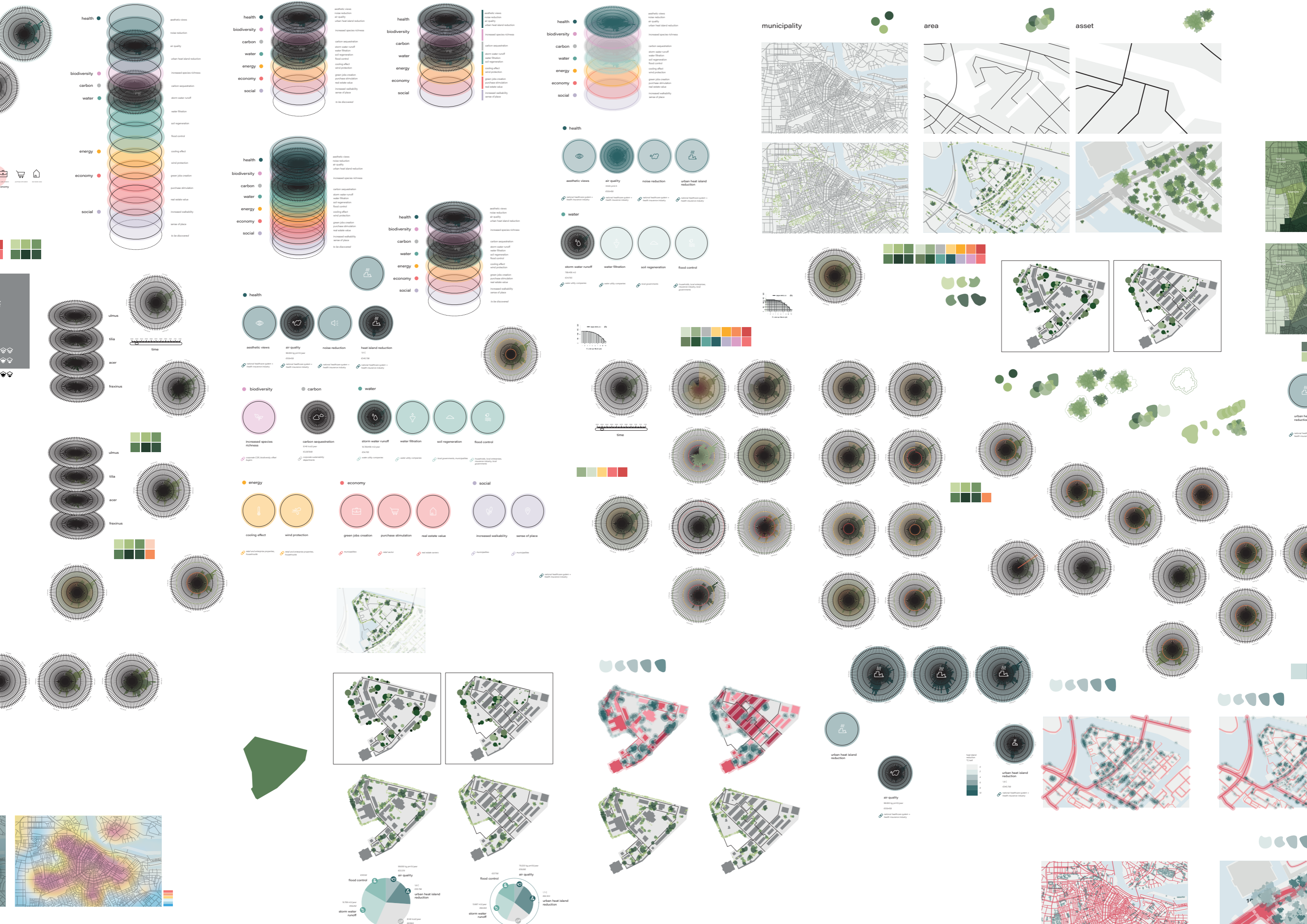
Signals for improvement

"Green is a means, not an end. Can you translate crown volume 1 on 1 to policy targets for liveable cities? For social cohesion and mental health, is that a causal relationship? In terms of water interception, what is the need in a certain area? Which rain shower do you want to intercept? How is the water interception in this area and where do you need the trees the most? Same for cooling, walking/biking routes should be included, should be placed in spatial context"

"You chose 0 to 100 years, the average of urban trees is 30-40 years, then they leave again, it is very fictional. In practice, trees are continuously removed and planted, this looks like a tree inventory assumed to be constant ... but I agree with you on the message"

"For example, the other one where you had Amsterdam, the monitor side, for people who have the expertise they understand that, for policymakers, it is less understandable. For tree managers, you do have an idea of okay, we have to be careful because we have an uneven distribution of trees, but this is a little less intuitive for policymakers."

"Does not say anything about ambitions yet, not knowing how we are doing at the moment, make it clear which areas on the map are most far off, maybe use colours"

The next section shows the iterated version of the Urban Forest Portfolio with an explanation of each update. The iterations were driven by a combination of recommended improvements and an attempt to embody the envisioned new paradigm in a more conspicuous way.

municipality   area   asset

health
biodiversity
carbon
water
energy
economy
social

aesthetic views
noise reduction
air quality
urban heat island reduction

increased species richness

carbon sequestration

storm water runoff
water filtration
soil regeneration
flood control

cooling effect
wind protection

green jobs creation
purchase stimulation
real estate value

increased walkability
sense of place

to be discovered

ulmus
tilia
acer
fraxinus

time

health
aesthetic views · air quality · noise reduction · urban heat island reduction

biodiversity
increased species richness

carbon
carbon sequestration

water
storm water runoff · water filtration · soil regeneration · flood control

energy
cooling effect · wind protection

economy
green jobs creation · purchase stimulation · real estate value

social
increased walkability · sense of place

Urban Forest Portfolio - iterated version

The overview of Figure 41 shows the wireframes of the Urban Forest Portfolio and the flow of interaction between them. The following section provides a walkthrough, highlighting the layouts, concepts and changes.
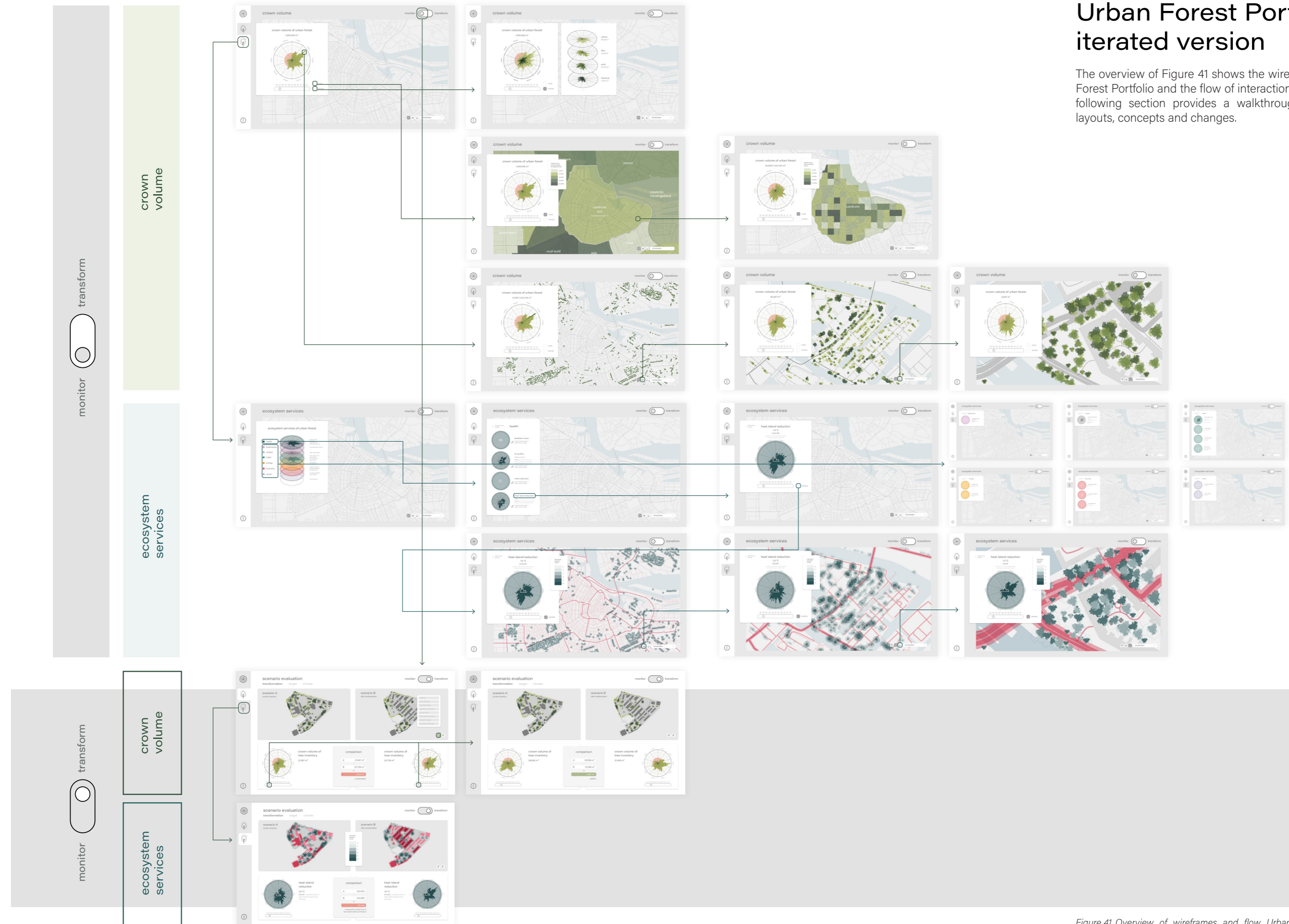
Figure 41. Overview of wireframes and flow Urban Forest Portfolio - iterated vesion
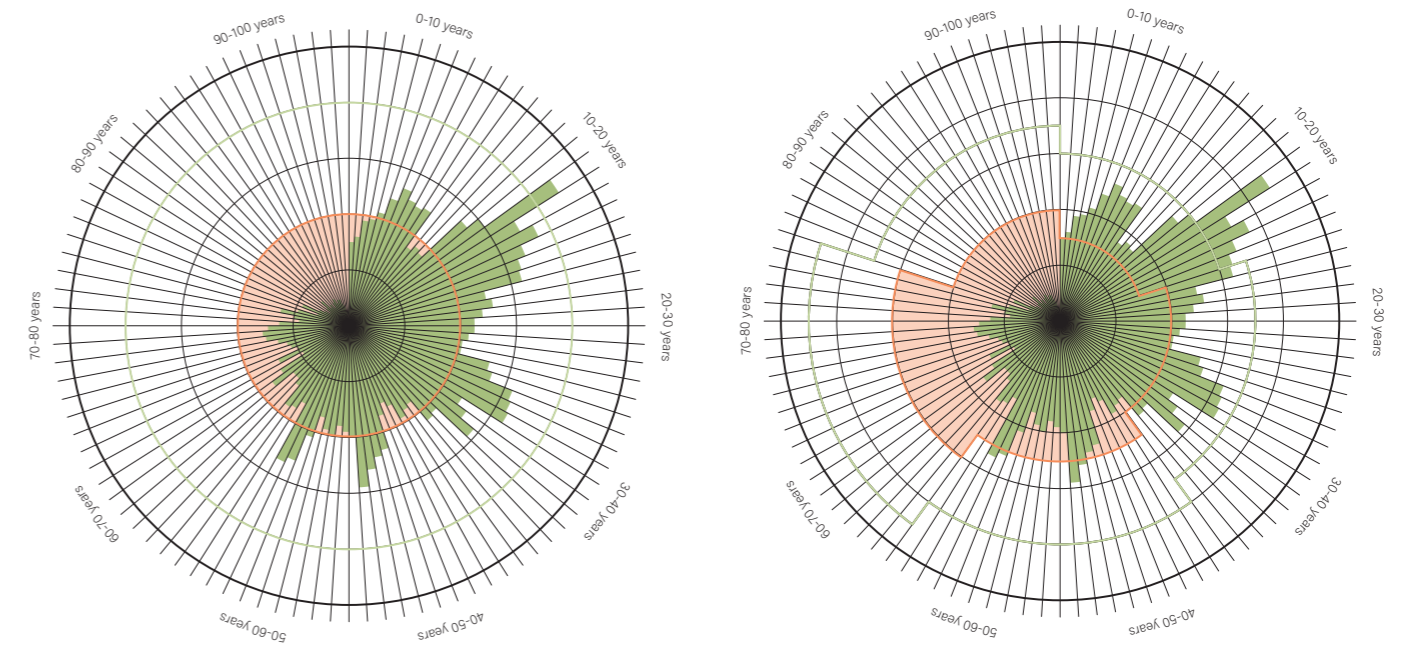
Targets and ambitions

The graph now includes targets to give more context to the data. In the example, a target is set for a uniform distribution of crown volume across different age classes of the inventory. In practice, the target would be more like a helix shape, as the mature part (60-80 years) of the inventory should be proportionally larger (see Figure 42). These targets can be set manually and can be based on established principles, such as the derivation of the 3-30-300 rule (Konijnendijk, 2021).

For diversity, targets can be set such as the 10-20-30 rule (Kendal et al., 2014), which states that no more than 10% of a particular species, 20% of a genus, or 30% of a family should be found in a municipal forest. In addition, new targets can be proposed, such as a constant stock of urban trees between 50 and 100 years old, or a fixed ratio between age classes.

Figure 42. Urban Forest Portfolio - diversity of inventory and target setting
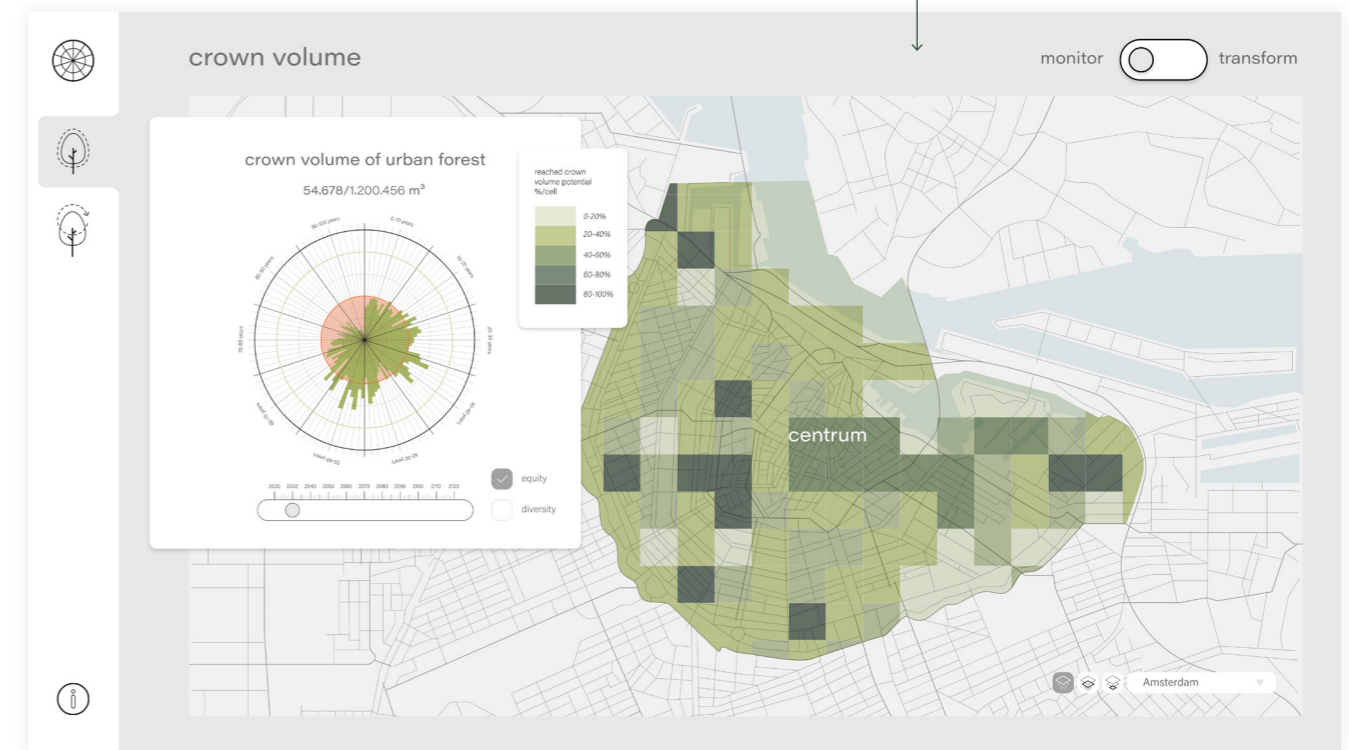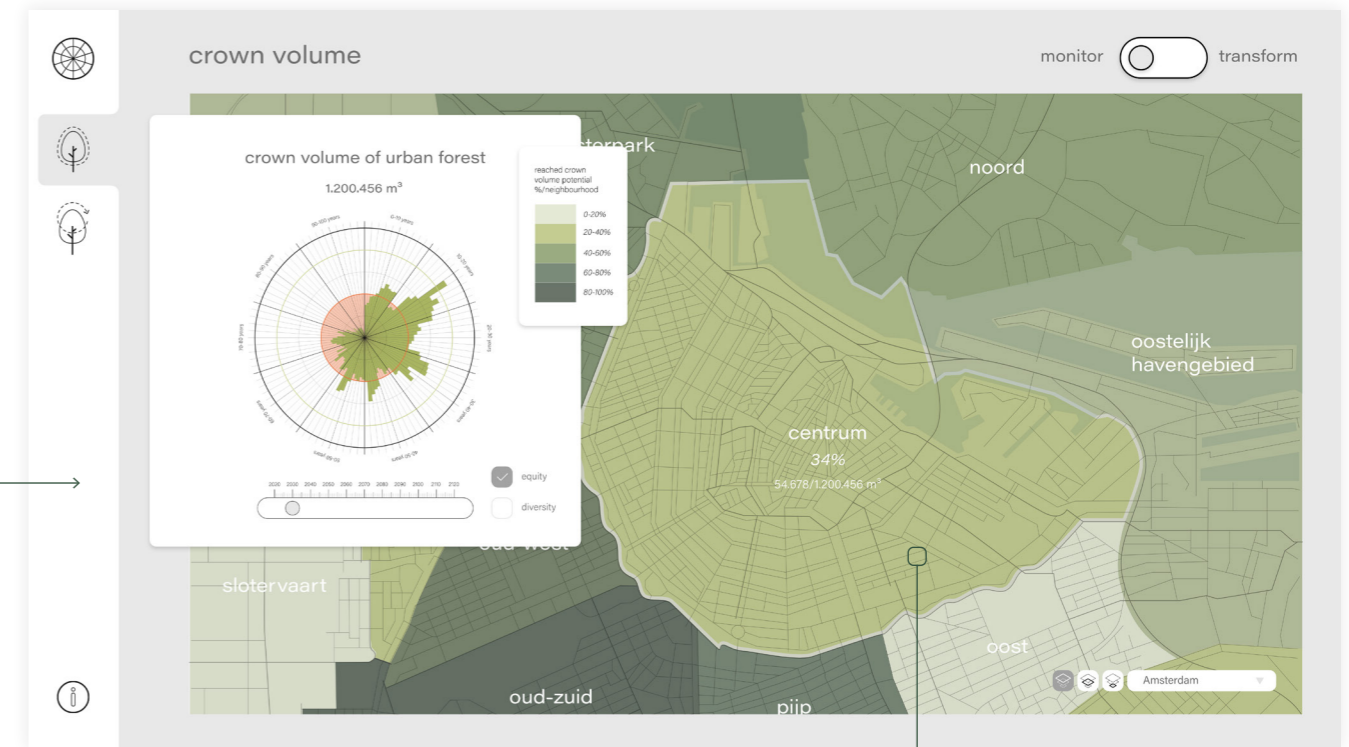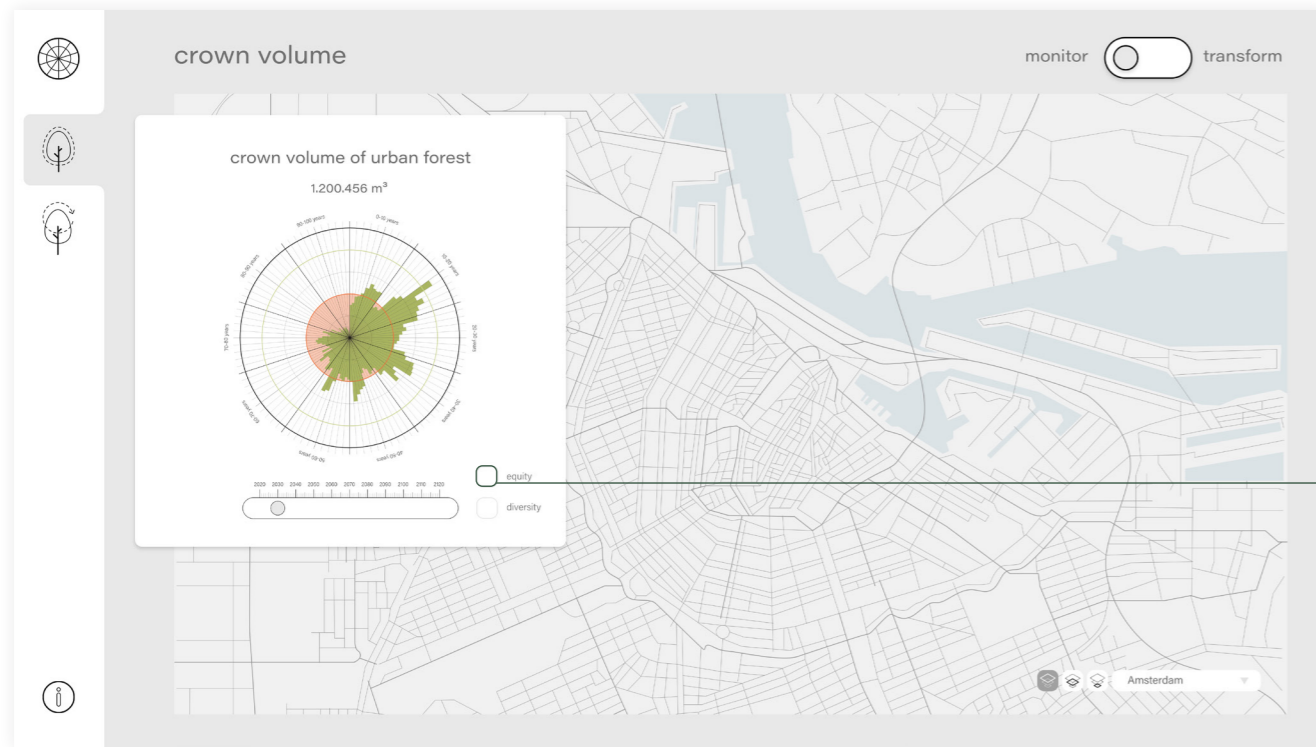
Equity and the potential for green

spatial solidarity

Inspired by the transition towards spatial solidarity and the growing importance of the issue, the functionality of displaying tree equity has been added (see Figure 43). The distribution of the total crown volume in the municipality is shown at the neighbourhood level, revealing which areas of the city require the most attention. By zooming in, a particular neighbourhood can be divided into cells of manually adjustable size, providing a more detailed understanding of the dispersal. To illustrate equity, percentages of crown volume potential achieved are chosen, inspired by the Birmingham Urban Forestry Masterplan (Birmingham City Council et al., 2021) and the Forestami project in Milan (Forestami, 2020). It is crucial to define what is meant by 'crown volume potential,' which could be an initial rough estimate based on aerial data analysis and current land use, and refined over time.

Figure 43. Urban Forest Portfolio - equity and potential for green
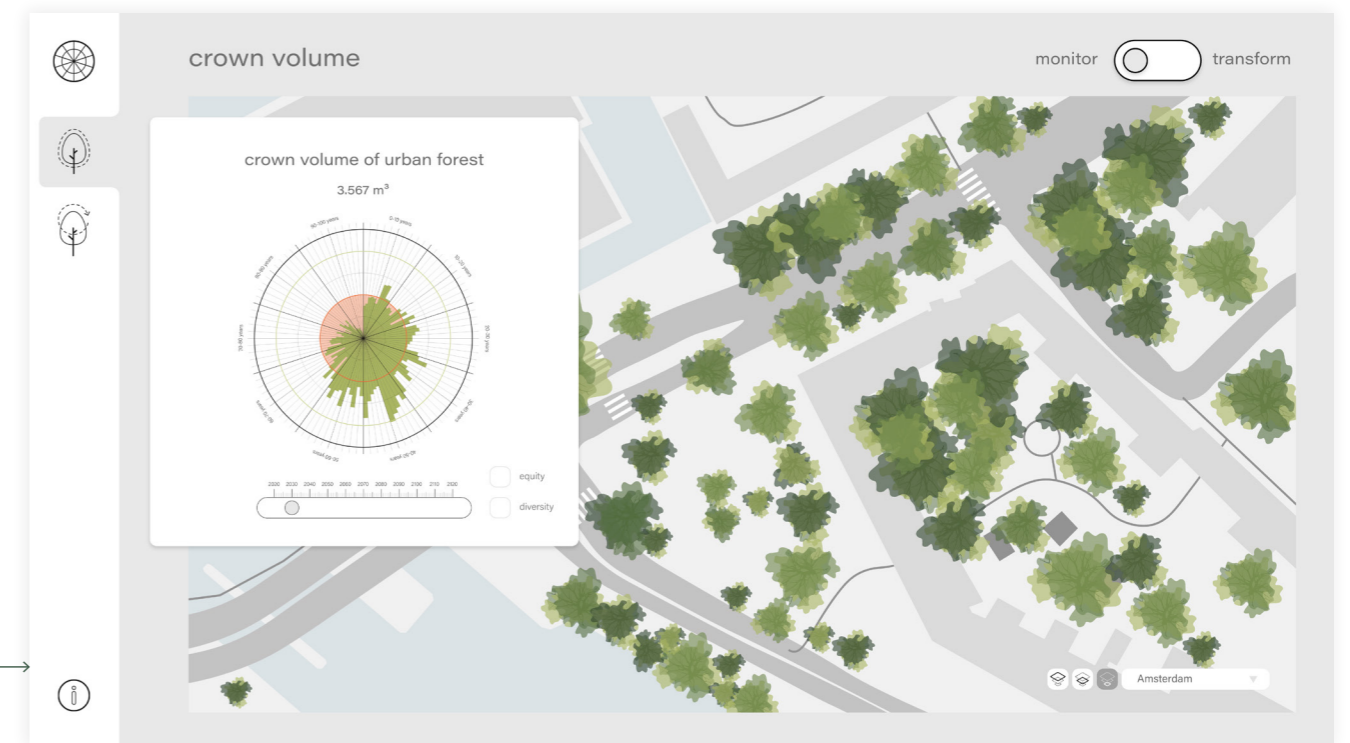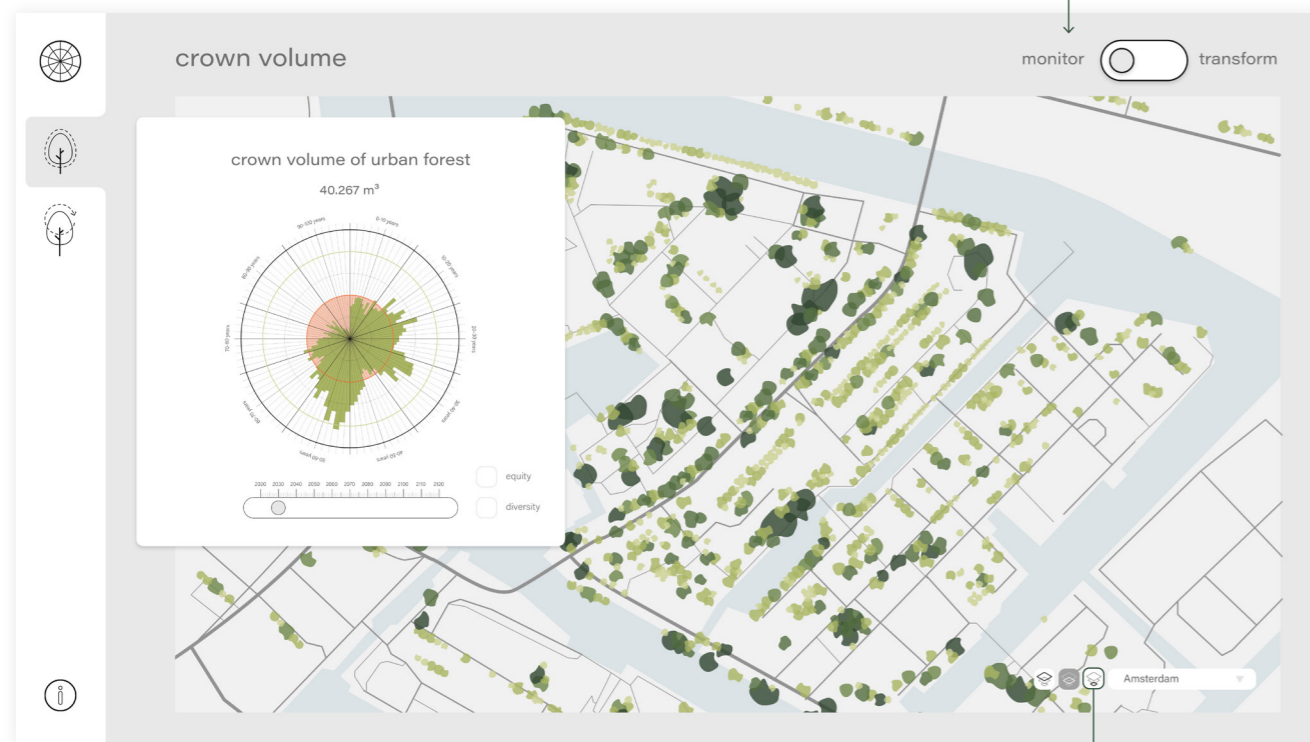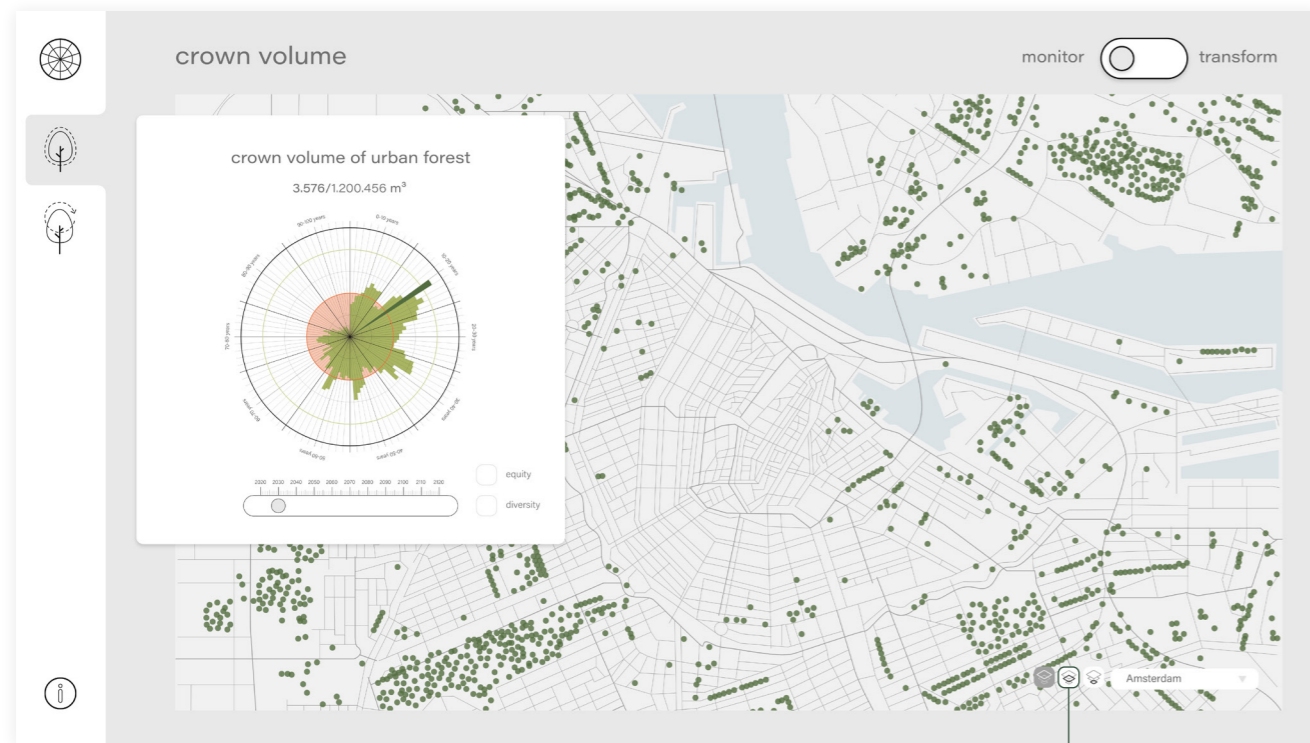
Scale levels and granularity

Within the dashboard, there are three different levels of scale: municipal level, area level, and asset level (see Figure 44). The granularity of the trees displayed on the maps increases by moving to a more detailed level of scale; from dots to rough shapes to corresponding silhouettes.

municipality

area

asset

Figure 44. Urban Forest Portfolio - scale levels and granularity

Quantitative and qualitative argument

The initial version of the dashboard only showed the quantified ecosystem services provided by i-Tree. During the presentation of these wireframes, a sense of injustice was experienced, as it failed to do right and fully showcase the multi-functional potential of urban trees. In response to this, and a suggestion from one of the stakeholders to include the qualitative aspects, an updated version was created, starting with a list of all currently recognised ecosystem services based on the Trees As Infrastructure project by Dark Matter Labs & Lucidminds (2021), showed in Figure 45. Seventeen ecosystem services have been categorised into seven domains and each is visualised using the same format. A graph is shown when quantifiable data is available. It is a matter of time to get up to speed with all of them and for most of the other services to be measured and financialised. However, some services may never be fit for quantification and new ones may be discovered in the future. The absence of data from an anthropocentric perspective does not mean that the trees are not currently providing these services.

The rich and righteous story of the urban forest needs to be told forcefully to overwrite the current narrative, which focuses solely on ornamentation and aesthetics.
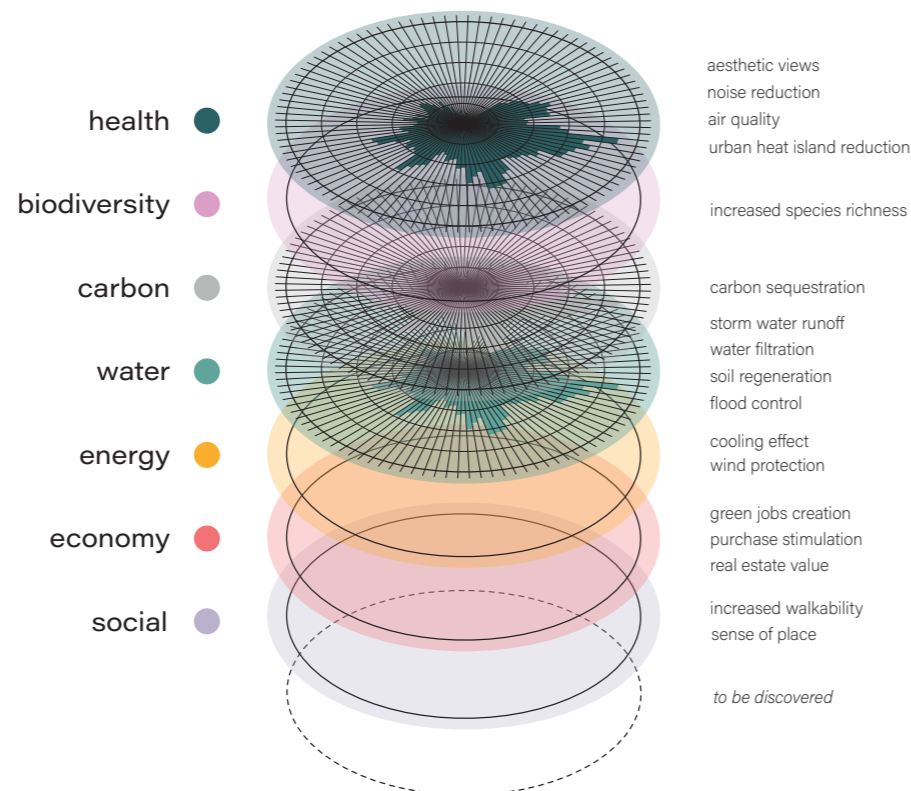
Beneficiaries and contextualised money

In this new narrative, the municipality is not the only protagonist to carry the financial weight, as the multiple beneficiaries are all given a role to show the interdependence of the urban forest and the collective responsibility. The monetary aspect is deliberately included, as it is currently unavoidable in order to effectively resonate with the language of power, but the money is contextualised in terms of avoided costs (see Figure 46 for the overview).

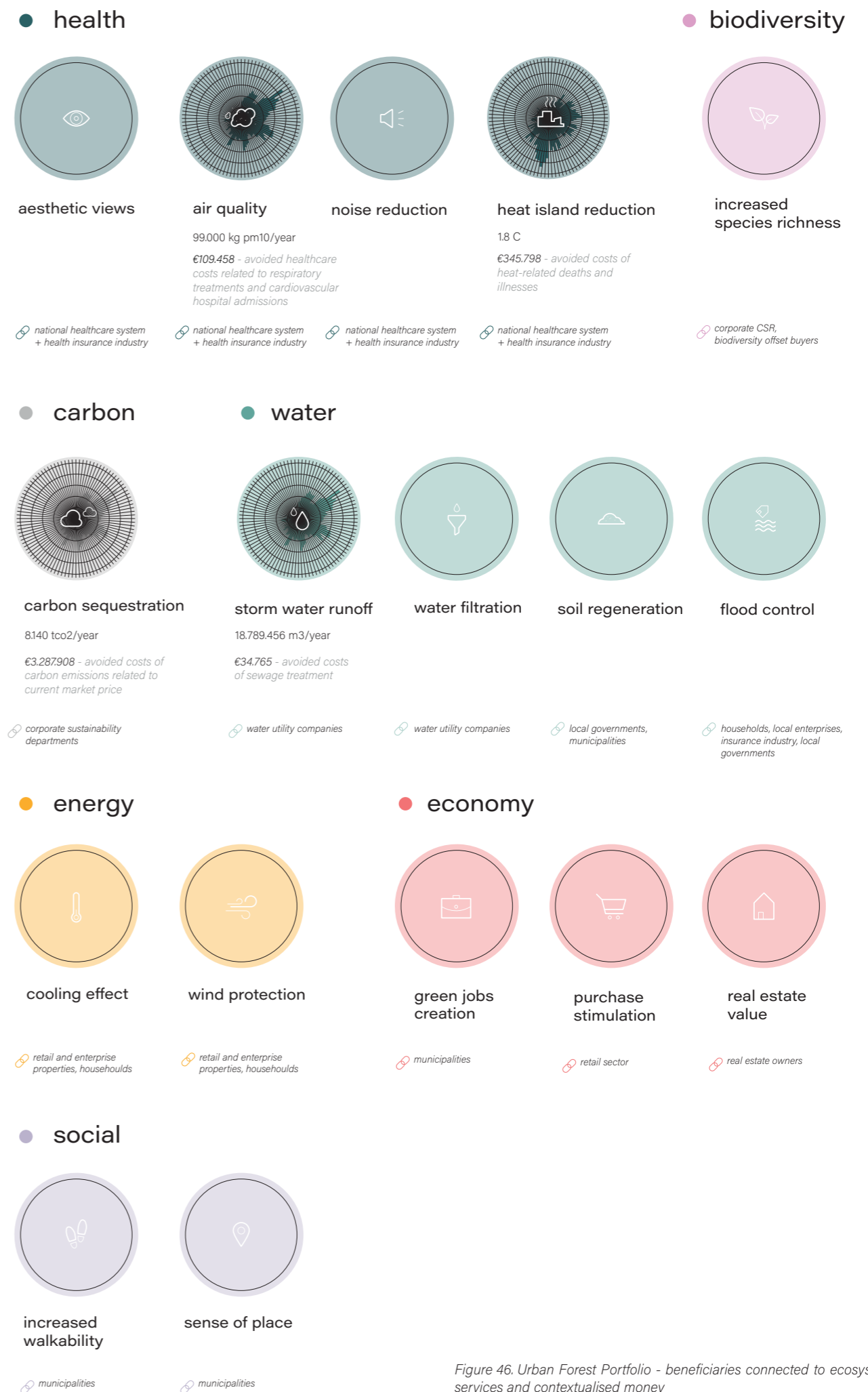This expanded ecosystem service narrative is shown in the dashboard in Figure 47 on the next page.

Figure 45. Urban Forest Portfolio - ecosystem services

health

aesthetic views

air quality
99.000 kg pm10/year
€109.458 - avoided healthcare costs related to respiratory treatments and cardiovascular hospital admissions

noise reduction

heat island reduction
1.8 C
€345.798 - avoided costs of heat-related deaths and illnesses

national healthcare system + health insurance industry

national healthcare system + health insurance industry

national healthcare system + health insurance industry

national healthcare system + health insurance industry

biodiversity

increased species richness

corporate CSR, biodiversity offset buyers

carbon

carbon sequestration
8.140 tco2/year
€3.287.908 - avoided costs of carbon emissions related to current market price

corporate sustainability departments

water

storm water runoff
18.789.456 m3/year
€34.765 - avoided costs of sewage treatment

water filtration

soil regeneration

flood control

water utility companies

water utility companies

local governments, municipalities

households, local enterprises, insurance industry, local governments

energy

cooling effect

wind protection

retail and enterprise properties, households

retail and enterprise properties, households

economy

green jobs creation

purchase stimulation

real estate value

municipalities

retail sector

real estate owners

social

increased walkability

sense of place

municipalities

municipalities

Figure 46. Urban Forest Portfolio - beneficiaries connected to ecosystem services and contextualised money

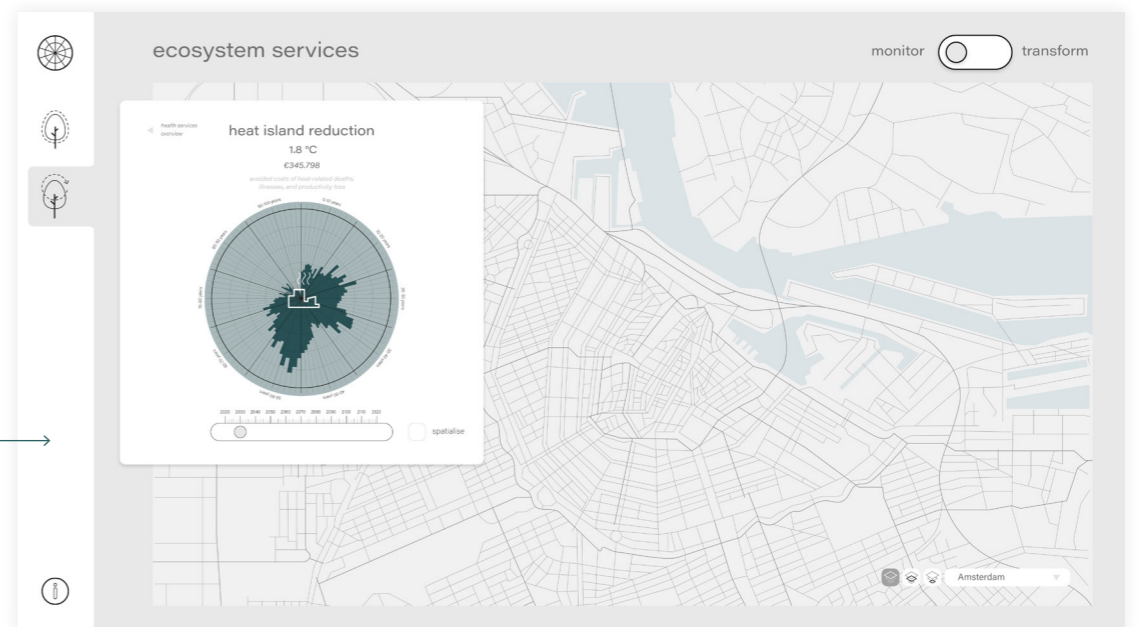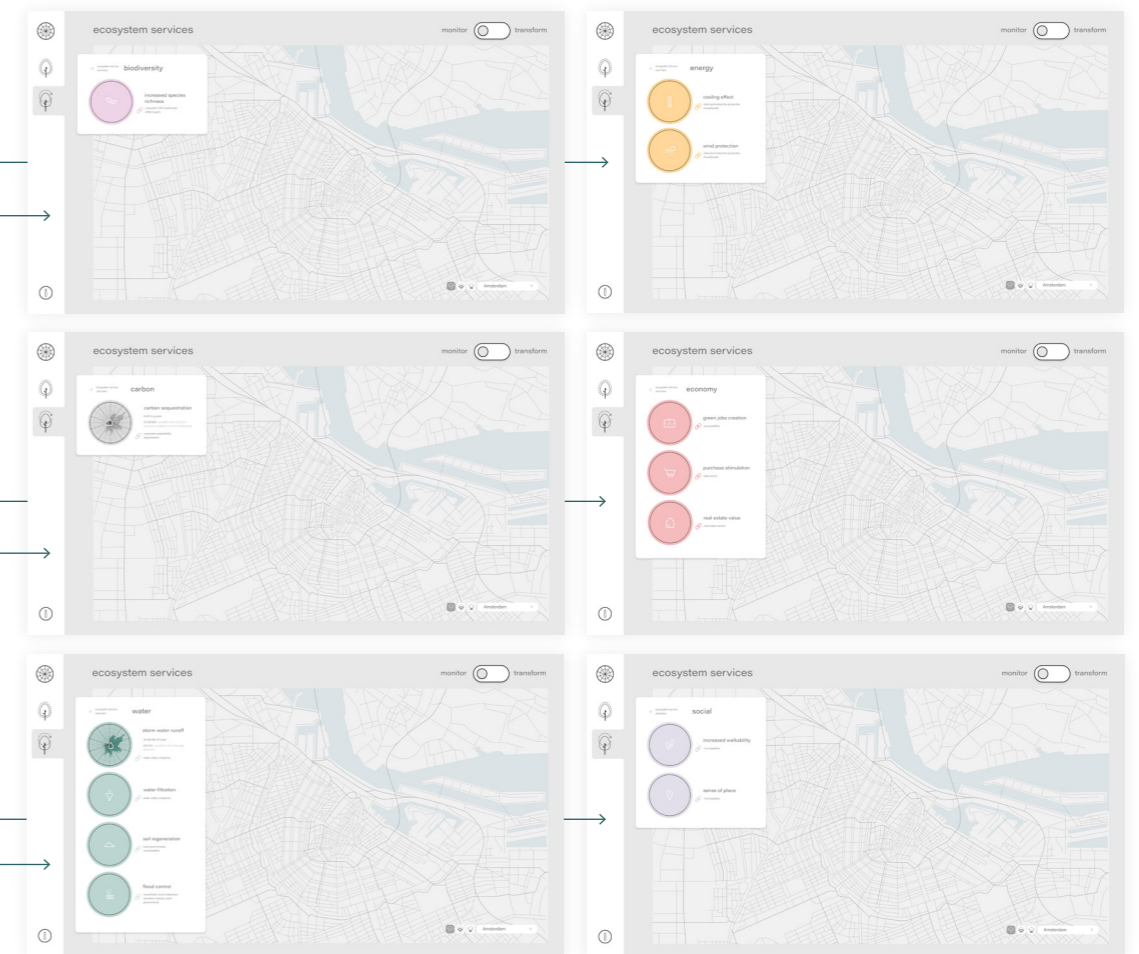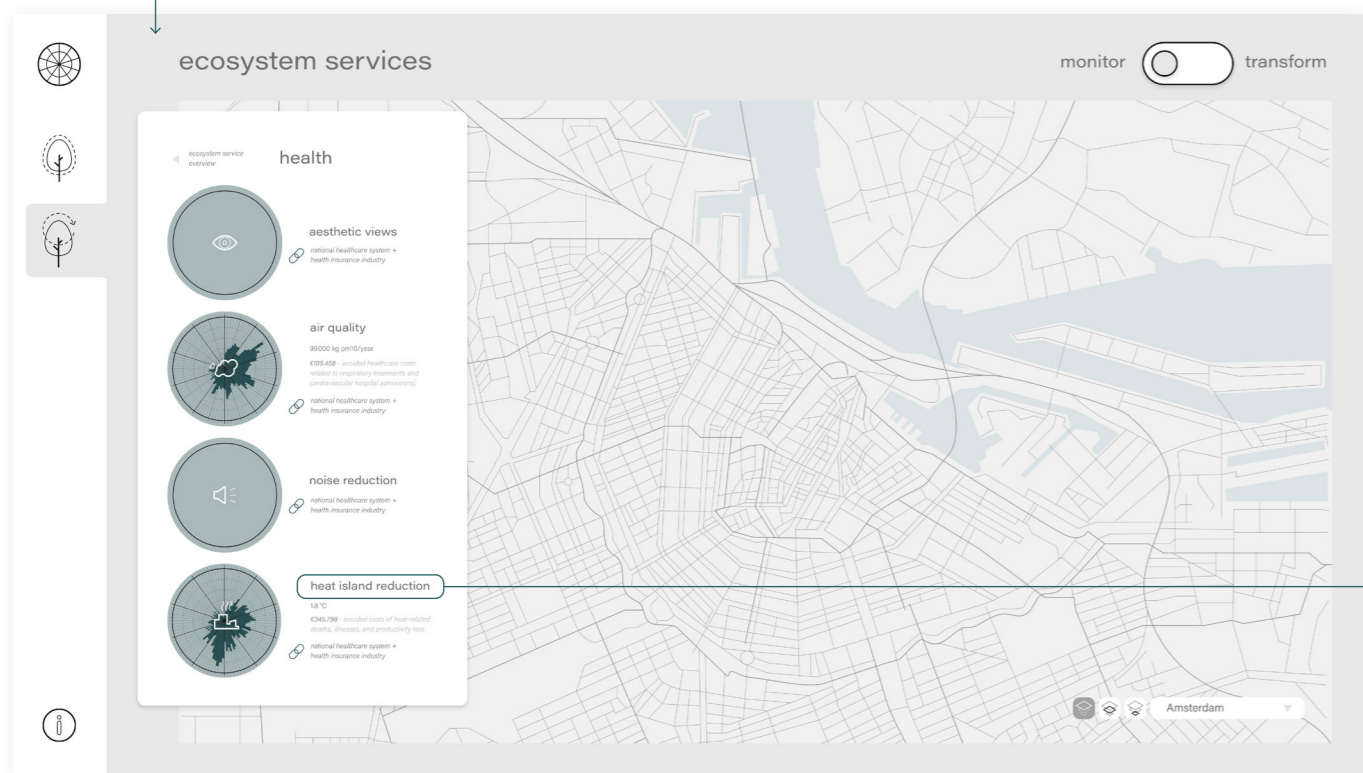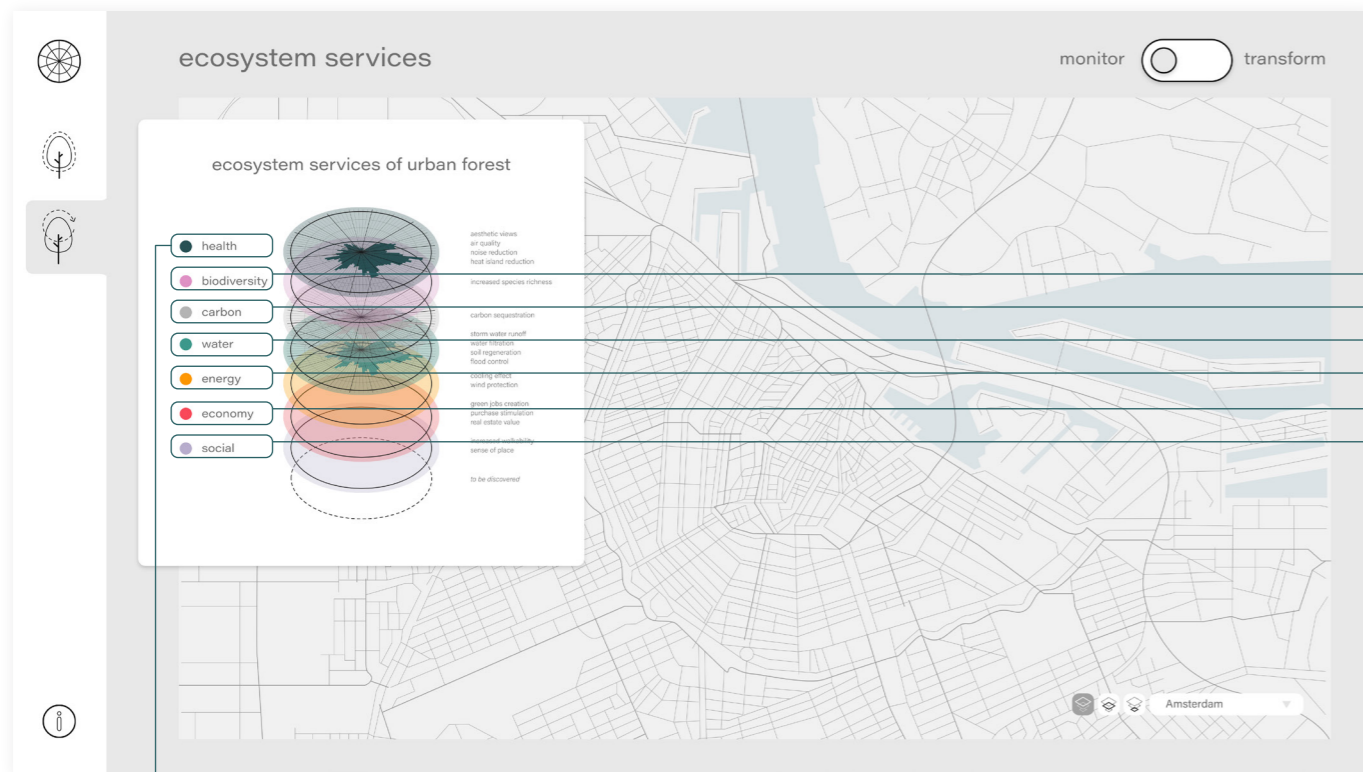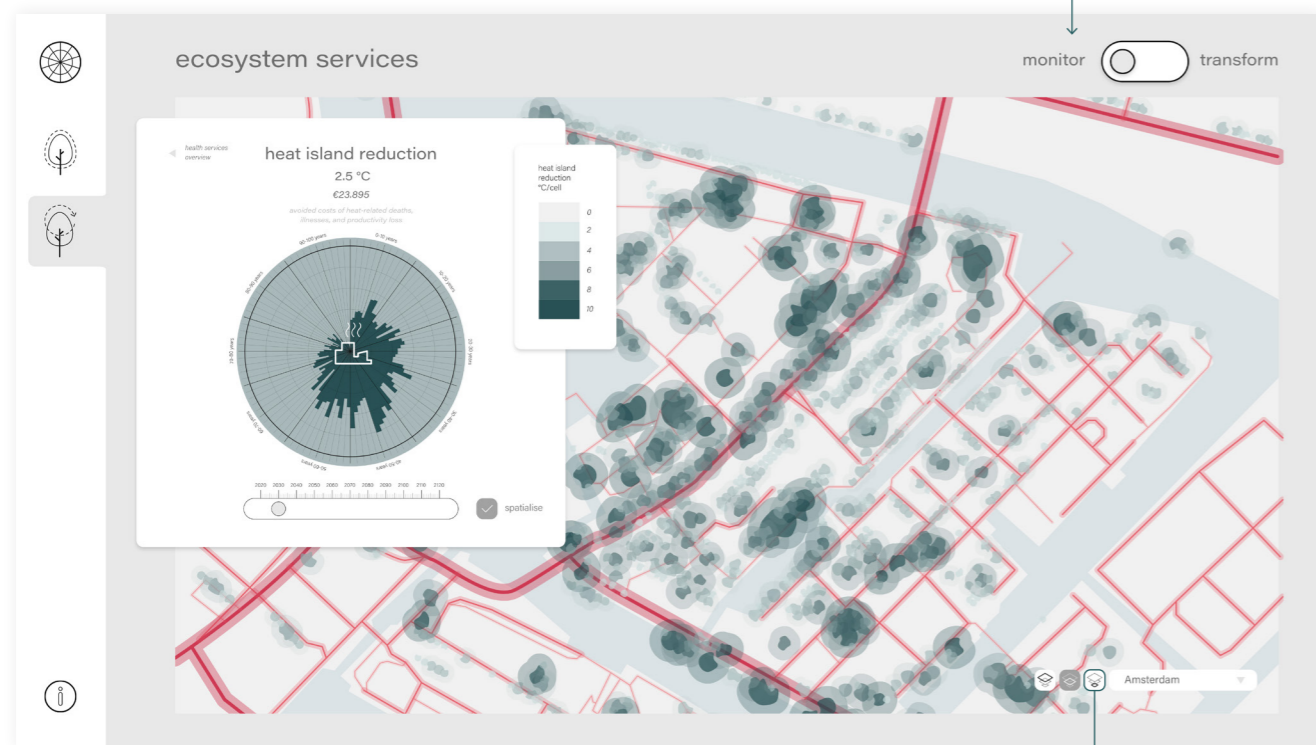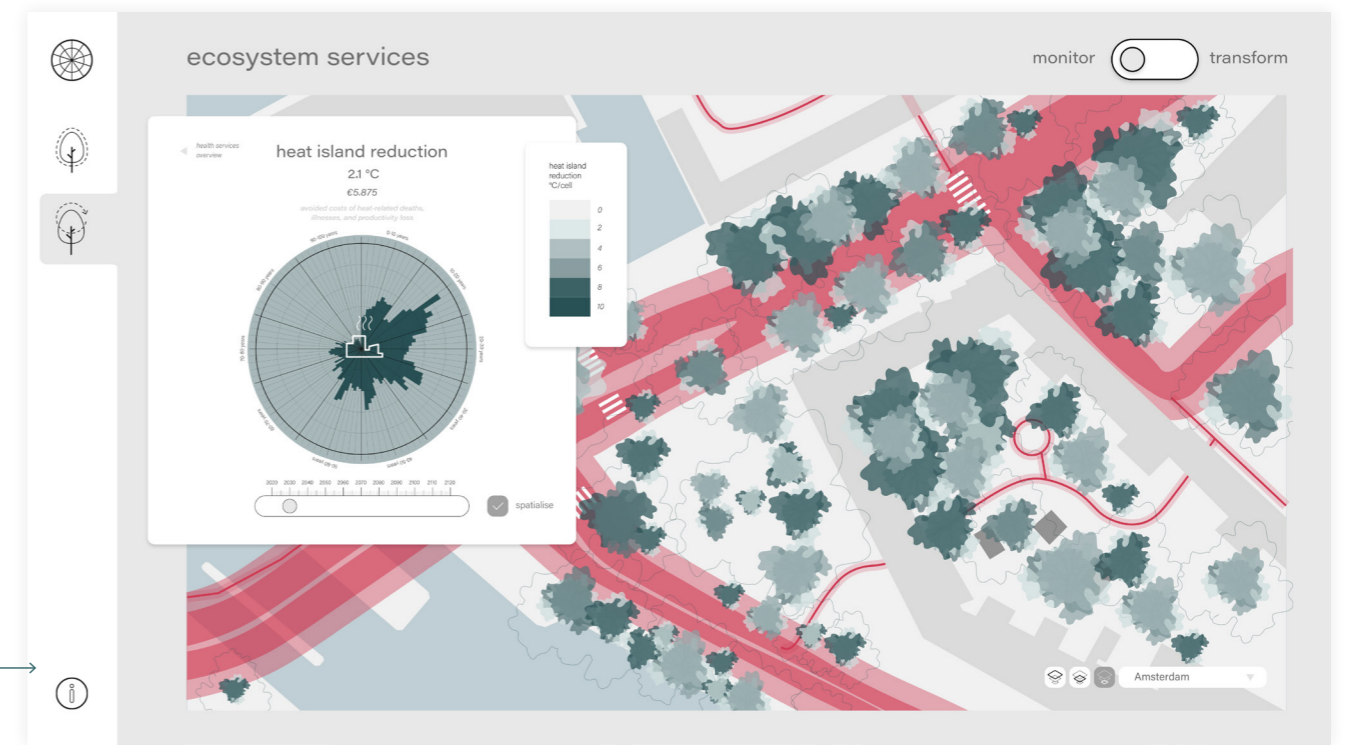*Figure 47. Urban Forest Portfolio - ecosystem services and connected beneficiaries*

Spatial services and granularity

As mentioned as one of the key elements of the proposition and suggested during the test, the relationship between the data and the spatial context is crucial in order to illustrate where trees distribute their services. As the cooling performance and reduction of the heat island effect is the focus of the consortium, this service is selected for further visualisation and granularity is applied at the three different scales, as can be seen in Figure 48. It is important to note again that the maps are based on hypothetical data, but they were inspired by the work of Paulin et al.(2020), on a standardised national approach to mapping and quantifying ecosystem services. The mapping of the heat island effect is currently simplified and based on the pavement of the roads in Amsterdam, but in order to more accurately simulate the situation, all paved areas and buildings should be considered.

municipality

area
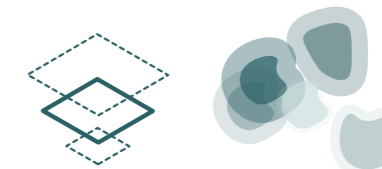
asset
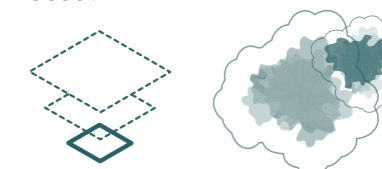
Figure 48. Urban Forest Portfolio - spatialised heat island reduction on three scale levels
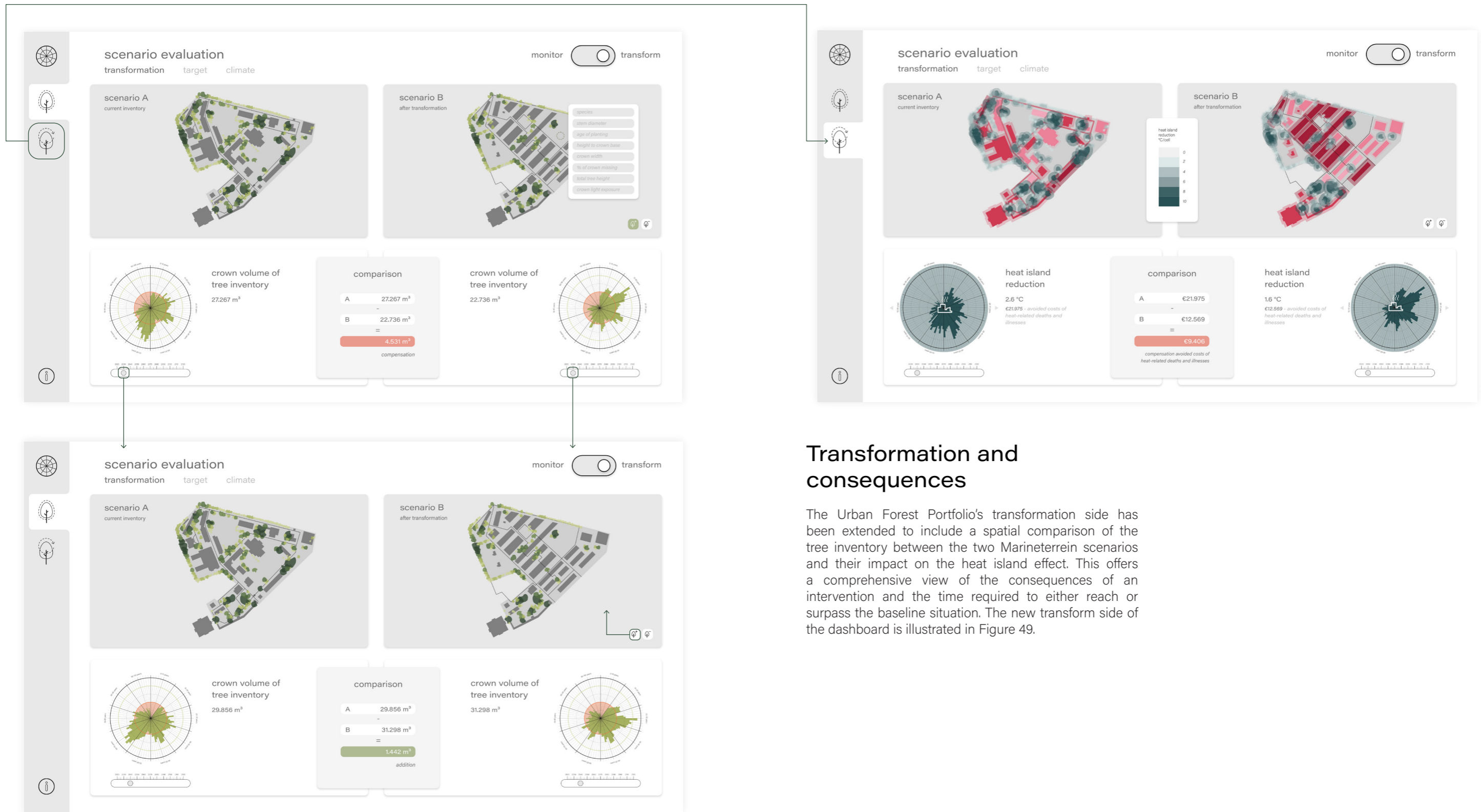
Transformation and consequences

The Urban Forest Portfolio's transformation side has been extended to include a spatial comparison of the tree inventory between the two Marineterrein scenarios and their impact on the heat island effect. This offers a comprehensive view of the consequences of an intervention and the time required to either reach or surpass the baseline situation. The new transform side of the dashboard is illustrated in Figure 49.

Figure 49. Urban Forest Portfolio - scenario evaluation for crown volume and heat island reduction

Proposition testing - iterated version

The revised version was reviewed once again with Wendy Batenbrug and several municipal stakeholders including Henk Langeveld, Wieteke de Boer, Jeroen van Gaalen, Hans Kaljee and Emma Reeskamp. A final round of signals was collected and presented below.

Signals of traction - iterated version

Resonating with current challenges

The selected functionalities of the dashboard resonate with the current challenges of the municipal officers, as they have expressed a focus on similar issues and topics.

"I recognise a lot of topics we, as green management, are also concerned with. We are also engaged in the search for potential space for green, I made a Tableaux document to map the space in streets the current trees have to determine the potential for growth and addition … We are also looking at different scale levels and are in need for this clear overview of ecosystem services of urban trees and what they can do for specific areas in the city"

"Those targets are a real struggle. The Court of Audit has come to us and said we sketch unattainable prospects lacking concrete standards and goals. How do we plan to get there? As it is not controllable right now"

"We recently got a new colleague who is busy with this kind of data, I think if he sees this he will start working on it tomorrow. I can already see him dreaming at night of being able to present these kinds of visualisations. I see a lot of potential in what you are already showing"

"We indeed need good communication about the functional story to really change the mindset, that needs improvement with us"

Fitting narrative on ecosystem services

The expanded ecosystem services narrative, which includes not only the quantified services but also the other services, was well received, extending the story they can currently tell with i-Tree.

"In this way you make it bigger than i-Tree, incorporating all ecosystem services. There is a lot of demand for telling this story, a good way of communicating the whole story"

"I do believe that you have to address the beneficiaries, a lot needs to change in order to understand and bear the costs together. At the moment no one voluntarily introduces themselves as benefit holder as the municipality has always been paying for the trees"

"Important to show that not everything can be quantified"

Importance of time dimension

The insufficient integration of the life cycle of trees was unanimously confirmed.

"The focus on lifecycle is well chosen. Until 10 years ago no attention was paid to the growth potential of trees, a good manager planted trees that did not require maintenance, such as a bonsai tree, small and not expensive. This has been in the DNA of managers, and I think this is still daily practice for 98% of the municipalities, it is the prevailing story in the Netherlands"

"On a project basis these visualisations can be perfectly applied, say much more than values. The time factor is really important, currently, we count trunks based on age, but it is really important to show the growth model and to explain that we sometimes do not immediately reach the same crown volume after transformation but after 10 years we do. This is good communication, both for management and development"

Signals of traction were also seen in the connections that were made with other instruments, illustrating the potential to enhance current practices.

Finally, the interviews revealed a need for further development, with a renewed emphasis on integration into the Oranjeloper project and a desire to bring the story to a wider audience.

Comments were made on certain simplifications, which will be considered in the proposition development timeline. Some questions were asked about the bigger picture of research and application, which partly explains the current reluctance to adopt the i-Tree software.

The narrative of the Urban Forest Portfolio can also help to tell the story of i-Tree in a different way, which is currently disappointing municipal stakeholders by expecting all services and only getting four. The story has gone the wrong way because it could be better told as: first we could not quantify the data, and now we already have four services and more to come. Without suggesting the ability to monetise the true value of the urban forest.

Enhancing current practices

"I think, based on the workshop with the architects, it could be an interesting linking concept for them as well, as part of the BEA, if it merges more to ecosystem services"

"I get really enthusiastic when I see this, we could definitely use this to steer within management and developments, to look at consequences and on the long-term. It is a great means of communication towards politicians and residents about why certain choices are made. It could also strengthen our relationship with these stakeholders because we can have better conversations"

"We could even let go of our replacement policies if we would set clear targets and steer on realising them with the dashboard values, it could be part of the tree effects analyses"

"How do I get my information in this dashboard? It provides the link between green policy and green space management. You show my range of concern: from a single tree up to a vision looking ahead twenty years in time, from management towards vision"

Urge for continuation

"We could fill in your model with the data from the Oranjeloper project, I think it already fits quite perfectly. Can you elaborate on it on Boominfodag together with Hans when he introduces the Oranjeloper project"

"I would find it extremely interesting to incorporate parts of this in the Oranjeloper project and discuss this somewhere in April linking it to a practical situation. Soon you continue with your own company, is it true we can hire you for these kinds of jobs?"

"We have 16.000 colleagues that need to hear this story, we need to plug this in the near future"

Signals for improvement - iterated version

"The reality would be 1:1 replacement right now, because of diseases trees fall out, on average we lose 1000 trees a year on a tree inventory of 130.000"

"Which compensation rule are you applying in comparing both scenarios?"

"You have to be careful with the money aspect, as you usually only get questions and scientifically this is taken down, money can be misleading"

"My aldermen are already convinced of the value of trees, however, when push comes to shove, it is a choice between pleasant living and having a place to live"

"Where are the other ecosystem services standing right now? Are we close to getting this data, or is it in ten years? To have a certain expectation. The use of i-Tree is very limited right now, which is why we do not really dare yet to take the step and think we can better wait a while until it is complete"

Proposition timeline of development

The presented Urban Forest Portfolio is a first exploration to monitor the urban forest as critical infrastructure. A boundary object to be suggestive of and encourage discussion about the possible application of i-Tree within the urban domain. It speculates based on hypothetical data, assumes optimal growth curves and constant inventories, and does not consider the varying morphologies and orientations. However, the process of conceptualising and testing the dashboard has revealed potential lines of development that can be used as guidelines for future advancements. These timelines listed in Figure 50 are not intended to be a specific roadmap or order of implementation, but rather to suggest potential directions for the evolution of the initiative and the way in which the urban forest is monitored, protected and valued.
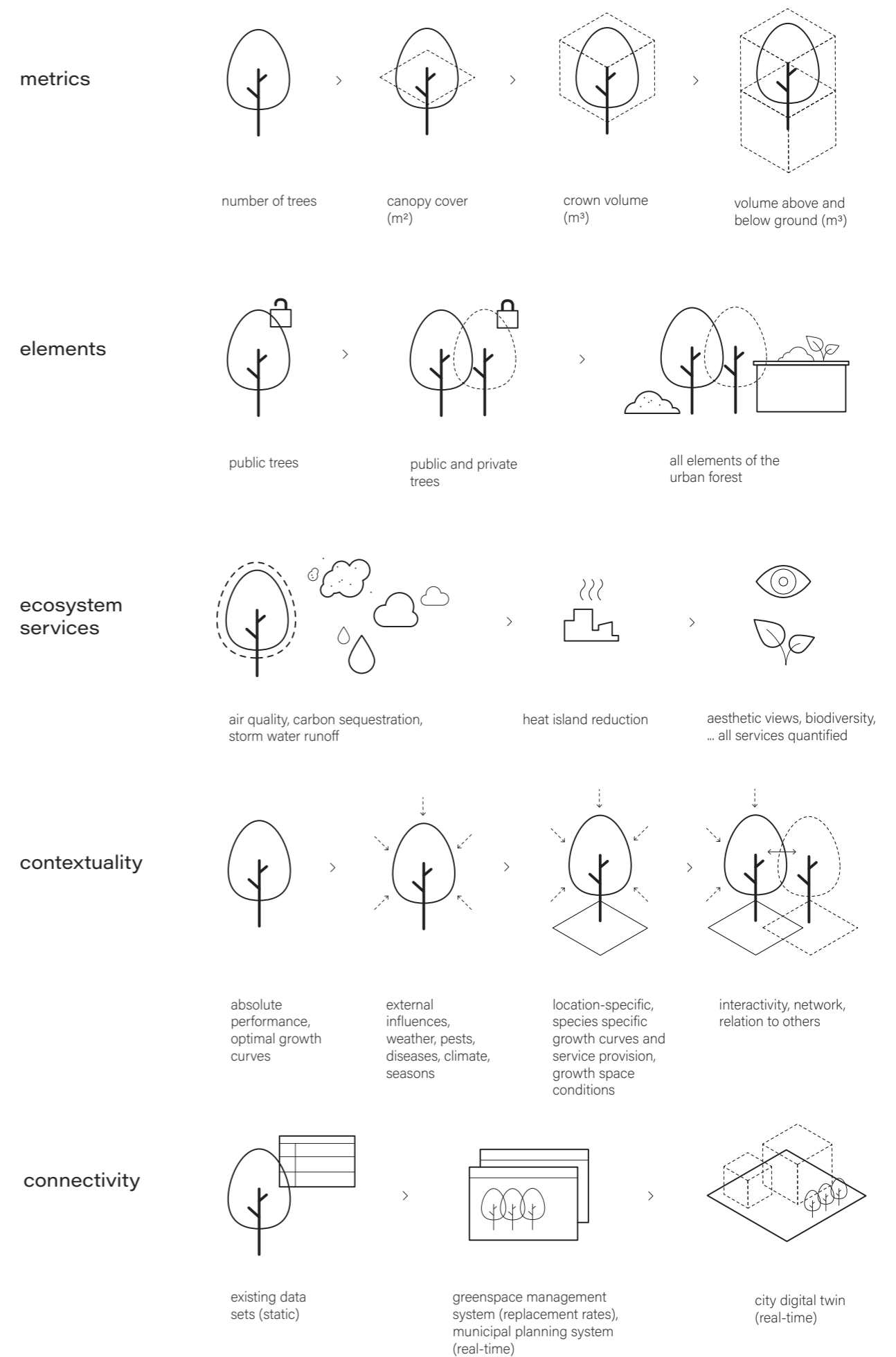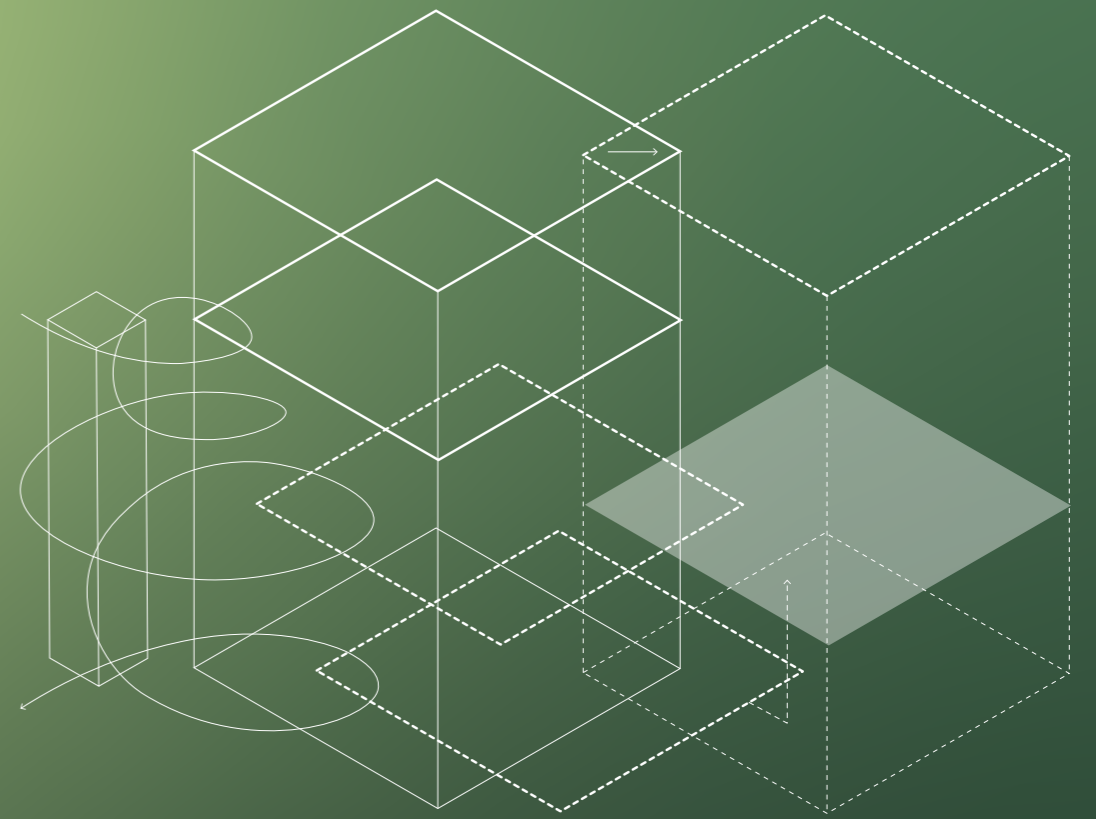

metrics

number of trees | canopy cover (m²) | crown volume (m³) | volume above and below ground (m³)

elements

public trees | public and private trees | all elements of the urban forest

ecosystem services

air quality, carbon sequestration, storm water runoff | heat island reduction | aesthetic views, biodiversity, ... all services quantified

contextuality

absolute performance, optimal growth curves | external influences, weather, pests, diseases, climate, seasons | location-specific, species specific growth curves and service provision, growth space conditions | interactivity, network, relation to others

connectivity

existing data sets (static) | greenspace management system (replacement rates), municipal planning system (real-time) | city digital twin (real-time)

Figure 50. Five proposition development timelines

part 5
THE INTEGRATION

Finally, Part 5 zooms out again and discusses the integration of the proposition into the system to bring the thinking back into the place where it was generated from. To have a last holistic view and speculate on the potential impact of the Portfolio, recognising that adoption does not happen all at once and is more likely to result in a gradual burn of changes. This section considers what it would imply for stakeholders, how conversations might be conducted differently, how roles and responsibilities might be affected, and most importantly, how the position of the urban forest might change if the dashboard and therefore new practices were to be in active use.

A first attempt at these discussions follows in this final chapter by forecasting how the current status quo could be influenced by concrete new practices and thereafter by proposing some system scale speculations that provide a glimpse of a potential new system. The part concludes by demystifying part of the new paradigm, operationalising the transitions and turning the lens to bring some of the abstract principles into focus.

SYSTEM INTEGRATION

Concrete practices enhancing status quo

Drawing on the knowledge generated from the processes and testing of the Urban Forest Portfolio, a set of eight new practices was envisioned as a result of integration. These practices would impact different domains of the current system, as shown in Figure 51, and most of them logically follow up on the previously identified opportunity areas. The justification for opportunity area 1 explained how the dashboard was expected to facilitate a cascade of new interactions and potentially enhance connections between multiple stakeholders. The operationalisation of these practices could be possible in the relatively short term, and they could be considered 'low hanging fruit' compared to the system scale speculations that follow. The order of the practices is deliberate to indicate the assumed path of change. The practices are linked to one or more principles and specify the document or interaction they affect.
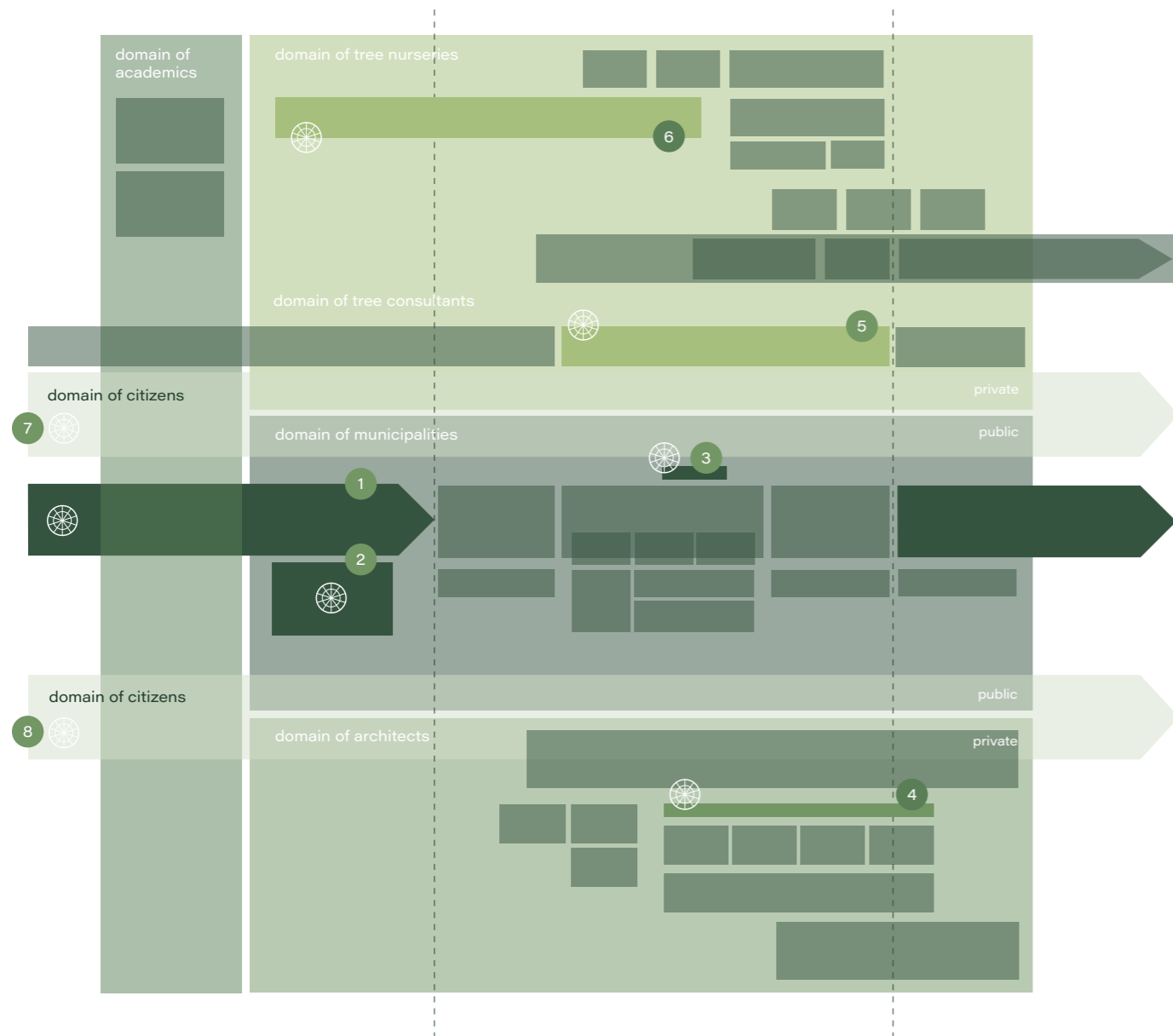
Figure 51. Eight practices enhancing processes of current system

Facilitate collective functional narrative

Monitor quantified long-term targets

Ensure equitable and collective distribution

Procure for functional performance

Design for functional performance

Connect functionality to scale

Manifest position in time and space

Position for contextual interaction and diversity

1. Communication to justify tree decisions to stakeholders

The dashboard can facilitate municipal green space officers to tell the functional story of the urban forest in relation to climate adaptation and city resilience, illustrating the full range of ecosystem services it provides. It shows both quantified performance, where data is available, as well as the services that can only be described qualitatively because the evidence is still being developed or the nature of the service does not lend itself to numerical representation.

In addition to overwriting the aesthetics-focused story with a multi-functional performance narrative, the dashboard can enhance communication with different stakeholders such as politicians, developers, action groups, and citizens by visually demonstrating why certain tree related decisions are made during management and development. By comparing inventory scenarios over time, officials can demonstrate how replanting with younger trees may result in a current decrease in canopy volume but a significant increase in twenty years. The Oranjeloper project would be a concrete example of such a discussion.

2. Foundation for green policy and urban forestry masterplan

The dynamic portfolio can be used to monitor and track progress towards targets for crown volume growth, equity, diversity, and ecosystem services. While this monitoring can serve as a foundation for current green policies, it has the potential to become the cornerstone of an urban forestry master plan if this approach is adopted by the Dutch municipalities. Designers, planners, growers, and tree experts could work together to develop this plan, which would anchor the targets and define a long-term vision and ambition for the potential of the urban forest.

3. Procurement framework for transformation projects

These monitored targets could find their way into the procurement process of transformations. Examples of requirements in the tender document could range from a ten per cent increase in existing crown volume over twenty years to meeting a specified equity baseline, and from maintaining a fixed species diversity ratio to maintaining a constant stock of trees between 50 and 100 years old. This would affect developers and designers as well as nurseries and landscapers. Leading to a framework that meets the larger ambitions, but is still flexible enough to let the creativity of the market flourish and come up with tailored, innovative solutions.

4. Spatial input for design process

To meet the new tender requirements, the architectural design process should be informed by new inputs. Spatial maps of ecosystem services can result from the Portfolio, indicating the site-specific performance of trees in a given area, moving from a black box of positive effects to a concrete contribution in relation to the context. Tree growth curves provide insight into the invisible envelope and its future development. The scales of the dashboard (municipality, area, and asset) can correspond with the architectural disciplines (landscape, urbanism, and architecture) to facilitate integration and granularity. It is assumed that not all ecosystem services are relevant at the same scale level, and this would provide an opportunity to link functionality to scale. At the different stages of the process, design scenarios can be evaluated using the dashboard.

5. Element of tree effect analysis (BEA), tree valuation, and replacement policy

Compensate for rightful preservation

Manifest position in time and space

The current tree effect analysis, abbreviated 'BEA' in Dutch, is a standardised assessment that maps out the potential impact of construction and development on the sustainable survival of trees. This assessment is increasingly required by the General Local Regulation ('APV') and is carried out by tree consultants. In addition, the tree valuation of the Dutch Association of Tree Appraisers ('NVTB') is regularly used to determine the replacement value of trees and stands in court. However, neither instrument takes into account the ecosystem services provided by the urban forest. The NVTB's tree valuation suggests that the optimum age of a tree is around 40 years. The dashboard could help to improve these valuations. Furthermore, the dashboard could be used to guide tree replacement policy, moving away from the current 1:1 (or other ratios) approach and instead focusing on achieving the targets monitored by the dashboard to ensure the correct spatial manifestation of the urban forest over time.

6. Support long-term nursery contract

Nurture for functional performance

Forecast future demand

Factoring in realistic rates of tree replacement, premature mortality, and external risks such as climate impacts, pests, and diseases, the Portfolio offers an insightful overview of the influx and efflux of the municipal tree inventory over time. These dynamics could be used to forecast the supply needs further in advance, leading to a more stable supply that could improve the relationship between municipalities and tree nurseries. This, in turn, could potentially serve as the basis for longer-term contracts tailored to the specific ecosystem service ambitions of cities, thus jointly shifting the focus from stem width and fast-growing trees to functional performance that increases the resilience of the urban environment.

7. Participatory urban green management

Diffuse division between public and private domain

Request mutual interdependence

So far, the focus has been on the public part of the urban forest, but in some areas, the private part can sometimes outweigh the public. The binary division between the two does not serve the urban forest well, as it is a system whose interconnections should not be hindered by human property rights. Part of the solution to diffusing the strict separation between the public and private domain is to involve citizens in a more substantial way in caring for the urban forest around them. A first step in this participatory management could be the joint mapping of the private part of the urban forest in the Portfolio. This could be a start to increasing local appreciation and ownership of the urban forest around people's homes.

8. Participatory urban green planning

Diffuse division between public and private domain

Facilitate collective functional narrative

Next to involving citizens in tree-related decisions, they should participate in the process of urban green planning by channelling the liveability needs into spatial proposals with a focus on ecosystem services. After all, local people have the best understanding of what is required in their environment and what is effective or not in terms of usability and interaction with the place.

System scale speculations

Imagine if … the world was different?

The previous eight practices are logical, possible, and relatively within reach. The following series of six proposals are playful propositions, just imaginable yet highly speculative. They present an outlook on a possible new system, rather than substantiated results, and carry disproportionate economic, technocratic, and legal implications, raising fundamental questions that have yet to be answered. Hopefully to excite and inspire by offering a glimpse of a potential future beyond what is currently achievable. These speculations are deliberately not mapped onto the current system, as they call for something new that is not yet ready to be captured by outlined frameworks, roles and set responsibilities, and would not do justice to the complexity of the issues at stake. But who knows, perhaps one day they will.

9. Shift in green space management rationale

Imagine if … the management cycle was continuous?

Connect cycle and realise true ecosystem

Manage for growth and maturity realisation

One of the project's reframes zoomed out of the current transformation process and presented a different circular view, where a transformation is followed by a period of maintenance. During the development process, management is paused and the trees are left to their fate, although they are actively protected at the margins through BEAs and tree valuations. What if management were continuous, contracts were extended for up to thirty years, and the transformation cycles were seen as a forward-building spiral (see Figure 52)? What if design was driven by management and supported the preservation of crown volume and the provision of ecosystem services? What if the developments were tuned to coincide with the planting season, giving trees a real chance to grow? Providing a level playing field for management and shifting the rationale from limiting nuisance and disservices to realising growth and maturity.
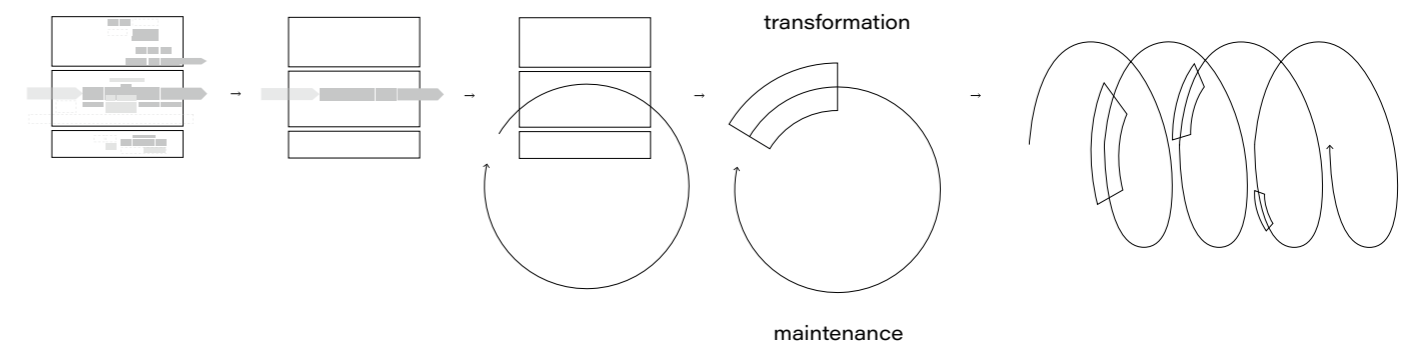

Figure 52. From transformation process, to cycle, to spiral

10. Move perceived 'climax' of transformation projects

Imagine if … the perceived climax of transformations was when trees reached maturity?

Stretch time horizon

The perceived climax of current transformation projects is projected to be the end of the realisation phase, when newly built properties are handed over to new owners and public space is returned to the municipality. The completed buildings are in their best condition and depreciate in value from this point onwards. For the green infrastructure, however, development has only just begun and will reach its optimum a few decades later. Considering the successional stages of a forest, this could take many decades. What if we were to rethink urban development and extend the horizon of transformations would be extended to be more in tune with the arborescent rhythm (see Figure 53 on the next page)?

transformation

"climax"
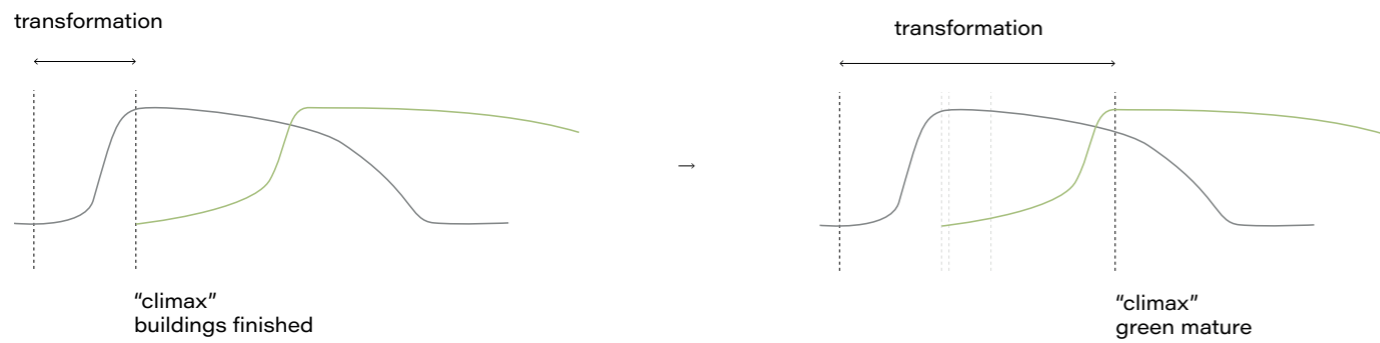buildings finished

transformation

"climax"
green mature

Figure 53. Different moment of transformation 'climax'

11. Enforce green infrastructure accountability of architects and developers

Imagine if … condition creators were hold accountable for all green in their spatial plans to grow old?

Create shared accountability

The momentum is lost after the grand opening, and the developer and architect are not held accountable for the green in their plans to grow old. It would not be tolerated if five out of the twenty promised apartments collapsed before the residents could move in, but they can get away with delivering 'sidewalk vegetables' that do not survive their first year in the city. What if the urban forest were underpinned by shared accountability in the form of life cycle contracts?

12. Integrate green sector organisation

Imagine if … the green sector was made up of five or six large organisations?

Connect cycle and realise true ecosystem

Tree nurseries select the species, landscape contractors provide the growing space and management of the trees, and tree consultants conduct the tree analysis and valuation. Compared to the grey infrastructure system, the green sector is very splintered. What if the system were more integrated and responsibilities were combined to reduce competition and fragmentation?

13. Create a market for ecosystem services

Imagine if … there was a market for ecosystem services?

Connect functional benefits and beneficiaries

Request mutual interdependence

To redress the financial imbalance of the urban forest, new financial instruments should be explored to link ecosystem services to their respective beneficiaries. How could new economic structures be put in place to generate deserved value for the city, just as the grey infrastructure does through road taxes, increased productivity-related GDP, and parking revenues? Another financial instrument could be along the lines of carbon credits and green certificates, engaging the private sector to invest in the urban forest in a regenerative and intergenerational way. As corporate responsibility laws and regulations continue to advance, interest in sustainable business practices and reputations is expected to increase even further. As some of these services are already being monetised, there are opportunities to explore and pursue (see Figure 54). What if current ecosystem 'donations' could be transformed into actual ecosystem services?
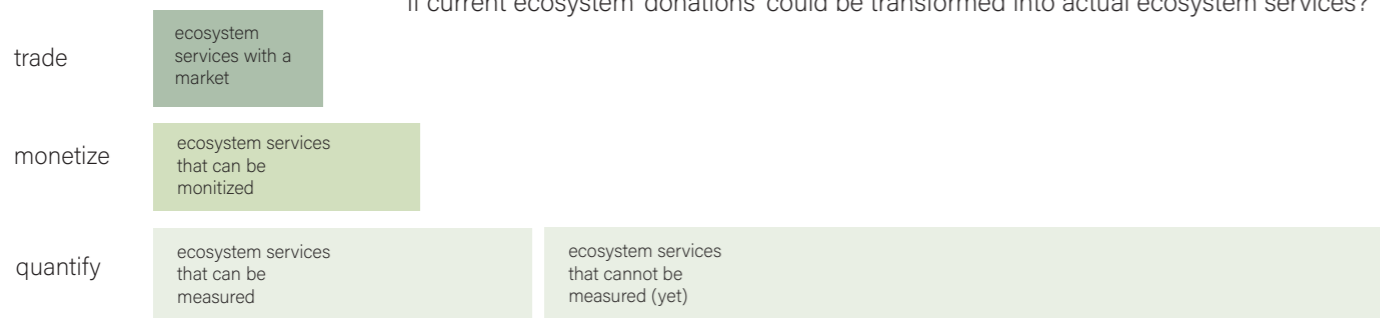

trade — ecosystem services with a market

monetize — ecosystem services that can be monitized

quantify — ecosystem services that can be measured | ecosystem services that cannot be measured (yet)

Figure 54. The current status of valuing ecosystem services, adapted from van Woudenberg (2021)

14. Establish green consortium, sectoral coalitions, meta coalitions and national body

Imagine if … there was a 'Rijksgroenstaat'?

Link to climate adaptation and city resilience

Connect cycle and realise true ecosystem

At present, the responsibility for the urban forest lies mainly with the municipal green sector, and most decisions are made within the framework of four-year coalition agreements or development projects. However, there is a need for more integrated cooperation and coordination that transcends specific transformations and short-term planning cycles, not only within the green sector but also on a larger scale (see Figure 55).

The first step would be to propose a green consortium of stakeholders from different domains of the current system to facilitate coordination within the sector. This consortium could be tasked with developing an urban forestry master plan that defines a long-term vision and aligns limited resources with unlimited ambitions. New urban rules can be developed, tested and implemented together, co-evolving between design and policy, infused with technical tree knowledge and citizen experience. The academic institutes have the potential to foster quintuple helix collaborations, bridging disciplines, building collective capacity, and guiding transitions through relevant research.

The urban environment accommodates a diverse range of programmes and functions, including space for residential, transport, communication, institutional, recreational, industrial, and commercial purposes. In addition to living and working, the underground, traffic, water and green systems each have their own unique challenges and objectives. This confluence of interests could benefit from a sectoral coalition that explores integration, prioritisation, and equity, deliberately placed outside the current siloed asset structure.

The paradigm shift in the urban green domain is just one of many transitions that society is currently undergoing, ranging from climate adaptation to energy transition, and from smart mobility to healthcare reform. A meta-coalition across city boundaries could provide a holistic view of how these futures are interconnected.

The ultimate proposal for coordination is the creation of a 'Rijksgroenstaat', a national body that can facilitate legal reform, develop national standards, and institutionalise uniform data obligations. To body could for example explore whether private trees could be included in the land register to revise felling permits. Ultimately, this will bring the urban forest into a governance structure that reflects the importance and indispensability of this critical infrastructure.
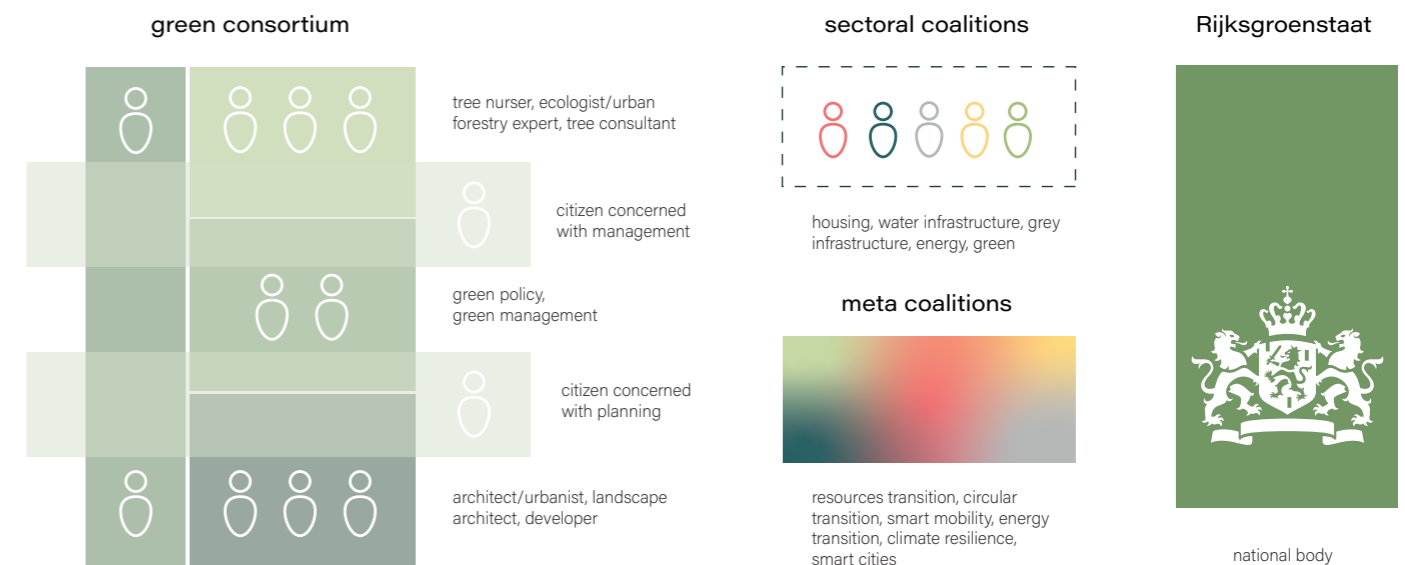

green consortium

tree nurser, ecologist/urban forestry expert, tree consultant

citizen concerned with management

green policy, green management

citizen concerned with planning

architect/urbanist, landscape architect, developer

sectoral coalitions

housing, water infrastructure, grey infrastructure, energy, green

meta coalitions

resources transition, circular transition, smart mobility, energy transition, climate resilience, smart cities

Rijksgroenstaat

national body

Figure 55. Proposal for coordinating bodies: green consortium, sectoral coalitions, meta coalitions and the Rijksgroenstaat

TANGIBILISE NEW PARADIGM

This thesis began with a far too broad and unscoped exploration of the relationship between nature, specifically trees, and the urban environment. With unbridled enthusiasm, a set of five abstract principles were distilled from a disparate collection of initiatives, projects, movements, scientific advances, revived ideas, and new mental models, which together formed the foundation of a new paradigm. These principles calibrated the compass of concept development and guided design decisions in a desired direction to ensure that the new piece would fit into the future envisioned puzzle.

In this final section, the perspective is reversed. In the process of concept development, the paradigm guided the creation of the piece, but now the piece contributes to a more focused puzzle, demonstrating the process of co-evolution as this forecasting oscillates between paradigm and practice. The exploration of the system, the identification of opportunities and the generation of concepts have led to more concrete, better understood and informed pieces within the new paradigm, looking through the lens of quantified urban forest data and a little beyond. The names of the five principles remain unchanged as they still 'hold' as the overarching narrative and present a cross-section of the most inspiring initiatives, developments, visionaries and cutting-edge research of the last decades. Rather, the transitions are made more specific, with the principles associated with the newly envisaged practices and speculations to colour in parts of the new paradigm related to the specific domain of this project (see Figure 56).

The next generation of i-Tree is only one of many pieces and offers a particular set of features and practices. As a result, it may affect only a small part of this new world, with certain transitions being more affected than others. For example, the main concepts of the software revolve around the spatial distribution of the urban forest and the quantification of its ecosystem services. This is in line with most of the new practices and speculations related to transitions two and three, which involve changes in the way society integrates and accounts for the urban forest. All five transitions are discussed briefly below and are made tangible with the new principles.

Co-inhabitance

The transition to co-inhabitance is partly operationalised by changing the management rationale. From taming the urban trees, limiting their growth to prevent nuisance and disservices, to letting them flourish, guided by an understanding of growth potential, connectivity, and time. To align human transformation efforts with the natural processes and bring both cycles closer to living together again. To highlight the critical position of the urban forest for the liveability of cities. In addition, the urban forest could

be given a more rightful place at the table through the establishment of the Rijksgroenstaat to develop national policies and regulations that manifest its integration into the built environment from a top-down perspective. The quintuple helix format also ensures the integration of the environmental perspective in future innovation projects. The meta-coalitions could be the start of a new kind of urban planning, in which the different levels of the city are mutually developed in a reinforcing way of this ideal.

Wood-wide-web

The link with nature's cycles is put into practice by considering the life cycle of the urban forest, which extends the time horizon of transformations and adapts to the arborescent rhythm, claiming the position of trees above and below ground over time. It is a transition from a trend-sensitive nursery sector to a nature-sensitive one, allowing for growth and long-term forecasting. To break out of the grid-like environments and isolated position of nature by providing the necessary knowledge and rules to design and plan for a context-specific inventory that is diverse and can interact. Finally, to operationalise the de-siloing of the green sector and move away from the splintered system. By working together in cross-sectoral coalitions that transcend transformations and coalition agreements.
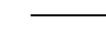
Collective benefits

In order to change the perception of urban trees from a mere cost on the city's balance sheet to one of its most essential assets, the functional performance and rightful quantification are presented. In both monetary and natural metrics, the quantitative and qualitative aspects of the urban forest's contribution to the urban environment are highlighted. By linking ecosystem services to their beneficiaries, co-investment and shared accountability can be established. Scenario assessment facilitates appropriate compensation to preserve the existing crown volume and ecosystem services. Monitored targets and a long-term vision allow the green sector to actively participate in the urban planning and make measurable progress. New financial instruments, such as carbon credits and green certificates, could create a new market and transform the current ecosystem 'donations' into actual ecosystem services.

I co-inhabitance
II wood-wide-web
III collective benefits
IV shared narrative
V spatial solidarity

Figure 56. Bringing parts of the abstract paradigm in focus through new practices and speculations

Shared narrative

From aesthetics to liveability, constructing a new socio-cultural urban forest narrative is requisite. This shift in narrative needs to be felt and supported through the inclusion of citizens. Their involvement can diffuse the strict separation between the public and private forest and can allow for a more organic, bottom-up design and care of their environment. This can not only give residents a greater sense of ownership of their localities but also promote a deeper understanding of the value of the urban forest. This, in turn, has the potential to reposition what is the public realm.

Spatial solidarity

The urban forest should be equitably distributed, providing a variety of landscapes and ecosystem services within reach. Emphasis is placed on prioritised planning for equity within the urban forest by highlighting the dispersal, proximity and visibility. The spatial distribution of services emphasises the interdependence of the city and green infrastructure as a prerequisite for walkable streets, clean air, and inclusive mobility for all urban dwellers.

I **co-inhabitance**

manage for growth and maturity realization (9)
link to climate adaption and city resilience (1, 14)

II **wood-wide-web**

connect functionality to scale (4)
stretch time horizon (9, 10)
position for contextual interactions and diversity (4)
manifest position in time and space (4, 5, 9)
forecast future demand (6)
connect cycle and realise true ecosystem (9, 12, 14)

III **collective benefits**

connect functional benefits and beneficiaries (13)
compensate for rightful preservation (5)
create shared accountability (11)
plan, design, procure, nurture for functional performance (3, 4, 6)
monitor quantified, long-term targets (2)

IV **shared narrative**

diffuse division between public and private domain (7, 8)
facilitate collective functional narrative (1)

V **spatial solidarity**

request mutual interdependence (13)
ensure equitable and collective distribution (2)

CONCLUSIONS

This very last chapter of the thesis provides a synthesis of the research process outcomes together with recommendations for future work, a last thought and a final personal reflection on the project.

CONCLUSION

Synthesis of project outcomes

The urban forest has a critical position in ensuring the liveability of future cities. However, the current indifference that runs through the veins of current anthropocentric systems limits the urban forest from being a central part of the built environment. This thesis is triggered by the need for a paradigm shift in urban design and green space planning to manifest the urban forest as critical infrastructure. To eventually arrive at concrete new practices driven by the next generation of i-Tree that could be added to the right side of the paradigm balance, tipping a little closer towards 'the new' outweighing 'the old', as illustrated in Figure Figure 57.

Part 1 started with illustrating the desired future direction for the urban green domain, presenting a glimpse of the potential outlook of the new paradigm. In order to anchor the green infrastructure in time and space, society must first change its relationship with the urban forest from one of taming it to one of co-inhabitation. The way in which it is integrated into the urban fabric should move from being isolated in our geometric grids to a wood-wide-web of interconnected ecosystems. The process of accounting must advance from presenting disappointing figures and thinking in terms of costs to recognising them as crucial collective benefits that need to be co-financed by all beneficiaries. Society also needs to collaborate with the urban forest in a different way, substituting the lack of urbanity and degradation of public spaces with a new shared socio-cultural narrative. Finally, the way access is provided to the urban forest needs to shift from inequitable entry to spatial solidarity.

Part 2 mapped the role of the public green sector in urbanisation to understand the current planning, design, implementation and management processes of the consortium stakeholders and their interrelationships. A disconnect was found between condition creators (green policy makers, planners, architects, and developers) and condition fulfilers (green managers, tree nurseries, and tree consultants). Their targets, constraints, and language are not properly aligned, even though they follow each other in the cyclical urban process. As a result, one side's future visions clash with the other side's daily practice.

Part 3 strategically separated the domains and examined the opportunities for infusing quantified urban forest data into the architectural, municipal and nursery parts in isolation. Ultimately, five opportunity areas were identified to reconnect stakeholders within the current system. For example, opportunities were found in integrating the time dimension of the urban forest, providing basemaps on ecosystem services, creating spatial rules for green functionality, increasing the granularity of green design, and

justifying green decisions based on life cycle forecasting. The first opportunity area of the management dashboard was selected for further elaboration as this concept was assumed to be the starting point of a cascade of needs and to potentially reinforce multiple connections with stakeholder domains.

Part 4 presented the Urban Forest Portfolio, which evolved the use of i-Tree from static assessments to a dynamic portfolio that allows progress towards quantified, long-term targets to be tracked. The dashboard aims to align the ambitions of green space policy and green space management. The main rationale behind the development is the integration of time, illustrating the life cycle of the urban forest, as this is insufficiently incorporated in all the areas examined in the current system. From a highly trend-sensitive nursery industry with no accountability for reaching maturity to green space management focused on limiting growth, and from green space policy applied to four-year coalition agreements to static snapshots of large healthy trees in architectural renderings.

Part 5 examines the potential impact of the proposition integration on the current system and presents eight concrete practices enhancing the status quo, such as facilitating a new narrative of the urban forest, new rules for procurement, long-term nursery contracts, and participatory management and planning. In addition, a series of six playful propositions are provided that speculate on a potential new system, such as a continuous management cycle, a market for ecosystem services, and the establishment of the Rijksgroenstaat. Finally, the circle is closed by making parts of the new paradigm tangible for the specific domain of this project by connecting the principles of the proposed practices and speculations.
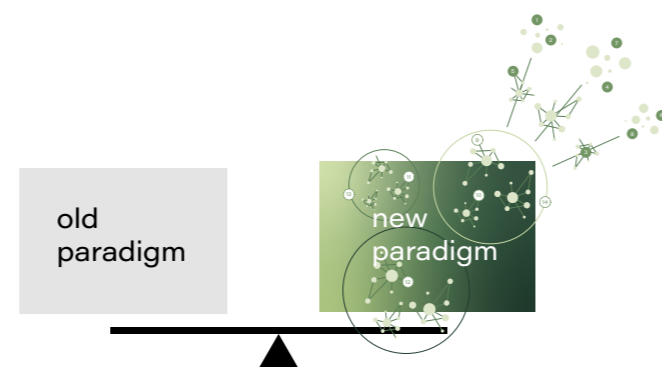

Figure 57. New practices and speculations added to the paradigm balance

RECOMMENDATIONS

Brief for future work

This project is part of a broader transition and ends with open-ended questions, unexplored directions, potential for continuation, and the need for further validation. Some final recommendations are proposed below, both within and beyond the scope of the i-Tree 2.0-NL project.

Radical consortium combinations

Two co-design sessions have been organised within this project, bringing together rather familiar and comfortable combinations of stakeholders from the architectural and municipal sectors. In future sessions, it would be not only interesting but essential to organise a more diverse and unconventional set-up, combining the perspectives of nurseries, municipalities, architects and academics in the same room. i-Tree can serve as the right vehicle to facilitate such collaborations.

Variations in urban transformation processes

The main focus of the project was the municipal area transformation process involving private property development. However, the processes of the project developer, executive organisations and landscape contractor should be further investigated to make the system more complete and integrate the perspectives of all consortium stakeholders. Additionally, other types of urban transformation should be investigated such as the renovation of public spaces or the replacement of sewerage systems. These developments follow a different course and have different rules and responsibilities. Besides, more attention should be paid to the differences and nuances of the processes between the municipalities as the current project focuses on the overlap between them.

Beyond the green sector

One of the major limitations of this project is the chosen scope of the green sector. Almost all interviews were conducted within this domain, meaning that people and organisations were already convinced of the essential value of the urban forest, potentially leading to a bias towards the necessary change. This imposes a risk that the findings of the project might only reflect a green echo chamber. Created in a relatively 'safe-to-fail' environment without having to withstand the remarks of opponents of green infrastructure. To mitigate this, the scope should be broadened and opened up to the city's 'grey', 'red', and 'blue' programmes. Unless these cross-domain connections and needs are properly integrated, siloed cities with isolated nature will still not belong to the past. Housing and mobility still drive most of the transformations and green fills the

gaps. The rules of the game should be changed, otherwise the outcome will remain the same.

A comparison with the grey infrastructure system would be very interesting to see how it's organised and managed, and to find out how actual critical infrastructure is taken care of and financed right now. A joint project between civil engineering and industrial design engineering, or architecture students could be valuable in this respect. With the current focus on decoupled networks, self-sufficiency and the creation of car-free cities as part of the energy and mobility transition, it is crucial for the green sector to seize available space in a timely manner before it is too late. In addition, it is crucial to strengthen the link with municipal climate officers, given their more appropriate budgets that can and should be allocated to the urban forest.

Urban Forest Portfolio implementation

The Urban Forest Portfolio has generated interest for implementation in a concrete case in Amsterdam. A possible first step could be to use the Oranjeloper project as a pilot study and test the current functionalities and visualizations of the dashboard to see if they meet the needs. In parallel, pilots could be conducted in other municipalities to ensure that the features are suitable for different contexts and scales. If adequate traction is observed, discussions could be held with i-Tree and the USDA Forest Service to explore opportunities. Once the solution is validated, a suitable development partner should be found. A personal suggestion would be Clever Franke, who are incredibly good at data design and technology and are also based in the United States (Clever Franke, 2023). It would be a smart move to link this party to the green domain.

It would also be interesting to connect the Urban Forest Portfolio to Gül's efforts on opportunity area 3, investigating new urban rules for procurement. Data from the Portfolio could be the input to generate targets, compare scenarios, and test policies on a small scale.

Unexplored areas of opportunity

As this is a strategic design project, limited resources had to be allocated to match unlimited ambitions, resulting in several opportunity areas being left unexplored.

Opportunity area 2 explored possibilities within the tree nursery sector. Friction was felt on both sides between the nurseries and municipalities, driven by different ambitions and mentalities. The reliance on the nursery industry is a crucial issue, as the targets for increasing canopy cover can only be achieved if the right species are grown. Although this is already an old and sensitive issue, dedicated research to bring these parties closer

FINAL THOUGHT

together would contribute to the feasibility of repositioning the urban forest. In addition, exploring the capitalisation of carbon credits and track and trace information could be interesting.

The granularity of urban green infrastructure decisions within the architectural processes, as presented in area 4, would also be worth exploring in greater depth to further bridge the gap between landscape and urban perspectives. To discover whether certain functionalities are related to certain scale levels of the urban fabric. Additionally, this project has explored the relationship between strategic design and architecture. It would be valuable to conduct more research on how the strategic focus on systemic transitions complements the spatial processes and how both perspectives can be mutually beneficial.

The involvement of citizens, the justification of decisions and the diffusion of the public and private forest boundaries

will be taken up in the new application for a Resilient Delta project submission, called T-Roffalab, which is already underway.

Finally, the disproportionate impact of the system-scale speculations on the economic, technocratic and legal spheres should be further explored. The market for ecosystem services and other financial instruments could be investigated from the perspective of Erasmus students. The development of the idea of establishing a Rijksgroenstaat would benefit from a political perspective. Another suggestion for this concept would be to liaise with the recently founded 'Nationaal Platform Bomen' (Nationaal Platform Bomen, 2023), which aims to connect the tree sector and promote the role of trees in urban areas. The Rijksgroenstaat could potentially complement or even replace this coalition, offering a more expressive and stronger character. To spice it up and create a fitting and desirable image with which people want to identify.

Duality of natural conception

I have one final reflection to share, a contradiction that has been occupying my mind since I was first introduced to the i-Tree software. It is a question around quantification, using vocabulary such as 'ecosystem service provider', 'functional performance', and 'avoided costs'. It is not the terms themselves that are being questioned, but their use in relation to the natural world. While the numbers may soon be impressive rather than disappointing, are we not still force-fitting the organic beauty of the forest into our anthropocentric systems? Can you reduce your closest, most meaningful relationships to numbers? Hiding the true moral, aesthetic and cultural value of nature behind a smokescreen of measured benefits. If we want to move towards a multi-species world, shouldn't we get rid of quantifying 'ecosystem services' and 'nature-based solutions' in a meta sense? What could happen beyond quantification, a different structure, beyond services and values to a more holistic relationship with nature?

However, by being cost-oblivious, the urban forest has no place in our current capitalist environment, which is obviously concerned with the performance of the economy. The language of power (Raworth, 2019) needs to be spoken in order to create a level playing field for green infrastructure. However, it is questionable whether the green sector would indeed act like 'cobblers who have abandoned their lasts', as Sagoff (2007) put it, by attempting to represent their domain as an economic matter rather than confronting society with the value of nature as an 'end-in-itself'. An important and difficult duality between the two opposing conceptions of nature: 'the idea of preserving the natural world or the idea of improving the performance of economy' (ibid.).

Regarding this thesis, the current position of the urban forest and the context of the consortium, I am at peace with the idea of emphasising both the quantitative and qualitative parts of the urban forest story, together with the system scale speculations that are pushing the boundaries of the current system. Definitely, something to think about a little longer, fittingly summed up:

"The test of a first-rate intelligence is the ability to hold two opposed ideas in the mind at the same time, and still retain the ability to function."

- F. Scott Fitzgerald (1936)

PERSONAL REFLECTION

A personal conquest

From the start of this project, I had one key objective - enjoy the journey. I have been working on this throughout my educational career, and I am proud to say: I finally did. The enthusiasm that fuelled the sentences from the beginning has made it this far. I will try to touch on some of the ingredients of this conquest and some personal lessons, hopefully making it a repeatable recipe.

Being in touch with the system and close to practice

The best part of this project was definitely the variety of conversations, largely made possible by the i-Tree consortium. I experienced a very warm welcome in the green sector and I was impressed by the passionate people working within it and their eagerness to collaborate and share. I was able to build relationships and shape the understanding together to continually test whether my assumptions and directions were resonating within the domain, which made the work extremely worthwile.

At times, the stakeholder management aspect of the project took up too much space and attention, particularly in the early stages, as I found it challenging to turn down meetings, events, and other commitments. Although all conversations contributed to the understanding of the domain, there were times when I could have been more strategic about when to allow stakeholder feedback and when to take a break from it. This search for validation has been a recurring theme in previous projects, and I am glad that, with the support of the discussions with Rebecca, I have finally managed not to let it get in the way of pushing boundaries.

Navigating layers of complexity

The granularity of this project was challenging, oscillating between the abstract paradigm and concrete practice. A quest for finding a balance between provocation and listening, radical change and incremental movement. Looking back, I believe I could have paid more attention to the nuances of the system dynamics and the decisions involved in framing them. I have experienced some tense feelings when presenting some of my more drastic interventions, fearing that they would be too far-fetched. I am aware that this is part of our job as designers, but it should be handled with care and modesty towards the current practices. The lack of familiarity with politics, economics, and architecture sometimes got in the way of speculation. The conversations with René helped in realising this, and the ones with Rebecca in overcoming.

In general, I feel very satisfied with the outcome of this project, especially that I was able to bring the proposition back to the system from which I started to generate it. I have never before been able to reach this stage of discovering concrete practices and speculations at the systemic level that could result from integration. This experience will certainly inspire my future projects. In the final phase, I was able to present the full story to a few key stakeholders, and the recognition these people expressed in the resonance of the new paradigm and interest in the proposition made me confident about the power of this project.

Thank you for reading.

Me, with the two opposed ideas of nature, retaining the ability to function

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